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FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 7 EBL AND WBL BRIDGES OVER RIVERBEND DRIVE TO SHIRLEY STREET CONNECTOR
HIGHWAY 7-NEW, KITCHENER TO GUELPH
G.W.P. 408-88-00

GEOCRES No. 40P8-284

Latitude 43.468162° , Longitude -80.464760 °

Report

to

WSP

Date: July 24, 2020
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TABLE OF CONTENTS

PART 1: FACTUAL INFORMATION

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

APPENDICES

THURBER

FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 7 BRIDGES OVER RIVERBEND DRIVE CONNECTOR
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PART 1: FACTUAL INFORMATION

1. INTODUCTION

This report presents the factual findings obtained from a detailed foundation investigation conducted at the site of two new bridge structures to carry the eastbound lanes (EBL) and westbound lanes (WBL) of Highway 7-New over Riverbend Drive to Shirley Street Connector in the Regional Municipality of Waterloo, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profiles, cross sections, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions under the potential foundation footprints was developed from the data obtained in the course of the investigation.

Thurber was retained by WSP to carry out the site investigation under the Ministry of Transportation Ontario (MTO) Agreement Order Number 3014-E-0013.

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

- Preliminary, Foundation Investigation and Design Report, Proposed Highway 7 Bridge over Riverbend Drive Connector, Highway 7-New, Kitchener to Guelph, G.W.P. 408-88-00, Geocres No. 40P8-178, Report to Ministry of Transportation Ontario Southwestern Region, File: 15-64-17, dated December 17, 2009. (Reference 1).

2. SITE DESCRIPTION

At the site, the Highway 7-New alignment runs approximately parallel to the existing Shirley Avenue. The site lies 700 m to the east of the existing Kitchener-Waterloo Expressway and 250 m to the east of existing Riverbend Drive. Lands to the north of the site are also vacant or undeveloped. The south side is occupied by commercial and industrial lands.

Based on the Ontario Geological Survey Special Volume 2, The Physiography of Southern Ontario, Third Edition by Chapman and Putnam, the site lies within the physiographic region known as the Waterloo Hills, characterized by ridges of sandy till kames or kame moraines, with outwash sands occupying the intervening hollows.

3. INVESTIGATION PROCEDURES

A preliminary geotechnical investigation was carried out at this site between June 11 and June 20, 2008. Four boreholes, numbered 08-033 to 08-036, were drilled for the WBL and EBL bridges. One borehole was drilled at each bridge abutment of possible one-span structure arrangements. The depths of three boreholes ranged from 20.0 m to 21.5 m (Elevation 293.2 to 292.1). Borehole 08-035 drilled at the EBL West abutment was terminated at 9.6 m depth (Elevation 305.7). The Record of Borehole sheets for the boreholes from the initial investigation are included in Appendix B.

A detailed geotechnical investigation was conducted between May 14 and July 3, 2018. Six boreholes (numbered RS16-01 to RS16-06) were drilled during the detailed investigation. Boreholes RS16-01 and RS16-02 were drilled at the west approach embankments and Boreholes RS16-05 and RS16-06 were drilled at the east approach embankments. Boreholes RS16-03, and RS16-04 were drilled between the west and east abutments of the WBL and EBL bridges, respectively. The boreholes ranged in depth from 15.8 m to 22.9 m (Elevations 299.7 to 289.9). The Record of Borehole sheets for the most recent boreholes are included in Appendix A.

The approximate locations of the boreholes from the previous and current investigations, are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix C. The coordinates and elevations of the current and previous boreholes are given on the drawings and on the individual Record of Borehole Sheets in Appendices A and B, respectively.

The ground surface elevations and coordinates of the recent as-drilled boreholes were provided by WSP.

Prior to commencing the site investigation, utility clearances were obtained for all borehole locations. Road occupancy permit was also obtained to complete site investigation.

During the current investigation, a track -mounted B-57 drill rig was used in conjunction with hollow-stem augers, mud rotary and casing advancer drilling methods to advance the boreholes. Samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in the overburden soils.

The drilling, sampling and in-situ testing 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. Results of field drilling and sampling of the investigation are presented on the Record of Borehole sheets in Appendix A.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. In Boreholes 08-034, 08-035, and RS16-04 a standpipe piezometer consisting of 25 mm diameter PVC pipe with a slotted screen was installed and enclosed in filter sand to permit longer-term groundwater level monitoring. Boreholes without piezometer installations were backfilled in general accordance with O. Reg. 903. The borehole completion details are also shown in Table 3.1.

The completion of the boreholes and the standpipe piezometers were carried out in accordance with the requirements of O. Reg. 903 (as amended by O. Reg. 372/07).

Table 3.1 – Borehole Completion Details

Foundation Unit		Borehole	Ground Surface Elevation (m)	Borehole Depth / Base Elevation (m)	Piezometer Tip Elevation (m)	Completion Details
WBL	West Approach	RS16-01	314.3	15.8/298.5	None Installed	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
	West Abutment	08-033	313.2	21.1/292.1	None Installed	Borehole backfilled with bentonite to 0.6 m, then holeplug to surface.

Foundation Unit		Borehole	Ground Surface Elevation (m)	Borehole Depth / Base Elevation (m)	Piezometer Tip Elevation (m)	Completion Details
		RS16-03	314.5	20.1/294.4	None Installed	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
	East Abutment	08-034	312.2	20.0/292.2	18.8/293.4	Piezometer with 1.5 m slotted screen installed with sand filter to 16.8 m, holeplug from 16.8 m to 16.2 m, bentonite seal from 16.2 m to 1.8 m, holeplug from 1.8 m to 0.6 m, then auger cuttings to ground surface.
		RS16-04	312.9	22.9/289.9	22.8/290.0	Piezometer with 3.0 m slotted screen installed with sand filter to 18.8 m, holeplug from 18.8 m to 15.8 m, then grout from 15.8 m to ground surface.
	East Approach	RS16-05	313.6	15.8/297.8	None Installed	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
EBL	West Approach	RS16-02	315.5	15.8/299.7	None Installed	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
	West Abutment	08-035	315.3	9.6/305.7	9.0/306.3	Piezometer with 1.5 m slotted screen installed with sand filter to 7.0 m, holeplug from 7.0 m to 6.6 m, bentonite seal from 6.6 m to 0.3 m, then holeplug to ground surface.
		RS16-03	314.5	20.1/294.4	None Installed	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
	East Abutment	08-036	314.6	21.5/293.2	None Installed	Borehole backfilled with bentonite to 0.9 m, then holeplug to surface.
		RS16-04	312.9	22.9/289.9	22.8/290.0	Piezometer with 3.0 m slotted screen installed with sand filter to 18.8 m, holeplug from 18.8 m to 15.8 m, then grout from 15.8 m to ground surface.

Foundation Unit		Borehole	Ground Surface Elevation (m)	Borehole Depth / Base Elevation (m)	Piezometer Tip Elevation (m)	Completion Details
	East Approach	RS16-06	314.7	15.8/298.8	None Installed	Borehole backfilled with bentonite holeplug and auger cuttings to surface.

4. LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size analysis and Atterberg Limits testing. All the laboratory tests were carried out in accordance with MTO and/or ASTM Standards, as appropriate. The results of the laboratory testing of current and previous investigations are summarized on the Record of Borehole sheets in Appendices A and B, and also presented on the figures included in Appendices A and B.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, a sample of the existing native silty clay soil was collected. The sample was submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing are summarized in Section 6 and are presented in Appendix A.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendices A and B. 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 should be recognized and expected that soil conditions may vary between and beyond borehole locations.

In general, the site is underlain by topsoil overlying layers of native stiff to hard silty clay and silty clay till, and compact to very dense silty sand till/sand and silt till. Layers of compact to very

dense sand and gravelly sand were encountered within the till deposits. Descriptions of the individual strata are presented below.

5.1 Topsoil

Topsoil was identified at the ground surface in all of the boreholes except for RS16-02. The topsoil thickness ranged from 100 mm to 600 mm. The topsoil thickness may vary between and beyond the borehole locations and the data is not intended for the purpose of estimating quantities.

5.2 Fill

A layer of silty clay fill with organics, trace sand, and trace gravel was encountered at the ground surface in Borehole RS16-02. The fill layer was 0.9 m thick and extended to Elevation 314.6.

The SPT 'N' value of the fill was 1 blow per 0.3 m of penetration, indicating a very soft consistency. The moisture content of the fill was 39 percent.

5.3 Sand to Silt

Layers of native brown sand containing trace gravel to gravelly and some silt were encountered below the topsoil in Boreholes 08-033 and 08-034. A 500-mm thick layer of silt was contacted within the sand in Borehole 08-033. The thickness of these upper sand layers range from 1.2 m to 1.3 m with the base of the layers at Elevation 310.7 to 311.7.

A layer of sandy silty with trace clay was encountered in Borehole 08-036 below the topsoil. The thickness of the layer was 1.9 m with the base of the layer at Elevation 312.6.

Layers of grey sand were also contacted within the glacial till deposits at lower depths, from 6.6 m to 16.2 m (Elevations 306.6 to 296.0) in Boreholes 08-033 and 08-034, respectively. The thickness of these layers ranged from 2.4 m to 3.8 m with the base of the layers at Elevations 293.6 to 302.8.

A 1.3 m thick layer of grey gravelly sand containing trace silt and trace clay was contacted at 16.5 m depth (Elevation 296.4) in Borehole RS16-04.

The upper layers of sand and silt have a compact relative density with SPT 'N' values of 13 to 17 blows per 0.3 m of penetration. SPT 'N' values measured in the lower layers of sand and gravelly

sand within the till deposit ranged from 93 blows per 0.3 m of penetration to higher than 100 blows per 0.15 m of penetration, indicating a very dense relative density. The moisture content ranged from 10 percent to 20 percent.

Grain size distribution curves for samples of the sand layers are presented on the Record of Borehole sheets and on Figure A6 of Appendix A and Figure B1 of Appendix B. The results of grain size distribution tests carried out on sand samples were as follows:

Soil Particle	Sand Percentage (%)	Gravelly Sand Percentage (%)
Gravel	2 to 13	27
Sand	76 to 91	62
Silt and Clay	7 to 11	11

5.4 Silty Clay and Silty Clay Till

Native brown to grey silty clay and silty clay till containing trace sand to sandy and trace gravel were observed in all the boreholes at depths and elevations indicated in Table 5.1.

Table 5.1 – Depths and Elevations of Native Silty Clay and Silty Clay Till

Foundation Unit		Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
WBL	West Approach	RS16-01	0.6 to 7.3 7.3 to 10.5* 10.5 to 15.8 (Borehole termination depth)	313.7 to 307.0 307.0 to 303.8 303.8 to 298.5	6.7 3.2 > 5.3
	West Abutment	08-033	1.5 to 4.1 12.2 to 17.4	311.7 to 309.1 301.0 to 295.8	2.6 5.2
		RS16-03	0.3 to 6.0 12.0 to 16.5	314.1 to 308.4 302.5 to 298.0	5.7 4.5
	East Abutment	08-034	1.4 to 6.1 10.0 to 16.2	310.7 to 306.1 302.2 to 296.0	4.7 6.2
		RS16-04	0.1 to 16.5	312.8 to 296.4	16.4

Foundation Unit		Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
	East Approach	RS16-05	0.2 to 15.8 (Borehole termination depth)	313.4 to 297.8	> 15.6
EBL	West Approach	RS16-02	0.9 to 4.9 7.5 to 10.0* 10.0 to 15.8 (Borehole termination depth)	314.6 to 310.7 308.0 to 305.5 305.5 to 299.7	4.0 2.5 > 5.8
	West Abutment	08-035	0.2 to 4.4 8.8 to 9.6* (Borehole termination depth)	315.1 to 310.9 306.5 to 305.7	4.2 > 0.8
		RS16-03	0.3 to 6.0 12.0 to 16.5	314.1 to 308.4 302.5 to 298.0	5.7 4.5
	East Abutment	08-036	2.1 to 13.3* 13.3 to 18.1	312.6 to 301.4 301.4 to 296.6	11.2 4.8
		RS16-04	0.1 to 16.5	312.8 to 296.4	16.4
	East Approach	RS16-06	0.3 to 15.8 (Borehole termination depth)	314.4 to 298.8	> 15.5

* Silty clay till

SPT 'N' values within the silty clay to silty clay till ranging from 8 to 100 blows per 0.3 m of penetration indicating a stiff to hard consistency. Lower blow counts ranging from 1 to 8 blows per 0.3 m of penetration were recorded at approximate depths between 2.5 and 10 m below ground surface (Elevations 312.5 and 305.0) in RS16-01, RS-02, RS16-03, RS16-04 and RS16-06. This weaker layer has a thickness ranging from approximately 2 to 5 m. Undrained shear strength values measured by in-situ vane shear tests in this weaker silty clay layer ranged from 95 kPa to greater than 150 kPa. These results suggest that the weaker silty clay deposit has a stiff to very stiff consistency. Vane shear test carried out in RS16-01 indicated that the sensitivity ratio of this silty clay was 6, indicating that the silty clay deposit has medium sensitivity. Below 8.0 to 10 m depth, SPT 'N' values were higher, generally ranging from 15 to 100, indicating a very stiff to hard consistency. SPT 'N' values higher than 100 blows per 0.1 m of penetration were

also measured at and below approximate elevation 306 in Boreholes 08-035 and 08-036, both boreholes were drilled at the proposed Highway 7 EBL.

The natural moisture contents generally lay in the range of 12 percent to 39 percent.

Grain size distribution curves for the silty clay and silty clay till samples are presented on the Record of Borehole sheets and on Figures A1 to A3 of Appendix A and B2 and B3 of Appendix B. Atterberg Limits test results are presented on Figures A7 and A8 of Appendix A and Figures B7 and B8 of Appendix B. The results of grain size distribution tests are summarized as follows:

Soil Particles	Silty clay (%)	Silty clay till (%)
Gravel	0 to 1	0 to 2
Sand	0 to 4	4 to 29
Silt	18 to 53	37 to 46
Clay	47 to 81	32 to 57

Liquid Limit	38 to 59
Plastic Limit	17 to 23

The above results show that the silty clay and silty clay till is of medium to high plasticity with a group symbol of CI-CH.

It should be noted that glacial tills are known to contain cobbles and boulders.

5.5 Sandy Silt Till to Silty Sand Till

Native deposits of brown to grey sandy silt till to silty sand till containing trace of gravel, trace to some clay and occasional cobbles were observed in Boreholes 08-033, 08-034, 08-035, 08-036, RS16-02, RS16-03, and RS16-04 at depths and elevations indicated in Table 5.2.

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Table 5.2 – Depths and Elevations of Native Sandy Silt Till to Silty Sand Till

Foundation Unit		Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
WBL	West Abutment	08-033	4.1 to 6.6 10.4 to 12.2 17.4 to 21.1** (Borehole termination depth)	309.1 to 306.6 302.8 to 301.0 295.8 to 292.1	2.5 1.8 > 3.7
		RS16-03	6.0 to 12.0 16.5 to 20.1** (Borehole termination depth)	308.4 to 302.5 298.0 to 294.4	6.0 >3.6
	East Abutment	08-034	6.1 to 10.0 18.6 to 20.0**(Borehole termination depth)	306.1 to 302.2 293.6 to 292.2	3.9 > 1.4
		RS16-04	17.8 to 22.9** (Borehole termination depth)	295.0 to 289.9	> 5.1
EBL	West Approach	RS16-02	4.9 to 7.5	310.7 to 308.0	2.6
	West Abutment	08-035	4.4 to 8.8	310.9 to 306.5	4.4
		RS16-03	6.0 to 12.0 16.5 to 20.1** (Borehole termination depth)	308.4 to 302.5 298.0 to 294.4	6.0 3.6
	East Abutment	08-036	18.1 to 21.5** (Borehole termination depth)	296.6 to 293.2	3.4
		RS16-04	17.8 to 22.9** (Borehole termination depth)	295.0 to 289.9	5.1

** Lower sandy silt till layer

SPT values measured in the sandy silt and sandy silt till ranged from 16 to 73 blows per 0.3 m of penetration, indicating a compact to dense relative density. SPT 'N' values of 90 blows per 0.3 m of penetration to higher than 100 blows per 0.1 m of penetration were measured below 6.0 m depth in Boreholes 08-033 and 08-035 (west abutments) and below 18.0 m depth in Boreholes 08-034, 08-036, RS16-03, and RS16-04. The high SPT 'N" values were generally measured in the lower silty sand till to sandy silt till layers.

The natural moisture contents generally lay in the range of 7 percent to 25 percent.

Grain size distribution curves for the sandy silt and sandy silt till samples tested are presented on the Record of Borehole sheets and on Figures A4 and A5 of Appendix A and Figures B4 to B6 of Appendix B. Atterberg Limits test results are presented on Figure B9 of Appendix B. The results of grain size distribution tests were as follows:

Soil Particles	(%)
Gravel	0 to 9
Sand	6 to 55
Silt	20 to 82
Clay	8 to 27

Liquid Limit (%)	16
Plastic Limit (%)	10

The above results show that the sandy silt and sandy silt till is of low plasticity with a group symbol of CL-ML.

Although not specifically identified in the boreholes, this layer may contain cobbles and boulders which may account for some high SPT 'N' values and resistance to augering.

5.6 Groundwater Conditions

Groundwater conditions were observed during drilling operations, and groundwater levels were measured in the open boreholes upon completion of drilling. Standpipe piezometers were installed in Boreholes 08-034, 08-035, and RS16-04 to monitor the groundwater level at the site.

The groundwater levels measured in the open boreholes and in the standpipe piezometers are summarized below.

Table 5.3 – Water Level Measurements

Foundation Unit		Borehole	Date	Water Level (m)		Remark
				Depth	Elevation	
WBL	West Approach	RS16-01	May 16, 2018	Water level not taken due to use of mud		Open Borehole
	West Abutment	08-033	June 19, 2008	Dry	-	Open Borehole
		RS16-03	May 18, 2018	-1.8*	316.3	Open Borehole
	East Abutment	08-034	August 20, 2008 August 27, 2008	12.5 12.4	299.7 299.8	Piezometer
		RS16-04	August 31, 2018	8.2	304.7	Piezometer
	East Approach	RS16-05	May 22, 2018	1.8	311.8	Open Borehole
EBL	West Approach	RS16-02	May 14, 2018	Water level not taken due to use of mud		Open Borehole
	West Abutment	08-035	February 7, 2008 June 13, 2008 July 2, 2008 August 20, 2008 August 27, 2008	-0.5* -0.5* -0.6* -0.7* -0.7*	315.8 315.8 315.9 316.0 316.0	Piezometer
		RS16-03	May 18, 2018	-1.8*	316.3	Open Borehole
	East Abutment	08-036	June 12, 2008	Dry	-	Open Borehole
		RS16-04	August 31, 2018	8.2	304.7	Piezometer
	East Approach	RS16-06	May 22, 2018	2.2	312.5	Open Borehole

*Above ground surface (artesian conditions)

The groundwater levels above are short-term readings, and seasonal fluctuations of the groundwater levels are to be expected. The groundwater levels may be at a higher elevation after periods of significant or prolonged precipitation.

Piezometric readings indicate the presence of artesian conditions on the site, where groundwater levels were measured 0.5 m to 1.8 m above ground surface (Elevations 315.8 to 316.3). The piezometers are planned to be decommissioned in the summer of 2020.

6. CORROSIVITY AND SULPHATE TEST RESULTS

A sample of the silty clay from Borehole RS16-03 was submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 6.1. The laboratory certificates of analysis are presented in Appendix A.

Table 6.1 – Analytical Test Results

Parameter	Units (Soil)	Test Results
		RS16-03 SS 4 Depth 2.7 m
		Silty Clay
Sulphide	%	<0.02
Chloride	µg/g	240
Sulphate	µg/g	70
pH	No unit	8.87
Electrical Conductivity	µS/cm	301
Resistivity	Ohms.cm	3320
Redox Potential	mV	246

7. MISCELLANEOUS

Landshark Drilling of Brantford, Ontario supplied a rubber track-mounted B-57 drill rig and conducted the drilling, sampling and in-situ testing operations for the present investigation.

The coordinates for the boreholes were obtained with GPS equipment by Thurber, and the elevations were provided by WSP.

The drilling and sampling operations in the field for the current investigation were supervised on a full-time basis by Thurber field technicians.

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

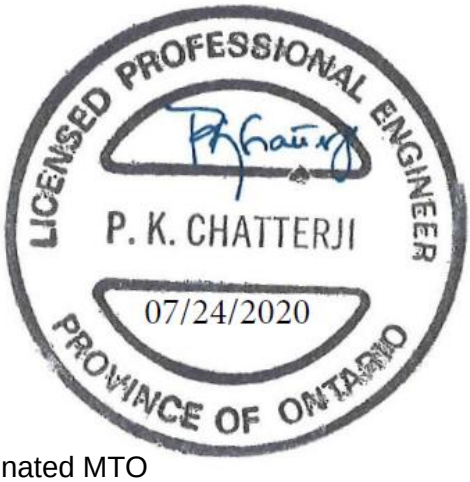
Overall supervision of the field program for the present investigation was conducted by Dr. Nancy Berg, P.Eng. Interpretation of the data and preparation of the current report was carried out by Ms. R. Palomeque Reyna, P.Eng. and Dr. Nancy Berg, P.Eng.

Mr. Jason Lee, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations projects, reviewed the report.

Thurber Engineering Ltd.

Nancy Berg, P.Eng.
Geotechnical Engineer

Jason Lee, P.Eng.
Principal/Senior Geotechnical Engineer



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Review Principal, Designated MTO

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

8. GENERAL

This report presents an interpretation of the geotechnical data in the factual report and presents geotechnical design recommendations to assist the design team to select and design a suitable foundation system for two new bridge structures to carry the proposed Highway 7-New EBL and WBL bridges over Riverbend Drive to Shirley Street Connector Road in the Regional Municipality of Waterloo, Ontario.

The General Arrangement (GA) drawings provided by WSP, dated June 2018, indicate that each bridge (WBL and EBL) will be a single-span structure supported on two abutments. Each of the two integral abutments is designed to be supported by a single row of driven steel H-piles. The new underpass bridges both have one span, 38.0 m in length, and approximately 16.3 m to 16.5 m and, 18.0 m to 19.6 m in width for the EBL and WBL, respectively.

The Highway 7-New EBL and WBL grades within the structure limits will be at approximate Elevation 326.9 m. The existing ground surface elevation ranges between 313.2 and 315.5 for the WBL and EBL west abutments and between 312.2 and 314.7 for the WBL and EBL east abutments. As a result, the height of Hwy 7 EBL and WBL approach fills will be up to 13.7 m and 14.7 m behind the west and east abutments respectively. The forward and side embankment slopes are proposed to be at an inclination of 2H:1V with a 2 m wide mid-height bench. The proposed finished grade of Riverbend Drive to Shirley Street Connector will be at approximate Elevations 319.5 to 320.0 (from south to north within the bridge limits).

This foundation investigation and design report, with the interpretation and recommendations, is intended for the use of the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The

contractors must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects, which could affect the design of the project. Contractors must make their own interpretation of the information provided as it may affect equipment selection, proposed construction methods and scheduling.

The discussions and recommendations presented in this report are based on the information provided by WSP and on the factual data obtained in the course of this investigation.

9. STRUCTURE CLASSIFICATION

In accordance with the currently applicable Canadian Highway Bridge Design Code (CHBDC) (2019) CSA S6-19, the analysis and design of structures are influenced by its importance category and consequence classification. Such designations are defined by the Regulatory Authority which, in this case, is the Ministry of Transportation of Ontario (MTO).

For the purpose of reporting, this structure has been classified as a Major-Route Bridge with Typical Consequence based on CHBDC S6-19 Sections 4.4.2 and 6.5.2, respectively.

Based on the above classification and Table 6.1 in Section 6.5.2 in the CHBDC (2019), a consequence factor, ψ, of 1.0 has been used for assessing ULS and SLS factored geotechnical resistances. Should the consequence classification changes, the geotechnical assessment and recommendations will need to be reviewed and revised as necessary.

10. STRUCTURE FOUNDATIONS

The stratigraphy identified in the geotechnical investigations consisted primarily of surficial topsoil overlying layers of native stiff to hard silty clay and silty clay till, and compact to very dense silty sand till/sand and silt till. Layers of compact to very dense sand and gravelly sand were encountered within the till deposits. The groundwater levels measured in the piezometers ranged from -1.8 m (artesian condition) to 12.5 m (Elevations 316.3 to 299.7).

In the preparation of the geotechnical design recommendations, consideration was given to the following foundation types:

1. Spread footings bearing on native soil

2. Spread footings on engineered fill

3. Augered Caissons in very dense glacial till (drilled shafts)

4. Steel H-piles or open ended steel pipe piles driven into the very dense glacial till soils

A comparison of the foundation alternatives based on advantages and disadvantages of each is included in Appendix E.

10.1 Spread Footing on Native Soil

Spread footings bearing on native soil are not recommended at this site due to the presence of a weaker compressible silty clay layer ranging from 2.5 m to 10 m below ground surface. Suitable founding strata are not present within a reasonable depth. Extensive/deep excavations in the order of 6 m to 11 m will be required to reach the competent soils.

For this reason, recommendations for spread footings have not been developed further.

10.2 Spread Footing on Engineered Fill

Spread footings on engineered fill are not considered to be a cost-effective and a practical foundation alternative at this site due to the need for a relatively deep excavation required to reach competent soils and the similar risks associated with spread footing on native soils indicated in Section 10.1 above. Accordingly, spread footings on engineered fill are not recommended at this site. For this reason, recommendations for this option have not been developed further.

10.3 Augered Caissons (Drilled Shafts)

Drilled shaft foundations founded on very dense silt and sand till were considered for the support of foundation loads at this site. However, augered caissons (drilled shafts) are not recommended for use as foundation support at this site due to high groundwater level and the presence of cohesionless soils potentially causing basal boiling and/or heave at the caisson base. These conditions will cause caisson installation difficulties and therefore, this option is not recommended and has not been developed further.

10.4 Steel H-Piles and Steel Pipe Piles

From a foundation engineering perspective, it is feasible to support the structure on steel H-piles driven to practical refusal. Open ended steel pipe piles may also be considered as a suitable foundation option.

It is recommended that the H-piles or pipe piles be driven to achieve resistance in the very dense silt and sand till/silty sand till/sandy silt till encountered at this site.

It should be noted that pipe piles driven into hard/very dense till deposits are more prone to pile tip damage in comparison to H-piles.

The GA drawing indicates that the proposed underside of the abutment stem at the east and west abutments is at Elev. 320.9 m.

10.4.1 Axial Resistance

The axial resistances of HP 310 X 110 and HP 360 x 132 steel piles, and 324 mm diameter and 356 mm diameter steel piles driven to refusal in very dense till were assessed based on the subsurface conditions encountered at the abutment locations. The estimated Ultimate Limit States (ULS) and geotechnical resistance at Serviceability Limit States (SLS), as well as the recommended pile tip elevations are summarized in Tables 10.3 and 10.4.

