THURBER ENGINEERING LTD.

FOUNDATION INVESTIGATION AND DESIGN REPORT
ROUGE RIVER NBL AND SBL BRIDGES
REPLACEMENT AND WIDENING
HIGHWAY 404 HOV LANE EXPANSION AND REHABILITATION
CONTRACT 2
MARKHAM, ONTARIO
SITES 37-347/1 AND 34-347/2
G.W.P. 2930-17-00

GEOCRES NO. 30M14-485

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Report

to

WSP Canada Inc.

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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted for the design and construction of the proposed replacement and widening of the existing mainline bridge structures at the crossing of Highway 404 over the Rouge River in the Regional Municipality of York, Ontario. The proposed works form a part of the project which includes rehabilitation and widening of Highway 404 with the addition of one High Occupancy Vehicle (HOV) lane in each direction from 407 ETR to Stouffville Road.

The purpose of the investigation was to explore the subsurface conditions at the site and, based on the data obtained, provide a borehole location plan, borehole logs, stratigraphic profiles and cross-sections, and a written description of the subsurface conditions. A model of the subsurface conditions was developed to describe the geotechnical conditions influencing design and construction of the foundations and approach embankments for the structures.

Thurber was retained by WSP Canada Inc. (WSP) to carry out this foundation investigation under the Ministry of Transportation Ontario (MTO) Assignment Number 2016-E-0014.

Reference has been made to information on subsurface conditions contained in previous foundation reports prepared for this site. The titles of these reports are:

- Preliminary Foundation Investigation and Design Report for Rouge River Bridges, Highway 404 HOV Lane Expansion from Highway 407 to Green Lane, WO 03-20024, Regional Municipality of York, Ontario, prepared by Peto MacCallum Ltd., PML Ref. 14TF003A-RR, Index No. 039FIDR, GEOCRES No. 30M14-416, dated May 27, 2015. (Reference 1).

- Foundation Investigation Report for Proposed Structure at the Crossing of Highway 404 and the Rouge River Diversion, Township of Markham, County of York, District No. 6, (Toronto), W.O. 70-11104, W.P. 107-62, GEOCRES 30M14-51, dated February 1971.

2. PROJECT AND SITE DESCRIPTION

The project involves replacement and inside widening (into the median of the existing bridges) of the northbound and southbound lane (NBL and SBL) bridges located at the crossing of Highway 404 over Rouge River.

The site is located approximately 1.0 km north of the Highway 404 and 16th Avenue interchange in Markham, Ontario (Regional Municipality of York). The approximate location of the proposed bridge replacement and widening is shown on the key plan on the Borehole Locations and Soil Strata Drawing in Appendix E.

The land use adjacent to the site is largely rural and agricultural, although there is increasing residential and commercial development in recent years. The vegetation cover beyond the paved areas of the highway comprises grass, bushes and stands of trees.

At the site location, the Rouge River runs in a west to east direction and its channel is approximately 6.0 m wide and 3.0 m deep. Photographs of the site and surrounding areas are presented in Appendix D.

The site is located within the physiographic region known as the Peel Plain. The topography is flat to gently undulating. The soil cover in the region typically comprises silty clay glacial tills with sand and silt layers. Shale bedrock of the Georgian Bay Formation is anticipated at an approximate depth of 50 m.

3. SITE INVESTIGATION AND FIELD TESTING

The current borehole investigation and field testing program for this site was carried out from April 10 to May 25, 2018 and consisted of drilling and sampling ten (10) boreholes, designated as Boreholes R-01 to R-10. Boreholes were drilled near the locations of the foundation elements and approaches.

Six boreholes (labelled R-03 to R-08) were drilled near the proposed north and south abutments ranging in depth from 23.1 m to 26.3 m (Elevations 176.9 to 180.4). Four boreholes (labelled R-01, R-02, R-09 and R-10), were drilled near the immediate approaches. Termination depths for the approach boreholes ranged from 16.9 m to 25.0 m (Elevations 178.1 to 186.6). The records of borehole sheets for the current investigation are included in Appendix A.

A preliminary geotechnical investigation was carried out at this site between October 5 to 8, 2014 (Reference 1), and consisted of advancing two boreholes (labelled RR-1 and RR-2). Boreholes, RR-1 and RR-2 were drilled within the median near the south and north abutments of the Highway 404 bridges. The depths of the boreholes were 20.0 m and 20.1 m (Elevations 182.9 to 183.1). The Record of Borehole sheets for the boreholes from this preliminary investigation are included in Appendix C.

Five boreholes (numbered 1 to 5) were drilled within the river floodplain during the investigation conducted in 1971 (Reference 2). The boreholes were terminated at depths ranging from 6.1 m to 9.6 m (Elevations 188.3 to 184.9). Records of Boreholes 1 to 5 are also included in Appendix C.

Lane closures and traffic control were planned for drilling each borehole for the current investigation. Prior to commencement of drilling, utility clearances were obtained for all borehole locations.

The approximate locations of the boreholes from the current and previous investigations are shown on the Borehole Locations and Soil Strata Drawing included in Appendix E. The coordinates and elevations of the boreholes are given on this drawing and on the individual Record of Borehole Sheets in Appendices A and C. Northing and easting co-ordinates at the current borehole locations were obtained by Thurber using a GPS unit, and the corresponding ground surface elevations were provided by WSP based on the project DTM survey. The survey data of the boreholes meet the precision requirements set out in the terms of reference.

The current boreholes were advanced using a truck-mounted D-90 drill rig and track-mounted D-53 and BM-2 drill rigs. Hollow stem augers were used to advance the boreholes, and soil samples were obtained at selected intervals using a 50-mm diameter split spoon sampler in conjunction with the Standard Penetration Test (SPT). The tricone method was also used to advance Borehole R-09 beyond 16.5 m depth (Elevation 186.7).

A member of Thurber's technical staff supervised the drilling and sampling operations on a full-time basis. The supervisor logged the boreholes, visually examined the recovered soil samples, and transported them to Thurber's laboratory for further examination and testing.

Groundwater conditions in the open boreholes were observed throughout the current drilling operations. Two standpipe piezometers were installed during the current investigation at the south and north abutments, to permit monitoring of groundwater levels. The standpipe piezometers consisted of a 19 mm diameter Schedule 40 PVC pipe with a 3.0 m long slotted screen and were installed within a column of filter sand. Upon completion, the boreholes were abandoned in general accordance with Ontario Regulation 903 amended by Ontario Reg. 372 (O.Reg. 903). Once the final readings are taken, the piezometers will be decommissioned in general accordance with O.Reg. 903. The details of current borehole completion are summarized in Table 3.1.

Two piezometers were also installed during the 2014 investigation (Reference 1) near the north and south abutments of the Highway 404 NBL and SBL bridges.

Table 3.1 – Borehole Completion Details

Foundation Unit		Borehole	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth/ Elevation (m)	Completion Details
Hwy 404 SBL	North approach	R-01	24.6/179.0	None installed	Borehole caved to 13.4 m. Borehole backfilled with auger cuttings to 7.6 m, bentonite holeplug to 1.2 m, concrete to 0.2 m, then asphalt cold patch to surface.
	North abutment	R-03	23.1/180.4	None installed	Borehole caved to 11.6 m. Borehole backfilled with bentonite holeplug to 2.4 m,

Hwy 404 SBL					grout to 1.5 m, concrete to 0.3m, then asphalt cold patch to surface.
	South abutment	R-06	26.3/176.9	None installed	Borehole caved to 15.8 m. Borehole backfilled with auger cuttings to 9.1 m, bentonite holeplug to 1.5 m, concrete to 0.3 m, then asphalt to surface.
		R-07	24.7/177.9	24.4/178.2	Piezometer with 3.0 m slotted screen installed with sand filter from 24.7 m to 20.7 m, bentonite holeplug from 20.7 m to 12.2 m, bentonite mixed with auger cuttings from 12.2 m to ground surface.
	South approach	R-09	21.9/181.3	None installed	Borehole caved to 12.5 m. Borehole backfilled with auger cuttings to 7.6 m, bentonite holeplug to 1.5 m, concrete to 0.3 m, then asphalt cold patch to surface.
Hwy 404 NBL	North approach	R-02	16.9/186.6	None installed	Borehole backfilled with auger cuttings to 6.1 m, bentonite holeplug to 0.8 m, concrete to 0.3 m, then asphalt cold patch to surface.
	North abutment	R-04	25.0/177.9	15.2/187.7	Borehole caved to 15.2 m. Piezometer with 3.0 m slotted screen installed with sand filter from 15.2 m to 10.9 m, bentonite from 10.9 m to 6.1 m, bentonite mixed with auger cuttings from 6.1 m to ground surface.
		R-05	24.5/179.0	None installed	Borehole caved to 16.8 m. Borehole backfilled with auger cuttings to 12.2 m, bentonite holeplug to 1.2 m, concrete to 0.3 m, then asphalt cold patch to surface.

	South abutment	R-08	24.6/178.5	None installed	Borehole caved to 14.6 m. Borehole backfilled with cuttings to 7.6 m, bentonite holeplug to 1.5 m, concrete to 0.3 m, then asphalt cold patch to surface.
	South approach	R-10	25.0/178.1	None installed	Borehole caved to 16.5 m. Borehole backfilled with cuttings to 10.7 m, bentonite holeplug to 1.8 m, concrete to 0.3 m, then asphalt cold patch 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 C, and also presented on the figures included in Appendices B and C.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for metal corrosion associated with the structure, a sample of the existing native 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 B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A for details of the encountered soil stratigraphy. Soil profiles along the Highway 404 NBL and SBL bridge alignments are presented on the “Borehole Locations and Soil Strata” drawing in Appendix E. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site

conditions. It must be recognized that soil conditions may vary between and beyond borehole locations.

Boreholes RR-1 and RR-2 from the preliminary investigation conducted in 2014 (Reference 1) have been incorporated in this report.

In general, the subsurface conditions encountered in the boreholes consist of pavement structure over embankment fill which typically consists of layers of sands and silts, and silty clay to clayey silt. Below the fill, an extensive deposit of compact to very dense sand to silty sand overlies dense to very dense sand and silt till with lenses of very dense gravelly sand. The site is underlain by hard silty clay till. The groundwater level is at greater than 9 m depth across the site.

More detailed descriptions of the individual stratum are presented below.

5.1 Topsoil

A 300 mm thick layer of topsoil was encountered surficially in Borehole RR-2 which was located within the median near the north abutment of the Highway 404 SBL structure.

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 Pavement Structure

Pavement structure consisting of approximately 150 mm to 300 mm of asphalt overlying granular (sand and gravel fill) road base was encountered in Boreholes R-01 to R-03, R-05, R-06, and R-08 to R-10 drilled on the Highway 404 platform. A layer of concrete (approach slab), ranging in thickness from 320 mm to 350 mm, was contacted below the asphalt in Boreholes R-05, R-06 and R-08,

The thickness of the granular road fill, where measured in Boreholes R-01 and R-02, ranged between 300 mm and 700 mm.

5.3 Embankment Fill

Embankment fill was contacted below the pavement structure in Boreholes R-01 to R-03, R-05, R-06 and R-08 to R-10 and surficially in Boreholes R-04, R-07, RR-1 and RR-2. The embankment fill generally consists of layers of cohesionless and cohesive soils.

Brown to grey silty clay to clayey silt fill containing some to with sand and trace gravel, was encountered at both embankments surficially, and also at depths ranging from 0.2 m to 5.8 m. The thickness of the silty clay fill ranged from 2.7 m to 9.5 m. The depths to the base of this fill ranged from 8.5 m to 10.0 m (Elevations 193.2 to 194.8). A 900 mm thick layer of silty clay fill was encountered at 4.0 m depth within the sand and silt fill in Borehole R-10.

In Boreholes R-05 to R-10, the cohesionless fill consists of varying proportions of sand, silt and gravel, trace clay and occasional cobbles. This fill was brown in colour, and was contacted surficially and at depths ranging from 0.2 m to 0.5 m. The thickness of the cohesionless fill ranged from 3.8 m to 7.6 m. The depth to the base of the cohesionless fill varied from 4.3 m to 8.8 m (Elevations 194.3 to 198.9). Layers of sand and silt fill, ranging in thickness from 0.9 m to 1.4 m were encountered at depths of 1.1 m to 3.0 m in Boreholes R-01, R-02 and RR-1.

SPT ‘N’ values for the silty clay fill ranged from 4 to 57 blows per 0.3 m penetration, indicating a firm to hard consistency. Moisture contents measured in this fill ranged from 2 percent to 22 percent.

SPT ‘N’ values for the cohesionless fill layer typically ranged from 4 to 75 blows per 0.3 m penetration indicating a loose to very dense state. An SPT ‘N’ value of 100 blows for less than 0.3 m of penetration infers the presence of cobbles near Elevation 197.8 in Borehole R-07. Occasional cobbles were noted in the fill in Borehole R-06. Measured moisture contents of sand, sand and silt, sand and gravel and silt fill samples ranged from 2 percent to 20 percent.

The results of grain size distribution analyses carried out on selected samples of the fill are presented on the Record of Borehole sheets included in Appendices A and C, and on Figures B1 to B3 of Appendix B, and on Figure RR-GS-1 in Appendix C. The results of the grain size distribution analyses are summarized below:

Soil Particle	Silty Clay to Clayey Silt Fill (percent)	Sand to Sand and Silt Fill (percent)	Sand and Gravel Fill (percent)
Gravel	0 to 5	0 to 2	34
Sand	27 to 50	16 to 72	49
Silt	27 to 40	49 to 75	-
Clay	17 to 37	4 to 9	-
Silty and Clay	-	26	17

The results of Atterberg Limits tests conducted on samples of the silty clay fill are provided on the Record of Borehole sheets in Appendices A and C, and illustrated in Figure B10 of Appendix B and on Figure RR-PC-1 of Appendix C. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	18 to 35
Plasticity Index	7 to 19

The results of the Atterberg Limits testing indicate the silty clay to clayey silt fill is of low plasticity with group symbols CL.

5.4 Organics

A layer of dark brown organics was contacted below the embankment fill at depths ranging from 9.6 m to 9.8 m in Boreholes R-02, R-03 and R-04. The thickness of the organics ranged from 300 mm to 600 mm. The depth to the base of the organics varied from 10.0 m to 10.4m (Elevations 192.9 to 193.5).

5.5 Sand to Silty Sand

A deposit of typically fine grained sand to silty sand containing trace to some gravel and trace to some clay was encountered in all boreholes below the fill at depths ranging from 8.5 m to 11.7 m. The thickness of the cohesionless deposit ranged from 3.1 m to 9.2 m. Occasional zones of silt or sand and silt were encountered at 8.8 m and 9.1 m depths in Boreholes R-01 and RR-2, respectively. The depths to the base of the sand to silty sand varied from 11.8 m to 17.7 m (Elevations 185.5 to 191.3).

SPT ‘N’ values for the sand to silty sand ranged from 12 to 94 blows per 0.3 m penetration, indicating a compact to very dense state. Occasional SPT ‘N’ values greater than 100 blows for less than 0.3 m of penetration infer the presence of cobbles within the cohesionless layers. Moisture contents measured in the sand to silty sand ranged from 9 percent to 23 percent.

Resistance to augering was encountered in Boreholes R-03 and R-07 at depths ranging from 5.8 m to 16.5 m (Elevations 196.8 to 186.1), and also in Borehole R-09 below 16.5 m to 19.4 m depth (Elevations 186.7 to 183.8).

The results of grain size distribution analyses carried out on selected samples of the sand and silt, sand to silty sand are presented on the Record of Borehole sheets included in Appendices A and C, on Figure B4 of Appendix B, and on Figure RR-GS-2 in Appendix C. The results of the grain size distribution analyses are summarized below:

Soil Particle	Sand Silty Sand (percent)	Silt (percent)	Sand and Silt (percent)
Gravel	0 to 11	0	0
Sand	72 to 95	10	39
Silt	10 to 20	73	53
Clay	3	17	8
Silt and Clay	4 to 28	-	-

The results of Atterberg Limits tests conducted on a sample of the silt are provided on the Record of Borehole sheets in Appendix C, and illustrated in Figure RR-PC-2 of Appendix C. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	19
Plasticity Index	3

The results of the Atterberg Limits testing indicate that the silt is slightly plastic with a group symbol ML.

5.6 Gravelly Sand

Layers of brown to grey gravelly sand containing trace silt and trace clay were contacted below the cohesionless soils at depths ranging from 11.8 m to 14.5 m in Boreholes R-02, R-04 and R-08. The thickness of the gravelly sand layer varied from 1.2 m to 2.1 m. The depth to the base of the gravelly sand varied from 13.0 m to 16.6 m (Elevations 186.3 to 190.1).

SPT 'N' values for the gravelly sand layers ranged from 27 blows per 0.3 m penetration to greater than 100 blows for less than 0.3 m of penetration, indicating a compact to very dense state. Moisture contents measured in the gravelly sand ranged from 12 percent to 13 percent.

The results of grain size distribution analyses carried out on selected samples of the gravelly sand are presented on the Record of Borehole sheets included in Appendices A and on Figure B6 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Gravelly sand (percent)
Gravel	20 to 28
Sand	60 to 75
Silt and Clay	5 to 12

5.7 Sand and Silt to Sandy Silt Till

Grey sand and silt till to sandy silt till containing trace gravel, trace clay and occasional cobbles was contacted at depths varying between 14.8 m and 17.2 m in Boreholes R-01, R-03, R-06, R-07 and R-09. The thickness of this cohesionless till varied from 1.6 m to 3.5 m. The depth to the base of this till ranged from 17.7 m to 20.7 m (Elevations 182.8 to 185.9).

SPT 'N' values for the sand and silt to sandy silt till range from 36 blows per 0.3 m of penetration to greater than 100 blows for less than 0.3 m of penetration, indicating a dense to very dense state. Moisture contents measured in this till ranged from 10 percent to 25 percent.

The results of grain size distribution analyses carried out on selected samples of the sand and silt to sandy silt till are presented on the Record of Borehole sheets included in Appendix A,

and on Figure B7 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Sandy Silt Till (percent)
Gravel	0 to 12
Sand	26 to 50
Silt	32 to 59
Clay	4 to 16

Glacial tills inherently contain cobbles and boulders.

5.8 Silty Clay Till

An upper and a lower deposit of brown to grey silty clay till with sand and containing trace gravel and occasional cobbles were encountered below the cohesionless soils at this site.

The upper silty clay till was encountered in Boreholes R-03 and R-05 at 10.0 m and 8.7 m depths, respectively. The thickness of the upper silty clay till varied from 1.7 m to 3.0 m. The lower silty clay till was contacted at depths ranging from 13.0 m to 20.7 m. All the boreholes were terminated within the lower silty clay till at depths ranging from 16.9 m to 26.3 m (Elevations 176.9 to 186.6).

It is noted that Boreholes RR-1 and RR-2 from Reference 1 have described this deposit as clayey silt till. Despite the presence of some clayey silt zones, it is considered appropriate to describe this deposit as silty clay till based on laboratory testing results and visual observations.

SPT 'N' values in the upper silty clay till ranged from 8 to 23 blows per 0.3 m penetration, indicating a stiff to very stiff consistency. SPT 'N' values measured in the lower silty clay till ranged from 44 blows per 0.3 m penetration to greater than 100 blows for less than 0.3 m of penetration, indicating a hard consistency. Moisture contents measured in the silty clay till ranged from 8 percent to 33 percent.

The results of grain size distribution analyses carried out on selected samples of the silty clay till are presented on the Record of Borehole sheets included in Appendices A and C, on

Figures B8 and B9 of Appendix B, and on Figure RR-GS-3 of Appendix C. The results of the grain size distribution analyses are summarized below:

Soil Particle	Silty Clay Till Percentage (%)
Gravel	0 to 2
Sand	0 to 23
Silt	33 to 63
Clay	23 to 65

The results of Atterberg Limits tests conducted on samples of the cohesive till are presented on the Record of Borehole sheets in Appendices A and C, and illustrated in Figure B11 of Appendix B and on Figure RR-PC-3 in Appendix C. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	26 to 52
Plasticity Index	13 to 32

The results of the Atterberg Limits testing indicate that the silty clay till has slight to medium plasticity with group symbols CL-ML (clayey silt zone), CL and CI. Occasional zones of high plasticity, group symbol CH, are also present.

Glacial tills inherently contain cobbles and boulders.

5.9 Groundwater Conditions

Groundwater levels in the boreholes were observed during the drilling operations and measured upon completion of drilling. Standpipe piezometers were installed in Boreholes R-04 and R-07 to permit monitoring of groundwater levels. During a previous investigation (Reference 1), two piezometers were installed in Boreholes RR-1 and RR-2. Water levels measured in the four installed standpipes and open boreholes are presented in Table 5.1 below.

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Table 5.1- Groundwater Level Measurements

Foundation Unit		Borehole	Date	Groundwater Level		
				Depth (m)	Elevation (m)	Comments
Hwy 404 SBL	North approach	R-01	April 11, 2018	11.7	191.9	Open borehole
	North abutment	R-03	April 13, 2018	12.5	191.0	Open borehole
		RR-2	October 6, 2014 December 18, 2014	10.1 9.9	193.1 193.3	Open borehole Piezometer
	South abutment	R-06	April 30, 2018	11.4	191.8	Open borehole
		R-07	June 22, 2018	9.3	193.3	Piezometer
	South approach	R-09	April 24, 2018	11.6	191.6	Open borehole
Hwy 404 NBL	North approach	R-02	May 14, 2018	11.6	191.9	Open borehole
	North abutment	R-04	May 25, 2018 June 22, 2018	11.6 9.5	191.3 193.4	Open borehole Piezometer
		R-05	May 11, 2018	9.8	193.7	Open borehole
	South abutment	R-08	May 17, 2018	11.6	191.5	Open borehole
		RR-1	October 8, 2014 December 18, 2014	10.1 9.4	192.8 193.5	Open borehole Piezometer
	South approach	R-10	May 2, 2018	10.2	192.9	Open borehole

The values shown in Table 5.1 are short-term readings, and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant or prolonged precipitation.

The General Arrangement (GA) drawings provided by WSP indicate that the water levels at the Rouge River are reported to be at the following elevations:

- 100-year water level – Elevation 194.5
- High water level (Regional) – Elevation 195.5
- Normal water level – Elevation 192.4

The measured groundwater levels are generally consistent with the normal river water level.

6. CORROSIVITY TEST RESULTS

Samples of the silty clay fill, silty clay till and sand and silt till from Boreholes R-03, R-05, R-08 and R-09 were submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 6.1 below. The laboratory certificates of analysis are presented in Appendix B.