Table 10.3 – Estimated Axial Resistance and Pile Tip Elevation for H-Piles

Foundation Unit		Borehole	Approx. Pile Tip Elevation (m)	Minimum Pile Length Assumed (m)	Plie Section HP 310 X 110		Pile Section HP 360 X 132	
					Factored ULS (kN)	Factored SLS_f (kN)	Factored ULS (kN)	Factored SLS_f (kN)
WBL	West Abutment	08-033 RS16-03	294.0	27	1,500	1,300	1,650	1,450
	East Abutment	08-034 RS16-04	292.0	29	1,500	1,300	1,650	1,450
EBL	West Abutment	08-035 RS16-03	294.0	27	1,500	1,300	1,650	1,450
	East Abutment	08-036 RS16-04	292.0	29	1,500	1,400	1,650	1,450

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Table 10.4 – Estimated Axial Resistance and Pile Tip Elevation for pipe piles

Foundation Unit		Borehole	Approx. Pile Tip Elevation (m)	Minimum Pile Length Assumed (m)	Plie Section 324 mm diameter Wall Thickness 12.7 mm		Pile Section 356 mm diameter Wall Thickness 12.7 mm	
					Factored ULS (kN)	Factored SLS_f (kN)	Factored ULS (kN)	Factored SLS_f (kN)
WBL	West Abutment	08-033 RS16-03	294.0	27	1,250	1,050	1,400	1,200
	East Abutment	08-034 RS16-04	292.0	29	1,250	1,050	1,400	1,200
EBL	West Abutment	08-035 RS16-03	294.0	27	1,250	1,050	1,400	1,200
	East Abutment	08-036 RS16-04	292.0	29	1,250	1,050	1,400	1,200

The values of the Factored Geotechnical Resistance at ULS were assessed assuming a Consequence Factor equal to 1 (Typical), and a Resistance Factor equal to 0.4 (Typical degree of understanding of the subsurface conditions), as per CHBDC 2019. The SLS values correspond to a maximum pile settlement of up to 25 mm. The Factored Geotechnical Resistance at SLS was assessed assuming a factor of 0.8 for typical degree of understanding of the subsurface conditions.

The structural resistance of the pile must be checked by the structural designer.

10.4.2 Downdrag

Downdrag forces could be induced on piles embedded within the stiff to very stiff silty clay deposit due to consolidation of the silty clay under the weight of the new fill to be placed at the site, particularly at the west abutment. Reference should be made to the CHBDC (2019) Clauses 6.11.4.10 and C6.11.4.10 (commentary) for downdrag calculations.

It is estimated that unfactored downdrag loads in the order of 180 kN to 255 kN per pile may act on each pile as indicated below:

Pile Section	Downdrag load (kN)
HP 310 x 110	220
HP 360 x 132	255

324 mm diameter	180
356 mm diameter	200

These values should be used to evaluate the impact of downdrag on the abutment piles. The location of the neutral plane for a pile or pile group should be determined by using unfactored loads and unfactored geotechnical parameters.

For structural design of a pile, the downdrag loads above should be multiplied by a load factor of 1.25 as per the CHBDC 2019. In accordance with the code, the sum of the factored downdrag load and the factored permanent loads acting on the pile should not exceed the structural resistance of the pile. In analysis of downdrag, transient and live load effects should not be considered.

10.4.3 Lateral Resistance

The geotechnical lateral resistance of a pile may be calculated using the coefficient of horizontal subgrade reaction (k_s) and the ultimate lateral resistance (P_{ult}) as follows:

Silty Clay/Silty Clay Till (cohesive soils)

$k_s = 67\ C_u / B$ (kN/m^3)

$p_{ult} = 9\ C_u$ (kPa) at and below a depth of 3B reduced to zero at ground surface

where p_{ult} = ultimate lateral resistance mobilized by a pile, kPa

C_u = undrained shear strength of cohesive soils, kPa

γ = unit weight of soil, kN/m^3

B = width of pile, m

Sandy Silt Till/Silty Sand Till /Sand and Silt Till (cohesionless soils)

$k_s = n_h . z / B$ (kN/m^3)

$p_{ult} = 3 . \gamma . z . K_p$ (kPa)

where z = depth of embedment of pile, m

B = pile width, m

n_h = coefficient related to soil density, kN/m^3 , Table 10.5

γ' = Unit weight of soil, kN/m^3, Table 10.5

K_p = passive earth pressure coefficient, Table 10.5

The above equations and recommended parameters may be used to analyze the interaction between a pile and the surrounding soil.

The spring constant, K, for analysis may be obtained by the expression, K = k_s x d_z x B (kN/m), where k_s is the coefficient of horizontal subgrade reaction (kN/m^3), B is the pile width (m), d_z is the length (m) of the pile segment or element used in the analysis. The ultimate lateral resistance on any one segment of pile, P_{ult}, may be obtained from the expression, P_{ult} = pult x d_z x B. This represents the ultimate load at which the pile fails and will not support any additional load at greater displacements.

For pile lateral resistance design below the flexible zone, soil-pile interaction analyses may be carried out using the geotechnical parameters provided in Table 10.5 below.

Table 10.5 – Recommended Geotechnical Parameters for Lateral Resistance Design

Location	Reference Boreholes	Approx. Elevation (m)	Undrained Shear Strength C_u (kPa)	Unit Weight γ (kN/m^3)	K_p	n_h (kN/m^3)	Soil Conditions
Hwy 7 EBL / WBL West Abutments	08-033 RS16-03 08-035	314.0 to 308.4	80	9*	-	-	Firm to stiff silty clay
		308.4 to 302.5	-	11*	3.5	7,500	Compact to very dense silty sand till
		302.5 to 298.0	200	9*	-	-	Hard silty clay
		298.0 to 294.5	-	11*	4.0	10,000	Very Dense Sand and Silt Till
Hwy 7 EBL / WBL	08-034 RS16-04 08-036	314.5 to 312.5	-	10*	3.0	3,000	Compact sandy silt
		312.5 to 304.0	80	9*	-	-	Firm to stiff silty clay/silty clay till

East Abutments		304.0 to 297.0	200	10*	-	-	Very stiff to hard silty clay/silty clay till
		297.0 to 290.0	-	11*	4.0	10,000	Very dense sandy silt till

* Buoyant unit weight below water table

The group efficiency factors can be calculated based on side-by-side and line-by-line factors shown in Figures C6.22, C6.23 and C6.24 of the CHBDC (2019), S6:19 (Commentary).

10.4.4 Pile Installation

All piles shall be installed in accordance with OPSS 903 and SP 109F57.

Pile driving must be controlled in accordance with Standard Provision SS103-11 (Hiley Formula) and an ultimate pile resistance must be specified by the designer. The Hiley formula does not need to be used until the pile tip is within 2 m of the design tip elevation. The appropriate pile driving note to be shown on the contract drawing is "Piles to be driven in accordance with Standard SS103-11 using an ultimate geotechnical resistance of R kN per pile" where "R" must have a minimum value of twice the factored design load at ULS. It is recommended that Pile Driving Analysis (PDA) testing be conducted in conjunction with the Hiley tests at this site, to ensure the integrity of the pile and to verify pile ultimate geotechnical resistance. PDA testing should be completed for 10 percent of the piles for each foundation element or a minimum of 2 piles tested at each foundation element, whichever is more.

To facilitate pile installation, embankment fill through which piles will be driven must not contain any material with particle sizes greater than 75 mm.

Glacially derived soils inherently contain cobbles and boulders. Hard driving conditions through the hard and very dense till soils should be expected. In order to minimize pile damage while driving through boulders, cobbles and harder/dense zones to achieve the required tip elevations and soil resistance, it is recommended that the pile tips be reinforced with Titus steel (Standard H-point). Pile tip protection should be provided for open ended pipe piles.

The Contract Documents must contain a NSSP alerting the Bidders to the presence of cobbles and boulders in the glacial tills. Suggested texts for the NSSP's are included in Appendix G. The

NSSP should contain a requirement to terminate driving before the pile is damaged by overdriving.

Two of the piezometers show water levels above the ground surface. However, it is anticipated that the thick layer(s) of silty clay till will be sufficient to seal the artesian flow during and after pile installation.

10.5 Abutment Design Considerations

From a geotechnical perspective, the conditions at this site are considered to be suitable for the design of conventional, semi-integral or integral abutments.

For integral abutments, the flexibility of the upper portion of the pile may be provided by a single corrugated steel pipe (CSP) system. Reference should be made to the integral abutment manual for details of this system. Piles should be driven first before pouring in loose uniform sand between the CSP surround and the pile.

10.6 Frost Cover

The design depth of frost penetration for this site is 1.4 m. The undersides of pile caps/abutment stems must be provided with at least 1.4 m of soil cover.

10.7 Recommended Foundation

From a geotechnical perspective, and based on current information, it is recommended that all bridge abutments at this site be supported on steel H-piles driven into the very dense sandy silt till/sand and silt till.

11. LATERAL EARTH PRESSURES

Earth pressures acting on a structure (e.g. abutment or retaining wall), may be assumed to be triangular 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 2019 but are generally given by the expression:

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

where: p_h = horizontal pressure on the wall at depth h (kPa)

K	=	earth pressure coefficient (see Table 11.1)
γ	=	unit weight of retained soil (see Table 11.1)
h	=	depth below top of fill where pressure is computed (m)
q	=	value of any surcharge (kPa).

In accordance with Clause 6.12.3 of the CHBDC 2019, a compaction surcharge should be added. Compaction equipment to be used adjacent to retaining structures should be restricted in accordance with OPSS.PROV 501.

Earth pressure coefficients for backfill to the abutment wall are dependent on the material used as backfill. Typical values are shown in Table 11.1.

Table 11.1 – Earth Pressure Coefficients

Wall Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or OPSS Granular B Type II $\phi = 35°, \gamma = 22.8$ kN/m^3		OPSS Granular B Type I $\phi = 32°, \gamma = 21.2$ kN/m^3	
	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)
Active (Unrestrained Wall)	0.27	0.40	0.31	0.48
At rest (Restrained Wall)	0.43	0.62	0.47	0.70
Passive (Movement Towards Soil Mass)	3.7	-	3.2	-

If some movement of the wall is allowed (unrestrained system), active horizontal earth pressure may be used in the geotechnical design of the structure. For rigid wall, at-rest horizontal earth pressures should be used.

In conventional design, 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 wall.

The factors in Table 11.1 are “ultimate” values and require certain movements for the respective conditions to be mobilized. The values to be used in the design can be estimated from Figure C6.27 in the Commentary to the CHBDC 2019.

It is recommended that perforated sub-drains and/or weep holes be installed, where applicable, to provide positive drainage of the granular backfill behind the abutment walls. Reference may be made to OPSD 3102.100 where appropriate.

12. APPROACH EMBANKMENTS

Based on the GA drawing dated May 2018, the Highway 7-New grade within the structure limits will be at approximate Elevation 326.9 m. The existing ground surface elevation ranges between 313.2 and 314.7 for the WBL and EBL west abutments and between 312.2 and 314.7 for the WBL and EBL east abutments. As a result, the height of Hwy 7 EBL and WBL approach fills will be up to 13.7 m and 14.7 m behind the west and east abutments respectively. The forward and side embankment slopes are proposed to be at an inclination of 2H:1V. The proposed finished grade of Riverbend Drive to Shirley Street Connector will be at approximate Elevations 319.5 to 320.0 (from south to north within the bridge limits).

All embankment fill must be constructed with adequate quality control in accordance with OPSS.PROV 206 and OPSS.PROV 501 requirements and the clean earth fill must not contain medium or high plastic clay.

It is also recommended that all permanent and temporary slope surfaces be vegetated and seeded in accordance with current MTO practice with reference to OPSS.PROV 804. Surface runoff and precipitation must be prevented from flowing perpendicularly down any slope surface. Erosion protection measures will have to be taken as necessary to maintain slope stability.

Prior to fill placement, the subgrade must be adequately prepared to receive the new fill. All vegetation, topsoil, organics, soft/loosened or wet soils should be sub-excavated.

12.1 Slope Stability of Side Slope

The global, internal and surficial stability of the approach embankment fills will depend on the slope geometry and also to a large degree on the material used to construct the embankments.

Embankments constructed using granular material, select subgrade material earth fill and clean earth will have stable side slopes at inclinations of up to 2H:1V.

Where earth fill embankments are higher than 8 m, mid-height berms should be incorporated in each 8 m vertical interval. The berms should:

- extend for the length through which the embankment height exceeds 8 m
- be at least 2 m wide
- have 2% positive grade to shed run-off water

In this section of the report a typical sideslope configuration was analysed for an embankment height of 14.7 m with a 2 m wide mid height bench.

The Morgenstern-Price method was employed in conjunction with a commercially available slope stability program GEO-SLOPE to carry out the analyses. The computed factors of safety are as shown in Table 12.1. Graphical outputs of these analyses are included in Appendix F.

Table 12.1 Computed Factors of Safety

Condition	Factor of Safety	Figure (Appendix F)
Embankment Height = 14.7 m		
Drained	1.5	F1
Undrained	1.5	F2
Seismic = 0.097g	1.1	F3

As per typical MTO requirements, a Factor of Safety (F.S.) of 1.3 is acceptable for short term conditions and for total stress (undrained) conditions. A F.S. of 1.5 is acceptable for effective stress (drained) conditions. Under the assumed seismic loading, the minimum acceptable factor of safety is 1.1. In the case of static loading, the factors of safety against global failure were 1.5 for drained and undrained conditions. Under the estimated seismic loading, the minimum factor of safety calculated was 1.1. These range of factors of safety are considered to be acceptable for this site.

12.2 Settlement

The settlements of the foundation soils were estimated to range between 60 and 90 mm under the loading imposed by up to 15 m of new approach fill. The settlement will cause downdrag on

abutment piles and settlement under the approach slabs. Time-dependent consolidation settlement is expected due to the presence of native silty clay at this site.

Embankment settlement due to fill compression is estimated to 0.5% of the fill height. Approximately 50% of the total fill compression (or 0.25% of the fill height) will occur during construction and the remaining 50% or approximately 35 to 40 mm at this site will occur after construction.

In accordance with MTO's Embankment Settlement Criteria for Design (July 2, 2010) for bridge approach areas, the following post-construction settlement criteria (within 20 years following paving) have been adopted for the design:

- No more than 25 mm within 20 m behind the bridge abutment;
- 25 mm to 50 mm from 20 m to 50 m from the bridge abutment;
- 50 mm to 75 mm from 50 m to 75 m from the bridge abutment; and
- 75 mm to 100 mm greater than 75 m from the bridge abutment.

Based on the results of the settlement analysis (Foundation Settlement and Embankment Compression), it is recommended that a preload period of 4 months be allowed for settlement to take place following construction to full height of the embankment. In order to mitigate post construction settlement to within tolerable limits and to reduce the lateral/downdrag force acting on the piles, it is recommended that the full height of fill be placed in advance of bridge and abutment pile construction and settlement should be monitored after the fill is placed.

As part of the embankment preloading, a geotechnical instrumentation and monitoring program should be implemented to monitor embankment settlements and to confirm that the foundation settlements beneath the embankment are essentially complete prior to pile installation. It is recommended that settlement rods be installed at the base of the embankments to assess the foundation settlement prior to piling and settlement pins be installed at the top of embankment to assess embankment settlement prior to paving and approach slab construction. The actual waiting period duration should be determined by the actual foundation behavior assessed from the settlement monitoring program by the foundation designer. The details and specifications of the settlement monitoring program will be provided in the Highway 7 New - High Fill and Deep Cut Report.

13. TEMPORARY EXCAVATION

All excavations at this site must be carried out in accordance with the Occupational Health and Safety Act (OHSA). The excavation and backfilling for foundations must be carried out in accordance with OPSS.PROV 902 and SP 109S12.

For the purposes of the OHSA, the fills and native soils (silty clay/sand) above the water table are classified as Type 3 and the cohesionless soils below the water table are classified as Type 4.

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

14. BACKFILL TO ABUTMENTS

For backfilling immediately behind the new abutment walls, it is recommended that the new fill be Granular A or Granular B Type II materials meeting the gradation and relevant requirements stipulated in OPSS.PROV 1010. Beyond this zone, Granular B Type I or clean earth fill may be used.

The backfill should be in accordance with OPSS.PROV 206 requirements and OPSD 3101.150. Compaction equipment to be used adjacent to abutments should be restricted in accordance to OPSS.PROV 501.

The design of the abutment must incorporate a subdrain as shown in OPSD 3102.100.

15. GROUNDWATER AND SURFACE WATER CONTROL

The groundwater levels measured in the piezometers at this site ranged from -1.8 m (artesian condition) to 12.5 m (Elevations 316.3 to 299.7). Seasonal fluctuations of the groundwater level are to be expected.

If temporary excavation is required at this sitein cohesionless soils below the groundwater level, such excavation should not be carried out without prior dewatering since the inflow of groundwater will cause base boiling and side wall sloughing of the soil below the water table making it difficult

to maintain a dry, sound base on which to work. Suitable systems that might be considered to maintain an unwatered condition at this site, include pumping from filtered sumprs for nominal penetration below the groundwater level and sheeted excavation (cofferdam) or vacuum well-points for deeper excavation.

Based on the grain size distribution curves, the coefficients of permeability (k) of the native soils are as follows:

Soil	Permeability, k (cm/sec)
Sand	5.6×10^{-3}
Silty Clay/Silty Clay Till	1×10^{-7} to 1×10^{-8}
Sand and Silt Till	2.3×10^{-6} to 6.3×10^{-6}

If required, dewatering of all excavations should be carried out in accordance with OPSS. PROV 517, SP 517F01 Amendment to OPSS 517, November 2016 (issued July 2017), and OPSS. PROV 902 and SP 109S12.

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

The groundwater and surface runoff must be controlled during construction to maintain a stable excavation and to allow concrete to be placed in an unwatered excavation. Placement of concrete or compacting engineered fill must be done in the dry. Unwatering must remain operational and effective until the footings or pile caps are constructed and backfilled. Suggested wording for an NSSP in the regard is included in Appendix G.

16. ROADWAY PROTECTION

If roadway protection is required during construction of the proposed bridges, an item titled “Protection System” as per OPSS 539 should be included in the contract documents. It is recommended that Performance Level 2 as per Clause 539.04.01.01 and the alignment of the shoring be specified on the contract drawings.

The design of roadway protection should be the responsibility of the Contractor. However, one option that is considered to be suitable for use as temporary shoring at this site is a soldier pile and

lagging wall. A temporary soldier pile and lagging wall may be designed using the parameters given below:

γ	=	19 kN/m^3 (silty clay)
	=	20 kN/m^3 (sand/sandy silt)
	=	21 kN/m^3 (silty clay till/sandy silt till/sand and silt till)
γ_w	=	9 kN/m^3 (silty clay)
	=	10 kN/m^3 (sand/sandy silt)
	=	11 kN/m^3 (silty clay till/sandy silt till/sand and silt till)
K_a	=	0.35 (silty clay)
	=	0.32 (sand/sandy silt)
	=	0.31 (silty clay till/sandy silt till/sand and silt till)
K_p	=	2.9 (silty clay)
	=	3.1 (sand/sandy silt)
	=	3.3 (silty clay till/sandy silt till/sand and silt till)

The actual pressure distribution acting on the shoring system is a function of the construction sequence, and the relative flexibility of the wall and these factors must be considered when designing the shoring system. All shoring systems should be designed by a Professional Engineer experienced in such designs.

17. SEISMIC CONSIDERATIONS

In accordance with the CHBDC 2019, the selection of the seismic site classification is based on the averaged soil conditions encountered in the upper 30 m of the stratigraphy. The stratigraphy of the site includes topsoil overlying layers of native stiff to hard silty clay and silty clay till, and compact to very dense silty sand till/sand and silt till. Layers of compact to very dense sand and gravelly sand were encountered within the till deposits. This would correspond to a Seismic Site Class D in accordance with Table 4.1, Clause 4.4.3.2 of the CHBDC. The peak ground acceleration, PGA, for a 2% in 50-year probability of exceedance at this site is 0.075 g as per the National Building Code of Canada (NBCC). Since this site is classified as Class D, the factored PGA for a 2% in 50-year probability of exceedance at this site is 0.097 g.

In accordance with Clause 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 17.1 may be used:

Table 17.1 – Earth Pressure Coefficients for Earthquake Loading

Condition	Earth Pressure Coefficient (K)	
	OPSS Granular A or Granular B Type II $\phi = 35°, \gamma = 22.8$ kN/m^3	OPSS Granular B Type I $\phi = 32°, \gamma = 21.2$ kN/m^3
Active (K_{AE})*	0.31	0.35
Passive (K_{PE})	3.6	3.1
At Rest (K_{OE})**	0.55	0.6

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

** After Woods

Liquefaction is not considered to be a concern at this site.

18. CORROSION AND SULPHATE ATTACK POTENTIAL

The results of the corrosivity and sulphate analytical tests conducted on the native silty clay soil during the current investigation indicates the following conditions at the locations tested:

- The potential for sulphate attack on concrete foundations from the surrounding native soils is considered to be negligible due to the low concentration of sulphate and chloride in the samples tested. The selection of class of concrete should consider the effects of the road de-icing salts.
- The potential for soil corrosion on metal is considered to be moderate.
- Appropriate protection measures commensurate with the above are recommended if metal structural elements are used. The effects of road de-icing salts should also be considered.

19. CONSTRUCTION CONCERNS

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

1. Pile Installation

   Although there was little direct evidence of their presence during drilling, glacial till deposits inherently contain cobbles and boulders. Hard driving conditions through the hard/very dense till soils should be expected. Pile tips should be reinforced with Titus steel (Standard H-point) to protect the driven piles from damage.

2. Groundwater Control

   Artesian conditions were encountered during investigation. If any excavation is required below the groundwater level at this site, ingress of groundwater and seepage are expected to be encountered within the cohesionless soils. The impact of seepage or surface water could destabilize the sides and or base of the excavation. The Contractor's dewatering plan must be available for rapid implementation should the need arise. Proper groundwater and surface water control measures must be in place prior to commencing excavation. All footings/pile caps must be constructed in the dry.

3. Settlement Monitoring Program

   Installation of embankment monitoring instrumentation should be completed by Contractor's geotechnical personnel prior to commencing embankment construction. During construction, the Contract Administrator should employ an experienced foundation specialist to implement the geotechnical monitoring program and to observe construction activities related to embankment/foundation construction. It is also Contractor's responsibility to provide access for installation and monitoring of instruments (settlement rods and plates) during and after embankment construction.

   The results of the settlement monitoring program will control the timing for completing the foundation preloading prior to pavement construction. Although not anticipated, there is a risk that the foundation will settle slower than anticipated. If this situation occurs, the proposed 4-month preload period may need to be extended which may impact the overall construction schedule. It is considered important that the construction contract includes clauses that allow for a flexible construction schedule in order to accommodate potential delays associated with foundation settlement slower than anticipated. In addition, a detailed and regular analysis of the results of the monitoring program during construction is considered critical to reduce the risk of ending the foundation preloading prematurely.

20. CLOSURE

Engineering analysis and preparation of the report were carried out by Dr. Nancy Berg, P.Eng. and Ms. R. Palomeque Reyna, P.Eng.

The report was reviewed by Mr. Jason Lee, P.Eng and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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THURBER

Appendix A

Record of Borehole Sheets, Laboratory Test Results, and Analytical Laboratory Test Results (Current Investigation)

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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

▼ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

(1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.

(2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

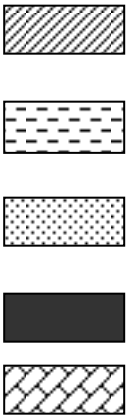
MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels,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

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

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

SYMBOLS



CLAYSTONE

SILTSTONE

SANDSTONE

COAL

Bedrock (general)

DISCONTINUITY SPACING

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

TERMS

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

STRENGTH CLASSIFICATION

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

THURBER

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No RS16-01 1 OF 2 METRIC

GWP# 408-88-00 LOCATION Riverbend-Shirley Connection, MTM NAD 83 Zone 10: N 4 814 693.0 E 226 704.2 ORIGINATED BY JP

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.05.15 - 2018.05.16 LATITUDE 43.468108 LONGITUDE -80.465223 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
314.3	GROUND SURFACE											
0.0	TOPSOIL		1	SS	2		314					
313.7												
0.6	Silty CLAY, trace sand, trace gravel Stiff to Soft Brown Moist		2	SS	12		313					
			3	SS	13		312					
	Grey		4	SS	8		311					
			5	SS	5		310					
			6	SS	3		309					0 1 32 67
			7	SS	1		308		6.0 +			
307.0							307					
7.3	Silty CLAY, sandy, trace gravel Soft to Very Stiff Grey Wet (TILL)		8	SS	4		306					
			9	SS	21		305					2 29 37 32

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

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Ontario

THURBER

RECORD OF BOREHOLE No RS16-01 2 OF 2 METRIC

GWP# 408-88-00 LOCATION Riverbend-Shirley Connection, MTM NAD 83 Zone 10: N 4 814 693.0 E 226 704.2 ORIGINATED BY JP

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.05.15 - 2018.05.16 LATITUDE 43.468108 LONGITUDE -80.465223 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
303.8	Silty CLAY, sandy, trace gravel (TILL)						304				
10.5	Silty CLAY, trace sand, trace gravel Very Stiff to Hard Grey Moist		10	SS	29		303		○ 20		
			11	SS	36		302		○ 20		
			12	SS	47		301				
			13	SS	27		300		⊢○⊣ 20		0 0 31 69
298.5							299				
15.8	END OF BOREHOLE AT 15.8m. BOREHOLE OPEN UPON COMPLETION. MUD WAS ADDED DURING DRILLING; THEREFORE, IT WAS NOT POSSIBLE TO MEASURE THE WATER LEVEL UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO SURFACE.										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

15 ⊕ 5 (20, 10) (%) STRAIN AT FAILURE

ONTMT4S2 MTO-11375(GINTDATA).GPJ 2017TEMPLATE(MTO).GDT 5/28/20

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THURBER

RECORD OF BOREHOLE No RS16-02 1 OF 2 METRIC

GWP# 408-88-00 LOCATION Riverbend-Shirley Connection, MTM NAD 83 Zone 10: N 4 814 671.8 E 226 713.0 ORIGINATED BY JP

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.05.14 - 2018.05.14 LATITUDE 43.467905 LONGITUDE -80.465086 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
315.5	GROUND SURFACE										
0.0	Silty CLAY, with organics, trace sand, trace gravel Very Soft Brown Moist (FILL)		1	SS	1		315				
314.6											
0.9	Silty CLAY, trace sand Very Stiff to Firm Brown Moist		2	SS	14		314				
			3	SS	19						0 0 40 60
			4	SS	14		313				
			5	SS	6		312				
310.7			6	SS	7		311				
4.9	SAND and SILT, trace clay Dense Grey Moist (TILL)						310				
			7	SS	39		309				0 37 54 9
308.0											
7.5	Silty CLAY, trace sand Hard Grey Moist (TILL)		8	SS	31		308				
							307				
			9	SS	41		306				
305.5											

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No RS16-02 2 OF 2 METRIC

GWP# 408-88-00 LOCATION Riverbend-Shirley Connection, MTM NAD 83 Zone 10: N 4 814 671.8 E 226 713.0 ORIGINATED BY JP

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.05.14 - 2018.05.14 LATITUDE 43.467905 LONGITUDE -80.465086 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
10.0	Silty **CLAY**, trace sand Very Stiff to Hard Grey Moist						305				
			10	SS	15						
							304				
			11	SS	48		303				0 4 39 57
							302				
			12	SS	77						
							301				
			13	SS	100		300				
299.7											
15.8	END OF BOREHOLE AT 15.8m. BOREHOLE OPEN UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO SURFACE.										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

15 (20/10) 5 (%) STRAIN AT FAILURE

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Ontario

THURBER

RECORD OF BOREHOLE No RS16-03 1 OF 3 METRIC

GWP# 408-88-00 LOCATION Riverbend-Shirley Connection, MTM NAD 83 Zone 10: N 4 814 692.7 E 226 723.0 ORIGINATED BY JP

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Casing Advance/Tricone COMPILED BY MP

DATUM Geodetic DATE 2018.05.18 - 2018.05.18 LATITUDE 43.468088 LONGITUDE -80.464972 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
314.5	GROUND SURFACE										
0.0 / 314.1	**TOPSOIL**		1	SS	3		314				
0.3	Silty **CLAY** Soft to Stiff Brown Moist		2	SS	8						0 0 45 55
			3	SS	13		313				
			4	SS	10		312				
			5	SS	8		311				
			6	SS	5		310				
308.4							309				
6.0	Silty **SAND**, some clay, trace to some gravel Compact to Very Dense Grey Wet (TILL)		7	SS	22		308				
			8	SS	34		307				9 55 21 15
			9	SS	57		306				
							305				

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No RS16-03 2 OF 3 METRIC

GWP# 408-88-00 LOCATION Riverbend-Shirley Connection, MTM NAD 83 Zone 10: N 4 814 692.7 E 226 723.0 ORIGINATED BY JP

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Casing Advance/Tricone COMPILED BY MP

DATUM Geodetic DATE 2018.05.18 - 2018.05.18 LATITUDE 43.468088 LONGITUDE -80.464972 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Silty **SAND**, some clay, trace gravel Very Dense Grey Wet (TILL)						304				
			10	SS	73				○		
302.5							303				
12.0	Silty **CLAY**, trace sand Hard Grey Moist										
			11	SS	53		302		○		0 0 53 47
			12	SS	47		301		○		
			13	SS	86		300		○		
298.0							299				
16.5	Silty **SAND**, some clay, trace gravel Very Dense Grey Wet (TILL)						298				
			14	SS	90				○		8 49 29 14
			15	SS	130/ 0.200		297				
							296		○		
			16	SS	108/		295		○		

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

ONTMT4S2 MTO-11375.GPJ 2017TEMPLATE(MTO).GDT 2/5/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No RS16-03 3 OF 3 METRIC

GWP# 408-88-00 LOCATION Riverbend-Shirley Connection, MTM NAD 83 Zone 10: N 4 814 692.7 E 226 723.0 ORIGINATED BY JP

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Casing Advance/Tricone COMPILED BY MP

DATUM Geodetic DATE 2018.05.18 - 2018.05.18 LATITUDE 43.468088 LONGITUDE -80.464972 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
294.4	Continued From Previous Page				0.275						
20.1	END OF BOREHOLE AT 20.1m UPON AUGER REFUSAL. A TEMPORARY PIPE WAS INSTALLED IN THE BOREHOLE TO MEASURE GROUND WATER LEVEL. WATER LEVEL WAS MEASURED AT 1.8m ABOVE THE GROUND SURFACE IN THE TEMPORARY PIPE (ARTESIAN CONDITION). BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO SURFACE.										

$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15 / 10 / 5 (%) STRAIN AT FAILURE

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No RS16-04 1 OF 3 METRIC

GWP# 408-88-00 LOCATION Riverbend-Shirley Connection, MTM NAD 83 Zone 10: N 4 814 713.9 E 226 763.3 ORIGINATED BY SB

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Mud Rotary COMPILED BY MP

DATUM Geodetic DATE 2018.07.03 - 2018.07.03 LATITUDE 43.468200 LONGITUDE -80.464593 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
312.9	GROUND SURFACE										
0.0	TOPSOIL: (100mm)										
0.1	Silty CLAY, trace sand, trace gravel Soft to Stiff Grey Moist		1	SS	2						
			2	SS	8		312				
			3	SS	11		311				0 1 41 58
			4	SS	15		310				
			5	SS	13		309				
			6	SS	14		308				
			7	SS	15		307				
			8	SS	11		306				
			9	SS	8	▼	305		>> 150 kPa		0 1 29 70
	Very Stiff		10	SS	26		304				
							303				

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 / 15 / 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S2 MTO-11375(GINTDATA).GPJ 2017TEMPLATE(MTO).GDT 5/28/20

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No RS16-04 2 OF 3 METRIC

GWP# 408-88-00 LOCATION Riverbend-Shirley Connection, MTM NAD 83 Zone 10: N 4 814 713.9 E 226 763.3 ORIGINATED BY SB

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Mud Rotary COMPILED BY MP

DATUM Geodetic DATE 2018.07.03 - 2018.07.03 LATITUDE 43.468200 LONGITUDE -80.464593 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Silty CLAY, trace sand Very Stiff to Hard Grey Moist						302				
			11	SS	20						
							301				
			12	SS	42						
							300				
			13	SS	30		299				0 1 18 81
							298				
			14	SS	38						
296.4							297				
16.5	Gravelly SAND, trace silt, trace clay Very Dense Grey Wet		15	SS	93		296				27 62 11 (SI+CL)
	Auger grinding at 17.4m										
295.0							295				
17.8	SAND and SILT, trace gravel, trace clay Very Dense Grey Wet (TILL)		16	SS	100/ 0.300		294				
							293				

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S2 MTO-11375(GINTDATA).GPJ 2017TEMPLATE(MTO).GDT 5/28/20

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No RS16-04 3 OF 3 METRIC

GWP# 408-88-00 LOCATION Riverbend-Shirley Connection, MTM NAD 83 Zone 10: N 4 814 713.9 E 226 763.3 ORIGINATED BY SB

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Mud Rotary COMPILED BY MP

DATUM Geodetic DATE 2018.07.03 - 2018.07.03 LATITUDE 43.468200 LONGITUDE -80.464593 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND and SILT, some clay, trace gravel Very Dense Grey Wet (TILL)		17	SS	100/ 0.225		292				
	clayey zone at 21.5m		18	SS	100/ 0.050		291				2 38 33 27
289.9			19	SS	100/ 0.075		290				
22.9	END OF BOREHOLE AT 22.9m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2018.08.31 8.2 304.7										

$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S2 MTO-11375(GINTDATA).GPJ 2017TEMPLATE(MTO).GDT 5/28/20

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No RS16-05 1 OF 2 METRIC

GWP# 408-88-00 LOCATION Riverbend-Shirley Connection, MTM NAD 83 Zone 10: N 4 814 726.8 E 226 765.6 ORIGINATED BY AF

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Casing Advance COMPILED BY MP

DATUM Geodetic DATE 2018.05.22 - 2018.05.22 LATITUDE 43.468419 LONGITUDE -80.464456 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
313.6	GROUND SURFACE										
0.0	**TOPSOIL**										
0.2	Silty **CLAY**, trace sand Soft to Stiff Grey Moist		1	SS	3		313		138		
			2	SS	5						
			3	SS	12	▽	312				
			4	SS	9		311				
			5	SS	12		310				
			6	SS	11		309				
			7	SS	14		308				
			8	SS	10		307				0 0 35 65
			9	SS	94		306				
	Hard						305				
							304				

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$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S2 MTO-11375.GPJ 2017TEMPLATE(MTO).GDT 2/5/19

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THURBER

RECORD OF BOREHOLE No RS16-05 2 OF 2 METRIC

GWP# 408-88-00 LOCATION Riverbend-Shirley Connection, MTM NAD 83 Zone 10: N 4 814 726.8 E 226 765.6 ORIGINATED BY AF

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Casing Advance COMPILED BY MP

DATUM Geodetic DATE 2018.05.22 - 2018.05.22 LATITUDE 43.468419 LONGITUDE -80.464456 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Silty **CLAY**, trace sand Hard Grey Moist						303				
			10	SS	61		302		○		
			11	SS	37		301		○		
			12	SS	44		300		○		
			13	SS	50		299		⊢○⊣		0 0 36 64
297.8							298				
15.8	END OF BOREHOLE AT 15.8m. WATER LEVEL AT 1.8m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO SURFACE.										

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\oplus^{20}_{15\ 10\ 5}$ (%) STRAIN AT FAILURE

ONTMT4S2 MTO-11375.GPJ 2017TEMPLATE(MTO).GDT 2/5/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No RS16-06 1 OF 2 METRIC

GWP# 408-88-00 LOCATION Riverbend-Shirley Connection, MTM NAD 83 Zone 10: N 4 814 701.3 E 226 779.2 ORIGINATED BY AF

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Casing Advance COMPILED BY MP

DATUM Geodetic DATE 2018.05.22 - 2018.05.22 LATITUDE 43.468175 LONGITUDE -80.464298 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
314.7	GROUND SURFACE										
0.0 / 314.4	TOPSOIL										
0.3	Silty CLAY, trace sand, trace gravel Soft to Firm Grey Moist		1	SS	2		314				
			2	SS	9						
			3	SS	19		313				
	Very Stiff to Firm					▽					
			4	SS	16		312				0 0 42 58
			5	SS	11		311				
			6	SS	8		310				
			7	SS	12		309				0 0 27 73
			8	SS	7		308				
			9	SS	6		307				
							306		→>> 150 kPa		
							305				

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No RS16-06 2 OF 2 METRIC

GWP# 408-88-00 LOCATION Riverbend-Shirley Connection, MTM NAD 83 Zone 10: N 4 814 701.3 E 226 779.2 ORIGINATED BY AF

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Casing Advance COMPILED BY MP

DATUM Geodetic DATE 2018.05.22 - 2018.05.22 LATITUDE 43.468175 LONGITUDE -80.464298 CHECKED BY RPR

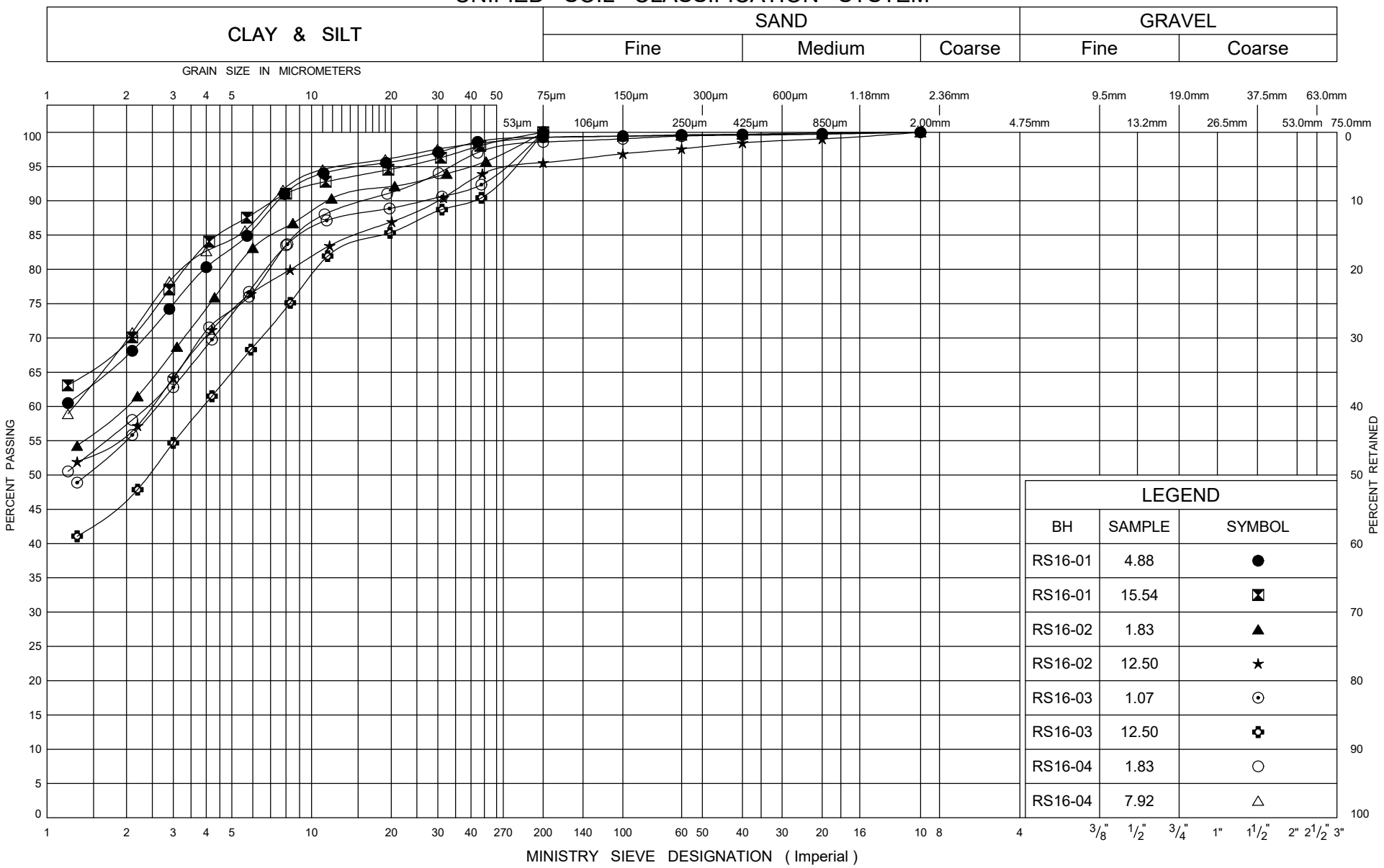
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page									
	Silty CLAY, trace sand, trace gravel Very Stiff to Hard Grey Moist							>>		
			10	SS	24		304			
							303			
			11	SS	52		302			
							301			
			12	SS	49					0 0 38 62
							300			
298.8			13	SS	55		299			
15.8	END OF BOREHOLE AT 15.8m. WATER LEVEL AT 2.2m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO SURFACE.									

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S2 MTO-11375(GINTDATA).GPJ 2017TEMPLATE(MTO).GDT 5/28/20

UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND		
BH	SAMPLE	SYMBOL
RS16-01	4.88	●
RS16-01	15.54	⊠
RS16-02	1.83	▲
RS16-02	12.50	★
RS16-03	1.07	⊙
RS16-03	12.50	✿
RS16-04	1.83	○
RS16-04	7.92	△

Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Silty Clay

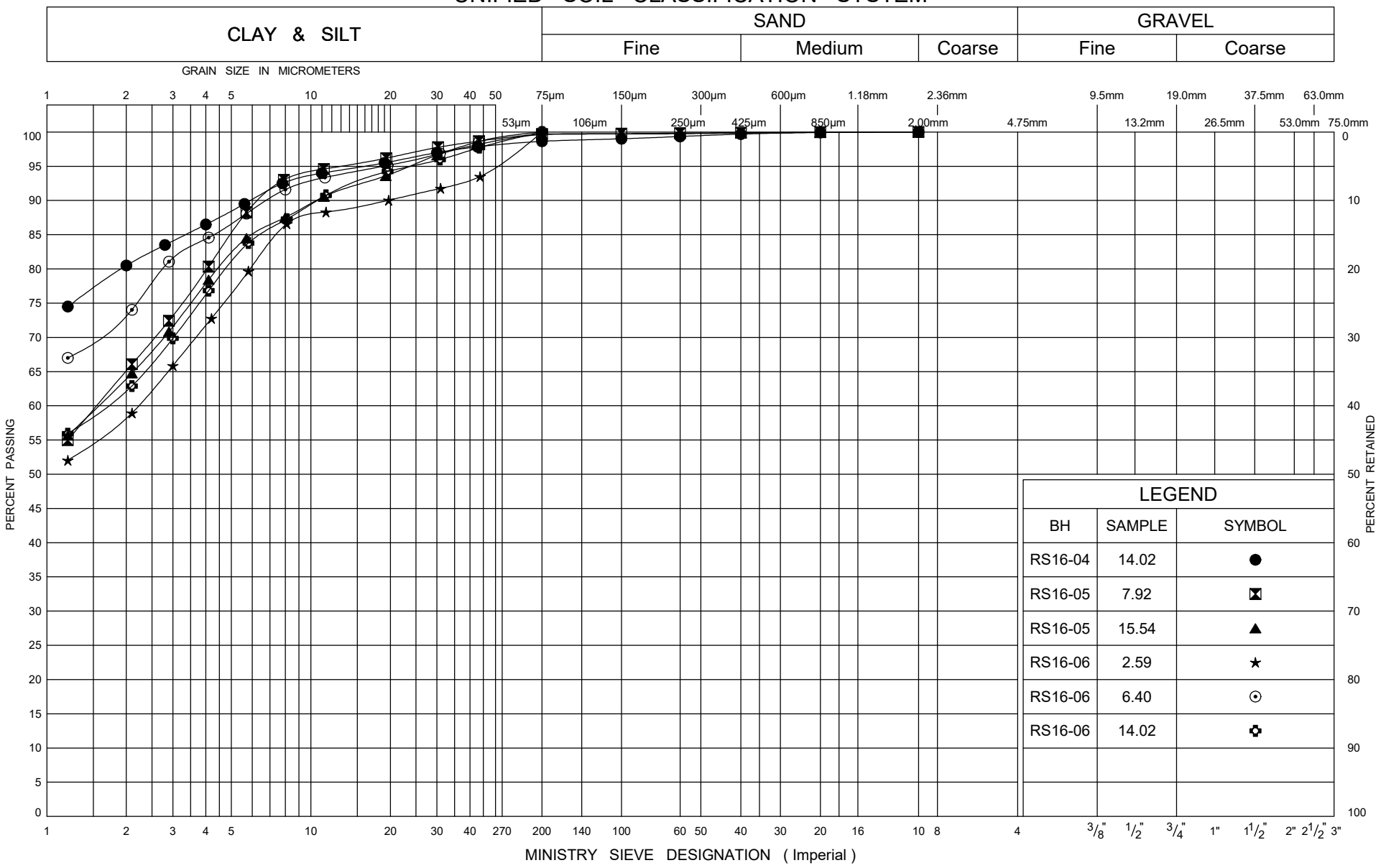
FIG No B1

W P 408-88-00

Riverbend-Shirley Connection

ONTARIO MOT GRAIN SIZE MTO-11375.GPJ ONTARIO MOT.GDT 10/18/18

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Silty Clay

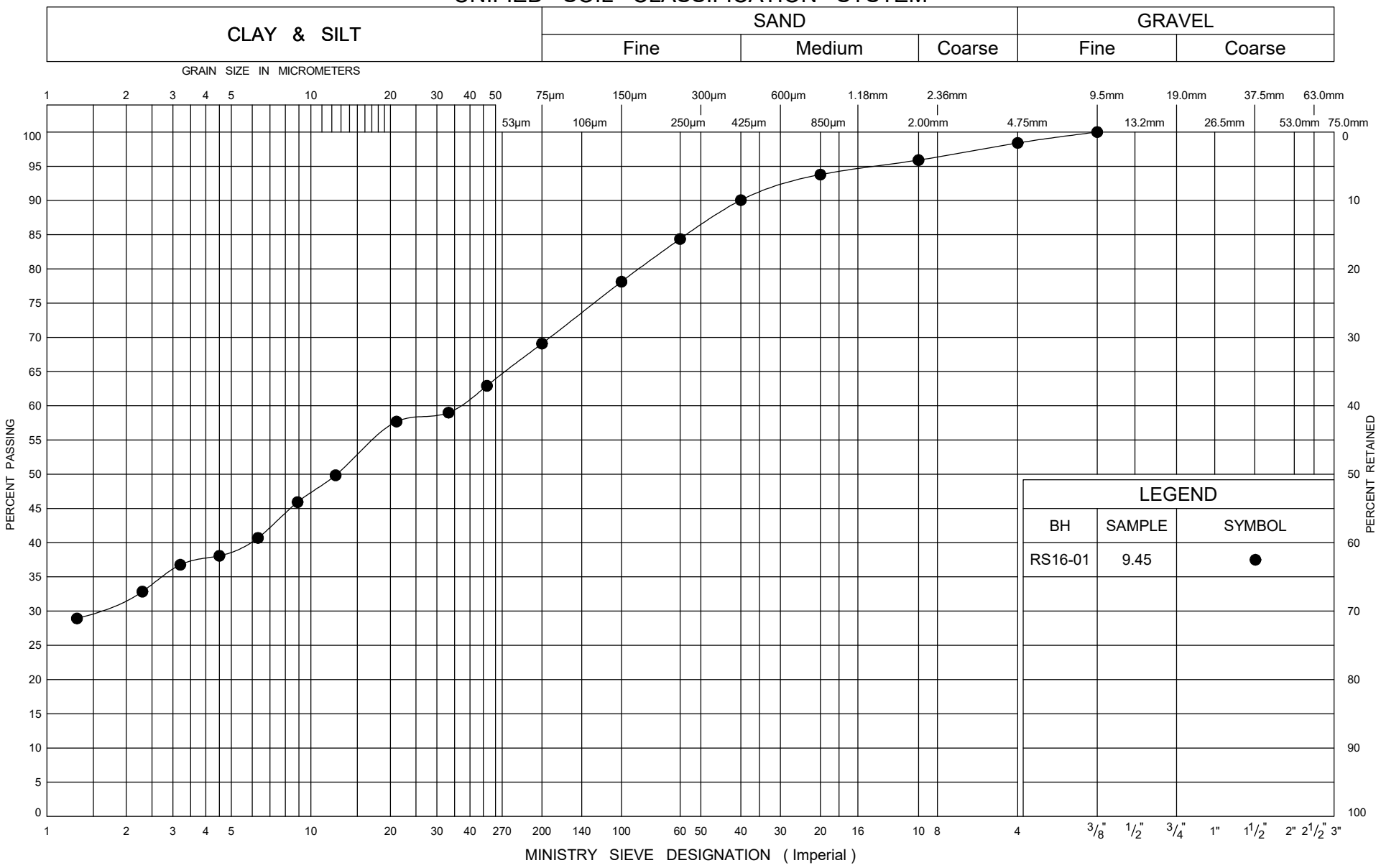
FIG No B2

W P 408-88-00

Riverbend-Shirley Connection

ONTARIO MOT GRAIN SIZE MTO-11375.GPJ ONTARIO MOT.GDT 10/18/18

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Silty Clay Till

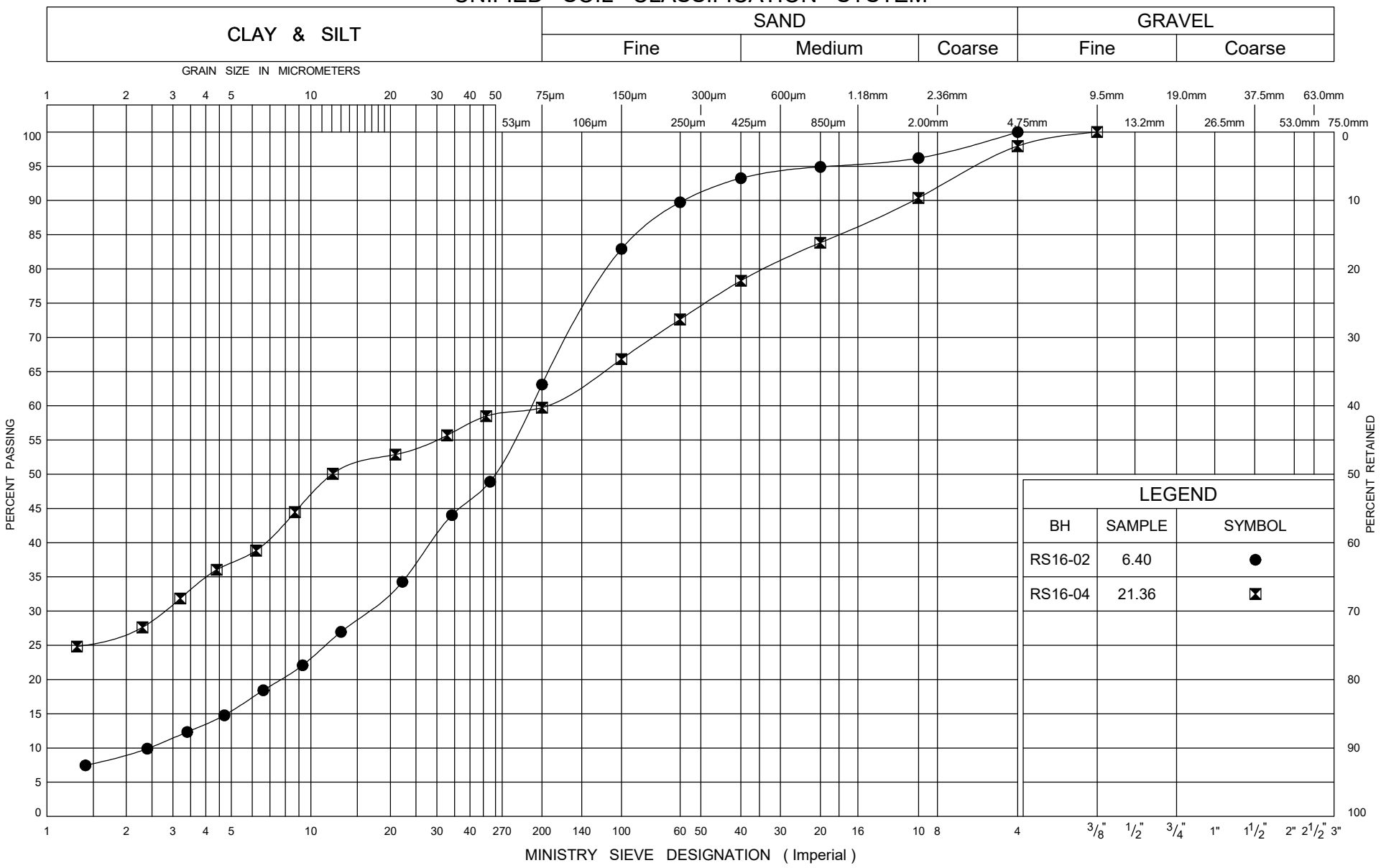
FIG No B3

W P 408-88-00

Riverbend-Shirley Connection

ONTARIO MOT GRAIN SIZE MTO-11375.GPJ ONTARIO MOT.GDT 10/18/18

UNIFIED SOIL CLASSIFICATION SYSTEM



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Ontario

GRAIN SIZE DISTRIBUTION

Sand and Silt Till

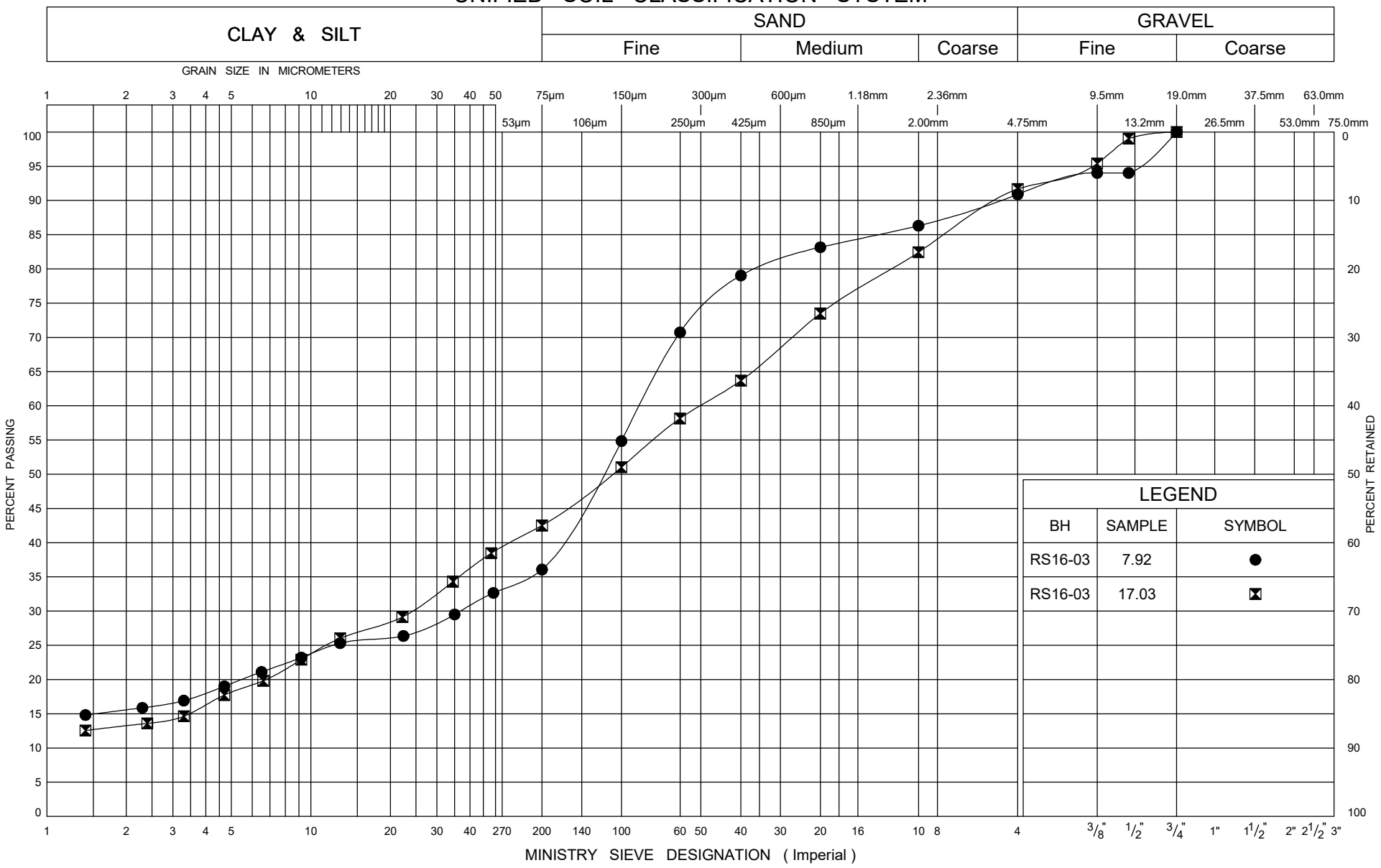
FIG No B4

W P 408-88-00

Riverbend-Shirley Connection

ONTARIO MOT GRAIN SIZE MTO-11375.GPJ ONTARIO MOT.GDT 10/18/18

UNIFIED SOIL CLASSIFICATION SYSTEM



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Ontario

GRAIN SIZE DISTRIBUTION

Silty Sand Till

FIG No B5

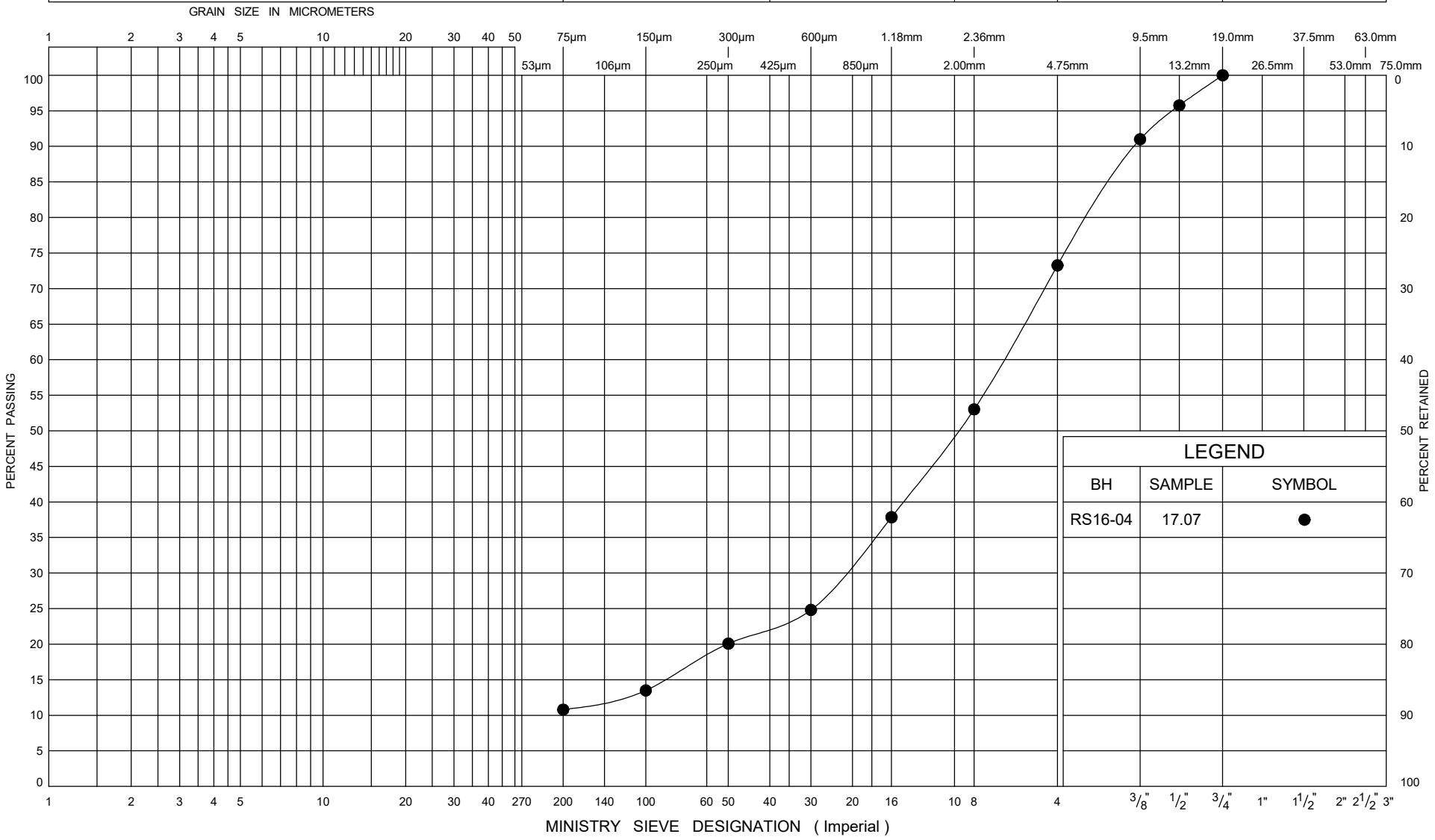
W P 408-88-00

Riverbend-Shirley Connection

ONTARIO MOT GRAIN SIZE MTO-11375.GPJ ONTARIO MOT.GDT 10/18/18

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Gravelly Sand

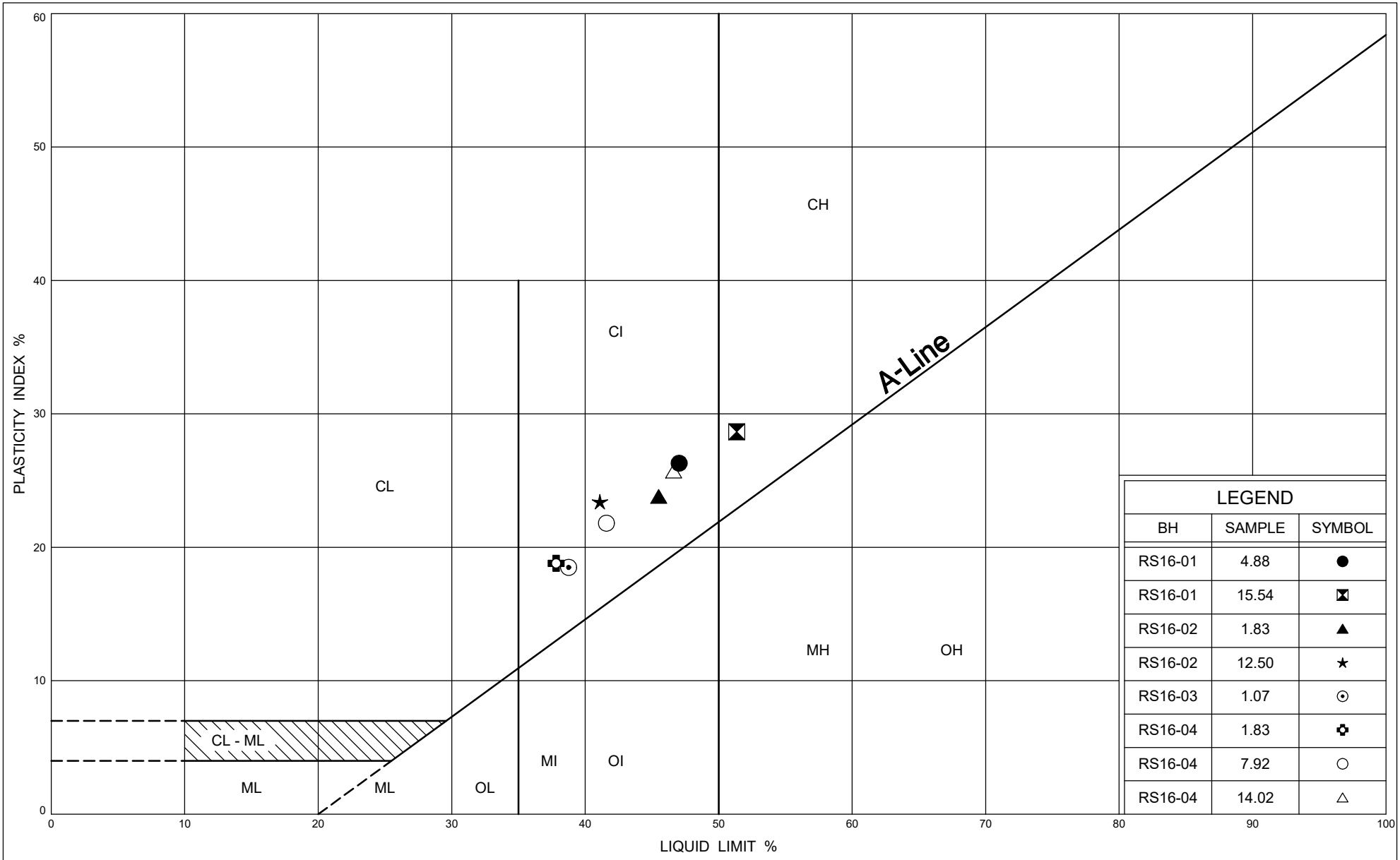
FIG No B6

W P 408-88-00

Riverbend-Shirley Connection

ONTARIO MOT GRAIN SIZE MTO-11375.GPJ ONTARIO MOT.GDT 10/18/18

Oct 75, FF - S - 21



LEGEND		
BH	SAMPLE	SYMBOL
RS16-01	4.88	●
RS16-01	15.54	⊠
RS16-02	1.83	▲
RS16-02	12.50	★
RS16-03	1.07	⊙
RS16-04	1.83	✿
RS16-04	7.92	○
RS16-04	14.02	△

Ministry of Transportation
Ontario

PLASTICITY CHART

Silty Clay

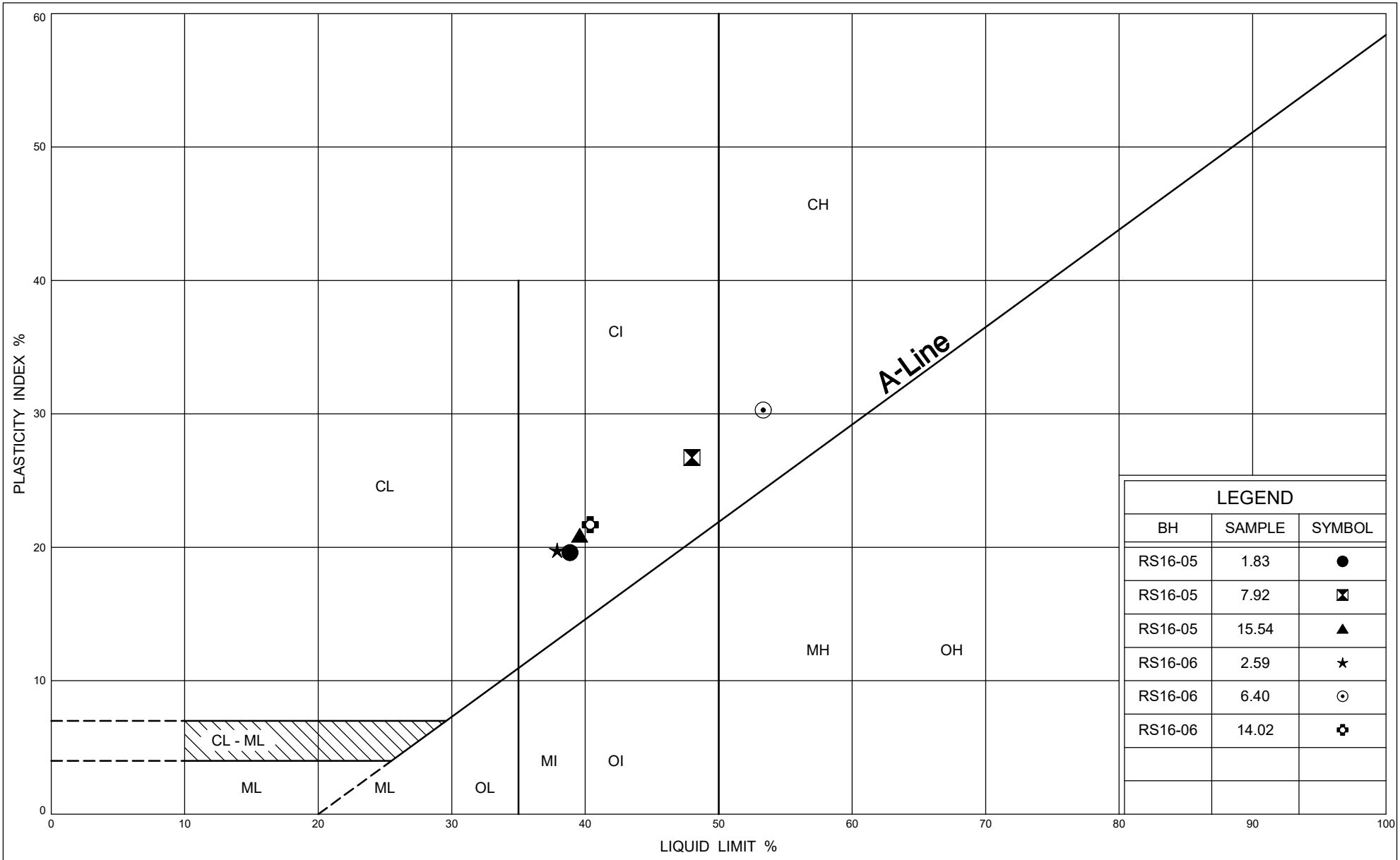
FIG No B7

W P 408-88-00

Riverbend-Shirley Connection

ONTARIO MOT PLASTICITY CHART MTO-11375.GPJ ONTARIO MOT.GDT 10/18/18

Oct 75, FF - S - 21



LEGEND		
BH	SAMPLE	SYMBOL
RS16-05	1.83	●
RS16-05	7.92	⊠
RS16-05	15.54	▲
RS16-06	2.59	★
RS16-06	6.40	⊙
RS16-06	14.02	✿

Ministry of Transportation
Ontario

PLASTICITY CHART

Silty Clay

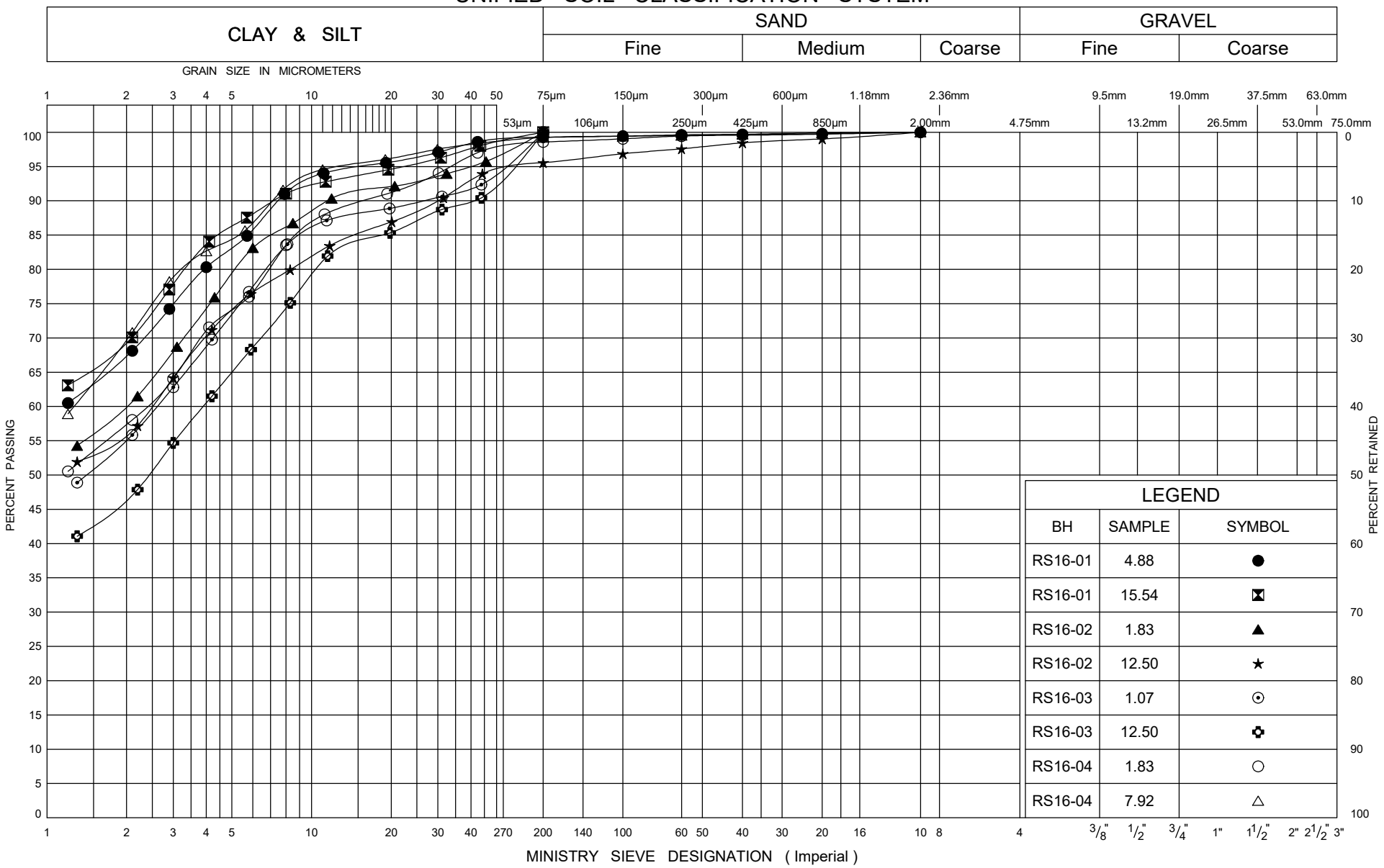
FIG No B8

W P 408-88-00

Riverbend-Shirley Connection

ONTARIO MOT PLASTICITY CHART MTO-11375.GPJ ONTARIO MOT.GDT 10/18/18

UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND		
BH	SAMPLE	SYMBOL
RS16-01	4.88	●
RS16-01	15.54	⊠
RS16-02	1.83	▲
RS16-02	12.50	★
RS16-03	1.07	⊙
RS16-03	12.50	✿
RS16-04	1.83	○
RS16-04	7.92	△

Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Silty Clay

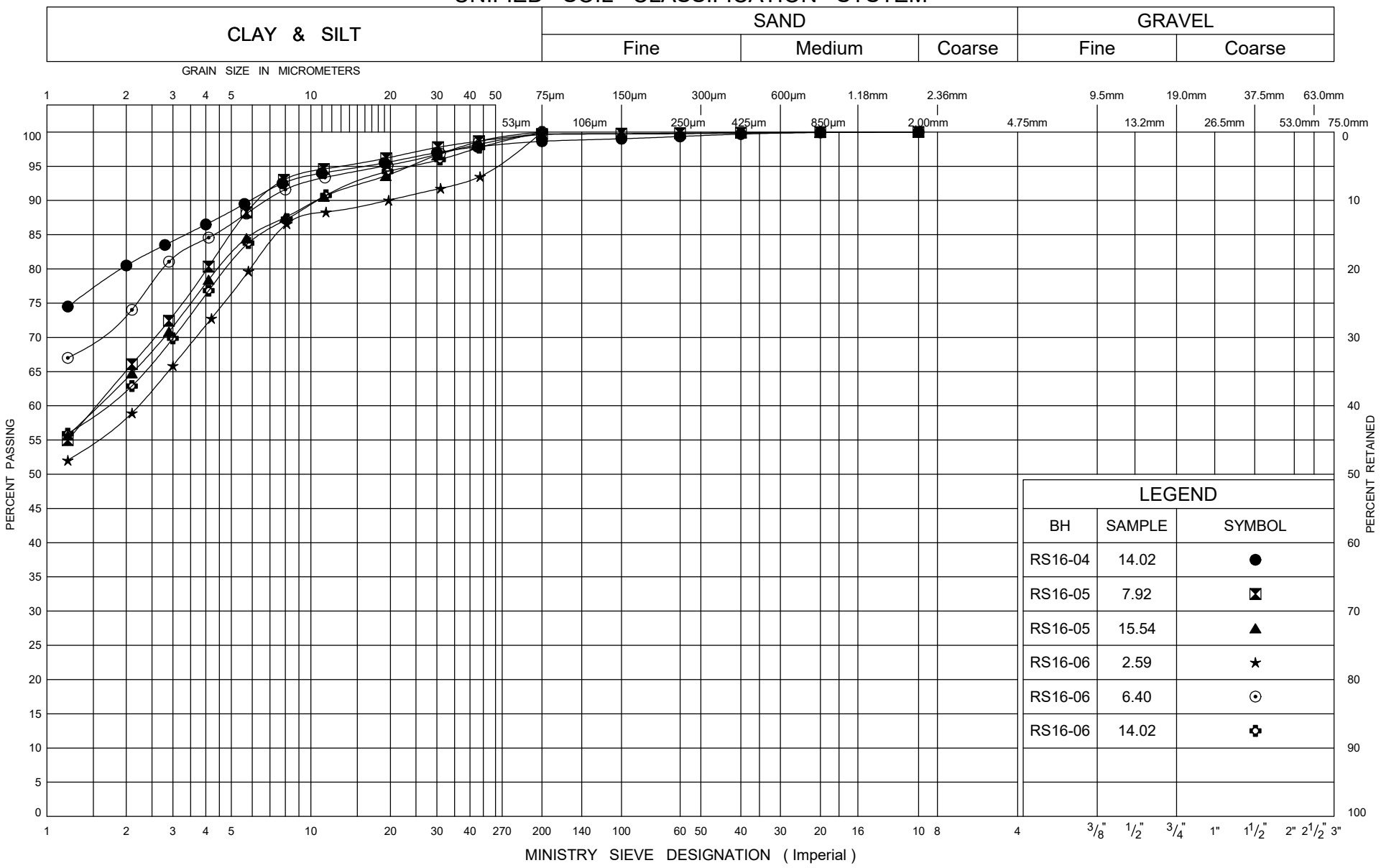
FIG No B1

W P 408-88-00

Riverbend-Shirley Connection

ONTARIO MOT GRAIN SIZE MTO-11375.GPJ ONTARIO MOT.GDT 10/18/18

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Silty Clay

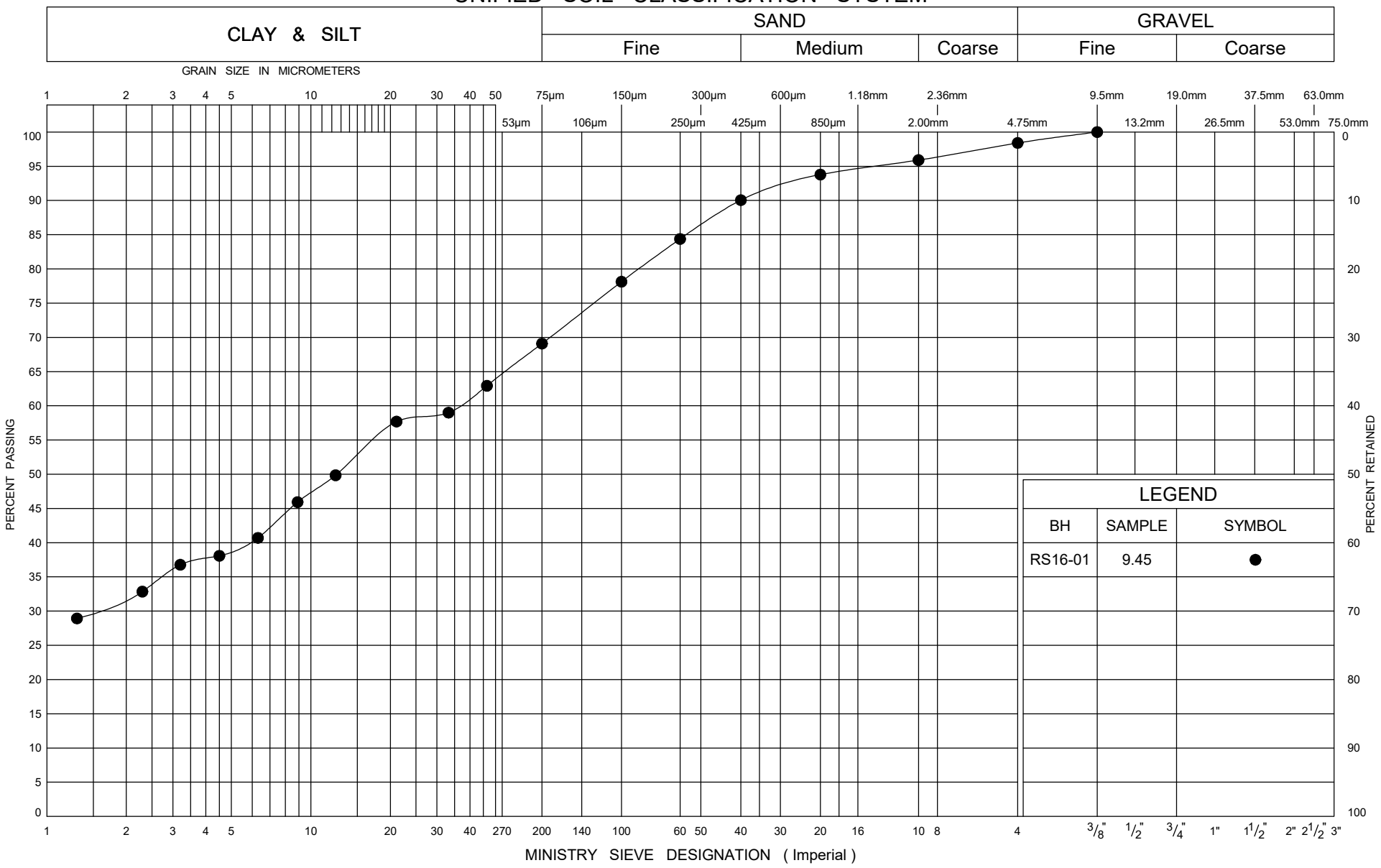
FIG No B2

W P 408-88-00

Riverbend-Shirley Connection

ONTARIO MOT GRAIN SIZE MTO-11375.GPJ ONTARIO MOT.GDT 10/18/18

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Silty Clay Till

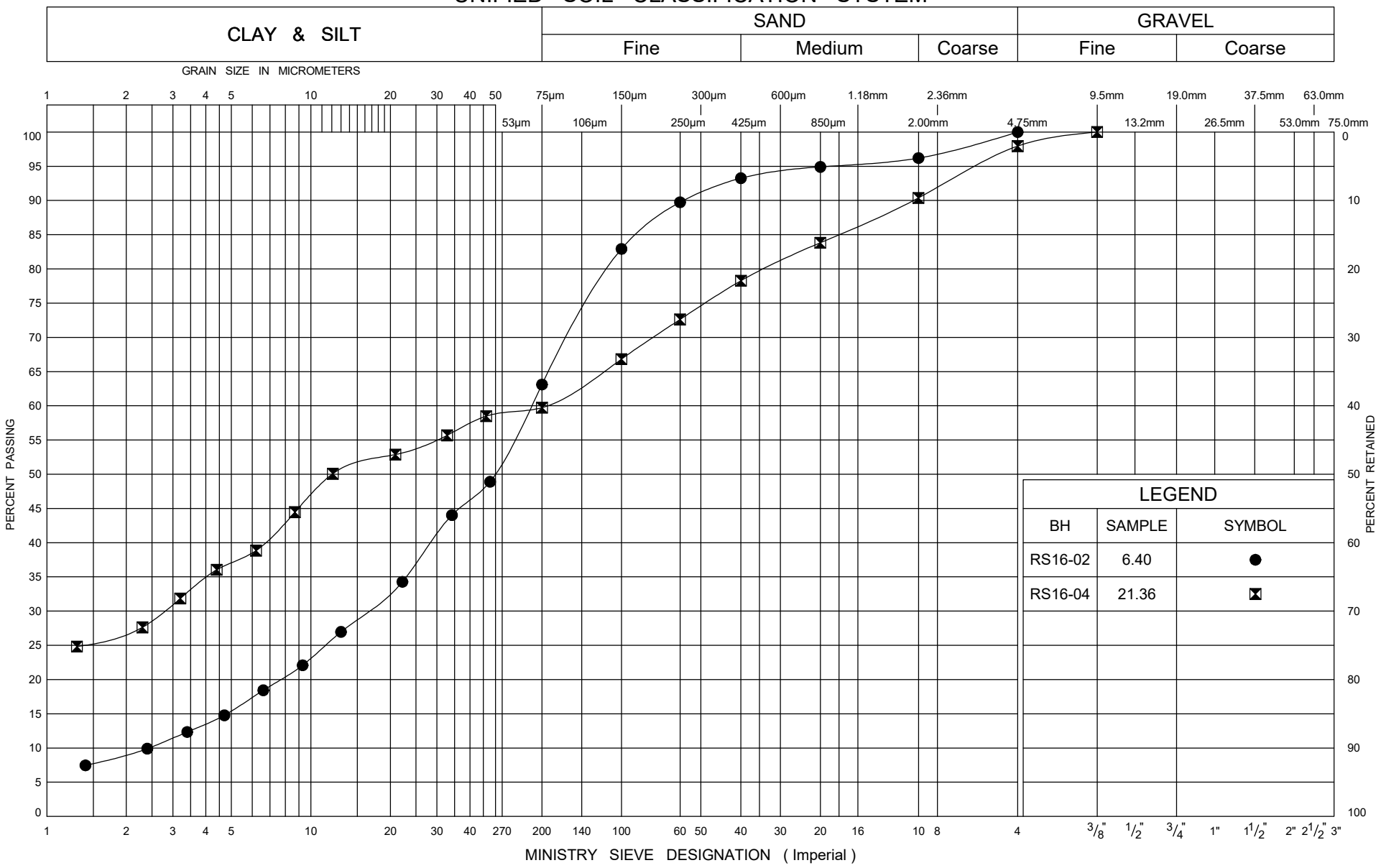
FIG No B3

W P 408-88-00

Riverbend-Shirley Connection

ONTARIO MOT GRAIN SIZE MTO-11375.GPJ ONTARIO MOT.GDT 10/18/18

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Sand and Silt Till

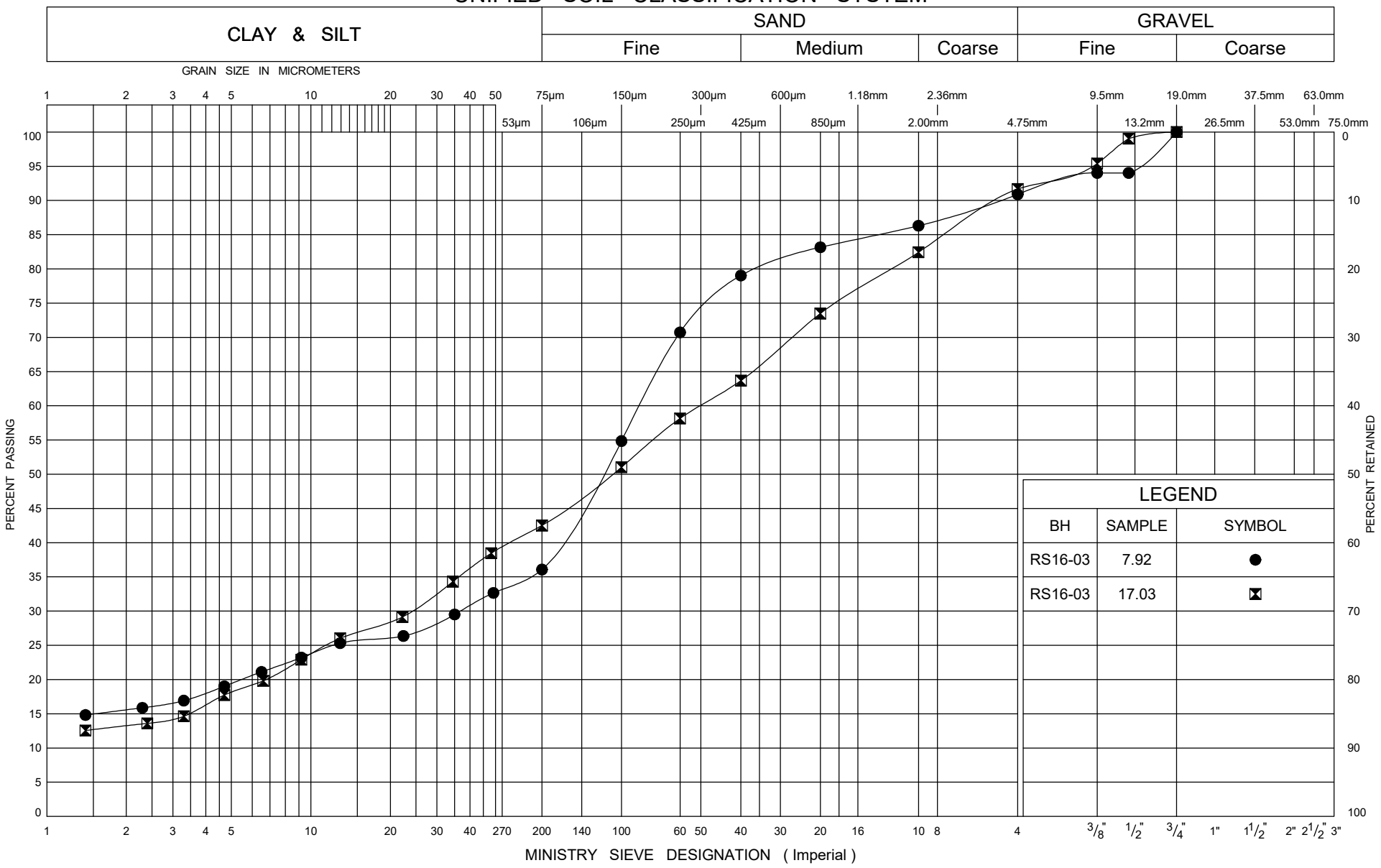
FIG No B4

W P 408-88-00

Riverbend-Shirley Connection

ONTARIO MOT GRAIN SIZE MTO-11375.GPJ ONTARIO MOT.GDT 10/18/18

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Silty Sand Till

FIG No B5

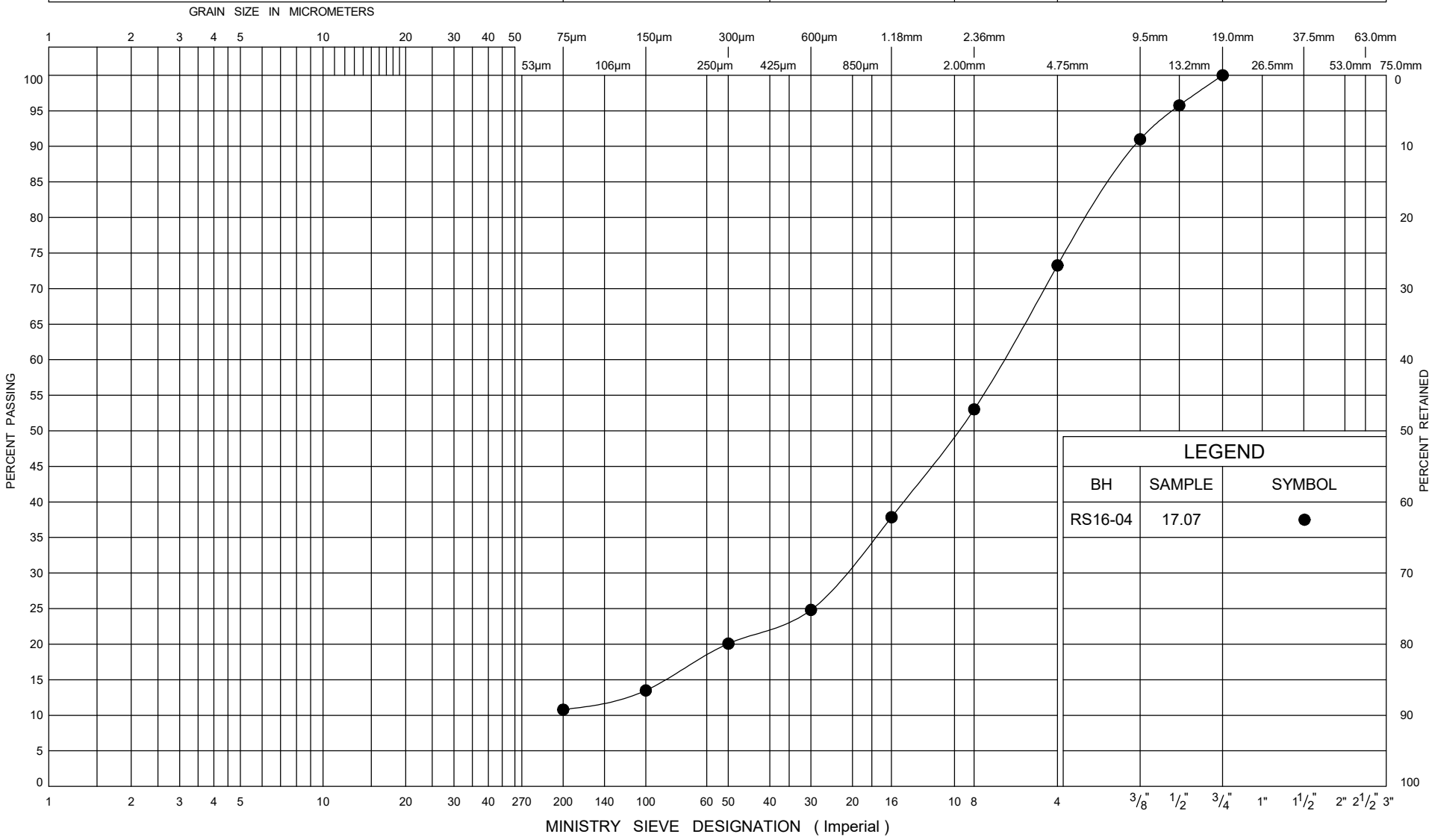
W P 408-88-00

Riverbend-Shirley Connection

ONTARIO MOT GRAIN SIZE MTO-11375.GPJ ONTARIO MOT.GDT 10/18/18

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Gravelly Sand

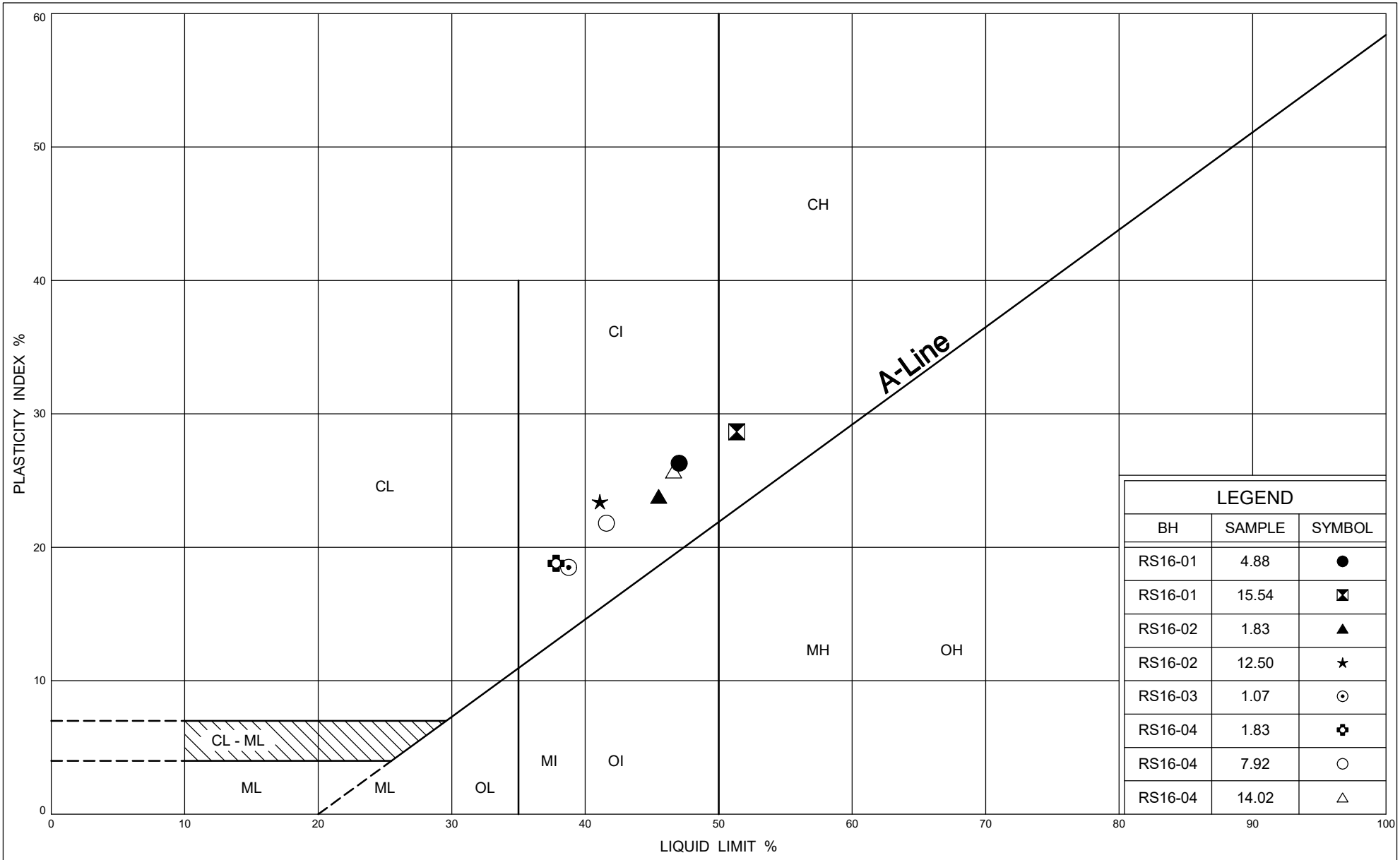
FIG No B6

W P 408-88-00

Riverbend-Shirley Connection

ONTARIO MOT GRAIN SIZE MTO-11375.GPJ ONTARIO MOT.GDT 10/18/18

Oct 75, FF - S - 21



LEGEND		
BH	SAMPLE	SYMBOL
RS16-01	4.88	●
RS16-01	15.54	⊠
RS16-02	1.83	▲
RS16-02	12.50	★
RS16-03	1.07	⊙
RS16-04	1.83	✿
RS16-04	7.92	○
RS16-04	14.02	△

Ministry of Transportation
Ontario

PLASTICITY CHART

Silty Clay

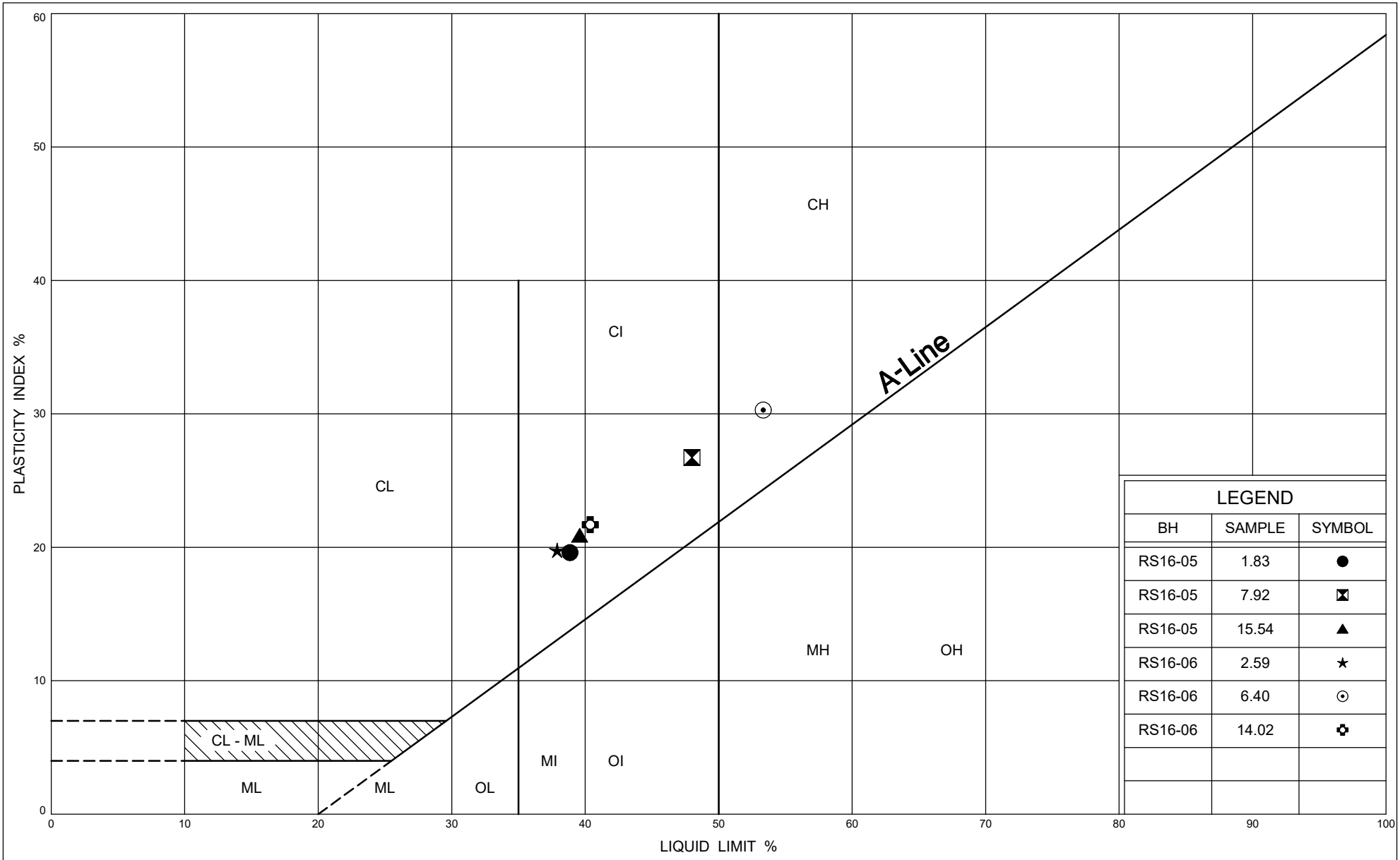
FIG No B7

W P 408-88-00

Riverbend-Shirley Connection

ONTARIO MOT PLASTICITY CHART MTO-11375.GPJ ONTARIO MOT.GDT 10/18/18

Oct 75, FF - S - 21



LEGEND		
BH	SAMPLE	SYMBOL
RS16-05	1.83	●
RS16-05	7.92	⊠
RS16-05	15.54	▲
RS16-06	2.59	★
RS16-06	6.40	⊙
RS16-06	14.02	✿

Ministry of Transportation
Ontario

PLASTICITY CHART

Silty Clay

FIG No B8

W P 408-88-00

Riverbend-Shirley Connection

ONTARIO MOT PLASTICITY CHART MTO-11375.GPJ ONTARIO MOT.GDT 10/18/18

FINAL REPORT

CA14445-AUG18 R1

11375

Prepared for

Thurber Engineering Ltd.

FINAL REPORT

CA14445-AUG18 R1

First Page

CLIENT DETAILS

Client	Thurber Engineering Ltd.
Address	103, 2010 Winston Park Drive Oakville, ON L6H 5R7. Canada
Contact	Rocío Palomeque
Telephone	905-829-8666 x 263
Facsimile	
Email	rreyna@thurber.ca
Project	11375
Order Number	
Samples	Soil (5)

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	CA14445-AUG18
Received	08/16/2018
Approved	08/23/2018
Report Number	CA14445-AUG18 R1
Date Reported	08/23/2018

COMMENTS

Temperature of Sample upon Receipt: 6 degrees C
Cooling Agent Present.
Custody Seal Present&intact.