Table 6.1- Analytical Test Results

Parameter	Units (Soil)	Test Results			
		R-03 SS 4 Depth 3.0 m	R-05 SS 16 Depth 21.3 m	R-08 SS 6 Depth 6.1 m	R-09 SS 13 Depth 16.8 m
		Silty Clay Fill	Silty Clay Till	Silty Clay Fill	Sand and Silt Till
Sulphide	%	<0.02	<0.02	<0.02	0.02
Chloride	µg/g	910	24	200	11
Sulphate	µg/g	110	92	40	78
pH	-	9.13	9.24	8.41	8.99
Electrical Conductivity	µS/cm	1180	162	291	153
Resistivity	Ohm.cm	847	6170	3440	6520
Redox Potential	mV	219	210	255	259

7. MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. Thurber obtained the northing and easting coordinates at this site, and WSP provided the ground surface elevations.

Walker Drilling of Utopia, Ontario, supplied and operated a truck-mounted D-90 drill rig, track-mounted D-53 and BM-2 drill rigs, to carry out the drilling, sampling and in-situ testing operations for the boreholes.

The drilling and sampling operations in the field were supervised on a full-time basis by Mr. Saeed Bastan of Thurber. Geotechnical laboratory testing was carried out by Thurber in its MTO-approved laboratory. Overall supervision of the field program was carried out by Mr. Stephane Loranger, CET.

Overall project management was provided by Dr. Sydney Pang, P.Eng. Interpretation of the field data and preparation of this report was completed by Ms. Rocío Palomeque Reyna, P.Eng. The report was reviewed by Dr. Sydney Pang, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

8. GENERAL

This report presents interpretation of the geotechnical data in the factual report and provides foundation design recommendations to assist the design team to select and design a suitable foundation system and approach fills for the proposed replacement and widening of the NBL and SBL bridges located at the crossing of Highway 404 over the Rouge River in Markham, Ontario.

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 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.

Based on available information, both existing structures are five-span, concrete slab twin bridges. Each bridge is supported on two abutments and four piers. The conventional abutments (north and south) are supported on battered steel 324 mm (12.75 in.) diameter pipe piles driven into the hard silty clay till at approximate Elevation 183.7. The four piers are supported on steel 406 mm (16 in.) diameter pipe piles driven into the hard silty clay till at

approximate Elevations 183.7 to 184.1. The abutment and pier pipe piles are filled with concrete. Each of the SBL and NBL bridges measures approximately 60.9 m in length between abutment bearings, and the approach slabs are 7.3 m long. Each of the five spans is 12.2 m in length. The width of each bridge is approximately 13.3 m. The approach slopes are in the order of 8 m to 9 m high with a design inclination of 2H : 1V for the side and forward slopes. The design loads for the 324 mm and 406 mm diameter pipe piles were approximately 700 kN (70 tons) and 1,000 kN (100 tons), respectively.

Visual observations of the existing bridges did not reveal obvious signs of settlement or distress at the foundation elements. The approach slopes appeared to be stable with no obvious signs of instability. The slope faces were generally well vegetated.

Based on the preliminary General Arrangement (GA) drawing provided by WSP, dated August 2018, the existing bridges will be replaced by one new, wider and longer bridge. Each new bridge will be a single span structure supported on two integral abutments. The length of each new bridge is proposed to be 65.0 m between abutments with 6.0 m long approach slabs on each side. The width of the new bridge will be about 48.35 m. The replacement structures will essentially span over the air gap between the two existing structures. It is understood that the new abutments will be located approximately 2 m away from the existing south and north abutment centrelines. Each integral abutment is proposed to be supported on a single row of driven steel H-piles. Highway 404 grade within the structure limits will be at approximate Elevation 203.

The discussion and recommendations presented in this report are based on information provided by WSP to Thurber, and on the factual data obtained during the course of this investigation.

9. STRUCTURE CLASSIFICATION

In accordance with the currently applicable Canadian Highway Bridge Design Code (CHBDC) (2014) CSA S6-14, 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 S6-14 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, a consequence factor, ψ, of 1.0 has been used for assessing factored ULS and SLS geotechnical resistances. Should the consequence classification change, the geotechnical assessment and recommendations will need to be reviewed and revised as necessary.

10. STRUCTURE FOUNDATIONS

The stratigraphy identified in the foundation investigations consisted primarily of pavement structure and layers of silty clay, sand and silt embankment fill overlying native compact to very dense sand to silty sand with gravelly sand lenses. A thin and discontinuous dense to very dense sand and silt till overlies hard silty clay till which extends throughout the site. The short term groundwater levels measured in the piezometers ranged from 9.3 m to 9.9 m depths below ground surface.

10.1 Foundation Alternatives

Based on the subsurface information discussed above and the design requirements, consideration was given to the following foundation types:

- Spread footings on native soils or engineered fill
- Augered caissons (drilled shafts) founded in hard glacial till
- Steel H-piles driven to refusal in the silty clay till
- Steel pipe piles driven to refusal in the silty clay till.

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

<u>Spread Footings on Native Soils or Engineered Fill</u>

From geotechnical and constructability points of view, spread footings on native soils or engineered fill are not recommended at the abutments due to the presence of embankment fill of extensive thickness, non-uniform nature and composition. It is not considered feasible

to carry out deep excavations up to 10 m in depth to reach the competent native cohesionless soils on which the spread footings may be founded. Foundation recommendations for spread footings are therefore not further developed.

Augered Caissons (Drilled Shafts)

If integral abutments are not used for the proposed bridge, augered caisson foundations founded on the hard silty clay till may be considered for foundation support of the proposed bridge at this site. However, this alternative carries a relatively high risk due to the presence of water-bearing cohesionless soils below the embankment fill. Construction of caissons through these soils will require use of a temporary steel liner and/or slurry methods to control the ingress of groundwater, support the sidewalls of the hole and mitigate basal instability. Potential loss of ground associated with caisson installation could have adverse impacts on the existing bridges. Accordingly, foundation recommendations for this alternative have not been further developed.

Steel H-Piles

Given the subsurface conditions at the site, it is considered feasible to support the integral abutments on steel H-piles driven to practical refusal within the hard silty clay till.

Comparison between a 1977 foundation layout drawing for the existing bridges and the current preliminary GA drawing indicates that there could be conflict between some new piles and the existing piles near the outer ends of the wingwalls. WSP is considering to re-position slightly the affected new piles during construction to avoid interference. Further comments will be provided once more detail design information is available. Prior to pile driving operations, it is imperative to expose and confirm the locations of the existing piles.

Vibration as a result of pile driving through the very dense sands and silts, and seating within hard silty clay till could have adverse effects on the adjacent existing foundations and structures. A vibration and settlement monitoring program should be implemented as discussed in Section 18 below.

Steel Pipe Piles

Open ended steel pipe piles may also be considered as a foundation alternative. All pipe piles should be driven to practical refusal which is anticipated to be achieved within the very dense

sand and silt till or the hard silty clay till. After seating the pile, the interior of each pipe should be filled with structural grade concrete.

It should be noted that pipe piles driven into very dense or hard soils are more prone to pile tip damage and may cause more vibration in comparison to driven H-piles.

Issues on new pile locations relative to the existing piles, vibration and settlement monitoring are similar to those outlined above for driven H-piles.

Recommended Foundations

An integral abutment design is considered feasible at this site. From a foundation engineering perspective and based on current information, the recommended abutment foundations for the proposed Highway 404 NBL and SBL replacement bridges may consist of steel H-piles driven into the hard silty clay till.

10.2 Driven Steel H-Piles

It is anticipated that the driven steel H-piles will achieve practical refusal within the hard silty clay till or the very dense sand and silt till ("100-blow till").

For planning and design purposes, the estimated elevations at which the piles are expected to develop the required resistance are given in Table 10.1 below.

Table 10.1 – Estimated Pile Tip Elevations

Foundation Unit		Borehole	Minimum Pile Length [1] (m)	Approx. Pile Tip [2] Elevation (m)
Hwy 404 SBL	North abutment	R-03	12	183
		RR-2		
	South abutment	R-06 (west)	16	179
		R-07 (east)	12	183
Hwy 404	North abutment	R-04	11	184
		R-05		

NBL	South abutment	R-08 (east)	9	186
		RR-1 (west)	11	184

(1) Bottom of integral abutment CSP at approximate Elevation 195.
(2) Piles could achieve capacity above or below the estimated elevations.

For piles achieving capacity above the estimated pile tip elevations in Table 10.1, an NSSP should be included in the contract to facilitate termination of pile driving and to avoid pile damage by overdriving (see Section 10.2.5 Pile Installation).

10.2.1 Axial Resistance

An integral abutment is typically required to be supported on a single row of steel H-piles. A standard HP 310 X 110 pile section or a heavier HP 360 x 132 driven to practical refusal may be used. For axial resistance, the geotechnical resistances presented in Table 10.2 below may be used.

Table 10.2 – Design Axial Resistance for H-Piles

Foundation Element	Pile Section HP 310 X 110		Pile Section HP 360 X 132 HP 360 x 174	
	Factored ULS (kN)	SLS (kN)	Factored ULS (kN)	SLS_f (kN)
North and south abutments	1,300	1,100	1,600	1,400

The above axial resistances were based on the pile tip elevations provided in Table 10.1.

The values of the Factored Geotechnical Resistance at ULS were assessed based on static analysis assuming a Consequence Factor equal to 1 (Typical), and a geotechnical resistance factor equal to 0.4 (Typical degree of understanding of the subsurface conditions), as per CHBDC 2014. The SLS values correspond to a maximum pile settlement of 25 mm. The Geotechnical Resistance at SLS was assessed based on static analysis assuming a geotechnical resistance 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.

10.2.2 Downdrag

Downdrag on the piles is not a design issue at this site.

10.2.3 Abutment Design Considerations

From a foundation engineering perspective, the conditions at this site are considered to be suitable for conventional integral abutments.

For integral abutments, the flexibility of the upper portion of the pile will be provided by a single corrugated steel pipe (CSP) system. For a single CSP system where the pile is installed through a 600 mm diameter, 3 m long, CSP, the void between the pile and the sidewall of the 600 mm CSP is to be backfilled with uncompacted uniformly graded sand. The sand for filling the hole should meet the gradation requirements presented in Table 10.3 and should be placed after driving the pile through the CSP.

Table 10.3 – Integral Abutment Sand Grading

Sieve Designation	Percentage Passing By Mass
2 mm (#10)	100%
600 µm (#30)	80% - 100%
425 µm (#40)	40% - 80%
250 µm (#60)	5% - 25%
150 µm (#100)	0% - 6%

Reference should be made to the integral abutment manual for details of the system.

10.2.4 Lateral Resistance

Lateral bridge loadings can be geotechnically resisted by the driven H-piles through passive pressure developed along the embedded portion of the piles below the CSPs under the abutment stems.

The geotechnical lateral resistance of a pile may be calculated using the coefficient of horizontal subgrade reaction (k_s) as follows:

Silty Clay Till (cohesive soils)

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

p_{ult} = $9\ C_u$ (kPa)

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

Sands and Silts,
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 = width of pile, m
n_h = coefficient related to soil density, kN/m^3, Table 10.4
γ' = bouyant unit weight of soil, kN/m^3, Table 10.4
K_p = passive earth pressure coefficient, Table 10.4

The above equations and recommended parameters may be used to analyze the interaction between a pile and the surrounding soil. The lateral pressure obtained from the analysis should not exceed the ultimate lateral resistance, p_{ult}.

The spring constant, K, for analysis may be obtained by the expression, $K = k_s \times d_z \times B$ (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, $P_{ult} = p_{ult} \times d_z \times B$. This represents the ultimate load at the contact between the pile and the surrounding soil, 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 coefficient of horizontal subgrade reaction values provided in Table 10.4 below.

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Table 10.4 – Recommended Geotechnical Parameters for Lateral Resistance Design

Location	Reference Boreholes	Approx. Elevat -ion (m)	Undrained Shear Strength C_u (kPa)	Unit Weight γ (kN/m^3)	K_p	n_h (kN/m^3)	Soil Conditions
North Abutment	RR-2 R-03 R-04 R-05	203.5 to 194	60	19	-	-	Firm to stiff (very stiff zones) silty clay fill
		194 to 192	75	20	-	-	Stiff to very stiff (upper) silty clay till
		192 to 186	-	11*	3.2	4,000	Compact to very dense sand to silty sand
		186 to 178	200	21	-	-	Hard silty clay till
South Abutment	RR-1 R-06 R-07 R-08	203 to 198	-	20	3.0	3,000	Loose to compact sand and silt fill
		198 to 194	60	20	-	-	Firm to very stiff silty clay fill
		194 to 186	-	11*	3.2	4,000	Compact to very dense sand to silty sand
		186 to 184	-	11*	3.4	6,000	Very dense sand and silt till (gravelly sand lenses)
		184 to 178	200	21	-	-	Hard silty clay till

* Buoyant unit weight of cohesionless soil below water table

The group efficiency factors can be calculated based on side-by-side and line-by-line factors shown in Figures C6.11.3(r), C6.11.3(s), and C6.11.3(t) of the CHBDC 2014, S6.1-14 (Commentary).

10.2.5 Pile Installation

All piles shall be installed in accordance with OPSS.PROV 903. An up to date version of an NSSP titled “Amendment to OPSS.PROV 903)” is attached in Appendix H for inclusion into the tender document.

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. In addition, high strain dynamic testing (also commonly known as PDA testing) should be carried out for selected piles as stipulated in the NSSP referenced above.

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 as well as existing embankment fill inherently contain cobbles and boulders. At this site, the piles will have to be driven through very dense/hard glacial tills and therefore difficult driving conditions should be expected. In order to protect the piles while being driven through boulders, cobbles and harder/denser zones to achieve the required tip elevations and soil resistance, it is recommended that the pile tips be reinforced with Titus Steel Standard H-points or an approved equivalent. Should a pile achieve the design ultimate geotechnical resistance at an elevation higher than that indicated above, the Contract Administrator (CA) should be informed immediately and should consult with the design team for resolution. Over-driving must be avoided to minimize the risk of damaging the pile.

The Contract Documents must contain a NSSP alerting the Bidders to the pile driving conditions, testing, pile protection, avoidance of over-driving etc. as outlined above. Suggested texts for the NSSP are included in Appendix H.

10.2.6 Frost Cover

The design depth of frost penetration for this site is 1.4 m with reference to OPSD 3090.101. The undersides of all pile caps/abutment stems must be provided with at least 1.4 m of soil cover or its thermal equivalent.

10.3 Driven Steel Pipe Piles

It is anticipated that steel pipe piles, driven open ended to achieve practical refusal within the hard silty clay till or the very dense sand and silt till ("100-blow till"), may be used to support the abutments.

For planning and design purposes, the estimated elevations at which the piles are expected to develop the required resistance are given in Table 10.1 above.

After the pile is seated, the interior of the pile should be filled with 30 MPa concrete.

10.3.1 Axial Resistance

A 324 mm or a 406 mm diameter pipe pile section driven to practical refusal may be used. For axial resistance, the geotechnical resistances presented in Table 10.5 below may be used.

Table 10.5 – Design Axial Resistance for Pipe Piles

Foundation Element	Pipe Section 324 mm diameter 12.7 mm thick wall		Pipe Section 406 mm diameter 12.7 mm thick wall	
	Factored ULS (kN)	SLS (kN)	Factored ULS (kN)	SLS (kN)
North and south abutments	1,100	900	1,500	1,300

The above axial resistances were based on the pile tip elevations provided in Table 10.1.

The values of the Factored Geotechnical Resistance at ULS were assessed based on static analysis assuming a Consequence Factor equal to 1 (Typical), and a geotechnical resistance factor equal to 0.4 (Typical degree of understanding of the subsurface conditions), as per

CHBDC 2014. The SLS values correspond to a maximum pile settlement of 25 mm. The Geotechnical Resistance at SLS was assessed based on static analysis assuming a geotechnical resistance 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.

10.3.2 Lateral Resistance

For lateral resistance design of pipe piles, soil-pile interaction analyses may be carried out using the coefficient of horizontal subgrade reaction values provided in Table 10.4, and in conjunction with the equations and method outlined in section 10.2.4 above.

10.3.3 Pile Installation

Pipe pile installation should be carried out as discussed in section 10.2.5 above.

Pile tip protection should be provided for open ended pipe piles. It is recommended that the pile tips be reinforced with Titus Steel Open Cutting Shoe or an approved equivalent.

11. LATERAL EARTH PRESSURES

Backfill to the abutment walls should consist of Granular A or Granular B Type II material meeting the requirements of OPSS.PROV 1010 and in accordance with OPSS 902. The backfill should be placed to the extents shown on OPSD 3101.150 where applicable.

Earth pressures acting on the abutment walls may be assumed to be triangular and governed by the characteristics of the abutment backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC 2014 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 2014, a compaction surcharge should be added. Compaction equipment to be used adjacent to the walls 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 the support system allows yielding of the wall (unrestrained system), active horizontal earth pressure may be used in the geotechnical design of the structure. If the support system does not allow yielding (restrained system), 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) might be 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 C6.16 in the Commentary to the CHBDC 2014.

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

12. APPROACH EMBANKMENTS

Based on the preliminary GA drawing dated August 2018, the finished grade level of the Highway 404 is at approximate Elevations 203.0 to 203.5 m at the abutments. The existing embankment fills are in the order of 8 m to 9 m in height with slope inclinations of 2H : 1V. Placement of new fill on the existing forward slopes within the existing air gap will be required for the new bridges. Given that the existing median is slightly below grade, the deeper portion of the new fill will be the backfill behind the new abutments.

All embankment fill must be constructed with adequate quality control in accordance with OPSS.PROV 206 and OPSS.PROV 501 requirements. As abutment backfill, OPSS.PROV 1010 Granular A or B Type II materials should be used.

It is 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. Scour and erosion protection measures must be provided for the slopes.

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. Any existing slope, where new fill is to be placed, must be benched in accordance with OPSD 208.010 prior to fill placement.

12.1 Embankment Slope Stability

The 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. The existing embankment fill comprises typically compact sands and silts, and typically firm to stiff silty clay fill, and will remain stable at an inclination of 2H : 1V.

Mid-height berms are typically provided for fill embankments greater than 8 m in height. This design was not adopted at this site for the existing embankments.

The upper portion of the forward slopes within the air gap will be reconstructed to accommodate the replacement bridges. Analyses of global stability was conducted for a new forward slope configuration assuming compact to dense sand and silt fill with a 2H : 1V slope inclination below the new abutment wall. A typical sideslope configuration was also analysed for confirmation. River water elevations corresponding to a regional flood level and normal operation have been used.

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 G.

Table 12.1 Computed Factors of Safety

Condition	Factor of Safety	Figure (Appendix G)
Forward Slope – Normal Operation		
Static (effective stress)	1.4	1G
Static (total stress)	1.5	2G
Seismic	1.25	3G
Forward Slope – High River Water Level		
Static (effective stress)	1.25	4G
Static (total stress)	1.35	5G
Seismic	1.05	6G
Side Slope		
Static (effective stress)	1.5	7G
Static (total stress)	1.6	8G
Seismic	1.25	9G

As per typical MTO requirements for static loading conditions, a minimum Factor of Safety (F.S.) of 1.3 should be achieved and an F.S. of 1.5 would be ideal for longer term (effective stress). The factors of safety presented in Table 12.1 above for the forward slope at normal

river level and the sideslope are considered to be acceptable for this site. Under seismic loading conditions, the estimated F.S. values are about 1.25. For the forward slope under high river level (regional flood), the F.S. values for the drained and undrained conditions range between 1.25 and 1.35, while the value for the seismic case decreases to 1.05. Since regional flooding is a rare occurrence and is not expected to last long, these F.S. values are considered acceptable.

12.2 Settlement

Placement of new fill for the proposed highway inside widening, will induce immediate (elastic) settlement in the underlying existing embankment fill. Since the existing median grade is relatively close to the proposed highway grade, the additional fill that will be required to raise the grade should be within the range of 1.0 m to 1.5 m, except for the new abutment backfill where its maximum height can be up to 3 m.

It is estimated that the magnitude of the immediate settlement would be less than 25 mm. This settlement is anticipated to take place as the fill is placed and be completed by the end of construction.

13. TEMPORARY EXCAVATION

Minor cutting will be required to construct the new abutments which will be located at several metres behind the existing abutments.

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.

Earth excavations for pile caps required at this site will penetrate through the embankment fill. For the purposes of OHSA, the embankment fill may be classified as Type 3.

All excavations must be carried out in a manner that avoids undermining or destabilising the foundations of the existing bridges and slopes.

Where required, construction will need to be carried out in conjunction with roadway protection (temporary shoring) which is discussed in more details in Section 16 below.

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. The requirements for groundwater control during excavation are discussed in Section 14.

14. GROUNDWATER AND SURFACE WATER CONTROL

Piezometric level obtained at this site indicate that the groundwater level is generally below 9m depth (Elevations 193.3 to 193.5) below the highway grade. Seasonal fluctuations of the groundwater level are to be expected.

The General Arrangement (GA) drawings provided by WSP indicate that the water levels at the Rouge River are reported to be at the following elevations:

- 100-year water level – Elevation 194.5
- High water level (regional) – Elevation 195.5
- Normal water level – Elevation 192.4

The new abutments are expected to be constructed above the groundwater table. Seepage or perched water from the embankment is to be expected. Groundwater control measures such as perimeter ditches and pumping from filtered sumps should be implemented to remove any accumulation of water from the pile cap base prior to placing concrete. Surface runoff and precipitation should be diverted away from the excavations at all times. The possibility exists that additional pumps may be required if localized zones of perched water are encountered.

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 design the dewatering system must take into account the maximum river level that would likely to occur during construction. Filtered sumps must be properly designed to control loss of fines and ground loss. Suggesting wording for an NSSP in this regard is included in Appendix H.

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), OPSS.PROV 902 and

NSSP FOUN0003. It is recommended that a pre-construction condition survey of existing structures within 100 m of the piling locations be carried out prior to commencement of piling. There is no design engineer requirement for dewatering at this site.

It is understood that the requirements for a Ministry of Environment (MOE) Permit to Take Water (PTTW) or Environmental Activity and Sector Registry (EASR) will be assessed by WSP as a collective issue for Contract 2.

Water discharged from unwatering operations or displaced during concrete placement may not be suitable for direct discharge to the river. The contract documents must alert the contractor to this fact and include an item for treatment of the water to the satisfaction of MOE, Ministry of Natural Resources (MNR), Department of Fisheries and Oceans (DFO) or other agencies having jurisdiction, prior to discharge to the river.

15. SCOUR AND EROSION PROTECTION

An archived general layout drawing titled “Hwy. 404 Crossing at Rouge River” prepared by McCormick, Rankin & Associates Limited dated July 1977, indicates that the pile caps are designed to be located above the river level.

The depth of scour of the river must be determined by a river hydraulics specialist who should assess if scour protection measures would be required to prevent undermining of the pile cap.

Erosion protection should be provided along the toe of any slopes that may be in contact with the river flow.

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

Erosion and scour protection measures for pile caps and slopes should be designed by a qualified and experienced professional.

16. ROADWAY PROTECTION

It is anticipated that the replacement bridges will be constructed in stages and that at least one highway lane per direction will be maintained open for traffic at any given time.

Roadway protection will be required during construction of the proposed bridges. An item titled “Protection System” as per OPSS.PROV 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 roadway protection 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 geotechnical parameters given below:

γ	=	20 kN/m^3
γ_w	=	10 kN/m^3
K_a	=	0.33 (approach fills)
	=	0.30 (native sands and silts)
	=	0.31 (native silty clay till)
K_p	=	3.0 (approach fills)
	=	3.4 (native sands and silts)
	=	3.2 (silty clay till)

It is recommended that lateral earth pressures acting on the wall be computed in accordance with the CHBDC 2014. The surcharge should include soil loadings above the top of the pile and other loadings adjacent to the wall. A properly designed and constructed soldier pile and lagging wall will be permeable and therefore water pressure acting on the retained height may be set to zero. 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 2014, the selection of the seismic site classification is based on the averaged soil conditions encountered in the upper 30 m of the stratigraphy. In general, the stratigraphy of the site consists of compact to very dense cohesionless fill and firm to hard cohesive fill overlying layers of native compact to very dense sands and silts, which are

underlain by very dense sand and silt till and sandy silt till. A deposit of stiff to hard silty clay till underlies the site.

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 0.105 g as per the National Building Code of Canada (NBCC). The factored PGA for a 2% in 50-year probability of exceedance for Site Class D is 0.13 g.

In accordance with Clause 4.6.5 of the CHBDC 2014, the abutments 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:

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})*	0.32	0.36
Passive (K_{PE})	3.5	3.1
At Rest (K_{OE})**	0.6	0.64

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

** After Woods

Based on the soil conditions outlined above, liquefaction is not considered to be a concern at this site.

18. ADJACENT STRUCTURES AND BURIED UTILITIES

The potential presence of underground utilities at the site should be confirmed prior to construction. It is recommended that the exact locations and elevations of any utilities be established by the designer, and compared with the extent of the potential work zones related to the foundations of the proposed replacement structures and associated works. Protection

and/or relocation of utilities may be required. Underground utilities should not be undermined or damaged during new foundation construction.

Pile driving will be required at locations as close as 2.5 m from the edges of the adjacent existing bridges. Therefore, it is recommended that the following be carried out prior to commencement of foundation construction:

- Carry out pre-construction condition survey including documentation of any existing distress on the bridge foundations and super-structures.
- Implement a vibration and settlement monitoring program during and after construction of the new abutments to assess any potential adverse impact on the existing operating bridges. Suggested wording of this program is included in Appendix H.
- Inspection of the existing operating bridges during foundation construction to monitor if there is any movement or distress.
- The structural designers should assess the magnitude of settlement or horizontal displacement that would constitute a concern for the stability or serviceability of the existing operational structures prior to their demolition. These limits should be incorporated into the monitoring program as review and alert levels.

19. CORROSION AND SULPHATE ATTACK POTENTIAL

The results of corrosivity and sulphate analytical tests conducted on selected soil samples during the current investigation are included in Appendix B. Based on the test results, the following statements can be made:

- The potential for sulphate attack on concrete from the surrounding fill and native soils is considered to be negligible due to the low concentration of sulphate and slightly alkaline pH values.
- The overall potential for corrosion on metal is considered mild to moderate, except for the relatively high chloride content and low resistivity values for a silty clay fill sample in Borehole R-03 near Elevation 200.2. However, it is anticipated that the piles will not be affected since this elevation is higher than the proposed top of piles.

- The effects of road de-icing salts should also be considered when selecting the class of concrete and corrosion mitigation measures.

20. CONSTRUCTION CONCERNS

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

Protection of the Existing Structure and Roadway Remaining in Service

- During the staged construction of the NBL and SBL widening structures, the existing structures and travelled lanes of the roadway are to remain in service. The Contractor must provide adequate protection to ensure that the performance of the existing foundations are not compromised and the existing roadway is protected.

  Piles driven through the very dense soils may achieve the required geotechnical resistance at varying elevations. These elevations must be checked against the design pile tip elevations to confirm that driving is not terminated prematurely. It is possible that a pile will achieve refusal at a higher elevation than anticipated due to encountering a cobble/boulder. If it is suspected that this is happening, the QVE must immediately bring it to the attention of the Contract Administrator (CA). If the CA cannot resolve the issue, it must be referred to the design team for resolution.
- During borehole drilling, there was evidence of the presence of cobbles and boulders within glacially derived deposits which may affect installation of H-piles. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions and extend the piles to competent foundation levels.
- Settlement monitoring of the existing bridge foundations and buried utilities close to the work areas during construction is recommended. In addition, vibration monitoring and pre-construction condition survey may also be required.
- Abutment construction must be carried out in the dry. Diversion of surface runoff, precipitation and other forms of dewatering may be required.

Impact of excavation on the existing pavement surface

- Daily visual inspection of the highway pavement surface must be carried out in the vicinity of the construction works. If cracks form in the pavement or settlement is observed to

occur, these matters must immediately be brought to the attention of the CA for determining if further action is required.

- Confirmation that the backfill to the abutments are adequately placed and compacted to specifications.

Existing slopes

- The forward and side embankment slopes should be inspected after construction for surficial disturbance. Where necessary, remedial measures such as re-vegetation and/or placement of gravel sheeting may be required.

Excavation and Dewatering

- For new abutment construction, adequate shoring must be in place to maintain stability of the excavation and to prevent loss of ground under the structure or embankment. Seepage and perched groundwater may be encountered within the embankment fill. The impact of seepage or surface water could destabilize the sides and or base of the excavation. Proper groundwater and surface water control measures must be in place prior to commencing excavation.

It is recommended that provision(s) be included in the contract requiring the Contractor to confirm that the above issues are adequately addressed. Should there be any doubts about issues such as pile driving and pile termination, these provision(s) should require the Contractor to retain qualified geotechnical personnel to assess the site conditions and to alert the Contract Administrator.

21. CLOSURE

Engineering analysis and preparation of the foundation design report was conducted by Ms. Rocío Palomeque Reyna, P.Eng and Dr. Sydney Pang, P.Eng. Dr. P. K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects, reviewed the report.

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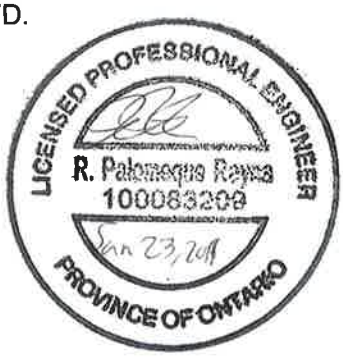

Rocío Palomeque Reyna, P.Eng.
Geotechnical Engineer

Sydney Pang, P.Eng.
Associate, Senior Foundations Engineer

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

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Appendix A

Record of Borehole Sheets

(Present Site 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

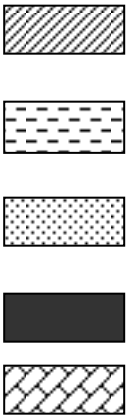
MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, 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

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RECORD OF BOREHOLE No R-01 1 OF 3 METRIC

G.W.P. 2930-17-00 LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 408.4 E 314 605.8 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.04.10 - 2018.04.11 LATITUDE 43.874583 LONGITUDE -79.377988 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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
203.6	GROUND SURFACE										
0.0 / 203.3	**ASPHALT:** (300mm)										
0.3 / 203.0	**SAND** and **GRAVEL**: (300mm) (FILL)										
0.6	Silty **CLAY**, with sand, trace gravel Very Stiff to Stiff Brown Moist (FILL)		1	SS	24		203	○	○		
			2	SS	16		202	○	○		
201.5											
2.1	**SAND** and **SILT** Compact Brown Moist (FILL)		3	SS	13		201	○	○		
200.6											
3.0	Silty **CLAY**, with sand, trace gravel Stiff to Very Stiff Brown Moist (FILL)		4	SS	11		200	○	○		2 33 38 27
			5	SS	12		199	○	○		
			6	SS	22		198	○	○		
	Hard		7	SS	39		197	○	○		
194.8							196				
8.8	**SAND** and **SILT**, trace clay Very Dense Grey Moist		8	SS	77		195	○	○		0 39 53 8
193.7							194				

Continued Next Page

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

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

ONTMT4S2 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 1/16/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No R-01 2 OF 3 METRIC

G.W.P. 2930-17-00 LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 408.4 E 314 605.8 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.04.10 - 2018.04.11 LATITUDE 43.874583 LONGITUDE -79.377988 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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page							20 40 60 80 100	20 40 60		
9.9	Silty **SAND**, trace clay Compact to Very Dense Grey Wet						193				
			9	SS	30						
						▽	192				
			10	SS	20		191				
			11	SS	15		190				
							189				
			12	SS	93		188				0 78 19 3
187.5											
16.1	**SAND** and **SILT**, some gravel, trace clay Very Dense Grey Wet (TILL)		13	SS	100/ 0.225		187				
185.9							186				
17.7	Silty **CLAY**, trace to some sand, trace gravel, occasional cobbles Hard Grey Moist (TILL)		14	SS	78		185				
							184				

Continued Next Page

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

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

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Ministry of Transportation
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THURBER

RECORD OF BOREHOLE No R-01 3 OF 3 METRIC

G.W.P. 2930-17-00 LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 408.4 E 314 605.8 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.04.10 - 2018.04.11 LATITUDE 43.874583 LONGITUDE -79.377988 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, trace gravel Hard Grey Moist (TILL)		15	SS	72		183				
			16	SS	100/ 0.300		182				0 7 39 54
	Wet		17	SS	90		181				
179.0			18	SS	100/ 0.100		180 179				
24.6	END OF BOREHOLE AT 24.6m. BOREHOLE CAVED TO 13.4m AND WATER LEVEL AT 11.7m UPON COMPLETION. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO 7.6m, BENTONITE HOLEPLUG TO 1.2m, CONCRETE TO 0.2m, THEN ASPHALT COLD PATCH TO SURFACE.										

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

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

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Ministry of Transportation
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RECORD OF BOREHOLE No R-02 1 OF 2 METRIC

G.W.P. 2930-17-00 LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 392.7 E 314 653.8 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.05.11 - 2018.05.14 LATITUDE 43.874441 LONGITUDE -79.377391 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS
203.5	GROUND SURFACE					
0.0	**ASPHALT:** (200mm)					
0.2	**SAND** and **GRAVEL** Brown Moist (FILL)					
202.6			1	SS	40	
0.9	Silty **CLAY**, with sand, trace gravel Hard Brown Moist (FILL)		2	SS	44	
			3	SS	30	
200.5						
3.0	**SAND** and **SILT**, trace gravel Very Dense Brown Moist (FILL)		4	SS	52	
199.1						
4.4	Silty **CLAY**, with sand, trace gravel Hard Brown Moist (FILL)		5	SS	43	
			6	SS	57	
			7	SS	30	
			8	SS	42	
193.7						
9.8	**ORGANICS:** (600mm)					

ELEVATION SCALE: 203, 202, 201, 200, 199, 198, 197, 196, 195, 194

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
2	38	39	21

Continued Next Page

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

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

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Ontario

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RECORD OF BOREHOLE No R-02 2 OF 2 METRIC

G.W.P. 2930-17-00 LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 392.7 E 314 653.8 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.05.11 - 2018.05.14 LATITUDE 43.874441 LONGITUDE -79.377391 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										
193.1	**ORGANICS:** (600mm) Dark Brown Moist										
10.4	Silty **SAND**, trace gravel Very Dense Brown Moist		9	SS	68	▽	193		○		
							192				
			10	SS	76		191		○		
190.0							190				
13.5	Gravelly **SAND**, trace silt, trace clay, occasional cobbles Very Dense Brown Wet		11	SS	100/ 0.225				○		24 71 5 (SI+CL)
188.1			12	SS	100/		189		○		
15.4	Silty **CLAY**, trace sand, trace gravel Hard Grey Wet (TILL)				0.075		188				
186.6			13	SS	100/		187		○		
16.9	END OF BOREHOLE AT 16.9m. WATER LEVEL AT 11.6m UPON COMPLETION. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO 6.1m, BENTONITE HOLEPLUG TO 0.8m, CONCRETE TO 0.3m, THEN ASPHALT COLD PATCH TO SURFACE.				0.150						

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

15 20 5 10 (%) STRAIN AT FAILURE

ONTMT4S2 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 1/16/19

Ministry of Transportation
Ontario

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RECORD OF BOREHOLE No R-03 1 OF 3 METRIC

G.W.P. 2930-17-00 LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 400.5 E 314 607.2 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.04.12 - 2018.04.13 LATITUDE 43.874512 LONGITUDE -79.377970 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
203.5	GROUND SURFACE						
0.0	**ASPHALT:** (200mm)						
0.2	Silty **CLAY**, some to with sand, trace gravel Stiff to Very Stiff Brown Moist (FILL)		1	SS	12		203
			2	SS	20		202
			3	SS	11		201
			4	SS	20		200
			5	SS	8		199
199.0	Grey						
4.5	Firm		6	SS	7		
197.9							198
5.6	Silty **CLAY**, with sand, trace gravel Stiff to Very Stiff Brown Moist (FILL)		7	SS	15		197
			8	SS	8		196
			9	SS	12		195
193.8							194
9.7	**ORGANICS:** (300mm)						
193.5	Dark Brown						

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa 20 40 60 80 100
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE

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
6	0	30	39	31

Continued Next Page

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

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

ONTMT4S2 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 1/16/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No R-03 2 OF 3 METRIC

G.W.P. 2930-17-00 | LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 400.5 E 314 607.2 | ORIGINATED BY SB

HWY 404 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY MP

DATUM Geodetic | DATE 2018.04.12 - 2018.04.13 | LATITUDE 43.874512 | LONGITUDE -79.377970 | 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, + FIELD VANE, ● QUICK TRIAXIAL, × 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							20 40 60 80 100	20 40 60		
10.0	Silty **CLAY**, with sand, trace gravel, occasional cobbles Stiff Grey Moist (TILL)		10	SS	12		193		○		Resistance to augering from 10.0m to 10.1m
191.8							192				
11.7	Silty **SAND**, trace clay Compact to Dense Brown Wet		11	SS	12	▽	191		○		0 72 28 (SI+CL)
			12	SS	33		190		○		
			13	SS	43		189		○		
186.3	Very Dense		14	SS	78		188		○ ○		
17.2	**SAND** and **SILT**, some gravel, trace clay Very Dense Grey Wet (TILL)		15	SS	100/ 0.150		187				12 35 49 4
							186				
							185		○		
							184				

Continued Next Page

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

15 20 10 5 (%) STRAIN AT FAILURE

ONTMT4S2 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 1/16/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No R-03 3 OF 3 METRIC

G.W.P. 2930-17-00 LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 400.5 E 314 607.2 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.04.12 - 2018.04.13 LATITUDE 43.874512 LONGITUDE -79.377970 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	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
182.8	**SAND** and **SILT**, some gravel, trace clay Very Dense Grey Moist (TILL)		16	SS	100/ 0.250		183				
20.7	Silty **CLAY**, trace sand, trace gravel Hard Grey Moist (TILL)		17	SS	100/ 0.225		182				
							181				
180.4			18	SS	100/ 0.125						
23.1	END OF BOREHOLE AT 23.1m. BOREHOLE CAVED TO 11.6m AND WATER LEVEL AT 12.5m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 2.4m, GROUT TO 1.5m, CONCRETE TO 0.3m THEN ASPHALT COLD PATCH TO SURFACE.										

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

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

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

ONTMT4S2 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 1/16/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No R-04 1 OF 3 METRIC

G.W.P. 2930-17-00 LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 394.1 E 314 640.6 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.05.24 - 2018.05.25 LATITUDE 43.874453 LONGITUDE -79.377555 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
202.9	GROUND SURFACE										
0.0	Silty **CLAY**, with sand, trace gravel, occasional organics Firm to Very Stiff Brown Moist (FILL)		1	SS	16				○		
			2	SS	10		202		○		
			3	SS	7		201		○		
			4	SS	9		200		○		
			5	SS	6				○		3 33 27 37
			6	SS	17		199		○		
			7	SS	17		198		○		
	Brown to Grey		8	SS	25		197		○		
193.3			9	SS	16		196		○		
9.6	**ORGANICS:** (400mm) Dark Brown						195				
192.9							194				
							193				

Continued Next Page

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

(%) STRAIN AT FAILURE

ONTMT4S2 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 1/16/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No R-04 2 OF 3 METRIC

G.W.P. 2930-17-00 | LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 394.1 E 314 640.6 | ORIGINATED BY SB

HWY 404 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY MP

DATUM Geodetic | DATE 2018.05.24 - 2018.05.25 | LATITUDE 43.874453 | LONGITUDE -79.377555 | 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										
10.0	**SAND**, trace silt, trace to some gravel Very Dense to Dense Brown Wet										
	Clay pockets		10	SS	78		192		○		
							191				
			11	SS	43				○		11 81 8 (SI+CL)
							190				
			12	SS	62		189		○		
188.4											
14.5	Gravelly **SAND**, trace silt, trace clay, occasional cobbles Very Dense Grey Wet						188				
			13	SS	100/ 0.275				○		28 60 12 (SI+CL)
186.3							187				
16.6	Silty **CLAY**, trace sand, trace gravel Hard Grey Wet (TILL)		14	SS	100/ 0.150		186		○		
							185				
			15	SS	100/ 0.125				○		
							184				
							183		○		

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

ONTMT4S2 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 1/16/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No R-04 3 OF 3 METRIC

G.W.P. 2930-17-00 LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 394.1 E 314 640.6 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.05.24 - 2018.05.25 LATITUDE 43.874453 LONGITUDE -79.377555 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, trace gravel Hard Grey Wet (TILL)		16	SS	100/0.200						
			17	SS	77		182				0 0 35 65
							181				
			18	SS	100/0.200		180				
							179				
177.9			19	SS	95		178				
25.0	END OF BOREHOLE AT 25.0m. WATER LEVEL AT 11.6m UPON COMPLETION. Well installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2018.06.22 9.5 193.4 2018.09.30 9.5 193.4 2018.11.23 12.3 190.6										

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

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

ONTMT4S2 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 1/16/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No R-05 1 OF 3 METRIC

G.W.P. 2930-17-00 | LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 383.7 E 314 653.4 | ORIGINATED BY SB

HWY 404 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY MP

DATUM Geodetic | DATE 2018.05.08 - 2018.05.11 | LATITUDE 43.874360 | LONGITUDE -79.377395 | 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
203.5	GROUND SURFACE									
0.0	**ASPHALT:** (150mm)									
0.2 / 203.0	**CONCRETE:** (350mm)									
0.5	**SAND**, trace silt, trace clay Compact Brown Moist (FILL)		1	SS	16		203	○		
			2	SS	18		202	○		
			3	SS	17		201	○		
			4	SS	13		200	○		
198.9										
4.6	Silty **CLAY**, with sand, trace gravel Firm to Very Stiff Grey Moist (FILL)		5	SS	8		199	⊖		0 27 40 33
			6	SS	20		198	○		
			7	SS	5		197	○		
194.8							196			
8.7	Silty **CLAY**, with sand, trace gravel Very Stiff Grey Moist (TILL)		8	SS	23	▽	195			
							194	○		

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No R-05 2 OF 3 METRIC

G.W.P. 2930-17-00 LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 383.7 E 314 653.4 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.05.08 - 2018.05.11 LATITUDE 43.874360 LONGITUDE -79.377395 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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page							20 40 60 80 100	20 40 60		
	Silty **CLAY**, with sand, trace gravel Stiff Grey Moist (TILL)		9	SS	8		193				0 23 33 44
191.8							192				
11.7	**SAND**, some gravel, trace silt Very Dense to Dense Brown Wet		10	SS	100/ 0.125		191				
			11	SS	45		190				
188.1							189				
15.4	Silty **CLAY**, some sand, trace gravel Hard Grey Moist (TILL)		12	SS	71		188				
			13	SS	100/ 0.300		187				
			14	SS	100/ 0.275		186				
							185				
							184				

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+ ³, × ³: Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No R-05 3 OF 3 METRIC

G.W.P. 2930-17-00 LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 383.7 E 314 653.4 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.05.08 - 2018.05.11 LATITUDE 43.874360 LONGITUDE -79.377395 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							20 40 60 80 100	20 40 60		
	Silty **CLAY**, trace sand, trace gravel Hard Grey Moist (TILL)		15	SS	100/ 0.300		183				
			16	SS	83		182				
			17	SS	100/ 0.150		181				0 9 42 49
179.0			18	SS	100/ 0.075		180				
24.5	END OF BOREHOLE AT 24.5m. WATER LEVEL AT 9.8m UPON COMPLETION. BOREHOLE CAVED TO 16.8m, BACKFILLED WITH AUGER CUTTINGS TO 12.2m, BENTONITE HOLEPLUG TO 1.2m, CONCRETE TO 0.3m, THEN ASPHALT COLD PATCH TO SURFACE.										