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

TABLE OF CONTENTS

FINAL REPORT

CA14445-AUG18 R1

Client: Thurber Engineering Ltd.
Project: 11375
Project Manager: Rocío Palomeque
Samplers: N/A

PACKAGE: **- Corrosivity Index** (SOIL)

			Sample Number	5	6	7	8	9
			Sample Name	RS16-03-SS4	RW7-01-SS3	RW1-04-SS2	NE16-10 SS4	EC16-08 SS3
			Sample Matrix	Soil	Soil	Soil	Soil	Soil
			Sample Date	18/05/2018	05/06/2018	06/06/2018	27/04/2018	27/04/2018
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**	**Result**	**Result**
Corrosivity Index								
Corrosivity Index	none	1		4.0	4.0	6.5	4.0	4.5
Soil Redox Potential	mV	-		246	362	187	205	169
Sulphide	%	0.02		< 0.02	< 0.02	0.04	< 0.02	0.86
pH	no unit	0.05		8.87	9.36	10.7	9.02	8.15
Resistivity (calculated)	ohms.cm	-9999		3320	10500	4120	4070	4410

PACKAGE: **- General Chemistry** (SOIL)

			Sample Number	5	6	7	8	9
			Sample Name	RS16-03-SS4	RW7-01-SS3	RW1-04-SS2	NE16-10 SS4	EC16-08 SS3
			Sample Matrix	Soil	Soil	Soil	Soil	Soil
			Sample Date	18/05/2018	05/06/2018	06/06/2018	27/04/2018	27/04/2018
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**	**Result**	**Result**
General Chemistry								
Conductivity	uS/cm	2		301	95	243	246	227

PACKAGE: **- Metals and Inorganics** (SOIL)

			Sample Number	5	6	7	8	9
			Sample Name	RS16-03-SS4	RW7-01-SS3	RW1-04-SS2	NE16-10 SS4	EC16-08 SS3
			Sample Matrix	Soil	Soil	Soil	Soil	Soil
			Sample Date	18/05/2018	05/06/2018	06/06/2018	27/04/2018	27/04/2018
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**	**Result**	**Result**
Metals and Inorganics								
Moisture Content	%	0.1		19.4	3.0	7.6	11.0	13.9
Sulphate	µg/g	0.4		70	6.6	270	9.1	710

FINAL REPORT

CA14445-AUG18 R1

Client: Thurber Engineering Ltd.
Project: 11375
Project Manager: Rocío Palomeque
Samplers: N/A

PACKAGE: **- Other (ORP)** (SOIL)

			Sample Number	5	6	7	8	9
			Sample Name	RS16-03-SS4	RW7-01-SS3	RW1-04-SS2	NE16-10 SS4	EC16-08 SS3
			Sample Matrix	Soil	Soil	Soil	Soil	Soil
			Sample Date	18/05/2018	05/06/2018	06/06/2018	27/04/2018	27/04/2018
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**	**Result**	**Result**
Other (ORP)								
Chloride	µg/g	0.4		240	13	60	130	4.4

QC SUMMARY

Anions by IC

Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-[ENV]IC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0280-AUG18	µg/g	0.4	<0.4	2	20	96	80	120	97	75	125
Sulphate	DIO0280-AUG18	µg/g	0.4	<0.4	5	20	97	80	120	81	75	125

Carbon/Sulphur

Method: ASTM E1915-07A | Internal ref.: ME-CA-[ENV]ARD-LAK-AN-020

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide	ECS0022-AUG18	%	0.02	<0.02	99	20	99	80	120			

Conductivity

Method: SM 2510 | Internal ref.: ME-CA-[ENV]EWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0253-AUG18	uS/cm	2	< 0.002	0	10	99	90	110	NA		

QC SUMMARY

pH

Method: SM 4500 I Internal ref.: ME-CA-[ENV]EWL-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0253-AUG18	no unit	0.05	NA	0		101			NA		

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

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

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

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

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

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

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

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

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

LEGEND

FOOTNOTES

NSS Insufficient sample for analysis.
RL Reporting Limit.
↑ Reporting limit raised.
↓ Reporting limit lowered.
NA The sample was not analysed for this analyte
ND Non Detect

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

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

-- End of Analytical Report --

SGS

Request for Laboratory Services and CHAIN OF CUSTODY

No: 00864

Page 1 of 1

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

Laboratory Information Section - Lab use only

Received By: Vulica Coll
Received Date: 08/16/18 (mm/dd/yy)
Received Time: 12:00 am / pm (circle)

Received By (signature):
Custody Seal Present: Y / N (circle)
Custody Seal Intact: Y / N

Cooling Agent Present: Y / N Type:
Temperature Upon Receipt (°C) 13.14, 12

LAB LIMS #: CA 14445-Aug18 6x3

REPORT INFORMATION

Company: Thurber Engineering Ltd.
Contact: Rocio Palomeque Reyna
Address: 103-2010 Winston Park Dr.
Oakville, ON L6H 5R7
Phone: 905-829-8666 x260
Fax:
Email: rreyna@thurber.ca

INVOICE INFORMATION

☐ (same as Report Information)
Company:
Contact:
Address:
Phone:
Email:

PROJECT INFORMATION

Quotation #: P.O. #:
Project #: 11375 Site Location/ID:

TURNAROUND TIME (TAT) REQUIRED

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

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

PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION

Specify Due Date: Rush Confirmation ID:

REGULATIONS

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

Other Regulations:
☐ Reg 347/558 (3 Day min TAT)
☐ PWQO ☐ MMER
☐ CCME ☐ Other:
☐ MISA

Sewer By-Law:
☐ Sanitary
☐ Storm
Municipality:

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

RECORD OF SITE CONDITION (RSC) ☐ YES ☐ NO

	SAMPLE IDENTIFICATION	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX	ANALYSIS REQUESTED: Corrosivity	COMMENTS: Field Filtered (F) Preserved (P)
1	RS16-03 - SS4	May 18, 2018		1	Soil	✓	
2							
3	RW7-01 - SS3	June 5, 2018		1	Soil	✓	
4							
5	RW1-04 - SS2	June 6, 2018		1	Soil	✓	
6							
7	WE16-10 SS4	April 27, 2018		1	Soil	✓	
8							
9	EC16-08 SS3	July 10, 2018		1	Soil	✓	
10							

Observations/Comments/Special Instructions

Sampled By (NAME): Signature: Date: 08 / 15 / 2018 (mm/dd/yy)

Relinquished by (NAME): Signature: Date: ___ / ___ / ___ (mm/dd/yy)

Pink Copy - Client
Yellow & White Copy - SGS

SGS

SAMPLE INTEGRITY REPORT

Project Number: 11375

ONTARIO REGULATION 153/04

SGS Sample ID: CA4445-Aug18

Date / Time Sampled: Please see COC

Client Sample ID

	ALL
Sample Submission General Sample Integrity Violations	
Temperature >10 C upon receipt if not sampled same day	☐
No evidence of cooling trend initiated if sampled same day	☐
Chain of Custody not submitted	☐
Chain of Custody incomplete	☐
Chain of Custody not signed / dated	☐ ✓
Chain of Custody not a current version	☐
Bottles / Samples listed on CoC but not received	☐
Bottles / Samples received but not listed on the CoC	☐
Sample container received empty	☐

Sample Specific Sample Integrity Violations							
Sample received past hold time	☐	☐	☐	☐	☐	☐	☐
Incorrect preservation (including no preservation where required)	☐	☐	☐	☐	☐	☐	☐
Headspace present in VOC vial (aqueous)	☐	☐	☐	☐	☐	☐	☐
Sample(s) received frozen	☐	☐	☐	☐	☐	☐	☐
Bottle(s) broken or damaged in transport	☐	☐	☐	☐	☐	☐	☐
Discrepancy between sample label and chain of custody	☐	☐	☐	☐	☐	☐	☐
Analysis requirements absent / unclear	☐	☐	☐	☐	☐	☐	☐
Missing or incorrect sample label(s)	☐	☐	☐	☐	☐	☐	☐
Inappropriate sample container used	☐	☐	☐	☐	☐	☐	☐
Insufficient number of bottles received	☐	☐	☐	☐	☐	☐	☐
Limited sample volume	☐	☐	☐	☐	☐	☐	☐
Insufficient sample volume	☐	☐	☐	☐	☐	☐	☐
Sample contains multiple phases	☐	☐	☐	☐	☐	☐	☐
Sediment Log							
Groundwater samples contain visible sediment / particulate	☐	☐	☐	☐	☐	☐	☐
Groundwater contains greater than 1cm of sediment / particulate matter in bottle	☐	☐	☐	☐	☐	☐	☐

Additional Comments/Remarks:

No issues upon receipt ☐ Initials: KH

THURBER

Appendix B

Record of Borehole Sheets and Laboratory Test Results (Previous Investigation)

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 08-033 1 OF 3 METRIC

G.W.P. 408-88-00 LOCATION N 4 814 712.66 E 226 708.59 ORIGINATED BY SLL
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY ES
DATUM Geodetic DATE 2008.06.19 - 2008.06.20 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
313.2											
0.0	**TOPSOIL**, occasional roots and rootlets: (150mm)										
0.2	**SAND**, some silt Compact Brown Moist						313				
	Layer of silt, some clay (500mm)		1	SS	14						
311.7							312				
1.5	Silty **CLAY**, trace sand Stiff to Very Stiff Brown to Grey		2	SS	22						
			3	SS	26		311				0 2 48 50
			4	SS	14		310				
309.1											
4.1	Sandy **SILT**, trace gravel, trace to some clay Compact to Very Dense Grey Moist (TILL)		5	SS	18		309				1 55 20 24
			6	SS	90		308				
306.6							307				5 45 40 10
6.6	**SAND**, trace silt, trace gravel, trace clay Very Dense Grey Wet		7	SS	93		306				2 91 7 (SI+CL)
							305				
			8	SS	100/250		304				

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 6417R.GPJ 8/6/08

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 08-033 2 OF 3 METRIC

G.W.P. 408-88-00 LOCATION N 4 814 712.66 E 226 708.59 ORIGINATED BY SLL
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY ES
DATUM Geodetic DATE 2008.06.19 - 2008.06.20 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
302.8	**SAND**, trace silt, trace gravel, trace clay						303				
10.4	Very Dense Grey Wet										
	Sandy **SILT**, trace clay Very Dense Grey Moist to Wet (TILL)		9	SS	100/.150		302		o		0 48 49 3
301.0											
12.2	Silty **CLAY**, trace sand, trace gravel Hard Grey		10	SS	35		301		o		
			11	SS	79		300		o		
			12	SS	85		299		o		1 4 40 55
			13	SS	53		298		o		
295.8							297				
17.4	Sandy **SILT**, trace to some clay, trace gravel Very Dense Grey Moist (TILL) Slow augering at 17.4m.		14	SS	100/.175		296		o		2 27 47 24
			15	SS	100/.075		295		o		2 44 42 12
							294				

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 6417R.GPJ 8/6/08

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 08-033 3 OF 3 METRIC

G.W.P. 408-88-00 LOCATION N 4 814 712.66 E 226 708.59 ORIGINATED BY SLL

HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY ES

DATUM Geodetic DATE 2008.06.19 - 2008.06.20 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	Sandy **SILT**, trace to some clay, trace gravel Very Dense Grey Moist (TILL)						293		o		
292.1			16	SS	100/						
21.1	END OF BOREHOLE AT 21.1m. BOREHOLE DRY UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE TO 0.61m THEN HOLEPLUG TO SURFACE.				.075						

+ 3 . × 3 . Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

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Ministry of Transportation
Ontario

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RECORD OF BOREHOLE No 08-034 1 OF 3 METRIC

G.W.P. 408-88-00 LOCATION N 4 814 735.77 E 226 754.73 ORIGINATED BY SLL

HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY ES

DATUM Geodetic DATE 2008.06.17 - 2008.06.18 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
312.2											
0.0	**TOPSOIL**, peaty, occasional roots and rootlets: (200mm) Black Moist						312				
0.2	**SAND**, some silt Compact Brown Wet		1	SS	13				c		
310.7							311				
1.4	Silty **CLAY**, trace gravel Stiff to Very Stiff Brown to Grey		2	SS	12				c		
			3	SS	18		310		o		0 0 47 53
			4	SS	14		309		o		
			5	SS	10		308		o		
306.1							307				
6.1	Sandy **SILT**, trace gravel, some clay Compact to Dense Grey Moist (TILL)		6	SS	16		306		H o		1 30 55 14
	occasional silt pockets		7	SS	37		305		o		3 40 41 16
							304		o		
			8	SS	39		303		o		
302.2											

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 6417R.GPJ 9/2/08

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 08-034 2 OF 3 METRIC

G.W.P. 408-88-00 LOCATION N 4 814 735.77 E 226 754.73 ORIGINATED BY SLL
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY ES
DATUM Geodetic DATE 2008.06.17 - 2008.06.18 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
10.0	Continued From Previous Page Silty **CLAY**, trace gravel, occasional silt pockets Very Stiff to Hard Grey						302				
			9	SS	29		301				0 1 22 77
			10	SS	34	▼	300				
			11	SS	45		299				
			12	SS	38		298				
296.0							297				
16.2	**SAND**, some gravel, trace silt, trace clay, occasional cobbles Very Dense Grey Wet		13	SS	100/ 150		296				13 76 11 (SI+CL)
293.6			14	SS	100/ 175		295				
18.6	Sandy **SILT**, some clay, trace gravel Very Dense Grey (TILL)						294				
292.2			15	SS	100/		293				2 32 47 19

Continued Next Page

$+^{3}$, $\times^{3}$ Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

ONTMT4S 6417R.GPJ 9/2/08

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 08-034 3 OF 3 METRIC

G.W.P. 408-88-00 LOCATION N 4 814 735.77 E 226 754.73 ORIGINATED BY SLL
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY ES
DATUM Geodetic DATE 2008.06.17 - 2008.06.18 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
20.0	END OF BOREHOLE AT 20.0m. Piezometer installation consists of 25mm diameter schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2008.08.20 12.5m 299.7 2008.08.27 12.4m 299.8				150						

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

ONTMT4S 6417R.GPJ 9/2/08

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 08-035 1 OF 2 METRIC

G.W.P. 408-88-00 LOCATION N 4 814 668.41 E 226 725.11 ORIGINATED BY SLL
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
DATUM Geodetic DATE 2008.06.11 - 2008.06.11 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
315.3											
0.0	**TOPSOIL**, trace sand and gravel, occasional roots and rootlets: (150mm)										
0.2	Silty **CLAY**, trace sand Very Stiff Brown		1	SS	16		315	○			
			2	SS	25		314	○			
			3	SS	30		313	⊖			0 4 45 51
			4	SS	25		312	○			
310.9											
4.4	Sandy **SILT**, trace clay, trace gravel Compact Brown Moist to Wet (TILL)		5	SS	22		311	○			1 45 46 8
	Very Dense Grey		6	SS	100/.250		310				
	trace sand, some clay		7	SS	100/.200		309	○			2 49 39 10
306.5							308	○			0 6 82 12
8.8	Silty **CLAY**, trace sand Hard Grey (TILL)		8	SS	64/100		307				
305.7							306	⊖			0 4 39 57
9.6	END OF BOREHOLE AT 9.6m. Piezometer installation consists of 25mm diameter schedule 40 PVC pipe										

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 6417R.GPJ 8/6/08

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 08-035 2 OF 2 METRIC

G.W.P. 408-88-00 LOCATION N 4 814 668.41 E 226 725.11 ORIGINATED BY SLL
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
DATUM Geodetic DATE 2008.06.11 - 2008.06.11 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE; ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	with a 1.52m slotted screen.										
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2008.02.07 0.5* 315.8 2008.06.13 0.5* 315.8 2008.07.02 0.6* 315.9 2008.08.20 0.7* 316.0 2008.08.27 0.7* 316.0 *Above ground level										

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15}\oplus\frac{5}{10}$ (%) STRAIN AT FAILURE

ONTMT4S 6417R.GPJ 9/11/08

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 08-036 1 OF 3 METRIC

G.W.P. 408-88-00 LOCATION N 4 814 685.09 E 226 764.24 ORIGINATED BY SLL
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
DATUM Geodetic DATE 2008.06.12 - 2008.06.12 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
314.6											
0.0	**TOPSOIL**, with roots and rootlets: (175mm)										
0.2	Sandy **SILT**, trace clay Compact Brown Wet		1	SS	15		314		o		
			2	SS	17		313		o		0 23 73 4
312.6											
2.1	Silty **CLAY**, trace sand Very Stiff Grey (TILL)		3	SS	19		312		o		
			4	SS	19		311		o		0 5 45 50
			5	SS	8		310		o		
	Hard Grey		6	SS	45		309		o		
			7	SS	17		308		o		
	Wet silty sand seam (150mm)						307		o		0 15 46 39
			8	SS	100/275		306		o		
304.6							305				

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 6417R.GPJ 8/6/08

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 08-036 2 OF 3 METRIC

G.W.P. 408-88-00 LOCATION N 4 814 685.09 E 226 764.24 ORIGINATED BY SLL
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
DATUM Geodetic DATE 2008.06.12 - 2008.06.12 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
10.0	Silty **CLAY**, trace sand Hard Grey (TILL)										
			9	SS	80/ .275		304				
							303				
			10	SS	73						0 6 42 52
301.4							302				
13.3	Silty **CLAY**, occasional silt pockets Hard Grey										
			11	SS	60		301				0 4 30 66
							300				
			12	SS	72		299				
							298				
			13	SS	63						0 4 31 65
296.6							297				
18.1	Sandy **SILT**, some clay, trace, gravel Very Dense Grey Moist (TILL)						296				
			14	SS	100/ .150						
							295				
			15	SS	100/						3 26 46 25

Continued Next Page

+ ³ , × ³ : Numbers refer to Sensitivity

15 (20 / 10) 5 (%) STRAIN AT FAILURE

ONTMT4S 6417R.GPJ 8/6/08

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 08-036 3 OF 3 METRIC

G.W.P. 408-88-00 LOCATION N 4 814 685.09 E 226 764.24 ORIGINATED BY SLL
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
DATUM Geodetic DATE 2008.06.12 - 2008.06.12 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	Sandy **SILT**, some clay, trace, gravel Very Dense Grey Moist (TILL)				.125		294				
293.2			16	SS	100/				○		1 15 71 13
21.5	END OF BOREHOLE AT 21.5m. BOREHOLE DRY UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE TO 0.90m THEN HOLEPLUG TO SURFACE.				.125						

$+^3$, $\times^3$: Numbers refer to Sensitivity

$15 \overset{20}{\underset{10}{\oplus}} 5$ (%) STRAIN AT FAILURE

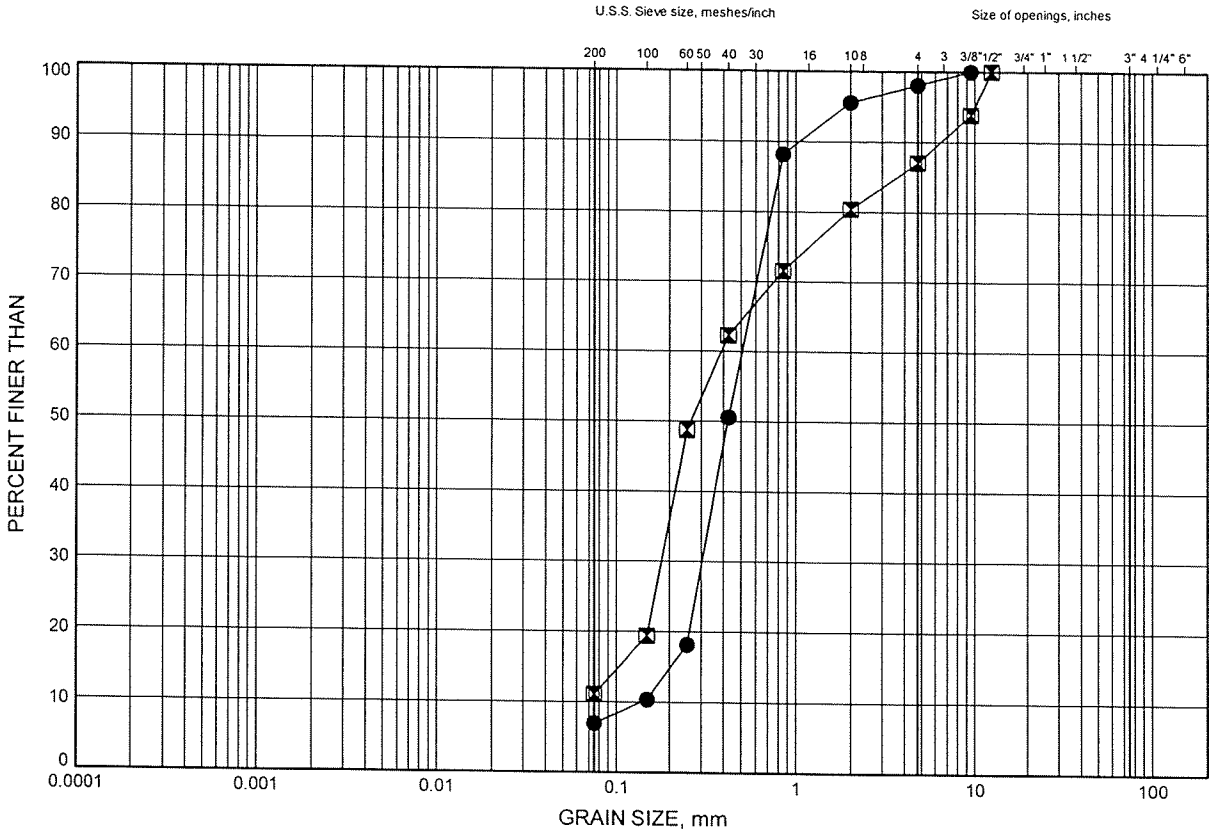
ONTMT4S 6417R.GPJ 8/6/08

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B1

Sand



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-033	7.85	305.36
⊠	08-034	16.92	295.28

W.P.# 408-88-00
Prepared By SA
Checked By RPR

THURBER

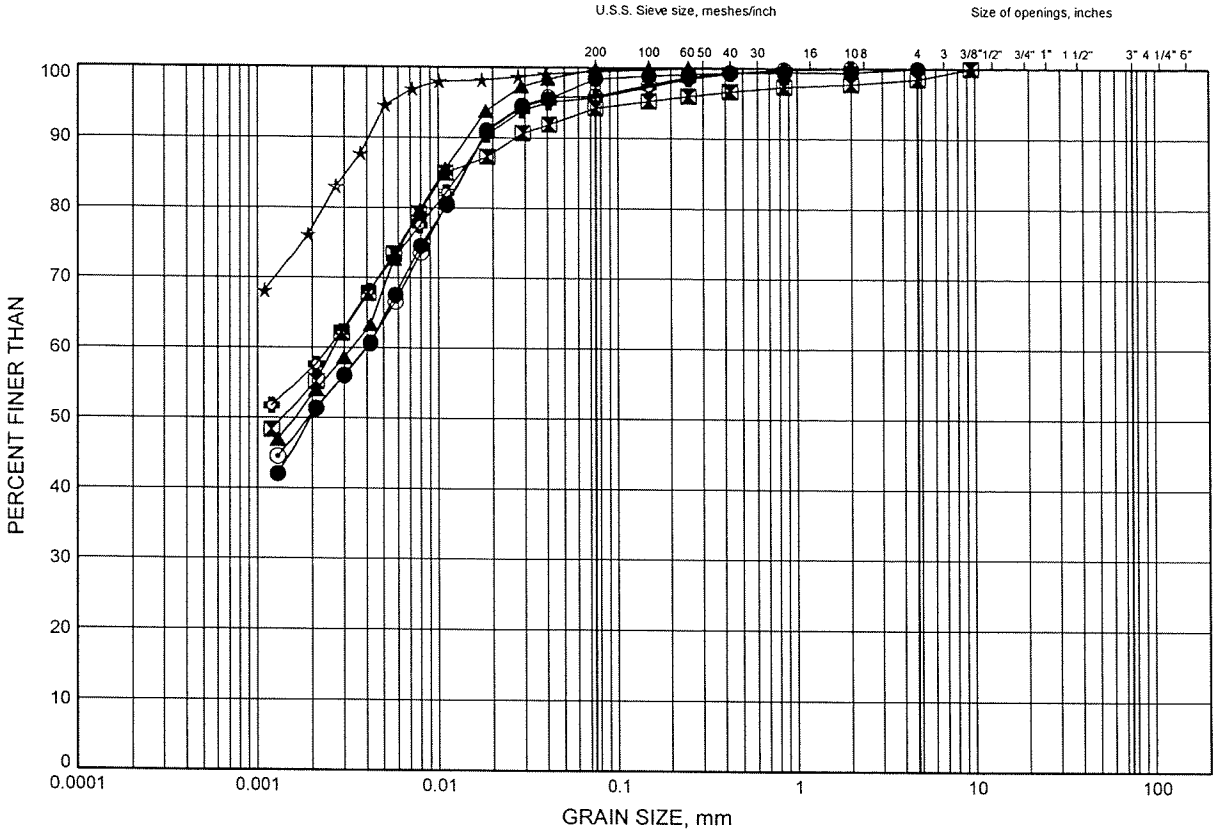
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 7/29/08

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B2

Silty Clay and Silty Clay Till



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-033	2.59	310.61
⊠	08-033	15.24	297.96
▲	08-034	2.59	309.60
☆	08-034	10.97	301.22
⊙	08-035	2.59	312.70
✿	08-035	9.36	305.93

W.P.# 408-88-00
Prepared By SA
Checked By RPR

THURBER

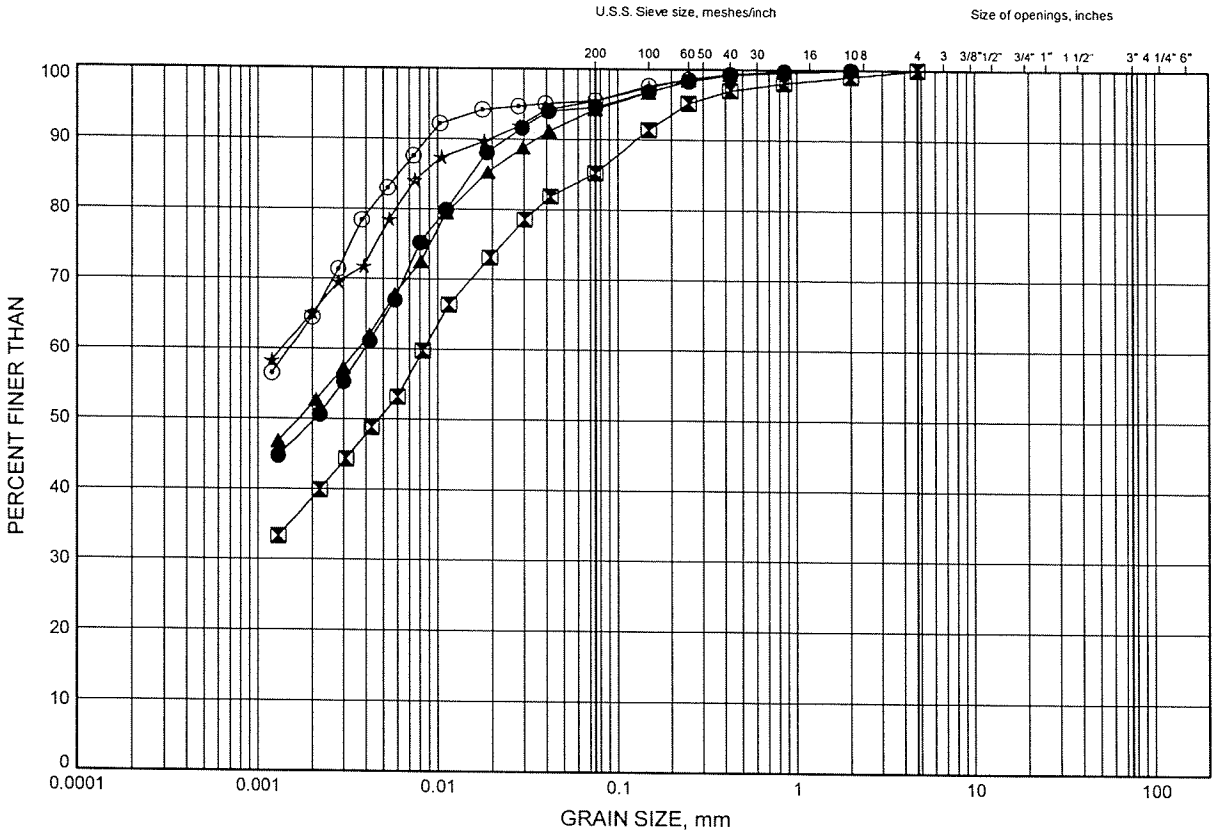
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 7/29/08

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B3

Silty Clay and Silty Clay Till



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-036	3.35	311.28
⊠	08-036	7.92	306.71
▲	08-036	12.48	302.15
☆	08-036	14.02	300.61
⊙	08-036	17.07	297.56

W.P.# 408-88-00
Prepared By SA
Checked By RPR

THURBER

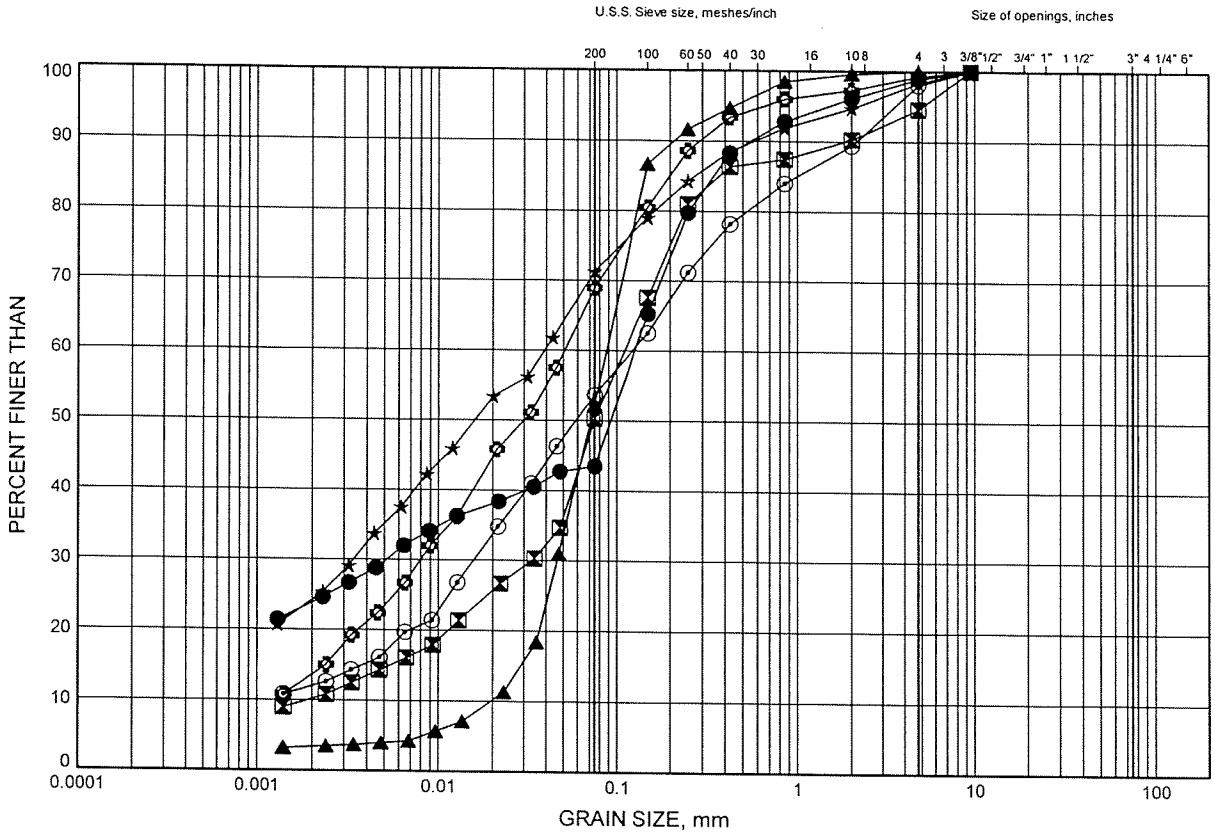
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 7/29/08