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No R-06 1 OF 3 METRIC

G.W.P. 2930-17-00 LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 329.1 E 314 620.0 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.04.27 - 2018.04.30 LATITUDE 43.873869 LONGITUDE -79.377812 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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
203.2	GROUND SURFACE						203				
0.0	**ASPHALT:** (180mm)										
0.2 / 202.7	**CONCRETE:** (320mm)										
0.5	**SAND** and **GRAVEL**, trace to some silt and clay Compact to Dense Brown Moist (FILL)		1	SS	10		202		○		
			2	SS	15				○		
	Occasional cobbles		3	SS	40		201		○		
			4	SS	29		200		○		34 49 17 (SI+CL)
198.9							199				
4.3	Silty **CLAY**, with sand, trace gravel Firm to Stiff Brown to Grey Moist to Wet (FILL)		5	SS	5				○		
			6	SS	5		198				
			7	SS	9		197		○		0 50 30 20
			8	SS	5		196				
193.2							195				
							194		○		

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No R-06 2 OF 3 METRIC

G.W.P. 2930-17-00 LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 329.1 E 314 620.0 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.04.27 - 2018.04.30 LATITUDE 43.873869 LONGITUDE -79.377812 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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
10.0	**SAND**, some silt, trace gravel, trace clay Dense to Very Dense Brown Wet						193				
			9	SS	48	▽	192		○		
			10	SS	32		191		○		0 87 10 3
			11	SS	57		190		○		
			12	SS	56		189		○		
187.0							188				
16.2	**SAND** and **SILT**, trace to some gravel, trace clay Very Dense Grey Wet (TILL)		13	SS	100/ 0.250		187		○		
185.2							186				
18.0	Silty **CLAY**, trace gravel, trace sand Hard Grey Wet (TILL)		14	SS	100/ 0.225		185		⊢○⊣		0 0 63 37
	Sand seams						184				
	Continued Next Page										

ONTMT4S2 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 1/16/19

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No R-06 3 OF 3 METRIC

G.W.P. 2930-17-00 LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 329.1 E 314 620.0 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.04.27 - 2018.04.30 LATITUDE 43.873869 LONGITUDE -79.377812 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 gravel, trace sand Hard Grey Moist (TILL) Sand seams at 20.8m		15	SS	44		183	○ at 20		
			16	SS	90		182	○ at 20		
			17	SS	100/ 0.200		181	○ at 20		
			18	SS	100/ 0.100		180	○ at 20		
176.9			19	SS	100/ 0.275		179	○ at 20		
26.3	END OF BOREHOLE AT 26.3m. WATER LEVEL AT 11.4m UPON COMPLETION. BOREHOLE CAVED TO 15.8m, BACKFILLED WITH AUGER CUTTINGS TO 9.1m, BENTONITE HOLEPLUG TO 1.5m, CONCRETE TO 0.3m, THEN ASPHALT COLD PATCH TO SURFACE.						178 177	○ at 20		

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

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

ONTMT4S2 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 1/16/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No R-07 1 OF 3 METRIC

G.W.P. 2930-17-00 LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 318.3 E 314 637.6 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.05.22 - 2018.05.23 LATITUDE 43.873771 LONGITUDE -79.377593 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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
202.6	GROUND SURFACE										
0.0	**SILT**, some sand, trace gravel, trace clay, occasional organics Loose to Compact Brown Moist (FILL)		1	SS	8		202		○		
			2	SS	20				○		
			3	SS	22		201		○		0 16 75 9
			4	SS	25		200		○		
			5	SS	20		199		○		
			6	SS	100/0.225		198		○		Resistance to augering at 5.8m
	Cobbles						197				
196.5	Sand seams at 5.9m										
6.1	Silty **CLAY**, with sand, trace gravel Stiff to Hard Grey Moist (FILL)		7	SS	11		196		○		Resistance to augering at 6.9m
			8	SS	32		195		⊢●		2 36 39 23
193.4						▼	194				
9.2	Silty **SAND**, trace gravel, trace clay Dense Grey Wet		9	SS	41		193		○		Resistance to augering at 9.4m
192.6											

Continued Next Page

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

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

ONTMT4S2 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 1/16/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No R-07 2 OF 3 METRIC

G.W.P. 2930-17-00 LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 318.3 E 314 637.6 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.05.22 - 2018.05.23 LATITUDE 43.873771 LONGITUDE -79.377593 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										
10.0	Silty **SAND**, trace gravel, trace clay Dense to very Dense Grey Wet		10	SS	40		192				
			11	SS	100/ 0.250		191				
			12	SS	100/ 0.150		190				
			13	SS	22		189				
	Compact						188				
186.3							187				
16.3	Sandy **SILT**, some clay, trace gravel Very Dense Grey Wet (TILL)		14	SS	100/ 0.025		186				Resistance to augering at 16.5m
			15	SS	100/ 0.150		185				
183.7							184				0 26 59 15
18.9	Silty **CLAY**, some sand, trace gravel Hard Grey Moist (TILL)						183				

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

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THURBER

RECORD OF BOREHOLE No R-07 3 OF 3 METRIC

G.W.P. 2930-17-00 LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 318.3 E 314 637.6 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.05.22 - 2018.05.23 LATITUDE 43.873771 LONGITUDE -79.377593 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
	Continued From Previous Page										
	Silty **CLAY**, trace sand, trace gravel Hard Grey Moist (TILL)		16	SS	100/ 0.250		182				
			17	SS	100/ 0.200		181		o		
			18	SS	100/ 0.225		180		o		
							179				
177.9				SS	100/ 0.175		178		o⊣⊢		0 0 63 37
24.7	END OF BOREHOLE AT 24.7m. WATER LEVEL AT 10.7m UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.										

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2018.06.22	9.3	193.3
2018.11.22	9.2	193.4

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

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

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Ontario

THURBER

RECORD OF BOREHOLE No R-08 1 OF 3 METRIC

G.W.P. 2930-17-00 | LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 314.2 E 314 669.4 | ORIGINATED BY SB

HWY 404 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY MP

DATUM Geodetic | DATE 2018.05.03 - 2018.05.17 | LATITUDE 43.873734 | LONGITUDE -79.377198 | 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
203.1	GROUND SURFACE						203				
0.0	**ASPHALT:** (180mm)										
0.2 / 202.6	**CONCRETE:** (320mm)										
0.5	**SAND**, trace gravel, trace to some clay, trace to some silt Loose to Compact Brown Moist (FILL)		1	SS	4		202		○		
			2	SS	14				○		
			3	SS	15		201		○		
			4	SS	7		200		○		2 72 26 (SI+CL)
			5	SS	4		199		○		
197.3							198				
5.8	Silty **CLAY**, some sand, trace gravel Stiff to Very Stiff Brown Moist (FILL)		6	SS	9		197		○		
			7	SS	20		196		○		
194.6							195				
8.5	**SAND**, trace gravel, trace to some silt, trace clay Compact Brown Moist		8	SS	18		194		○		

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

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RECORD OF BOREHOLE No R-08 2 OF 3 METRIC

G.W.P. 2930-17-00 LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 314.2 E 314 669.4 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.05.03 - 2018.05.17 LATITUDE 43.873734 LONGITUDE -79.377198 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										
	SAND, trace to some gravel, trace silt, trace clay Dense Brown Moist to Wet						193				
			9	SS	31		192		○		
191.3						▽					
11.8	Gravelly **SAND**, trace silt, Compact Brown Wet		10	SS	27		191		○		20 75 5 (SI+CL)
190.1											
13.0	Silty **CLAY**, some sand, trace gravel Hard Grey Moist (TILL)						190				
			11	SS	100/ 0.225		189		○		
			12	SS	100/ 0.200		188		○		
			13	SS	100/ 0.075		187		○		0 15 62 23
			14	SS	100/ 0.050		186				
							185		○		
			15	SS	100/		184		○		

Continued Next Page

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

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

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RECORD OF BOREHOLE No R-08 3 OF 3 METRIC

G.W.P. 2930-17-00 LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 314.2 E 314 669.4 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.05.03 - 2018.05.17 LATITUDE 43.873734 LONGITUDE -79.377198 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 (20 40 60 80 100): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE	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**, some sand, trace gravel Hard Grey Moist (TILL)				0.050		183				
			16	SS	100/ 0.125		182		○		0 9 44 47
			17	SS	100/ 0.100		181		○		
178.5			18	SS	100/ 0.100		180		○		
24.6	END OF BOREHOLE AT 24.6m. WATER LEVEL AT 11.6m UPON COMPLETION. BOREHOLE CAVED TO 14.6m, BACKFILLED WITH AUGER CUTTINGS TO 7.6m, BENTONITE HOLEPLUG TO 1.5m, CONCRETE TO 0.3m, THEN ASPHALT COLD PATCH TO SURFACE.						179				

+ ³, × ³: Numbers refer to Sensitivity

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

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RECORD OF BOREHOLE No R-09 1 OF 3 METRIC

G.W.P. 2930-17-00 LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 323.2 E 314 621.0 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY MP

DATUM Geodetic DATE 2018.04.23 - 2018.04.24 LATITUDE 43.873815 LONGITUDE -79.377799 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
203.2	GROUND SURFACE										
0.0	**ASPHALT:** (200mm)										
0.2	**SILT**, some sand, trace clay, trace gravel Compact to Loose Brown Moist (FILL)		1	GS			203		○		
			1	SS	29		202		○		
			2	SS	18				○		
			3	SS	4		201		○		0 18 75 7
			4	SS	9		200		○		
			5	SS	15		199		○		
197.6							198				
5.6	Silty **CLAY**, with sand, trace gravel Very Stiff to Hard Grey Moist (FILL)		6	SS	16		197		○		
			7	SS	23		196		○		
			8	SS	30		195		○		
	Sand seams						194		○		
193.2											

Continued Next Page

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

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

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RECORD OF BOREHOLE No R-09 2 OF 3 METRIC

G.W.P. 2930-17-00 | LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 323.2 E 314 621.0 | ORIGINATED BY SB

HWY 404 | BOREHOLE TYPE Hollow Stem Augers/Tricone | COMPILED BY MP

DATUM Geodetic | DATE 2018.04.23 - 2018.04.24 | LATITUDE 43.873815 | LONGITUDE -79.377799 | 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
	Continued From Previous Page										
10.0	Silty **SAND**, trace clay, trace gravel Dense to Very Dense Grey Moist to Wet						193				
			9	SS	40		192		○		
						▽					
			10	SS	44		191		○		
							190				
			11	SS	71		189		○		
188.4											
14.8	**SAND** and **SILT**, trace gravel, occasional cobbles Dense to Very Dense Grey Wet (TILL)		12	SS	36		188		○		2 50 32 16
			13	SS	100/ 0.200		187		○		
185.5							186				Resistance to augering at 16.5m
17.7	Silty **CLAY**, some sand, trace gravel Hard Grey Moist (TILL)		14	SS	100/ 0.250		185		○		
							184				Resistance to augering at 19.4m

Continued Next Page

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

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

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RECORD OF BOREHOLE No R-09 3 OF 3 METRIC

G.W.P. 2930-17-00 LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 323.2 E 314 621.0 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY MP

DATUM Geodetic DATE 2018.04.23 - 2018.04.24 LATITUDE 43.873815 LONGITUDE -79.377799 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 (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, occasional cobbles Hard Grey Moist (TILL)		15	SS	96		183				0 0 46 54
							182				
181.3			16	SS	85						
21.9	END OF BOREHOLE AT 21.9m. WATER LEVEL AT 11.6m UPON COMPLETION. BOREHOLE CAVED TO 12.5m, BACKFILLED WITH AUGER CUTTINGS TO 7.6m, BENTONITE HOLEPLUG TO 1.5m, CONCRETE TO 0.3m, THEN ASPHALT COLD PATCH TO SURFACE.										

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE

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

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

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RECORD OF BOREHOLE No R-10 1 OF 3 METRIC

G.W.P. 2930-17-00 | LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 304.1 E 314 670.0 | ORIGINATED BY SB

HWY 404 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY MP

DATUM Geodetic | DATE 2018.05.01 - 2018.05.02 | LATITUDE 43.873643 | LONGITUDE -79.377190 | 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 (20 40 60 80 100): ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE	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
203.1	GROUND SURFACE									
0.0 / 202.8	**ASPHALT:** (280mm)						203			
0.3	**SAND** and **SILT**, trace clay, occasional cobbles Compact to Very Dense Brown Moist (FILL)		1	SS	23		202			
			2	SS	100/ 0.025					Spoon bouncing at 1.8m
			3	SS	75		201			
	Occasional cobbles		4	SS	10		200			
199.1										
4.0	Silty **CLAY**, some sand Very Stiff Grey Moist (FILL)		5	SS	22		199			
198.2										
4.9	**SAND** and **SILT**, trace clay Compact to Dense Brown Moist (FILL)		6	SS	20		198			0 42 49 9
			7	SS	37		197			
194.3							196			
8.8	**SAND**, trace gravel, trace silt, trace clay Dense Brown Wet		8	SS	46		195			
							194			

Continued Next Page

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

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

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RECORD OF BOREHOLE No R-10 2 OF 3 METRIC

G.W.P. 2930-17-00 | LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 304.1 E 314 670.0 | ORIGINATED BY SB

HWY 404 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY MP

DATUM Geodetic | DATE 2018.05.01 - 2018.05.02 | LATITUDE 43.873643 | LONGITUDE -79.377190 | 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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND, trace gravel, trace silt, trace clay Dense to Very Dense Brown Wet					▽	193				
			9	SS	36		192		○		1 95 4 (SI+CL)
			10	SS	74		191		○		
			11	SS	94		190				
			12	SS	100/ 0.150		189		○		
187.3							188				
15.8	Silty **CLAY**, trace sand, trace gravel Hard Grey Moist (TILL)		13	SS	100/ 0.200		187				0 0 59 41
			14	SS	95		186		○		
							185				
							184		○		

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

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

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RECORD OF BOREHOLE No R-10 3 OF 3 METRIC

G.W.P. 2930-17-00 | LOCATION Rouge River Bridge - MTM NAD 83 Zone10: N 4 859 304.1 E 314 670.0 | ORIGINATED BY SB

HWY 404 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY MP

DATUM Geodetic | DATE 2018.05.01 - 2018.05.02 | LATITUDE 43.873643 | LONGITUDE -79.377190 | 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							20 40 60 80 100	20 40 60		
	Silty **CLAY**, trace sand, trace gravel Hard Grey Moist (TILL)		15	SS	100/ 0.225		183				
			16	SS	100/ 0.200		182				
							181				
			17	SS	100/ 0.225		180				
							179				
178.1			18	SS	76						
25.0	END OF BOREHOLE AT 25.0m. WATER LEVEL AT 10.2m UPON COMPLETION. BOREHOLE CAVED TO 16.5m, BACKFILLED WITH AUGER CUTTINGS TO 10.7m, BENTONITE HOLEPLUG TO 1.8m, CONCRETE TO 0.3m, THEN ASPHALT COLD PATCH TO SURFACE.										

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

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

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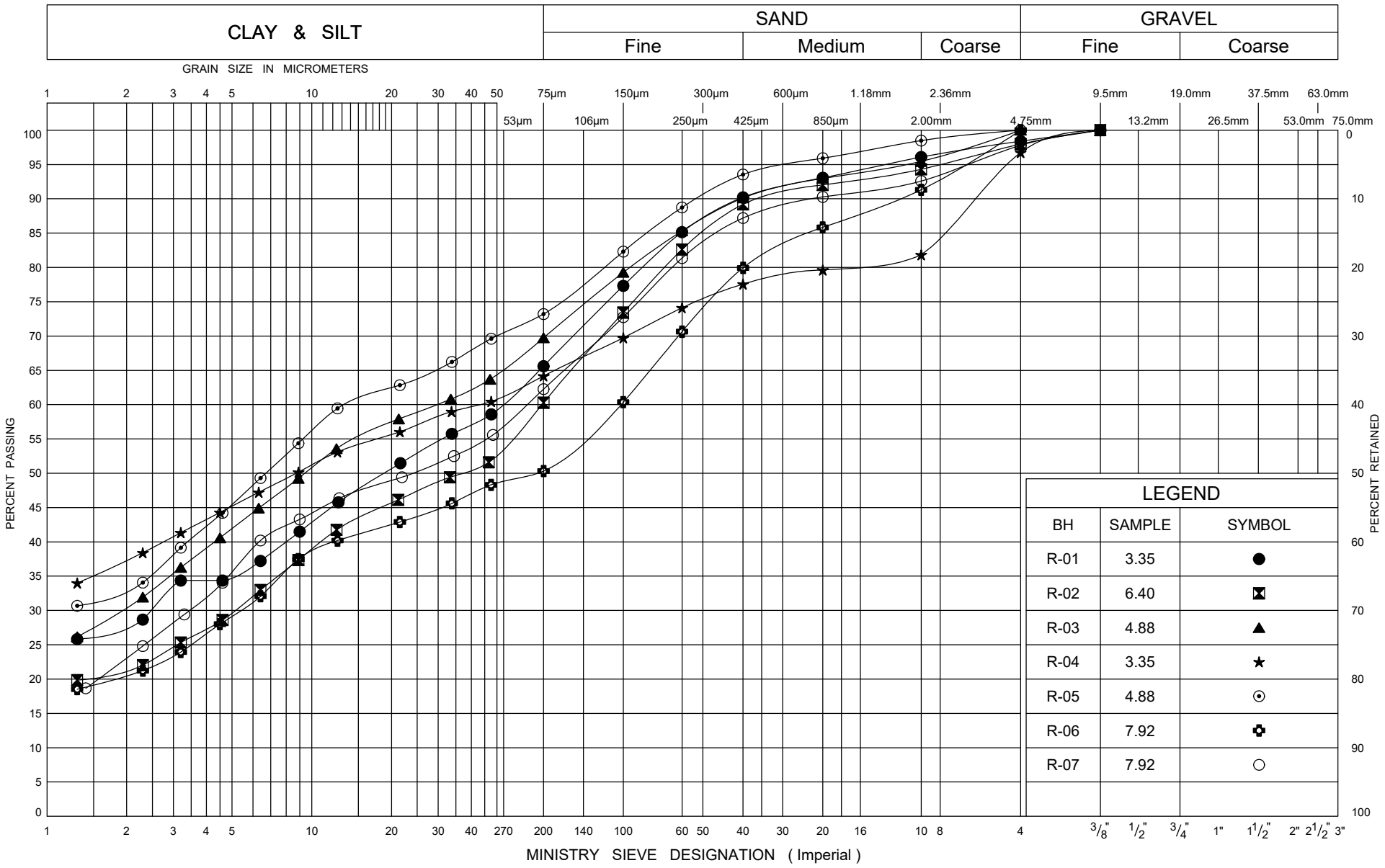
Appendix B

Geotechnical and Analytical Laboratory Test Results

(Present Site Investigation)