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B4

Sandy Silt and Sandy Silt Till



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-033	4.88	308.33
⊠	08-033	6.38	306.83
▲	08-033	10.82	302.38
☆	08-033	18.07	295.13
⊙	08-033	19.54	293.66
✿	08-034	6.40	305.79

W.P.# 408-88-00
Prepared By SA
Checked By RPR

THURBER

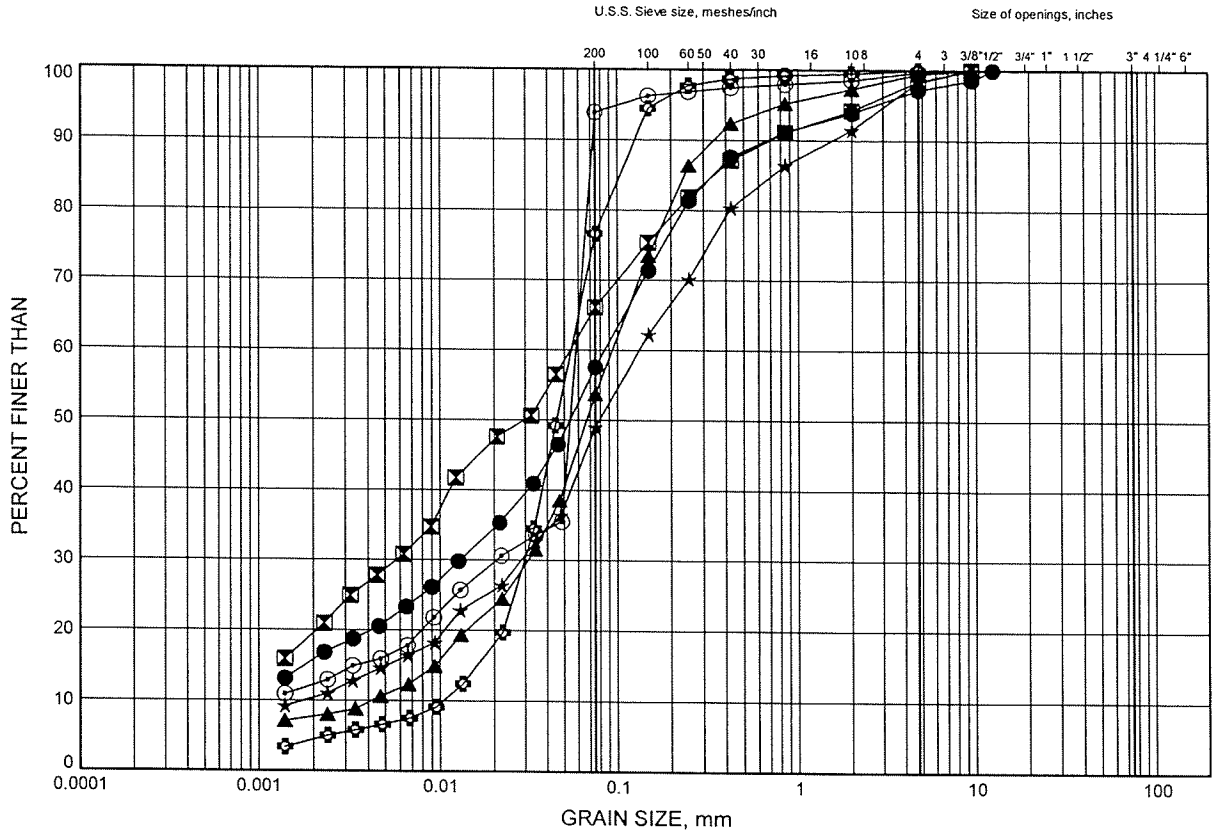
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 7/29/08

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B5

Sandy Silt and Sandy Silt Till



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-034	7.89	304.31
⊠	08-034	19.89	292.30
▲	08-035	4.88	310.41
☆	08-035	6.22	309.07
⊙	08-035	7.72	307.57
✿	08-036	1.83	312.80

W.P.# 408-88-00
Prepared By SA
Checked By RPR

THURBER

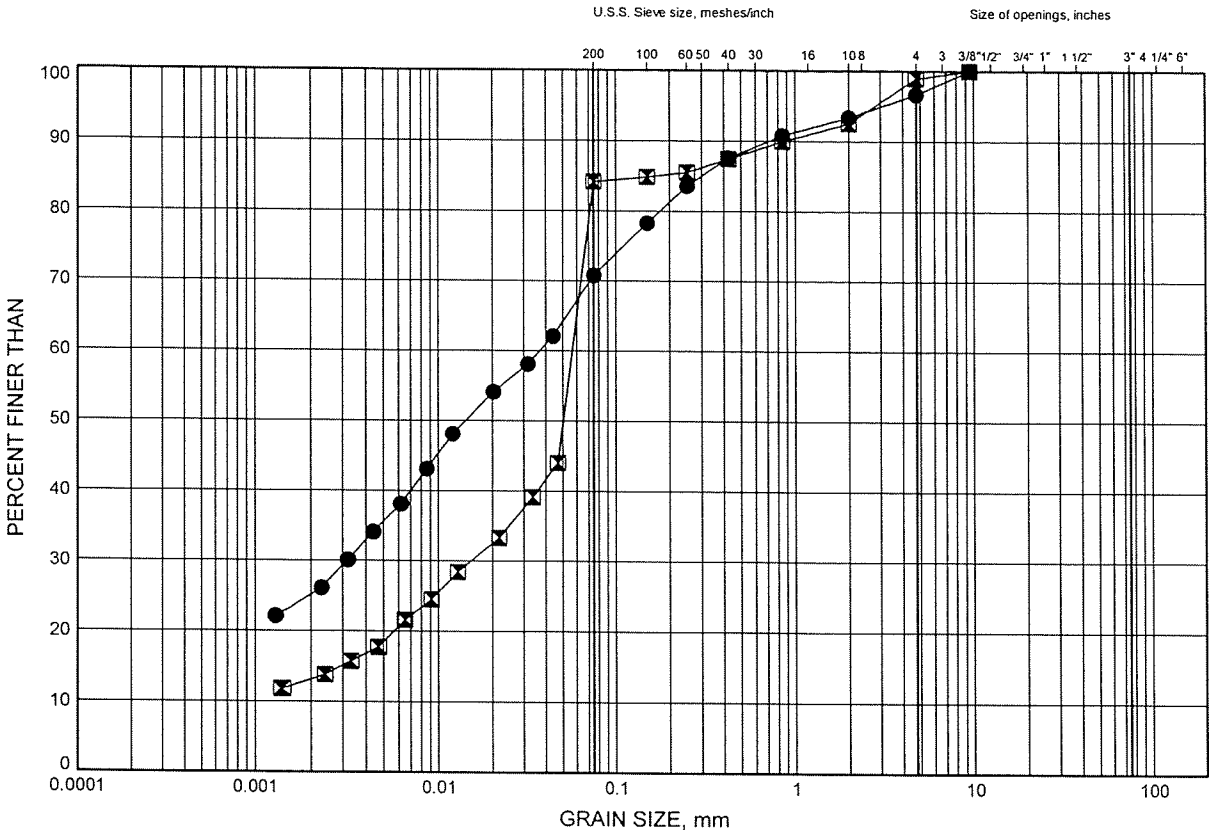
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 7/29/08

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B6

Sandy Silt and Sandy Silt Till



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-036	19.87	294.76
⊠	08-036	21.40	293.23

W.P.# 408-88-00
Prepared By SA
Checked By RPR

THURBER

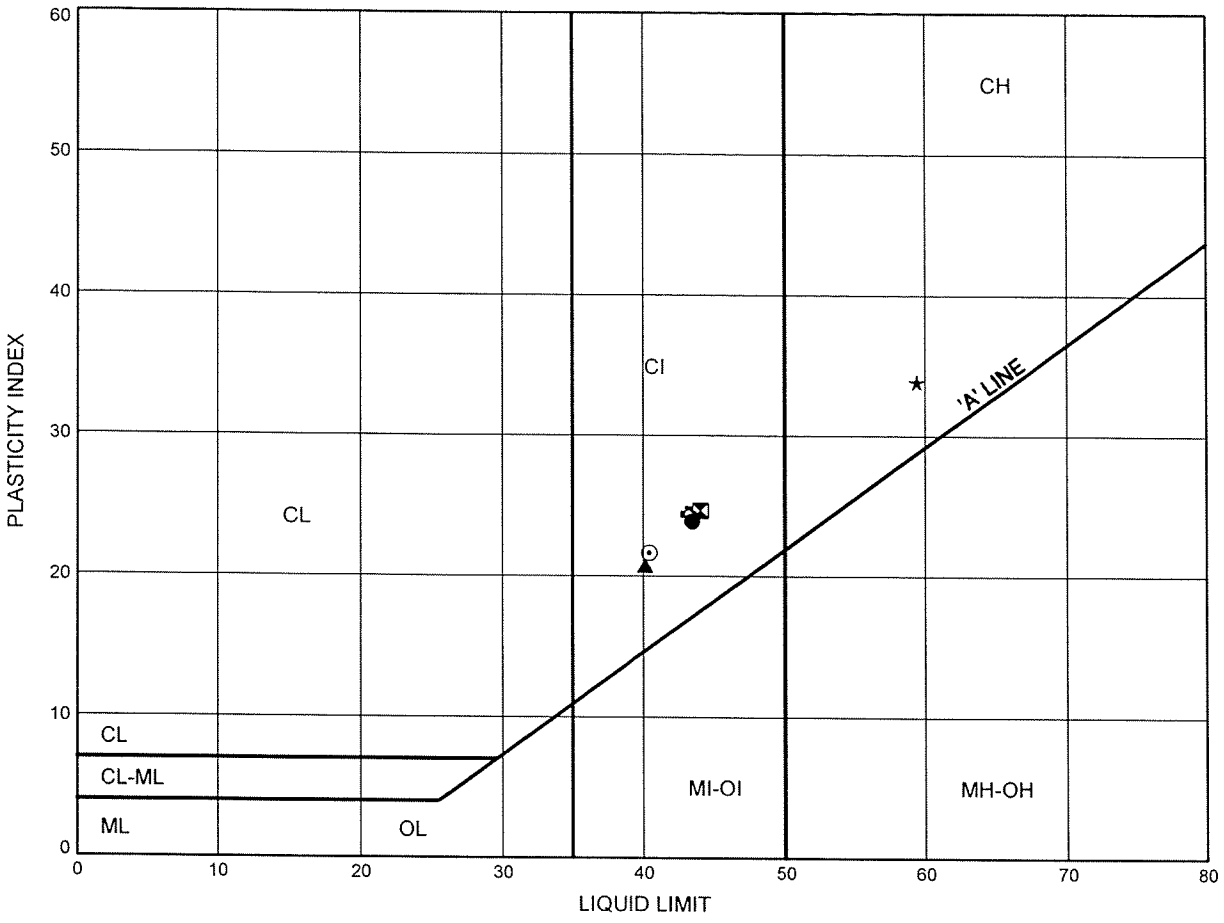
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 7/29/08

Highway 7 - New

ATTERBERG LIMITS TEST RESULTS

FIGURE B7

Silty Clay and Silty Clay Till



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-033	2.59	310.61
⊠	08-033	15.24	297.96
▲	08-034	2.59	309.60
★	08-034	10.97	301.22
⊙	08-035	2.59	312.70
✪	08-035	9.36	305.93

Date July 2008

Project 408-88-00

THURBER

Prep'd SA

Chkd. RPR

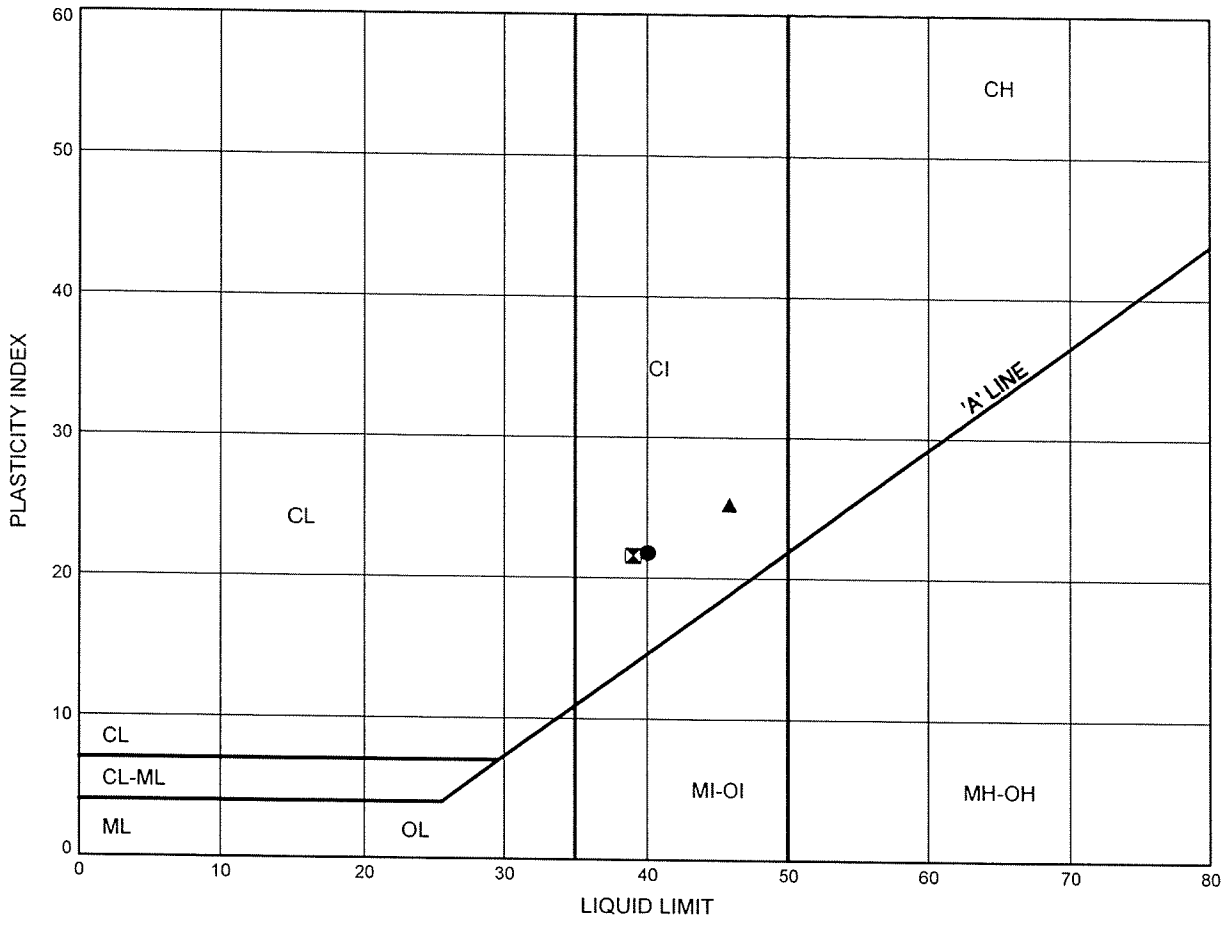
THURBALT 6417R.GPJ 7/29/08

Highway 7 - New

ATTERBERG LIMITS TEST RESULTS

FIGURE B8

Silty Clay and Silty Clay Till



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-036	3.35	311.28
⊠	08-036	12.48	302.15
▲	08-036	17.07	297.56

Date July 2008

Project 408-88-00

THURBER

Prep'd SA

Chkd. RPR

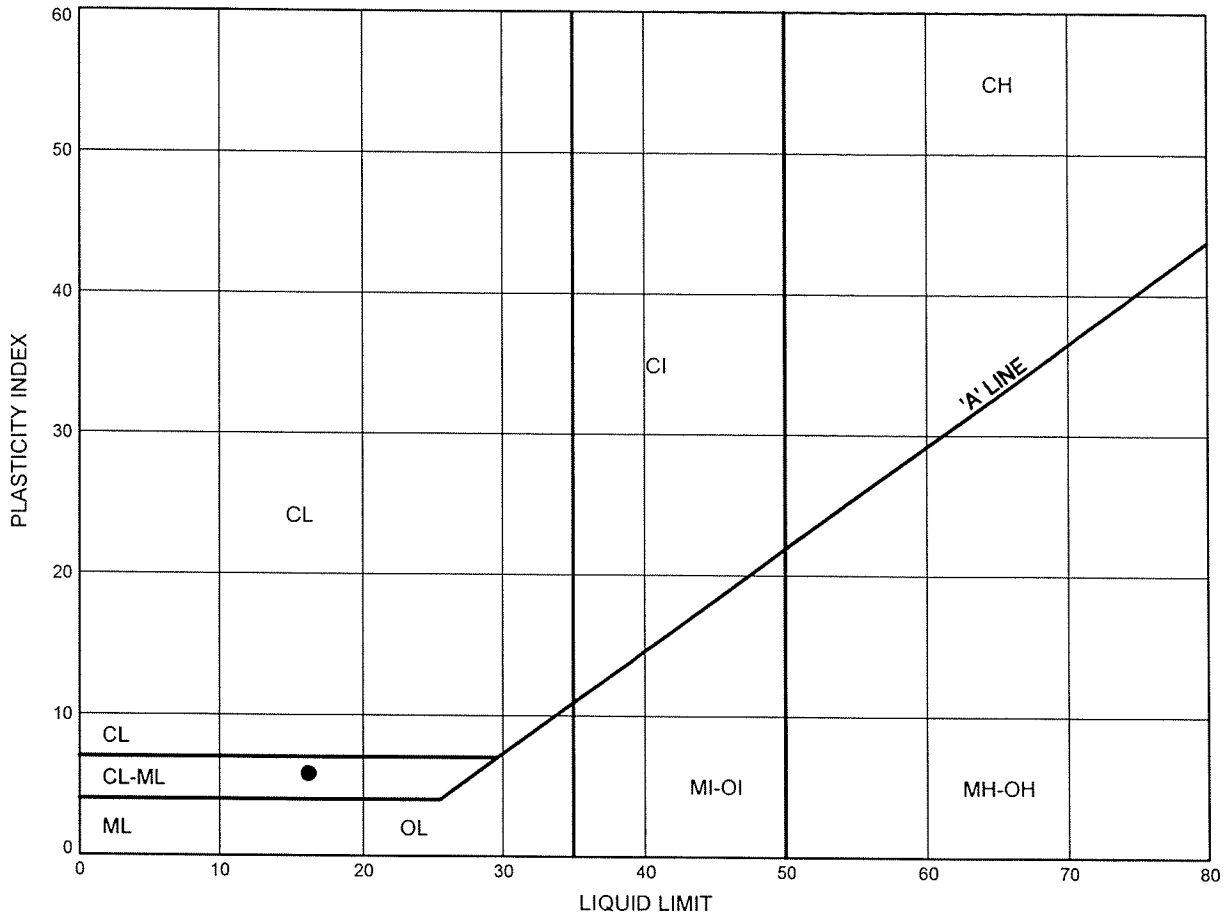
THURBALT 6417R.GPJ 7/29/08

Highway 7 - New

ATTERBERG LIMITS TEST RESULTS

FIGURE B9

Sandy Silt and Sandy Silt Till



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-034	6.40	305.79

Date July 2008

Project 408-88-00

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Chkd. RPR

THURBALT 6417R.GPJ 7/29/08

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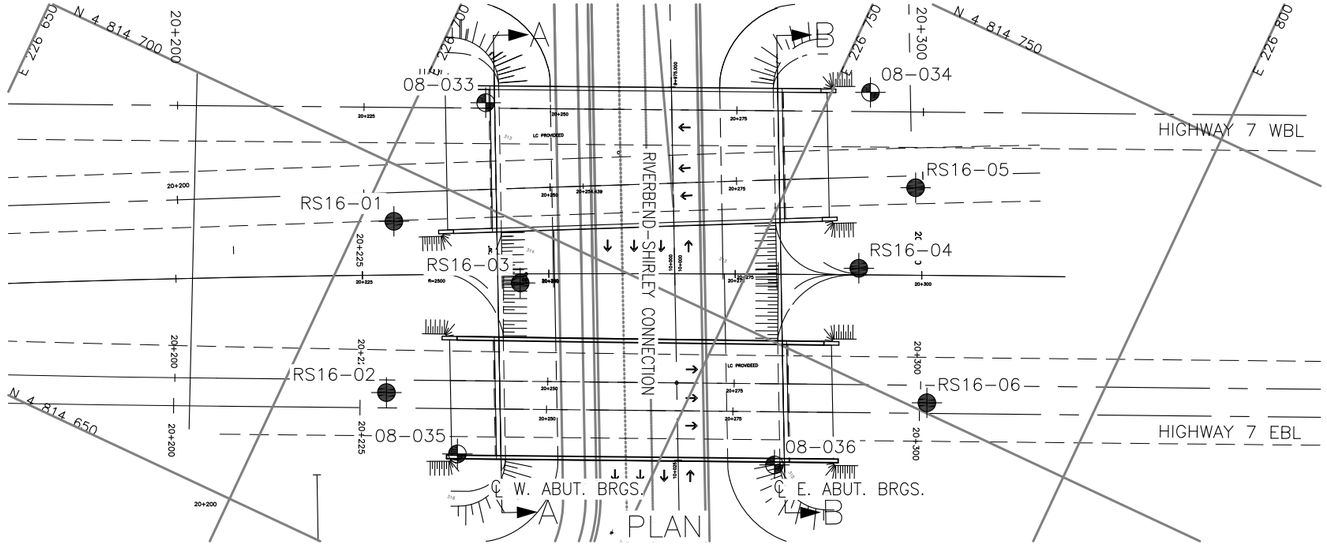
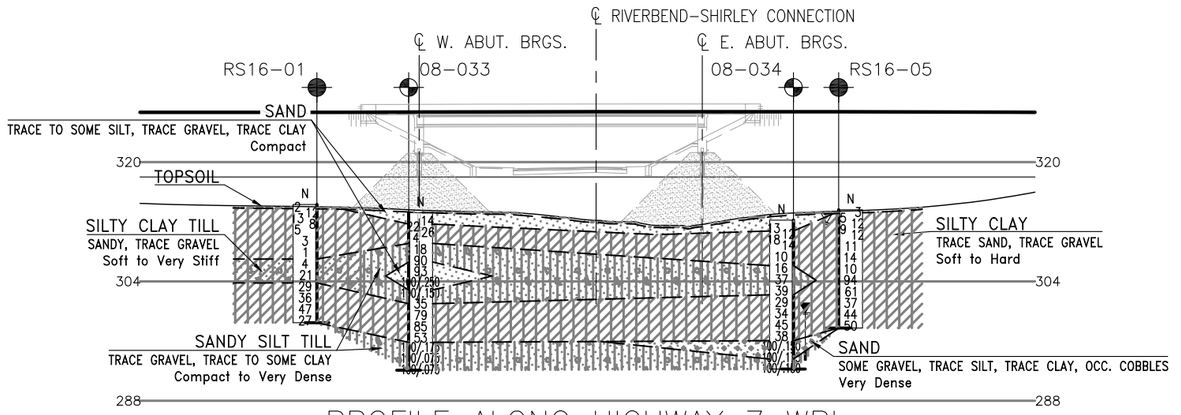
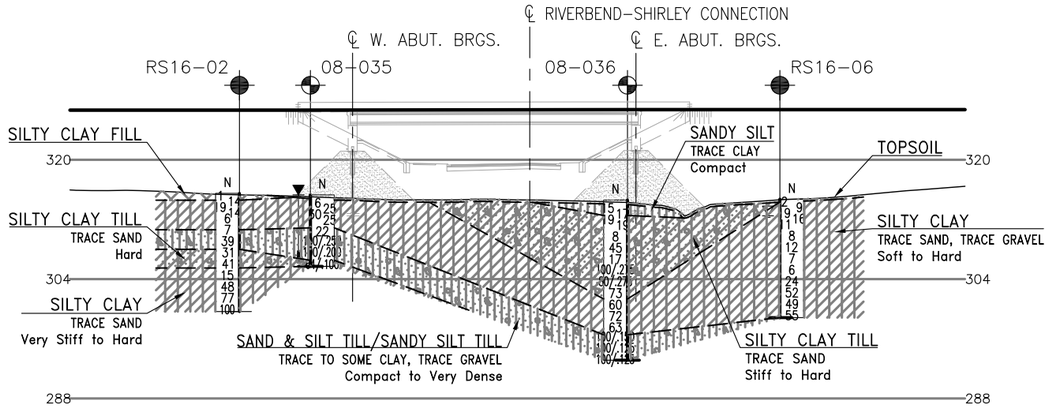
Appendix C

Borehole Locations and Soil Strata Drawing





PROFILE ALONG HIGHWAY 7 WBL



PROFILE ALONG HIGHWAY 7 EBL

16 0 16 32m

SCALE 1:800

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

LICENSED PROFESSIONAL ENGINEER
J.P.K. LEE
100086735
07/24/2020
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
07/24/2020
PROVINCE OF ONTARIO

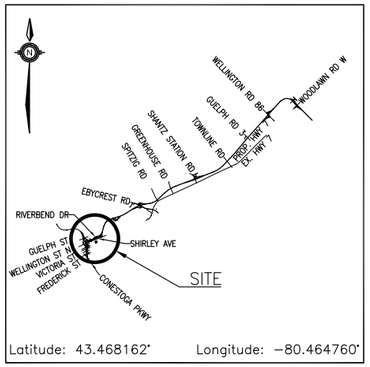
CONT No
GWP No 408-88-00

SHEET

HIGHWAY 7
RIVERBEND-SHIRLEY CONNECTION
PROPOSED BRIDGES
BOREHOLE LOCATIONS AND SOIL STRATA

wsp

THURBER ENGINEERING LTD.