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GRAIN SIZE DISTRIBUTION

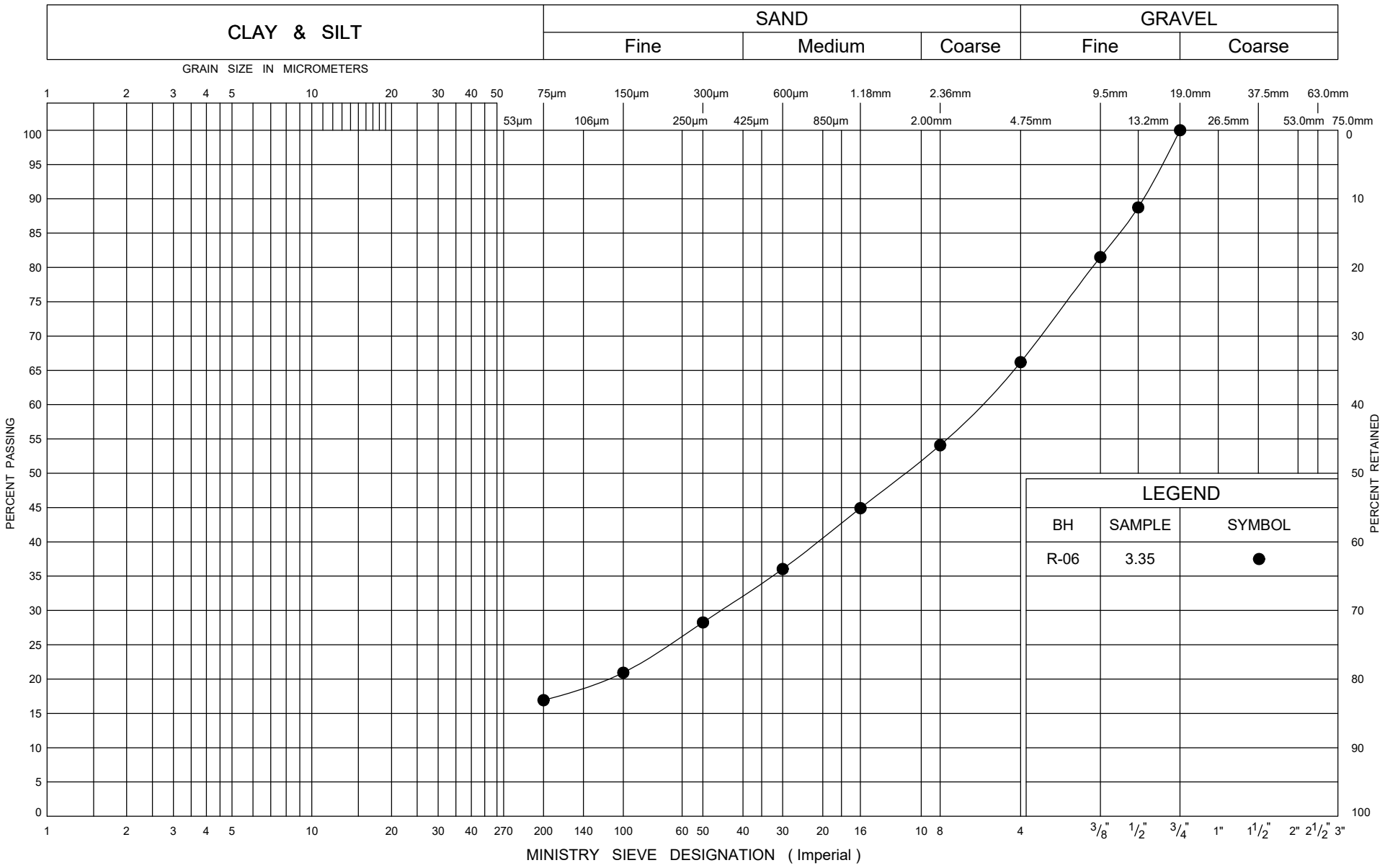
Silty CLAY FILL

FIG No B1

G W P 2930-17-00

Rouge River Bridge

ONTARIO MOT GRAIN SIZE MTO-15786.GPJ ONTARIO MOT.GDT 6/29/18



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GRAIN SIZE DISTRIBUTION

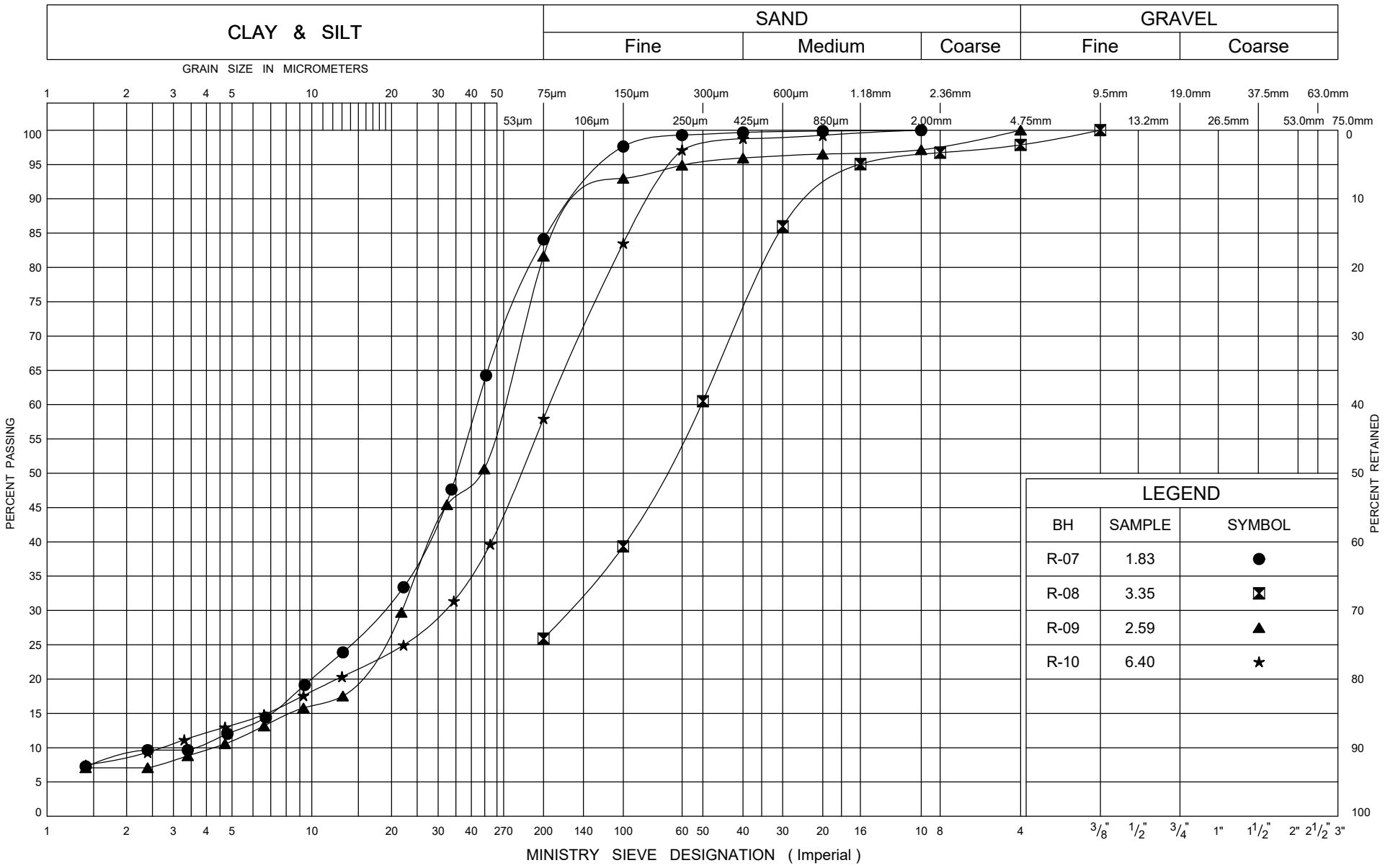
SAND and GRAVEL FILL

FIG No B2

G W P 2930-17-00

Rouge River Bridge

ONTARIO MOT GRAIN SIZE MTO-15786.GPJ ONTARIO MOT.GDT 6/29/18



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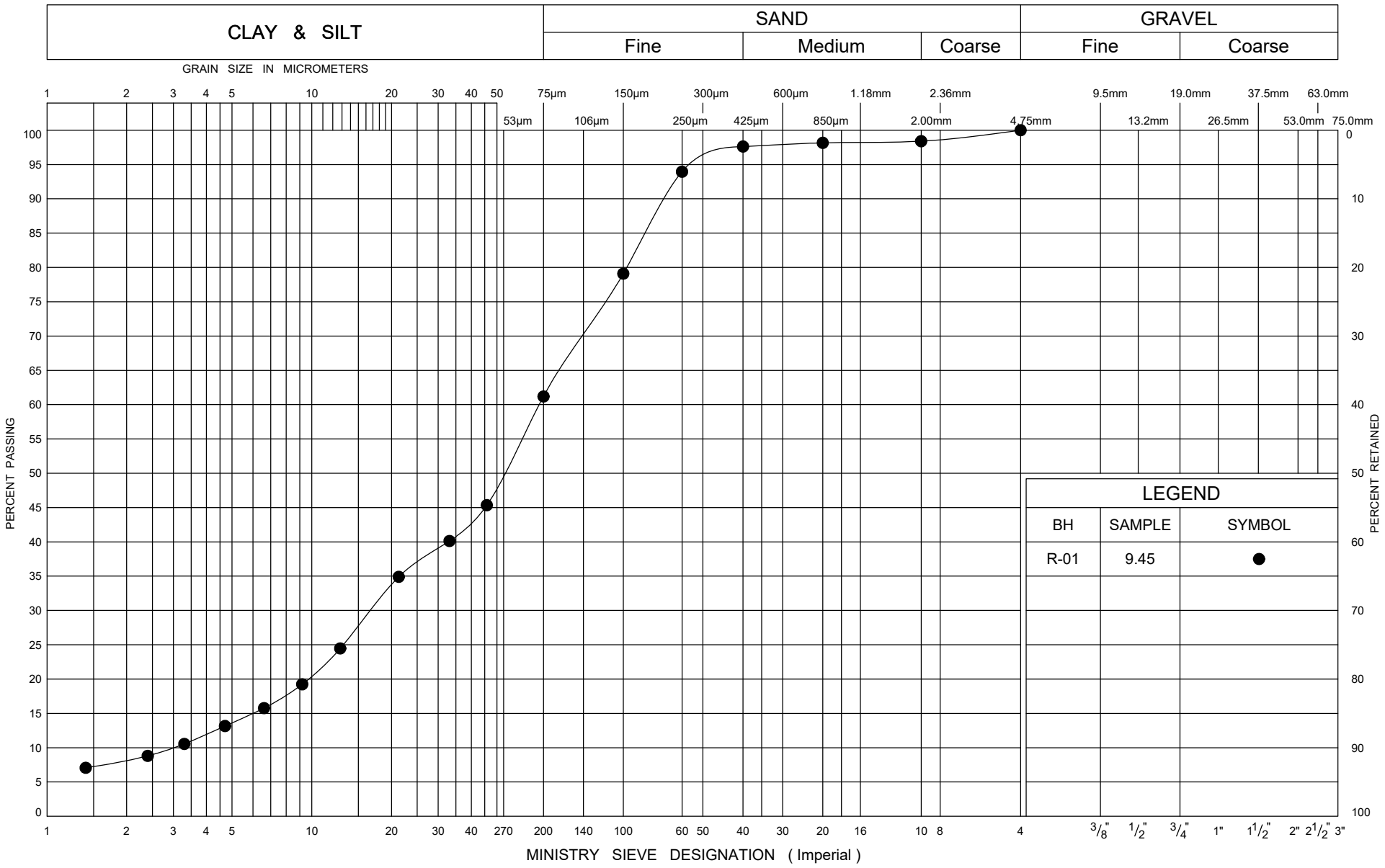
GRAIN SIZE DISTRIBUTION

SAND FILL/SILT FILL/SAND and SILT FILL

FIG No B3

G W P 2930-17-00

Rouge River Bridge



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GRAIN SIZE DISTRIBUTION

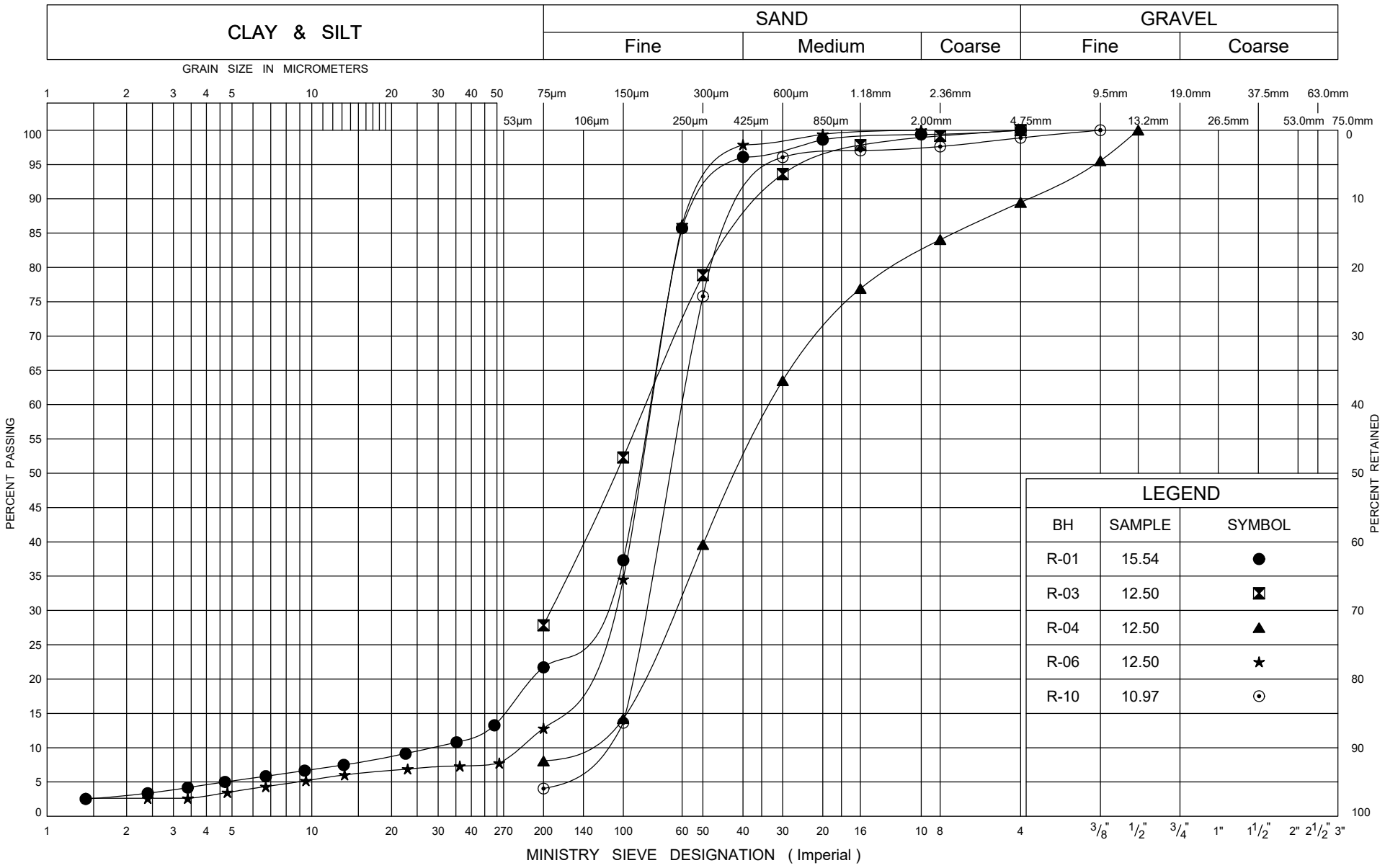
SAND and SILT

FIG No B4

G W P 2930-17-00

Rouge River Bridge

ONTARIO MOT GRAIN SIZE MTO-15786.GPJ ONTARIO MOT.GDT 6/29/18



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GRAIN SIZE DISTRIBUTION

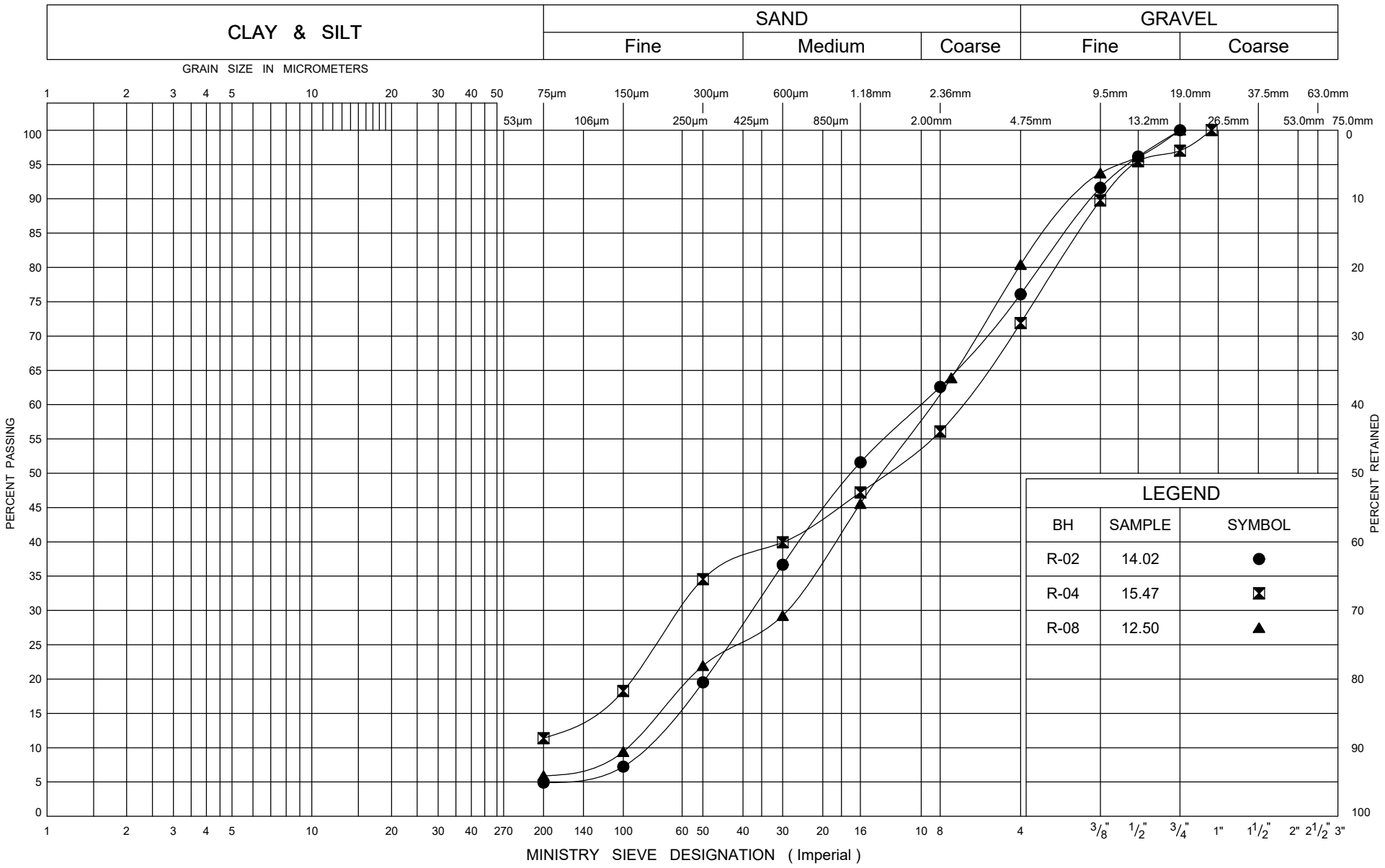
SAND to Silty SAND

FIG No B5

G W P 2930-17-00

Rouge River Bridge

ONTARIO MOT GRAIN SIZE MTO-15786.GPJ ONTARIO MOT.GDT 6/29/18



ONTARIO MOT GRAIN SIZE MTO-15786.GPJ ONTARIO MOT.GDT 6/29/18

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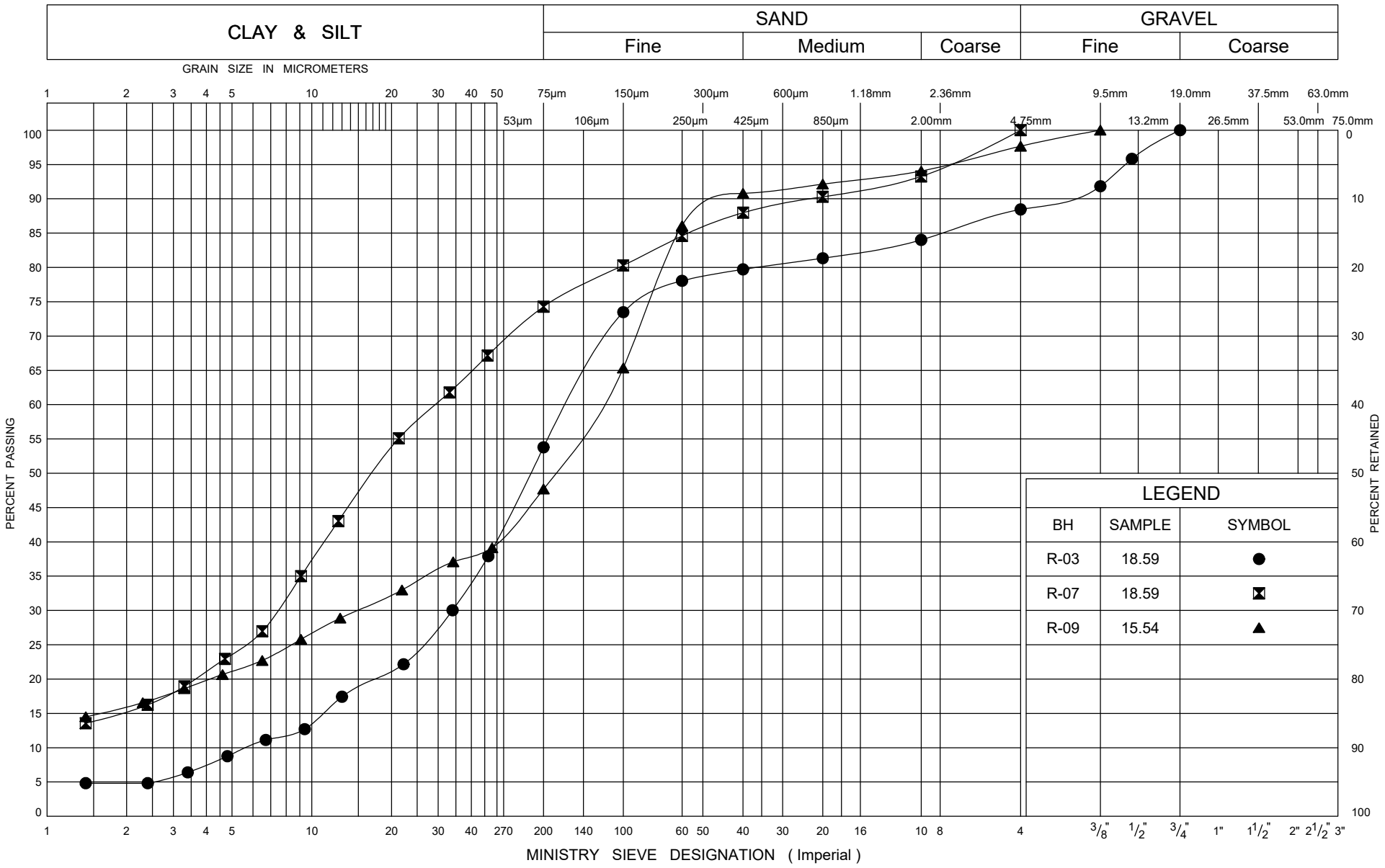
GRAIN SIZE DISTRIBUTION