Latitude: 43.468162° Longitude: -80.464760°

KEYPLAN

LEGEND

⊕	Borehole (Current Investigation)
⊕	Borehole (2008 Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
▼	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
RS16-01	314.3	4 814 693.0	226 704.2
RS16-02	315.5	4 814 671.8	226 713.0
RS16-03	314.5	4 814 692.7	226 723.0
RS16-04	312.9	4 814 713.8	226 763.3
RS16-05	313.6	4 814 726.8	226 765.6
RS16-06	314.7	4 814 701.3	226 779.2
08-033	313.2	4 814 712.7	226 708.6
08-034	212.2	4 814 735.8	226 754.7
08-035	315.3	4 814 668.4	226 725.1
08-036	314.6	4 814 685.1	226 764.2

-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 10.

GEOCRES No. 40P8-284

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	RPR	CHK	PKC	CODE		LOAD	DATE JUL 2020
DRAWN	MFA	CHK	RPR	SITE		STRUCT	DWG 1

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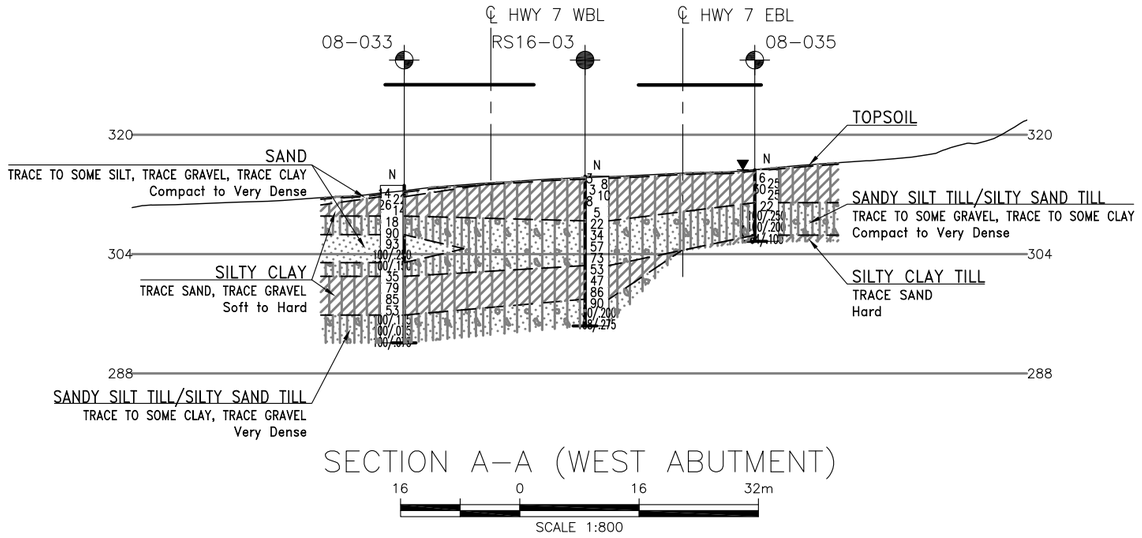
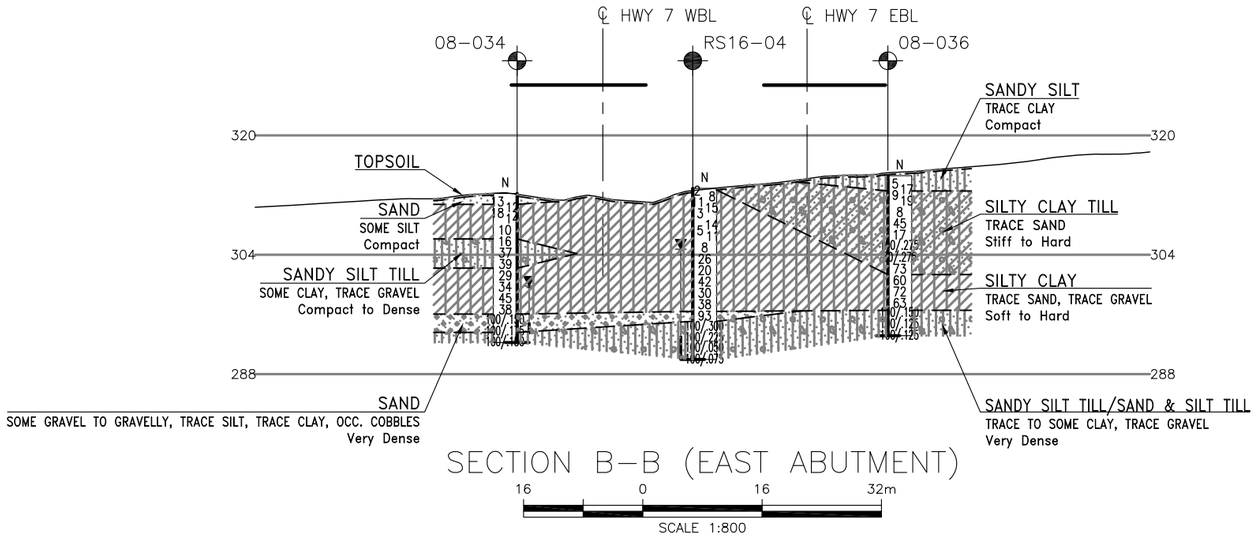


SECTION A–A (WEST ABUTMENT)

16 0 16 32m

SCALE 1:800



SECTION B–B (EAST ABUTMENT)

16 0 16 32m

SCALE 1:800

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No

GWP No 408-88-00

HIGHWAY 7
RIVERBEND–SHIRLEY CONNECTION
PROPOSED BRIDGES
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

wsp

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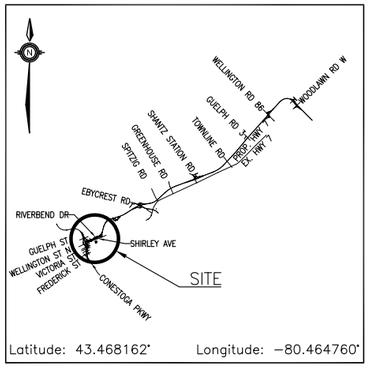
LICENSED PROFESSIONAL ENGINEER
J.P.K. LEE
100086735
07/24/2020
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
07/24/2020
PROVINCE OF ONTARIO



KEYPLAN

	LEGEND
⊕	Borehole (Current Investigation)
⊕	Borehole (2008 Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
▼	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
RS16-01	314.3	4 814 693.0	226 704.2
RS16-02	315.5	4 814 671.8	226 713.0
RS16-03	314.5	4 814 692.7	226 723.0
RS16-04	312.9	4 814 713.8	226 763.3
RS16-05	313.6	4 814 726.8	226 765.6
RS16-06	314.7	4 814 701.3	226 779.2
08-033	313.2	4 814 712.7	226 708.6
08-034	212.2	4 814 735.8	226 754.7
08-035	315.3	4 814 668.4	226 725.1
08-036	314.6	4 814 685.1	226 764.2

-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 10.

GEOCRES No. 40P8-284

REVISIONS			
DATE	BY	DESCRIPTION	
DESIGN RPR	CHK PKC	CODE	LOAD DATE JUL 2020
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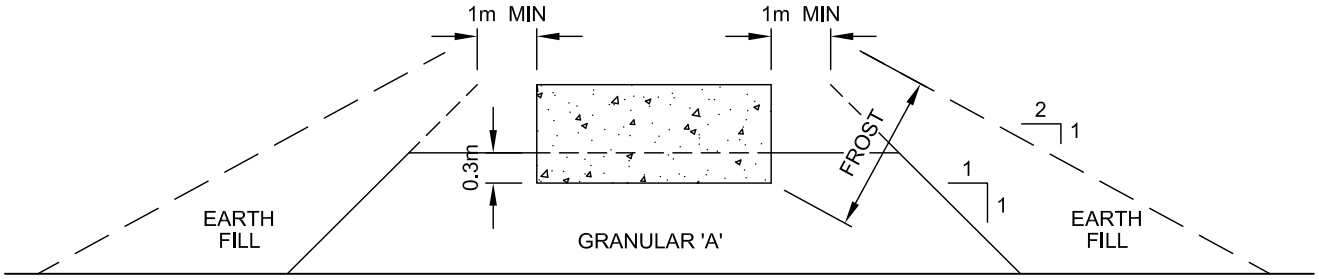
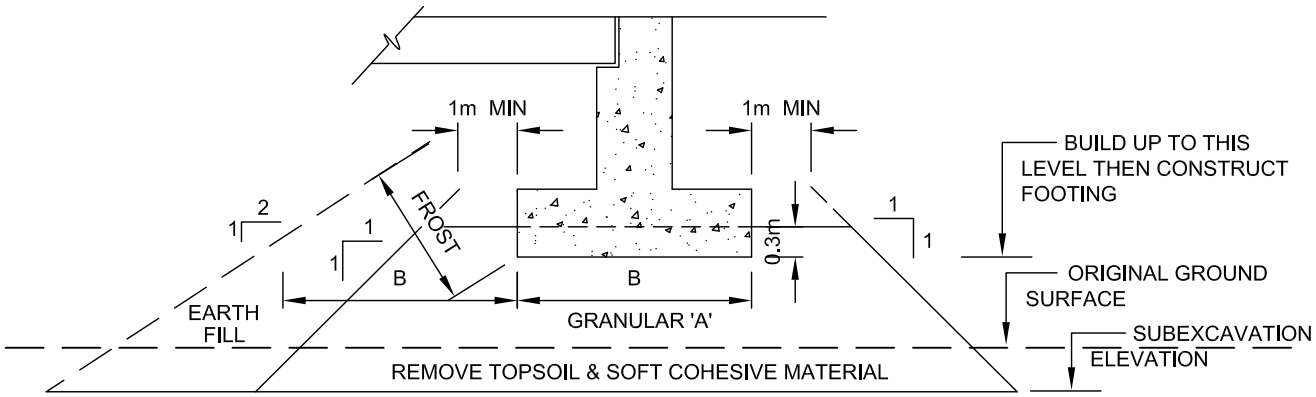
Appendix D

Figure For
Engineered Fill Pad



CROSS-SECTION



LONGITUDINAL SECTION

NOTES:

1. REMOVE TOPSOIL AND OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' AND EARTH FILL.
2. PLACE GRANULAR 'A' AND EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO O.P.S.S. 501.
3. CONSTRUCT CONCRETE FOOTING.
4. PLACE REMAINDER OF GRANULAR 'A' AND EARTH FILL AS REQUIRED.
5. SOURCE M.T.C. 1982.

ABUTMENT ON COMPACTED FILL
SHOWING GRANULAR 'A' CORE

THURBER ENGINEERING LTD.

ENGINEER :	DRAWN :	APPROVED :
-	MFA	-
DATE :	SCALE :	DRAWING No.
SEPTEMBER 2016	N.T.S.	FIGURE 1

H:\Drafting\CAD\TEMPLATE\AbutmentFill.dwg - Layout1 - Nov. 15, 2017 10:49am

THURBER

Appendix E

Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT

Foundation Element	Spread Footings	Spread Footings on Engineered Fill	Driven Piles	Caissons
Abutments	***Advantages:*** i. Generally less costly construction than deep foundation elements. ***Disadvantages:*** i. Artesian conditions were noted at the site. Dewatering will be required. ii. Relatively deep excavations (up to 9m) would be required to bear footings on competent soils. **NOT RECOMMENDED**	***Advantages:*** i. Generally less costly construction than deep foundation elements. ***Disadvantages:*** i. Better geotechnical resistance than spread footings on native, but still influenced by the soft to stiff soils at the surface. ii. Artesian conditions were noted at the site. Dewatering will be required. **NOT RECOMMENDED**	***Advantages:*** i. High geotechnical resistance may be developed by driving the piles into very dense till. ii. Comparatively short abutment stem. iii. Permit integral abutment design. iv. Readily installed. ***Disadvantages:*** i. Higher unit cost compared to footings. ii. When driven into hard/very dense till deposits, pipe piles are more prone to pile tip damage in comparison to H-piles. iii. Construction concerns related to the possibility of piles being obstructed by a boulder during driving. **RECOMMENDED**	***Advantages:*** i. Construction of caissons could continue in freezing weather. ii. High geotechnical resistance available for units founded on very dense till. ***Disadvantages:*** i. Higher cost than spread footings. ii. Specialized installation measures such as temporary liners and drilling mud will be required to install caissons under the water table. iii. Potential difficulty in cleaning and inspecting bases. **NOT RECOMMENDED**

THURBER

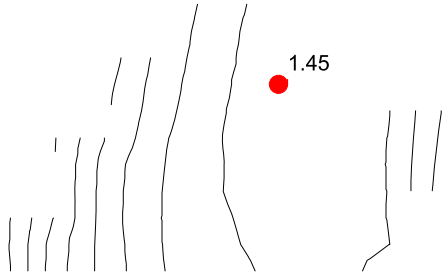
Appendix F

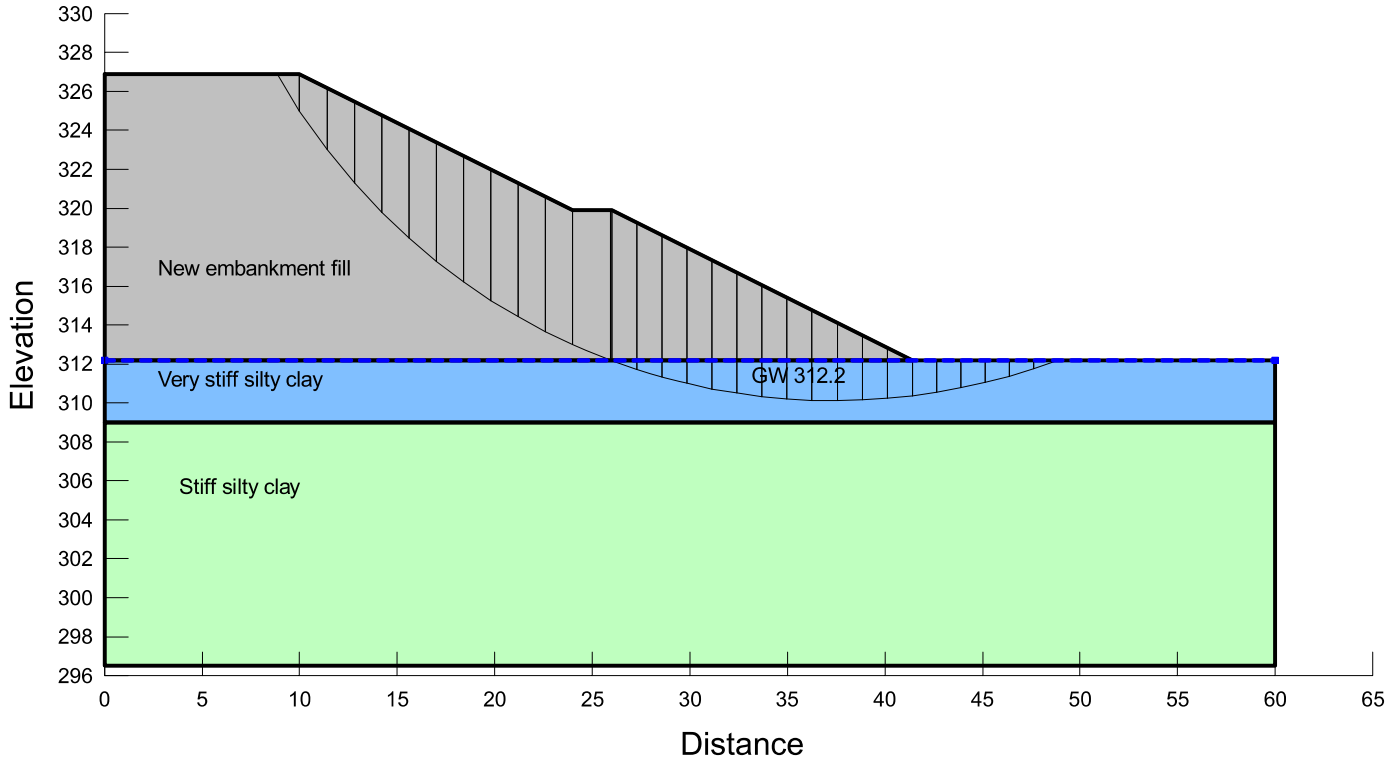
Slope Stability Output

THURBER

Project Number: 11375
Highway 7 - New
Riverbend Drive Connector
Embankment height approximatly 14 .7 m
Drained Analysis

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	New embankment fill	20	0	30	0	1
	Stiff silty clay	19	0	28.5	0	1
	Very stiff silty clay	19	0	29.5	0	1





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File Name: 11375- Riverbend -Slope stability - side slope-drained_June 16.gsz
Date: 2020-06-18 ,Time: 04:32:27 PM

Figure F1

THURBER

Color	Name	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	New embankment fill	20		0	30	0	1
	Stiff silty clay	19	80				1
	Very stiff silty clay	19	110				1

Project Number: 11375
Highway 7 - New
Riverbend Drive Connector
Embankment height approximatly 14 .7 m
Undrained Analysis

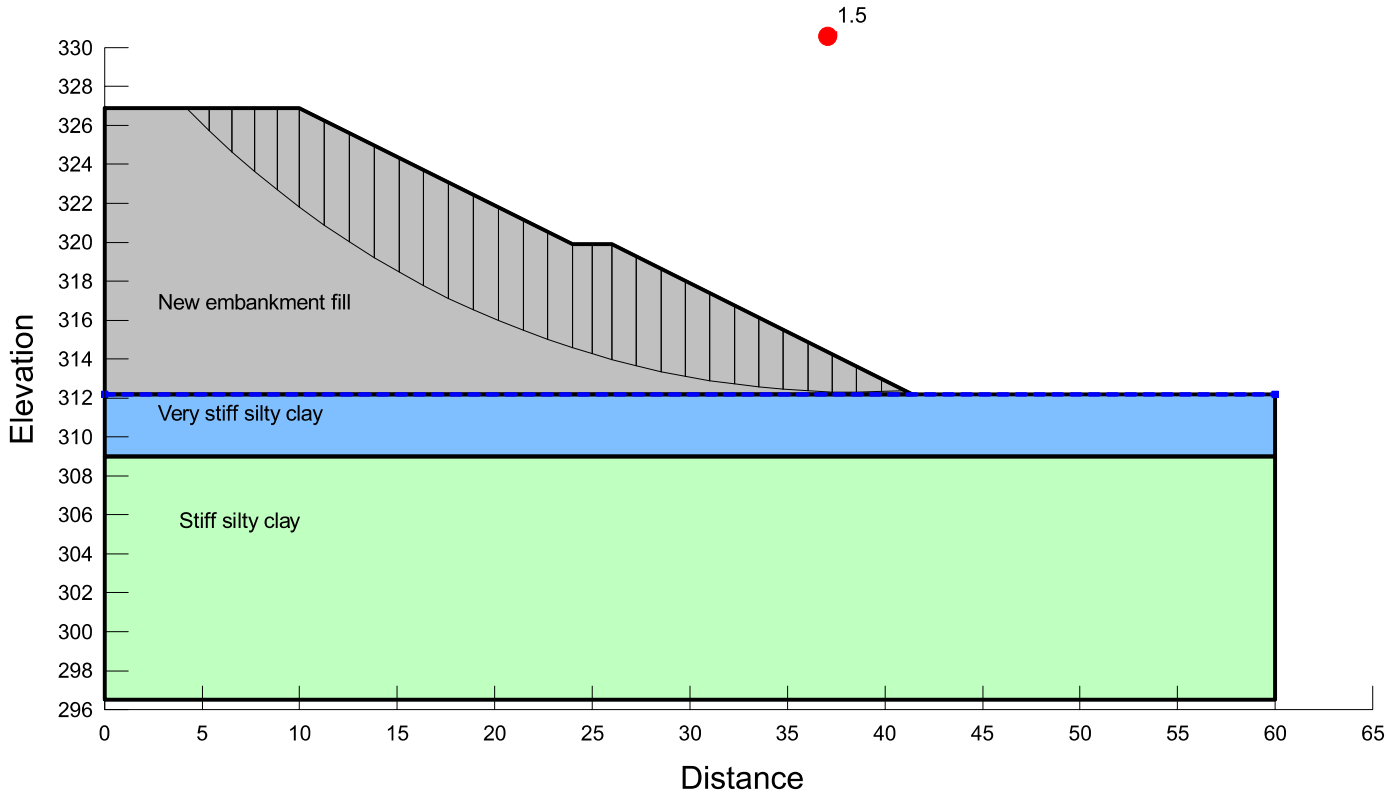

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Figure F2

THURBER

Color	Name	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	New embankment fill	20		0	30	0	1
	Stiff silty clay	19	80				1
	Very stiff silty clay	19	110				1

Project Number: 11375
Highway 7 - New
Riverbend Drive Connector
Embankment height approximatly 14 .7 m
Seismic Analysis PGA=0.097

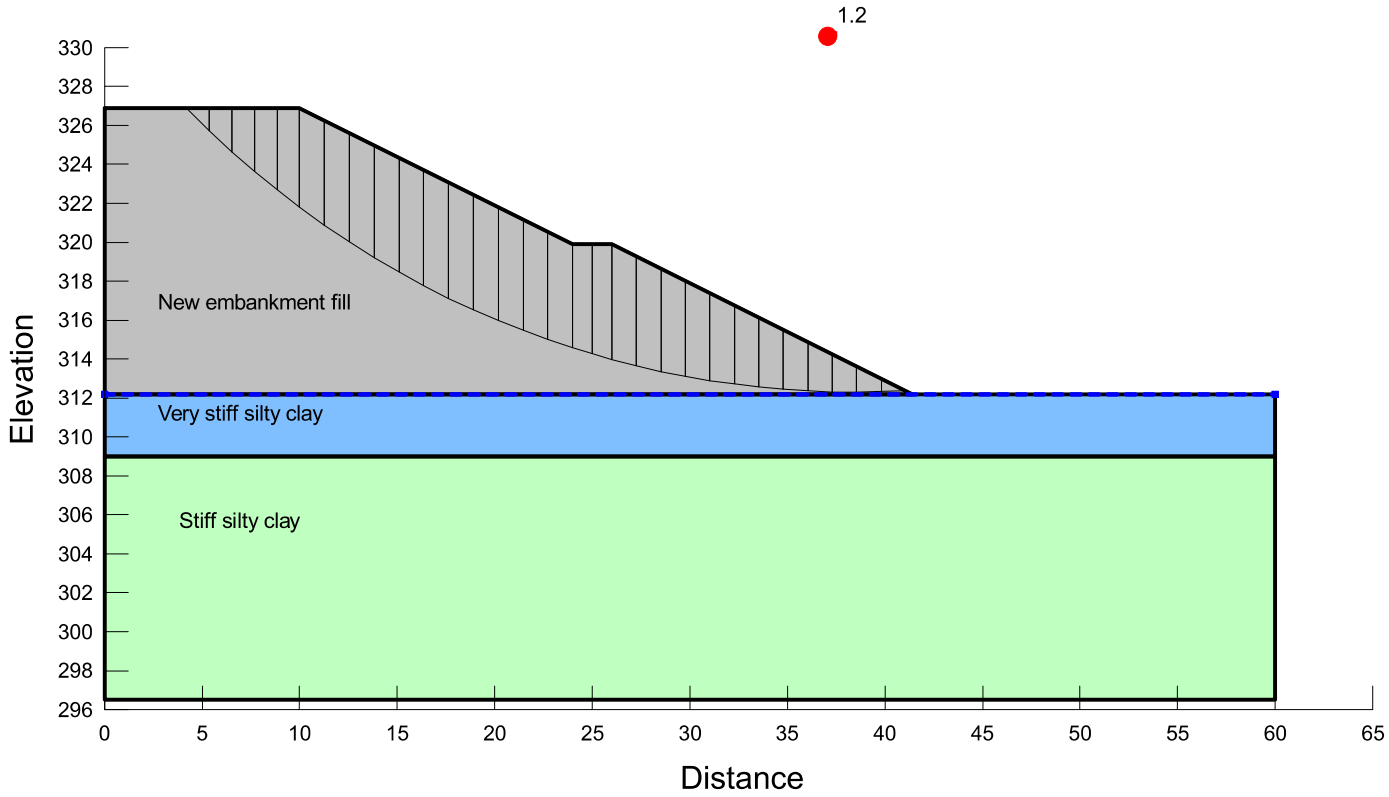

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Figure F3

THURBER

Appendix G

List of OPSS Documents and NSSP Wording

THURBER

1. List of Special Provisions and OPSS Documents Referenced in this Report

- OPSS PROV 206 Construction specification for grading
- OPSS PROV 501 Construction specification for compacting
- OPSS.PROV 517 Construction specification for dewatering
- SP 517F01 Amendment to OPSS 517
- OPSS PROV 539 Construction specification for temporary protection systems
- OPSS PROV 804 Construction specification for seed and cover
- OPSS PROV 902 Construction specification for excavating and backfilling – Structures
- SP 109S12 Amendment to OPSS 902
- OPSS PROV 903 Construction specification for deep foundations
- SP 109F57 Amendment to OPSS 903
- OPSS PROV 1010 Material specification for aggregates - base, subbase, select subgrade, and backfill material
- OPSD 3000.100 Foundation piles, Steel H-pile driving shoe
- OPSD 3102.100 Wall abutments, backfill drain
- OPSD 3101.150 Wall Abutment, Backfill minimum granular requirement

2. Suggested text for a NSSP on Pile Installation

Installation of H-piles shall be in accordance with OPSS.PROV 903 and the following.

The native soils at the Riverbend Bridge are comprised of glacial till and are known to contain cobbles and boulders. Appropriate equipment and construction procedures will be required to penetrate or remove obstructions, such as cobbles and boulders, to permit pile installation. Pile driving must be controlled according to the criteria specified for the site.

Should a pile achieve the design ultimate geotechnical resistance or refusal at a tip elevation higher than that indicated in the contract, the Contract Administrator (CA) shall be informed immediately who should consult with the design team for resolution. Over-driving must be avoided to minimize the risk of damaging the pile.

3. Suggested Text for NSSP on Groundwater Control

Water seepage due to perched water in the slope, surface runoff and precipitation should be expected. Moreover, artesian conditions were noted at this site. For temporary excavations at this site, groundwater control will likely be limited to diverting surface runoff and preventing precipitation from entering the excavations supplemented by sump pumping and use of perimeter ditches where required. Filtered sumps must be designed properly so that construction drainage water containing eroded soil and fines do not flow onto the existing roadways. For bridge foundation construction, appropriate dewatering systems must be installed and made operational prior to excavating below the groundwater level. The dewatering scheme must be effective to lower the groundwater level at least 0.5 m below the footing/pile cap grade level to avoid base boiling in the native soils.

Effective dewatering shall be designed and provided by the Contractor during excavation to allow the work to proceed in the dry. Dewatering systems must be installed and made operational prior to excavating below the groundwater level.