Gravelly SAND

FIG No B6

G W P 2930-17-00

Rouge River Bridge



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GRAIN SIZE DISTRIBUTION

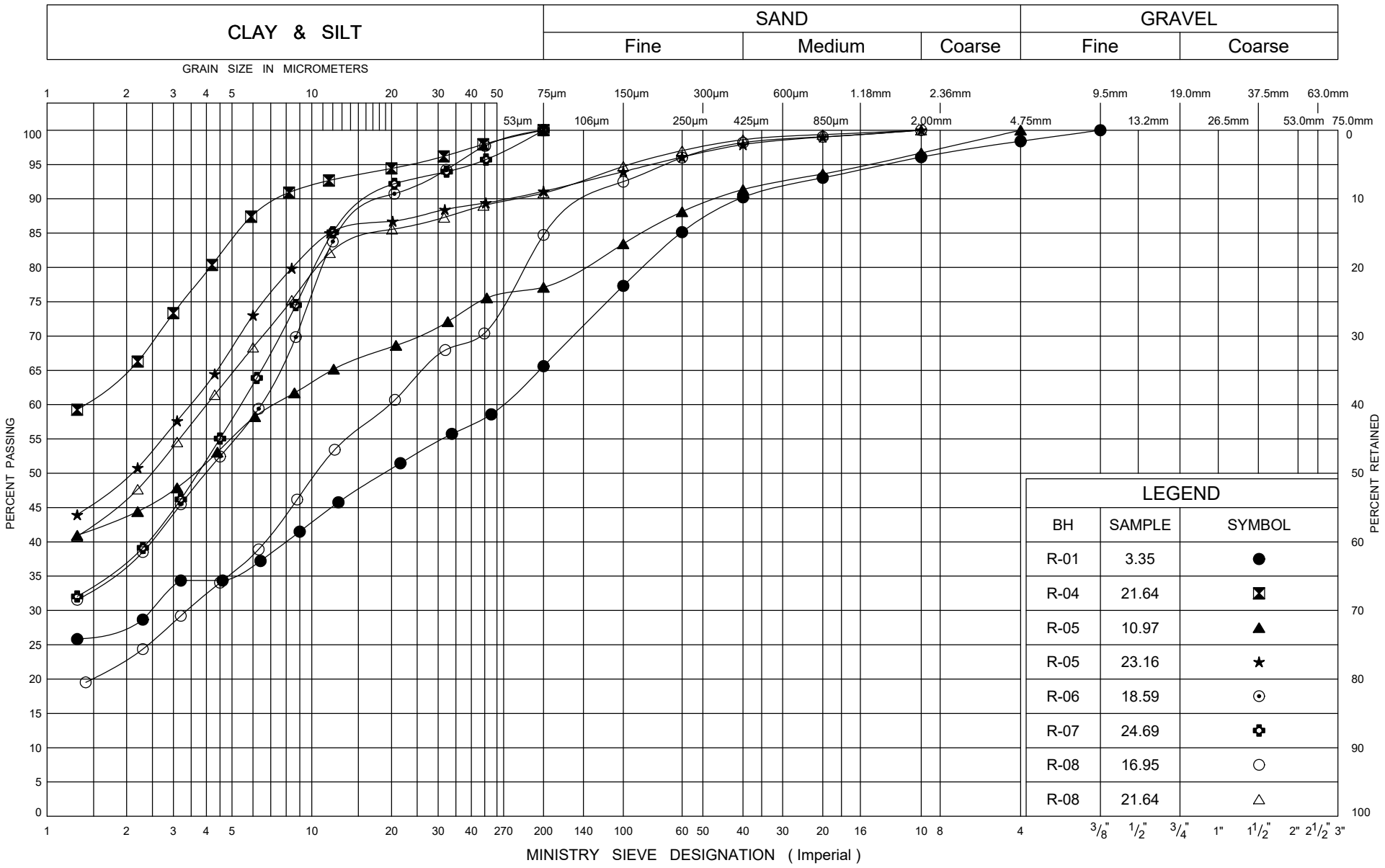
SAND and SILT to Sandy SILT TILL

FIG No B7

G W P 2930-17-00

Rouge River Bridge

ONTARIO MOT GRAIN SIZE MTO-15786.GPJ ONTARIO MOT.GDT 6/29/18



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GRAIN SIZE DISTRIBUTION

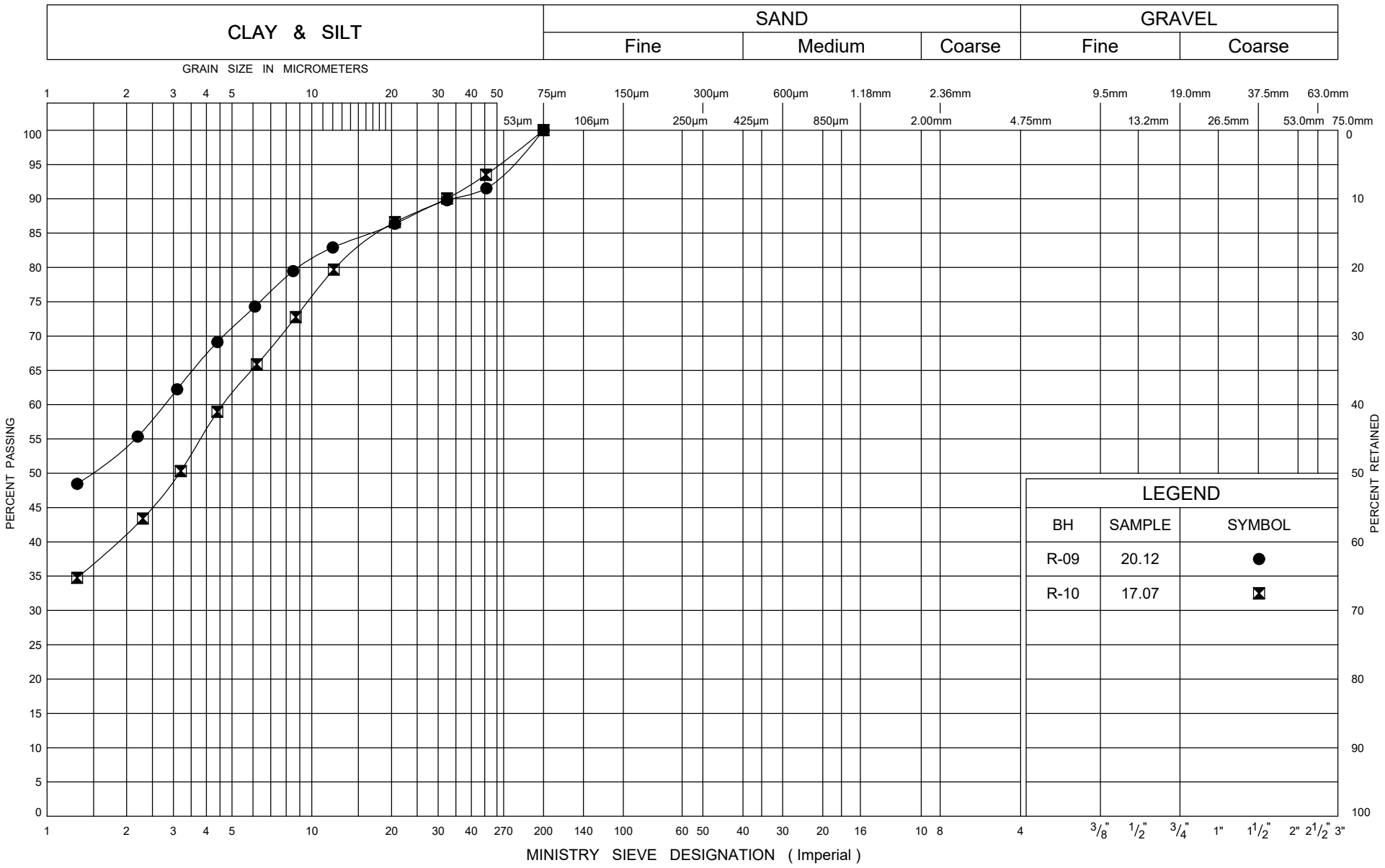
Silty CLAY TILL

FIG No B8

G W P 2930-17-00

Rouge River Bridge

ONTARIO MOT GRAIN SIZE MTO-15786.GPJ ONTARIO MOT.GDT 6/29/18



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Silty CLAY TILL

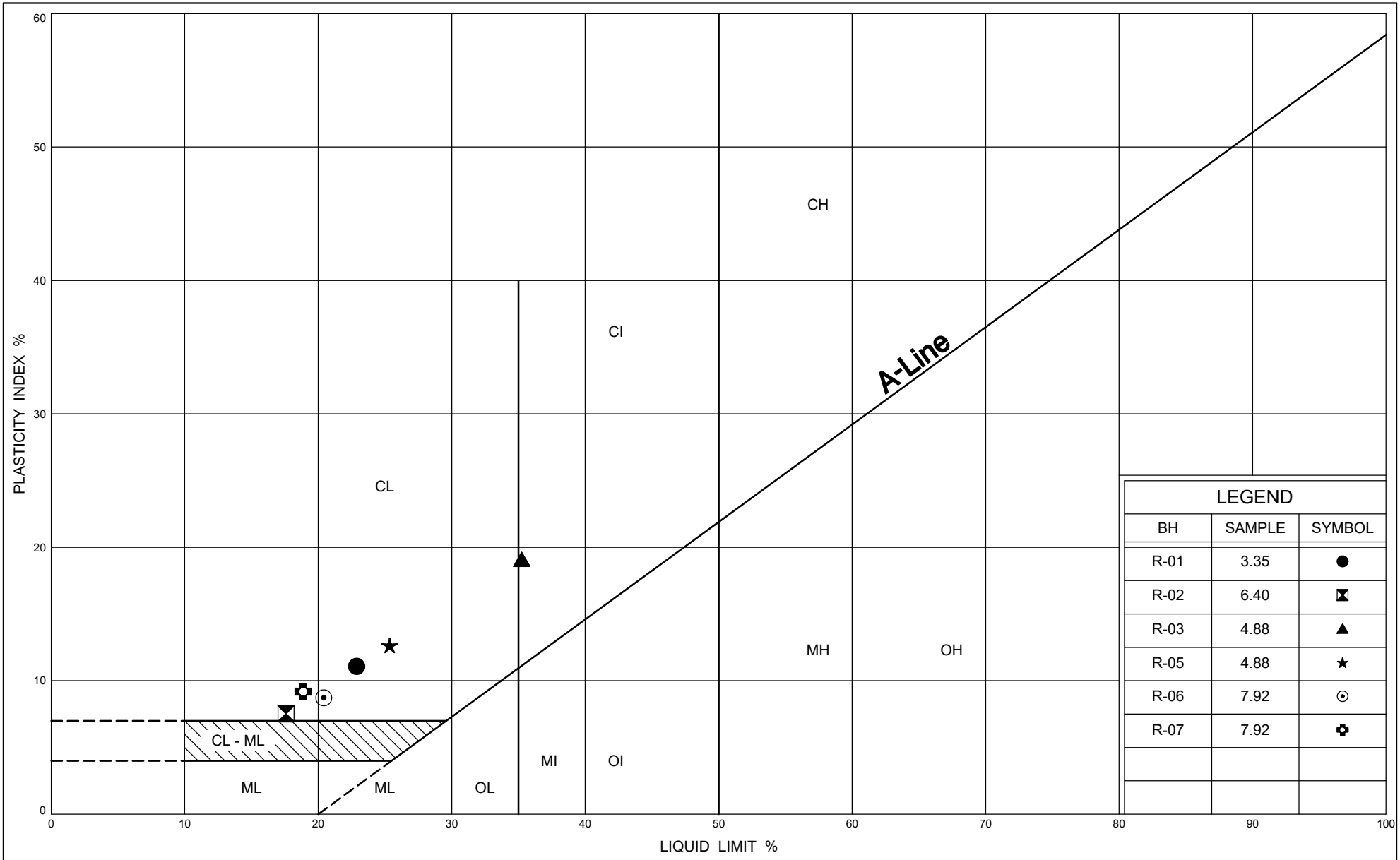
FIG No B9

G W P 2930-17-00

Rouge River Bridge

ONTARIO MOT GRAIN SIZE MTO-15786.GPJ ONTARIO MOT.GDT 6/29/18

Oct 75, FF - S - 21



ONTARIO MOT PLASTICITY CHART MTO-15786.GPJ ONTARIO MOT.GDT 6/29/18

Ministry of Transportation
Ontario

PLASTICITY CHART

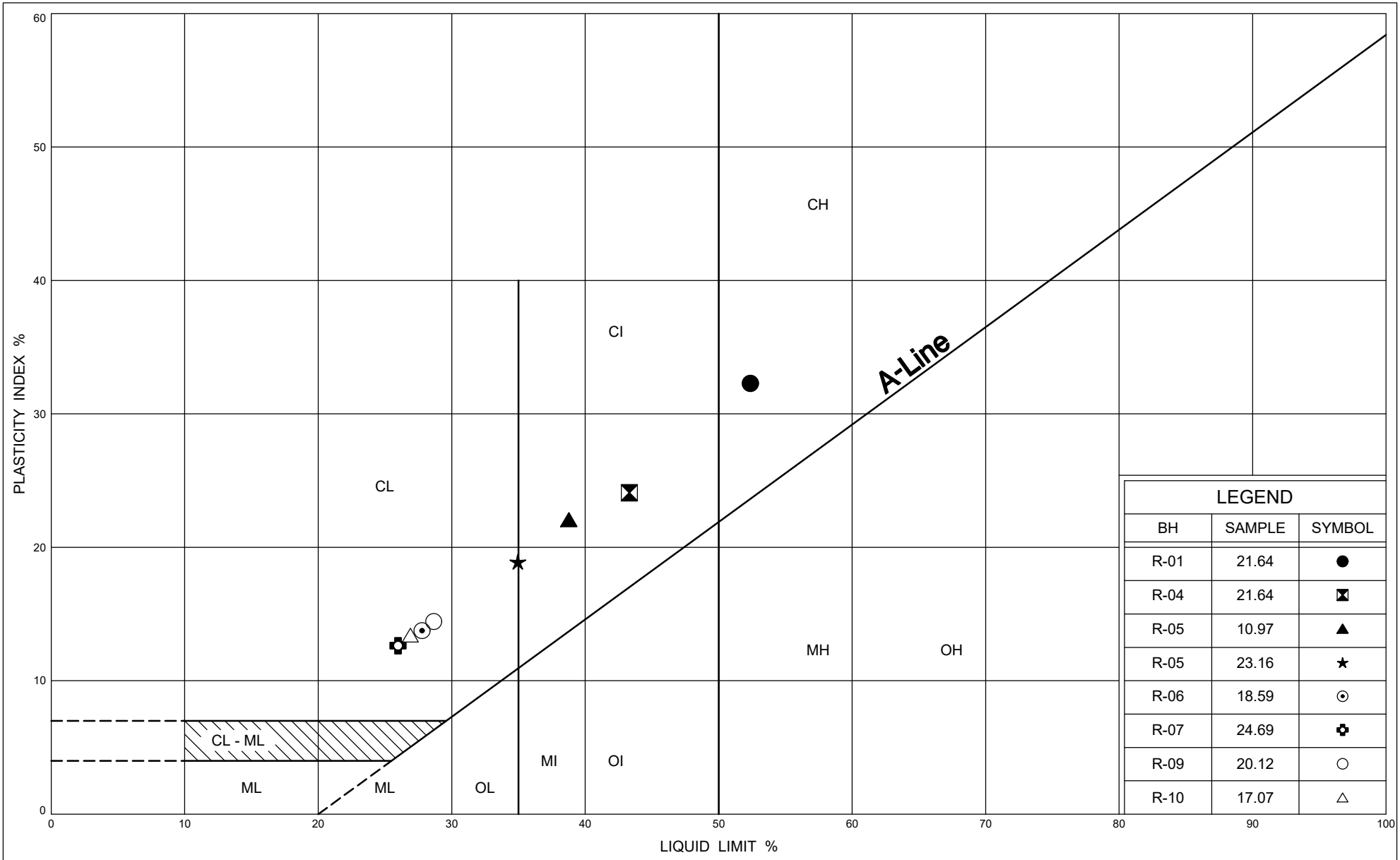
Silty CLAY FILL

FIG No B10

G W P 2930-17-00

Rouge River Bridge

Oct 75, FF - S - 21



LEGEND		
BH	SAMPLE	SYMBOL
R-01	21.64	●
R-04	21.64	⊠
R-05	10.97	▲
R-05	23.16	★
R-06	18.59	⊙
R-07	24.69	✿
R-09	20.12	○
R-10	17.07	△

ONTARIO MOT PLASTICITY CHART MTO-15786.GPJ ONTARIO MOT.GDT 6/29/18

Ministry of Transportation
Ontario

PLASTICITY CHART

Silty CLAY TILL

FIG No B11

G W P 2930-17-00

Rouge River Bridge

FINAL REPORT

CA14856-MAY18 R1

15786

Prepared for

Thurber Engineering Ltd.

FINAL REPORT

CA14856-MAY18 R1

First Page

CLIENT DETAILS		LABORATORY DETAILS	
Client	Thurber Engineering Ltd.	Project Specialist	Deanna Edwards, B.Sc, C.Chem
		Laboratory	SGS Canada Inc.
Address	103, 2010 Winston Park Drive Oakville, ON L6H 5R7.	Address	185 Concession St., Lakefield ON, K0L 2H0
Contact	Rocío Reyna	Telephone	705-652-2000
Telephone	905-829-8666 x 263	Facsimile	705-652-6365
Facsimile		Email	deanna.edwards@sgs.com
Email	rreyna@thurber.ca	SGS Reference	CA14856-MAY18
Project	15786	Received	05/28/2018
Order Number		Approved	06/01/2018
Samples	Soil (4)	Report Number	CA14856-MAY18 R1
		Date Reported	06/01/2018

COMMENTS

Temperature of Sample upon Receipt: 11 degrees C
Cooling Agent Present: No
Custody Seal Present: No
7

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

Client: Thurber Engineering Ltd.
Project: 15786
Project Manager: Rocío Reyna
Samplers: N/A

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

Sample Number			5	6	7	8
Sample Name			RO3-SS4	RO9-SS13	RO8-SS6	RO5-SS16
Sample Matrix			Soil	Soil	Soil	Soil
Sample Date			12/04/2018	22/04/2018	03/05/2018	08/05/2018
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**	**Result**
Corrosivity Index						
Corrosivity Index	none	1		14	7.5	1.0	4.0
Soil Redox Potential	mV	-		219	259	255	210
Sulphide	%	0.02		< 0.02	0.02	< 0.02	< 0.02
pH	no unit	0.05		9.13	8.99	8.41	9.24
Resistivity (calculated)	ohms.cm	-9999		847	6520	3440	6170

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

Sample Number			5	6	7	8
Sample Name			RO3-SS4	RO9-SS13	RO8-SS6	RO5-SS16
Sample Matrix			Soil	Soil	Soil	Soil
Sample Date			12/04/2018	22/04/2018	03/05/2018	08/05/2018
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**	**Result**
General Chemistry						
Conductivity	uS/cm	2		1180	153	291	162

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

Sample Number			5	6	7	8
Sample Name			RO3-SS4	RO9-SS13	RO8-SS6	RO5-SS16
Sample Matrix			Soil	Soil	Soil	Soil
Sample Date			12/04/2018	22/04/2018	03/05/2018	08/05/2018
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**	**Result**
Metals and Inorganics						
Moisture Content	%	0.1		9.3	10.1	14.1	18.3
Sulphate	µg/g	0.4		110	78	40	92

Client: Thurber Engineering Ltd.
Project: 15786
Project Manager: Rocío Reyna
Samplers: N/A

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

Sample Number	5	6	7	8
Sample Name	RO3-SS4	RO9-SS13	RO8-SS6	RO5-SS16
Sample Matrix	Soil	Soil	Soil	Soil
Sample Date	12/04/2018	22/04/2018	03/05/2018	08/05/2018

Parameter	Units	RL		Result	Result	Result	Result
Other (ORP)							
Chloride	µg/g	0.4		910	11	200	24

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	DIO0502-MAY18	µg/g	0.4	<0.4	12	20	93	80	120	108	75	125
Sulphate	DIO0502-MAY18	µg/g	0.4	<0.4	0	20	97	80	120	97	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	ECS0053-MAY18	%	0.02	<0.02	ND	20	91	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	EWL0517-MAY18	uS/cm	2	< 0.002	5	10	101	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	EWL0517-MAY18	no unit	0.05	NA	0		100			NA		

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

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

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

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

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

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

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

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

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

LEGEND

FOOTNOTES

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

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

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

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated. This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at http://www.sgs.com/terms_and_conditions.htm. The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents.

-- End of Analytical Report --

SGS

Request for Laboratory Services and CHAIN OF CUSTODY

No: Page 1 of 1

SGS Environmental Services - 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: Ismail
Received Date (mm/dd/yyyy): 05/28/18 (mm\dd\yy)
Received Time: 12:45 pm
Received By (signature):
Custody Seal Present: ☐ NO
Custody Seal Intact: ☐ NO
Cooling Agent Present: ☐ NO
Temperature Upon Receipt (°C): 11X3
LAB LIMS #: CA14856-May 18

REPORT INFORMATION

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

INVOICE INFORMATION

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

PROJECT INFORMATION

Quotation #: 15786
Project #: 15786
P.O. #:
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 ☐ Table 2 ☐ Table 3 ☐ Table ____ ☐ Res/Park ☐ Ind/Com ☐ Agri/Other Soil Texture: ☐ Coarse ☐ Medium ☐ Fine

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

ANALYSIS REQUESTED

	SAMPLE IDENTIFICATION	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX	PHC F1-F4 BTEX	O.Reg153 Metals (ICP & hydride metals)	☐Hg ☐B-HWS ☐Cr(VI)	O.Reg 153 VOCs	Corrosivity								COMMENTS: Field Filtered (F) Preserved (P)
1	R03-SS4	April 12/18		1	Soil					✓								
2																		
3	R09-SS13	April 22/18		1	Soil					✓								
4																		
5	R08-SS6	May 03/18		1	Soil					✓								
6																		
7	R05-SS16	May 08/18		1	Soil					✓								
8																		
9																		
10																		

Observations/Comments/Special Instructions

Sampled By (NAME): **Signature:** Date: May / 23 / 2018 (mm/dd/yy)

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

Pink Copy - Client
Yellow & White Copy - SGS

Revision #: 1.0
Date of Issue: 01 June, 2014

SGS

SAMPLE INTEGRITY REPORT

Project Number: 15786

ONTARIO REGULATION 153/04

SGS Sample ID CA14856-May 18

Date / Time Sampled See CofC

Client Sample ID See CofC

	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: _____

THURBER

Appendix C

Record of Borehole Sheets and Laboratory Test Results

(Previous Site Investigation)

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No RR-1 1 of 2 METRIC

G.W.P. 03-20024 **LOCATION** Coords: 4 859 313.0 N; 314 655.4 E **ORIGINATED BY** F.P.

DIST Central **HWY** 404 **BOREHOLE TYPE** Continuous Flight Hollow Stem Augers **COMPILED BY** N.R.

DATUM Geodetic **DATE** Ocotober 6-8, 2014 **CHECKED BY** D.D.

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
202.9	Ground Surface										
0.0	Clayey silt, organics sand and gravel inclusions Stiff Brown Moist		1	SS	9				○		
	Silt and sand, trace clay Compact Brown Moist		2	SS	13		202		○		
			3	SS	16		201		○		0 40 56 4
	Loose to compact Wet		4	SS	5		200		○		
			5	SS	15				○		
			6	SS	20		199		○		
			7	SS	10		198		○		
			8	SS	10				○		
			9	SS	17		197		○⊣		5 42 36 17
	(FILL)		10	SS	23		196		○		
194.2							195				
8.7	Silty sand trace clay, trace gravel Dense to very dense Grey Moist to wet sand layers		11	SS	44	▽	194		○		3 91 (6)
			12	SS	42		193		○		
	sand and silt layer		13	SS	45		192		○		3 46 45 6
			14	SS	50/13cm		191				
	Cont'd						190				
							189				
							188				

+7, ×5 : Numbers refer to Sensitivity

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

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No RR-1 2 of 2 METRIC

G.W.P. 03-20024 **LOCATION** Coords: 4 859 313.0 N; 314 655.4 E **ORIGINATED BY** F.P.

DIST Central **HWY** 404 **BOREHOLE TYPE** Continuous Flight Hollow Stem Augers **COMPILED BY** N.R.

DATUM Geodetic **DATE** Ocotober 6-8, 2014 **CHECKED BY** D.D.

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
187.9	Silty sand trace clay, trace gravel										
187.2	Very dense Grey Wet (Cont'd.)		15	SS	68				○		
15.7	Clayey silt some sand, trace gravel Hard Grey Moist sandy silt seams (TILL)		16	SS	103/23cm		187 186 185		○		
			17	SS	102		184		H		2 18 52 28
182.9			18	SS	50/8cm		183				
20.0	End of borehole										

* 2014 10 06 to 08

▽ Water level observed during drilling

Water Level Readings:

Date	Depth (m)	Elev.
Dec.18/2014	9.4	193.5

Piezometer Legend:

- Bentonite
- Filter sand
- Screen
- Bentonite Seal

+7, ×5 : Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No RR-2 1 of 2 METRIC

G.W.P. 03-20024 **LOCATION** Coords: 4 859 398.1 N; 314 621.9 E **ORIGINATED BY** F.P.

DIST Central **HWY** 404 **BOREHOLE TYPE** Continuous Flight Hollow Stem Augers **COMPILED BY** N.R.

DATUM Geodetic **DATE** Ocotober 5 & 6, 2014 **CHECKED BY** D.D.

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
203.2	Ground Surface										
0.0 / 202.9	Topsoil										
0.3	Clayey silt sand and gravel inclusions Firm to stiff Brown Moist (FILL)		1	SS	5		203		○		
			2	SS	7		202		○		
			3	SS	7		201		○		
			4	SS	4		200		○		
			5	SS	8		199		○		
			6	SS	13				○		
198.7											
4.5	cobbles		7	SS	50/8cm		198				
			8	SS	15		197		○		
			9	SS	13		196		○		
			10	SS	21		195		○		3 29 36 32
194.7											
8.5	Silty sand trace to some clay trace gravel clayey silt seams Very dense Grey to dense Wet to moist		11	SS	62	▽	194		○		0 10 73 17
	silt layer		12	SS	48		193		○		
	sand layers		13	SS	11		192		○		0 77 20 3
			14	SS	2		191		○		
	Cont'd						190				
							189				

+7, ×5 : Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No RR-2 2 of 2 METRIC

G.W.P. 03-20024 **LOCATION** Coords: 4 859 398.1 N; 314 621.9 E **ORIGINATED BY** F.P.

DIST Central **HWY** 404 **BOREHOLE TYPE** Continuous Flight Hollow Stem Augers **COMPILED BY** N.R.

DATUM Geodetic **DATE** Ocotober 5 & 6, 2014 **CHECKED BY** D.D.

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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
188.2	Silty sand trace to some clay trace gravel clayey silt seams Dense Brown Wet (Cont'd.)		15	SS	34		188		○		
	Gravelly sand layers some silt, trace clay						187				
	Very dense Grey Wet		16	SS	50/8cm		186				36 50 11 3
185.5											
17.7	Clayey silt trace sand, trace gravel Hard Grey Moist silty clay layers		17	SS	104/23cm		185		○		3 9 35 53
	silty sand layers (TILL)						184				
183.1			18	SS	50/10cm						
20.1	End of borehole										

* 2014 10 05 to 06

▽ Water level observed during drilling

NOTE: Low 'N' values suspectible to hydraulic disturbances

Water Level Readings:

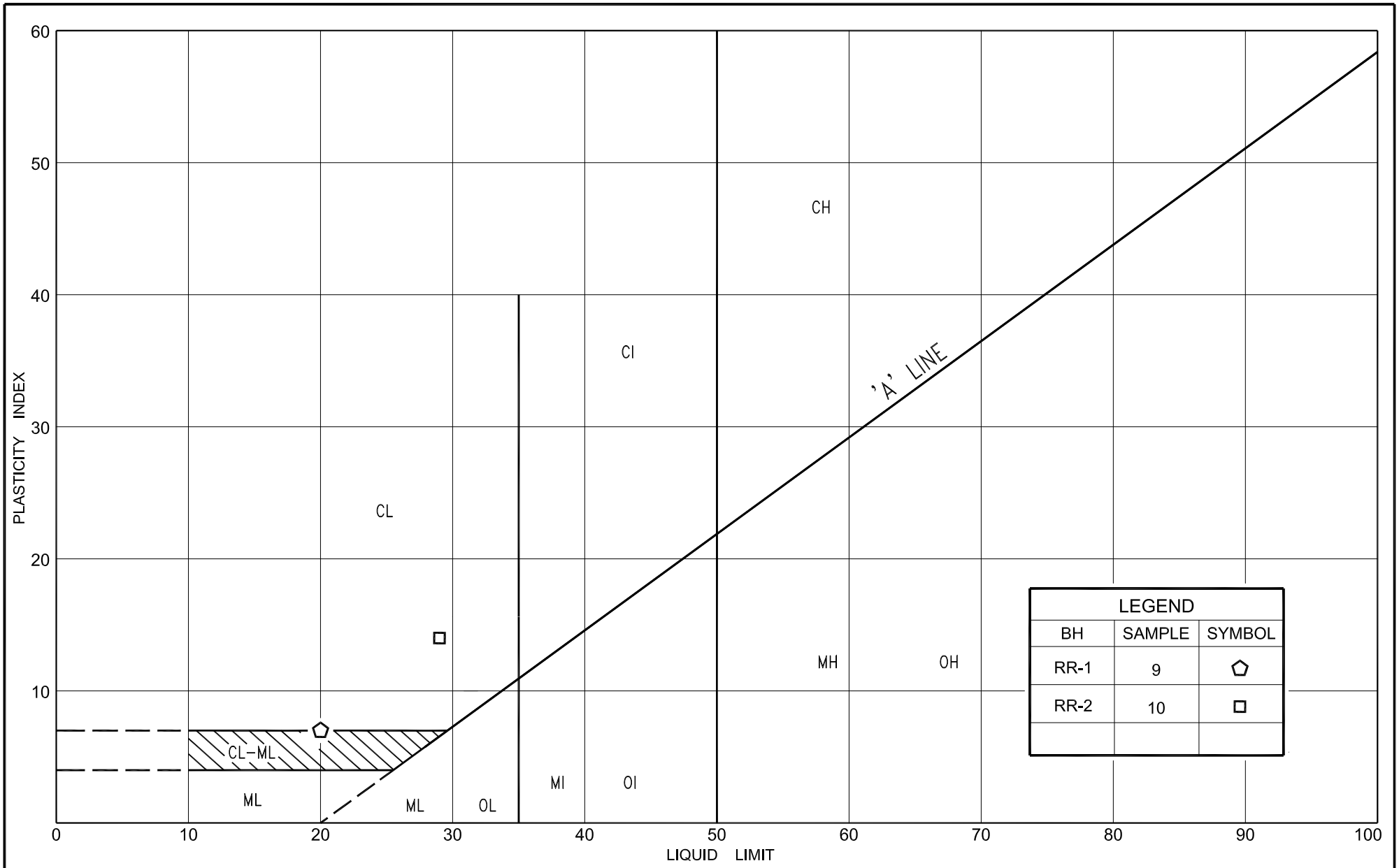
Date	Depth (m)	Elev.
Dec.18/2014	9.9	193.3

Piezometer Legend:

- Bentonite
- Filter sand
- Screen
- Bentonite Seal

+ , × : Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

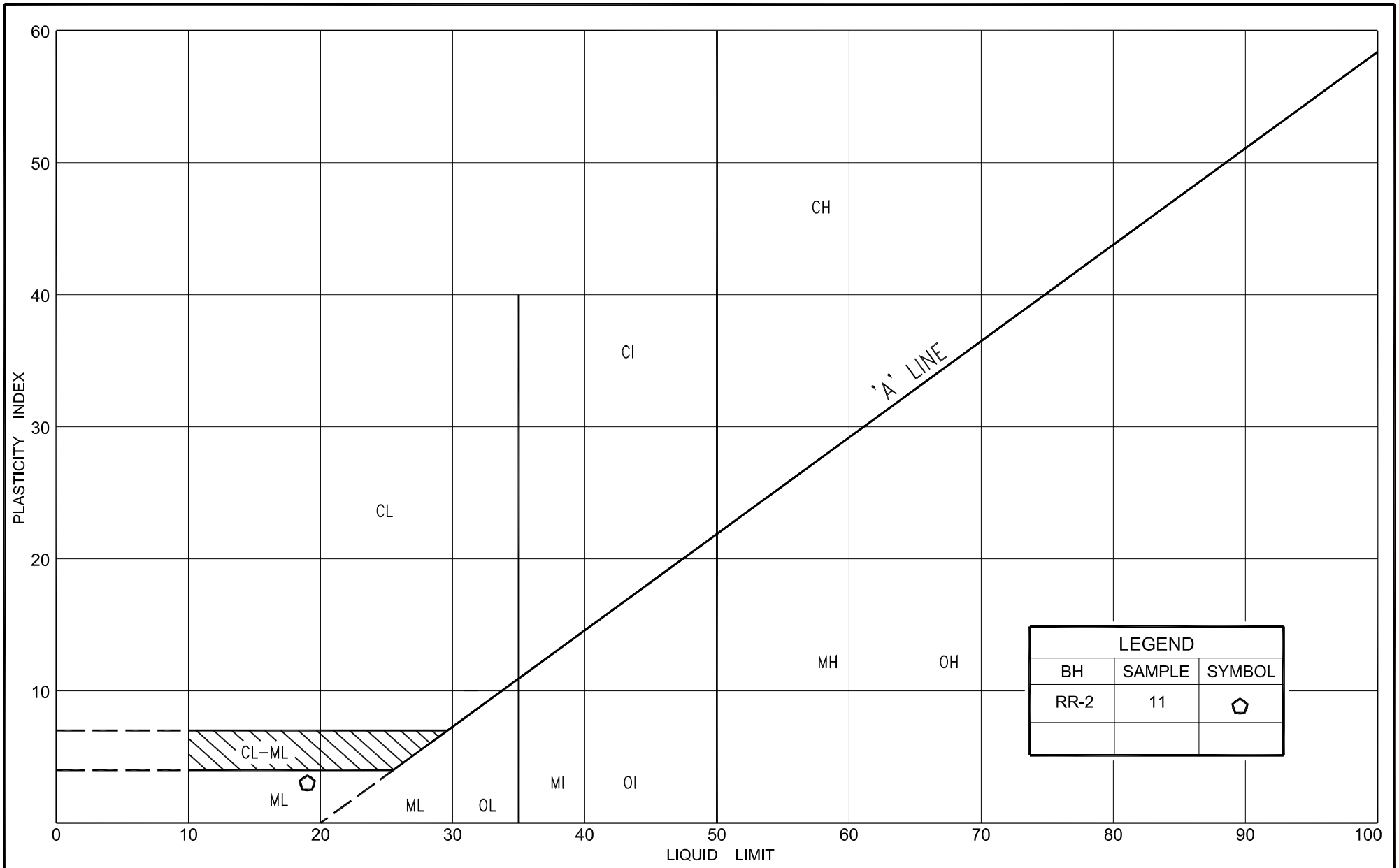


Ontario

PLASTICITY CHART

CLAYEY SILT, Silt and sand layers
(FILL)

FIG No.	RR-PC-1
HWY:	404
G.W.P. No.	03-20024

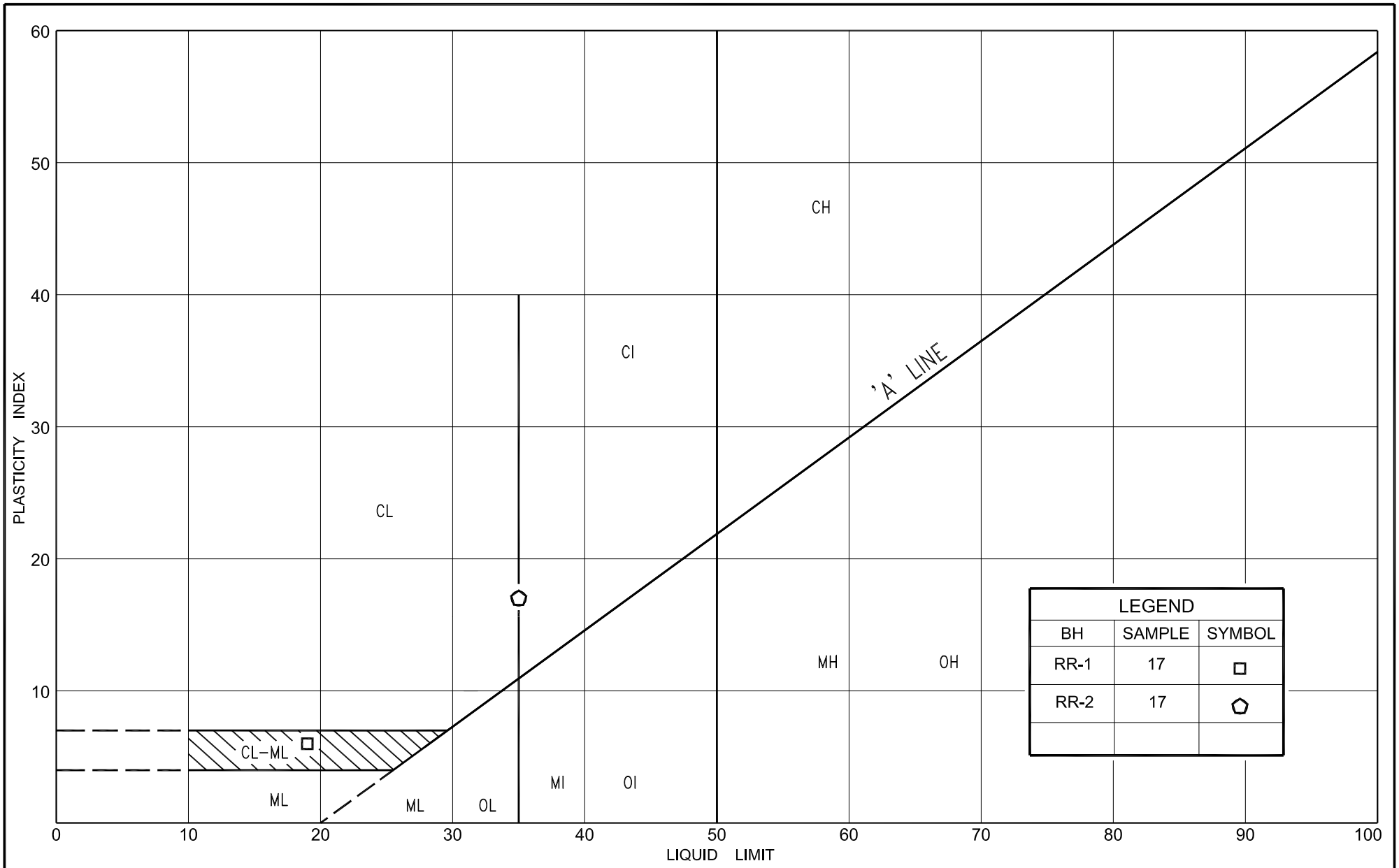


Ontario

PLASTICITY CHART

SILTY SAND, trace clay, trace gravel
silt and gravelly sand layers

FIG No.	RR-PC-2
HWY:	404
G.W.P. No.	03-20024

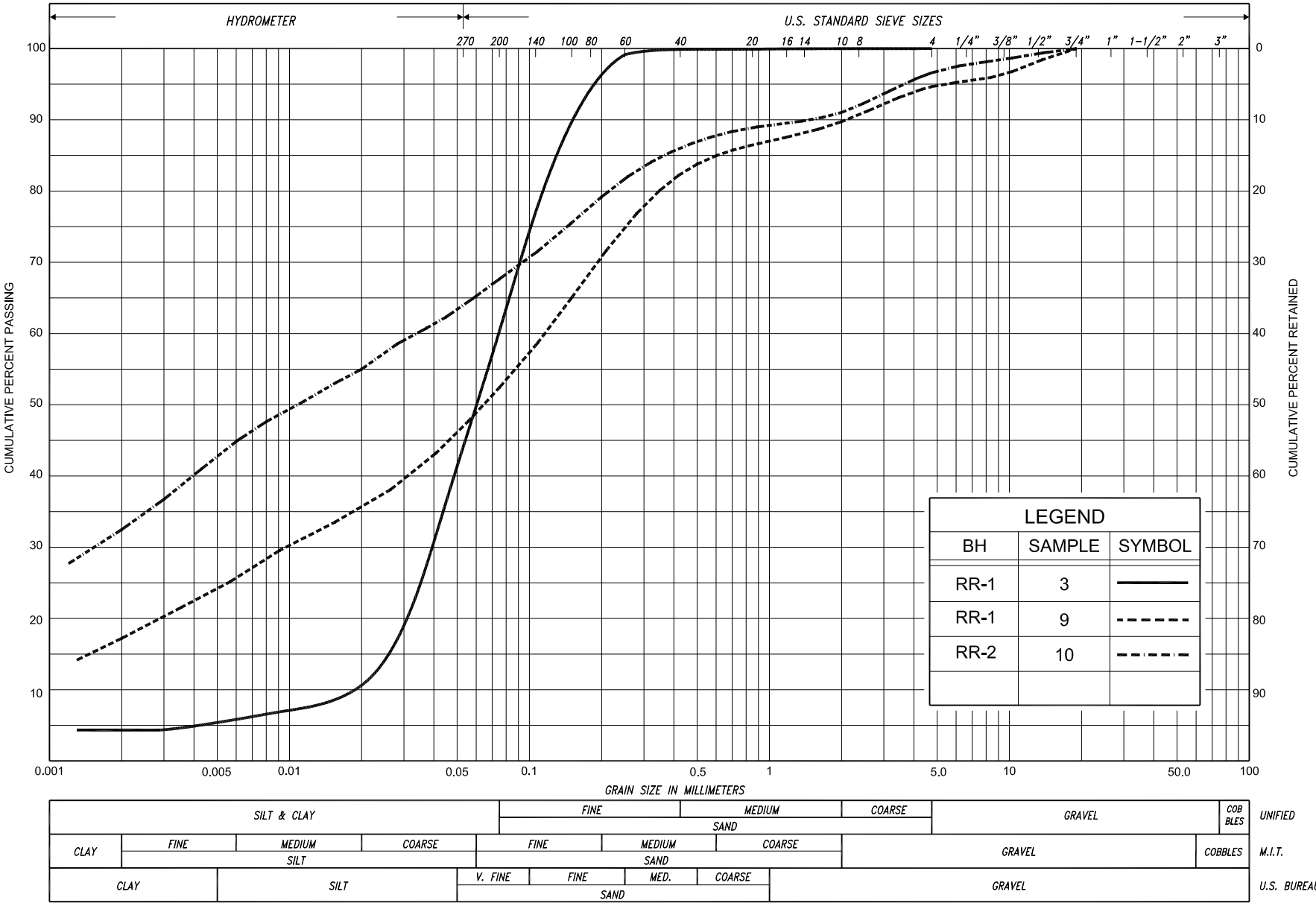


Ontario

PLASTICITY CHART

CLAYEY SILT, trace sand, trace gravel (CL)
silty clay layers
(TILL)

FIG No.	RR-PC-3
HWY:	404
G.W.P. No.	03-20024

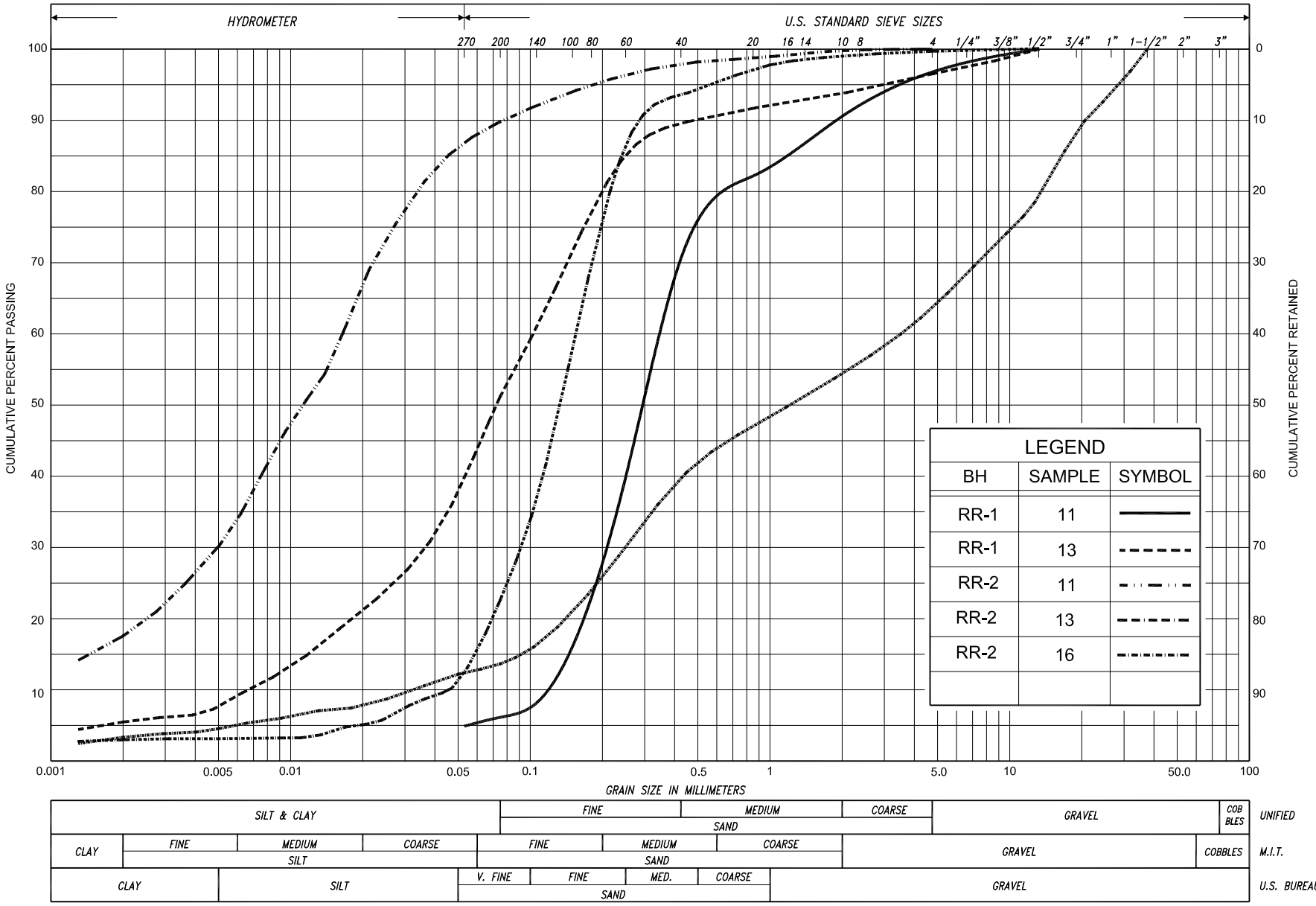


Ontario

GRAIN SIZE DISTRIBUTION

CLAYEY SILT, Silt and sand layers
(FILL)

FIG No.	RR-GS-1
HWY:	404
G.W.P. No.	03-20024

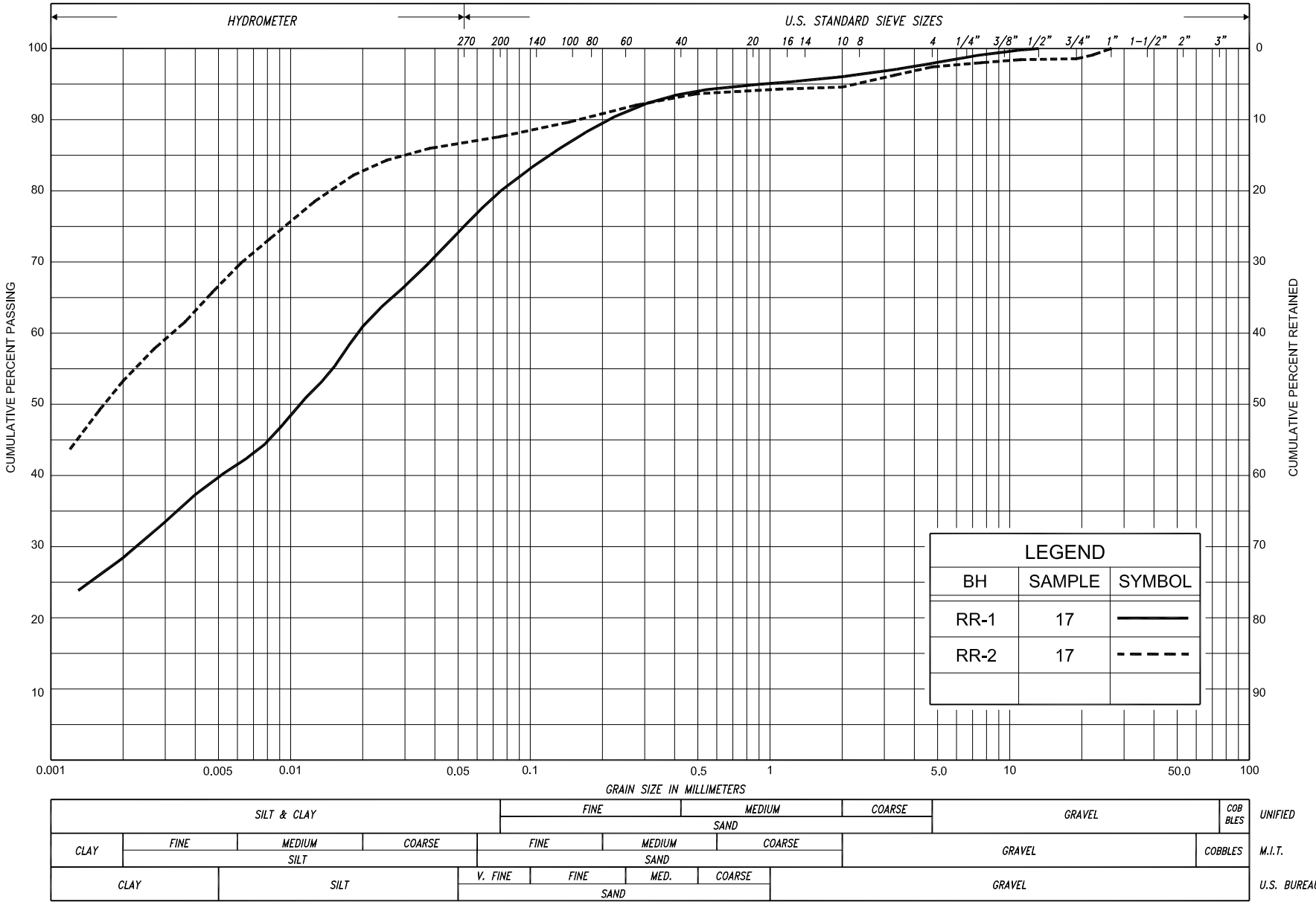


Ontario

GRAIN SIZE DISTRIBUTION

SILTY SAND, trace clay, trace gravel
silt and gravelly sand layers

FIG No.	RR-GS-2
HWY:	404
G.W.P. No.	03-20024



Ontario

GRAIN SIZE DISTRIBUTION

CLAYEY SILT, trace sand, trace gravel (CL)
silty clay layers
(TILL)

FIG No.	RR-GS-3
HWY:	404
G.W.P. No.	03-20024

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 1

WP 160-74-26 LOCATION Co-ords. N 15 942 080; E 1 032 064 ORIGINATED BY VK

DIST 6 HWY 404 BORING DATE January 15, 1971 COMPILED BY VK

DATUM Geodetic BOREHOLE TYPE Washboring-NX Casing; Cone CHECKED BY RS

SOIL PROFILE ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) SHEAR STRENGTH: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE	LIQUID LIMIT w_L, PLASTIC LIMIT w_P, WATER CONTENT w (w_P — w — w_L) WATER CONTENT %	UNIT WEIGHT γ	REMARKS % GR SA SI CL
638.2	Ground Level									
	Topsoil									
1.0	Silty sand with some gravel		1	SS	17					
	Compact to Very Dense Brown Grey		2	SS	16	630				
			3	SS	40					
			4	SS	66					
623.2										
15.0	Gravel		5	SS	26					
16.5						620				
			6	SS	34					0 54 43 3
612.2										
25.0	Clayey Silt		7	SS	45					
27.0						610				
606.7			8	SS	187					
31.5	End of Borehole									

20
15 0-5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE Nº 2

W/P 160-74-26 LOCATION Co-ords. N 15 942 100; E 1 032 158 ORIGINATED BY VK

DIST 6 HWY 404 BORING DATE Jan. 20, 1971 COMPILED BY VK

DATUM Geodetic BOREHOLE TYPE Washboring-NX Casing; Cone CHECKED BY [illegible]

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w	UNIT WEIGHT	REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	ELEV	20 40 60 80 100 SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	w_P — w — w_L WATER CONTENT %	γ	% GR SA SI CL
638.0	Ground Level									
	Topsoil	≈≈								
1.0	Silty sand with some gravel-trace of clay		1	SS	23					
			2	SS	16	630				7 72 19 2
	Brown		3	SS	24					
	Grey		4	SS	60					
			5	SS	48		100/6"			9 79 10 2
						620				
			6	SS	64					
			7	SS	167					
						610				
607.0			8	SS	165					
31.0	End of Borehole									

OFFICE REPORT ON SOIL EXPLORATION

20
15 ○ S % STRAIN AT FAILURE
10

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS - ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 3

WP 160-74-26 LOCATION Co-ords N 15 942 024; E 1 032 223 ORIGINATED BY VK

DIST 6 HWY 404 BORING DATE January 21, 1971 COMPILED BY VK

DATUM Geodetic BOREHOLE TYPE Washboring-NX Casing; Cone CHECKED BY [illegible]

SOIL PROFILE ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) SHEAR STRENGTH: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	LIQUID LIMIT w_L PLASTIC LIMIT w_P WATER CONTENT w (w_P — w — w_L) WATER CONTENT %	UNIT WEIGHT γ	REMARKS % GR SA SI CL
637.9	Ground Level									
	Topsoil									
1.0	Silty sand with gravel-trace of clay		1	SS	3					
			2	SS	19	630				
	Loose - Very Dense		3	SS	64					
	Brown		4	SS	42					33 54 10 3
			5	SS	67	620				
617.9	Boulder		6	SS	100/6"					
20.0	End of Borehole									

OFFICE REPORT ON SOIL EXPLORATION

20
15 G-5 % STRAIN AT FAILURE
10

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE Nº 4

WP 160-74-26 LOCATION Co-ords. N 15 942 040; E 1 032 309 ORIGINATED BY VK

DIST 6 HWY 404 BORING DATE January 21, 1971 COMPILED BY VK

DATUM Geodetic BOREHOLE TYPE Washboring-MX Casing; Cone CHECKED BY RS

SOIL PROFILE ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) SHEAR STRENGTH: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	LIQUID LIMIT w_L PLASTIC LIMIT w_P WATER CONTENT w (w_P — w — w_L) WATER CONTENT %	UNIT WEIGHT γ	REMARKS % GR SA SI CL
635.5	Ground Level									
	Topsoil									
1.0	Silty sand with some gravel-trace of clay		1	SS	15	630				
			2	SS	17					8 82 (10)
	Compact to Very Dense		3	SS	44					
	Brown		4	SS	60					34 55 10 1
617.5			5	SS	91	620				
18.0	Clayey silt									
19.5			6	SS	156/6"					
609.0			7	SS	157/6"	610				
26.5	End of Borehole									

OFFICE REPORT ON SOIL EXPLORATION

20
15 ⊕ 5 % STRAIN AT FAILURE
10

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS - ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 5

WP 160-74-26 LOCATION co-ords N 15 941 969; E 1 032 379 ORIGINATED BY VK

DIST 6 HWY 404 BORING DATE Jan. 20, 1971 COMPILED BY VK

DATUM Geodetic BOREHOLE TYPE Washboring-NX Casing; Core CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH P.S.F. (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	LIQUID LIMIT W_L / PLASTIC LIMIT W_P / WATER CONTENT W (W_P — W — W_L) / WATER CONTENT %	UNIT WEIGHT γ	REMARKS / % GR SA SI CL
637.1	Ground Level									
	Topsoil									
1.0	Silty sand with some gravel-trace of clay		1	SS	9					
						630				
			2	SS	13					16 73 (11)
	Loose to Very Dense		3	SS	67					
			4	SS	73		125			
	Brown									
			5	SS	148					1 57 38 4
						620				
			6	SS	135/4"					
611.1			7	SS	130/5"					
26.0	End of Borehole									

OFFICE REPORT ON SOIL EXPLORATION

20
15 Q-5 % STRAIN AT FAILURE
10

THURBER

Appendix D

Selected Site Photographs

Photo 1.- Highway 404 SBL Piers (looking southeast)
Photo taken on November 3, 2016

Photo 2.- Highway 404 SBL, North Approach (looking north)
Photo taken on November 3, 2016

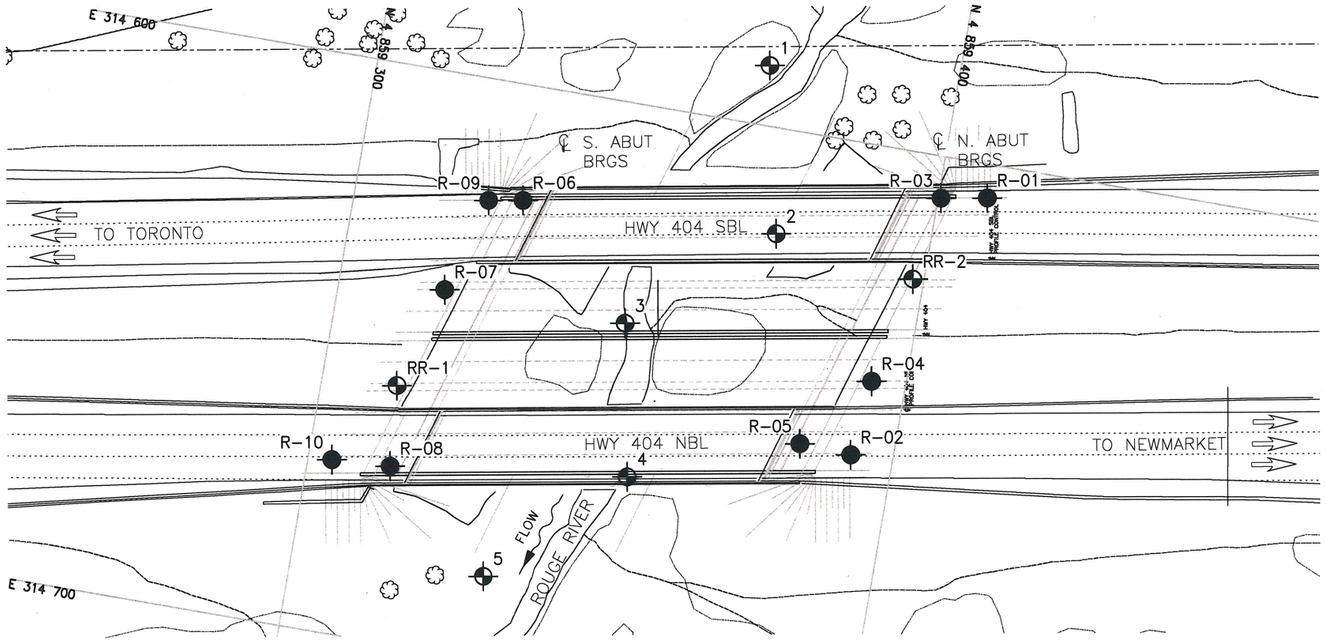
Photo 3.- Highway 404 SBL, South Abutment and Pier (looking east)
Photo taken on November 3, 2016

Photo 4.- Highway 404 NBL, North Abutment and Approach (looking north)
Photo taken on November 3, 2016

THURBER

Appendix E

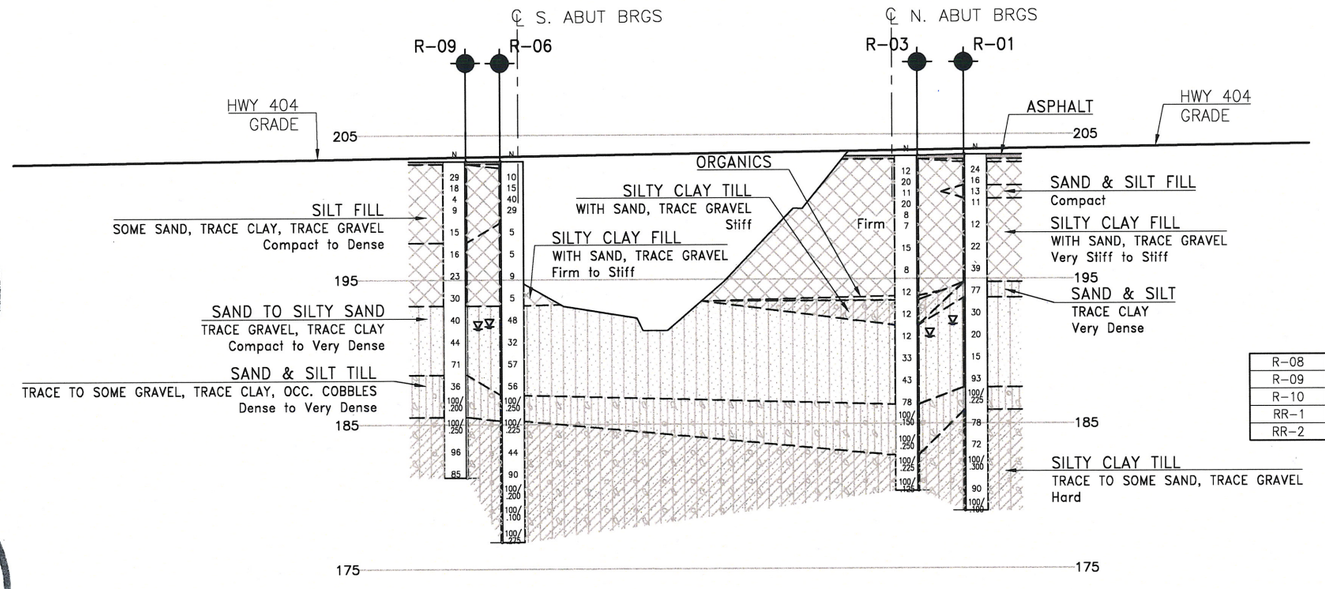
Borehole Locations and Soil Strata Drawings



PLAN

20 0 20 40m

SCALE 1:1000



PROFILE ALONG HWY 404 SBL

20 0 20 40m H 1:1000

8 0 8 16m V 1:400

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
GWP No 2930-17-00

HIGHWAY 404
ROUGE RIVER BRIDGE REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

wsp

THURBER ENGINEERING LTD.

KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
1	194.5	4 859 367.3	314 589.5
2	194.5	4 859 373.4	314 618.2
3	194.4	4 859 350.2	314 638.0
4	193.7	4 859 355.1	314 664.2
5	194.2	4 859 333.4	314 685.5
R-01	203.6	4 859 408.4	314 605.8
R-02	203.5	4 859 392.7	314 653.8
R-03	203.5	4 859 400.5	314 607.2
R-04	202.9	4 859 394.1	314 640.6
R-05	203.5	4 859 383.7	314 653.4
R-06	203.2	4 859 329.1	314 620.0
R-07	202.6	4 859 318.3	314 637.6
R-08	203.1	4 859 314.2	314 669.4
R-09	203.2	4 859 323.2	314 621.0
R-10	203.1	4 859 304.1	314 670.0
RR-1	202.9	4 859 313.0	314 655.4
RR-2	203.2	4 859 398.1	314 621.9

-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. 30M14-485

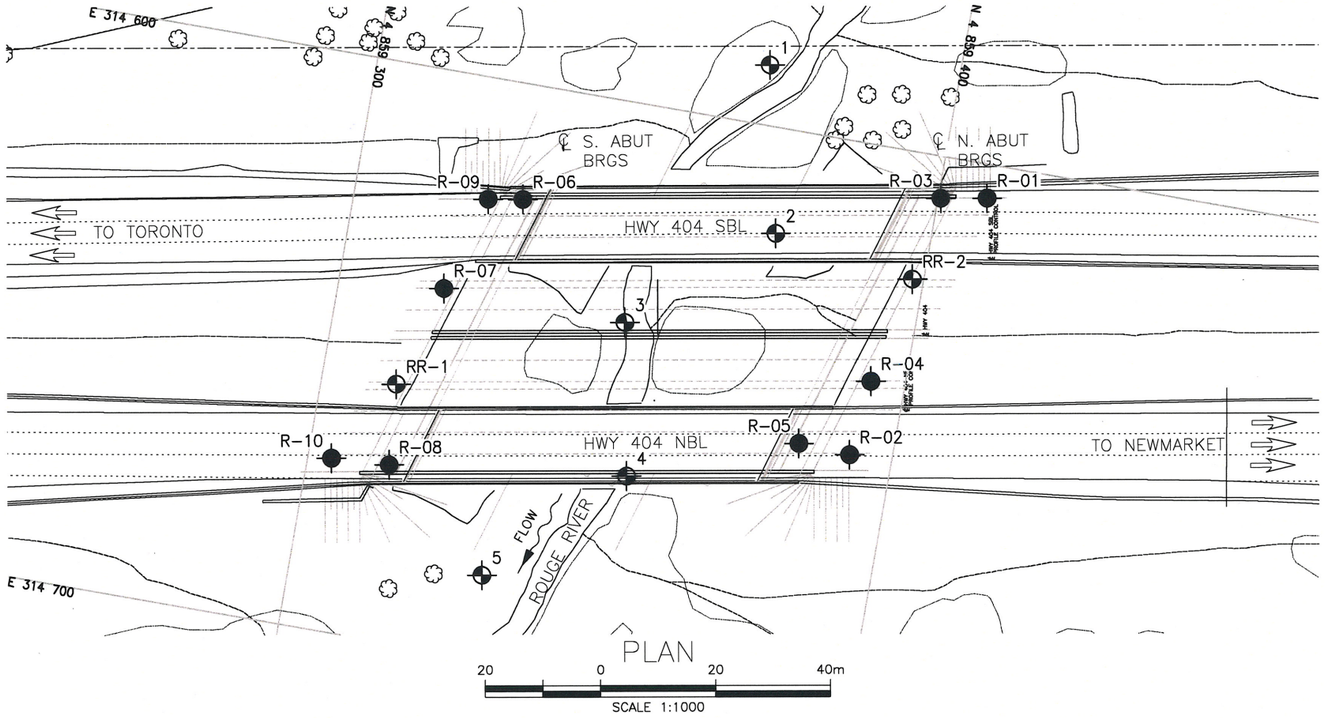
REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	RPR	CHK	SKP	CODE	LOAD
DRAWN	AN	CHK	RPR	SITE	STRUCT

DATE JAN 2019
DWG 1

FILENAME: H:\Drafting\15000\15786\TES-15786-PLRR-RougeRiver.dwg
PLOTDATE: 1/17/2019 2:16 PM

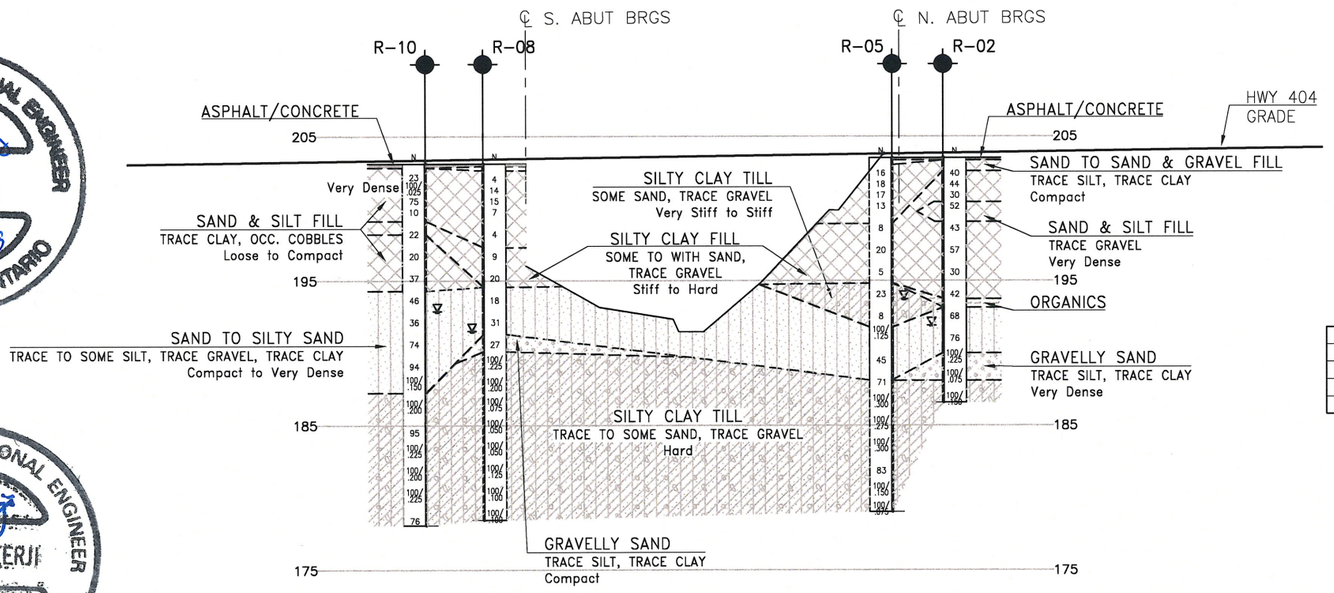
MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

20 0 20 40m

SCALE 1:1000



PROFILE ALONG HWY 404 NBL

20 0 20 40m H 1:1000

8 0 8 16m V 1:400

LICENSED PROFESSIONAL ENGINEER
S. PANG
95316509
Province of Ontario

LICENSED PROFESSIONAL ENGINEER
P.K. CHATTERJI
Province of Ontario

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
GWP No 2930-17-00

SHEET

HIGHWAY 404
ROUGE RIVER BRIDGE
REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

wsp

THURBER ENGINEERING LTD.

KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
1	194.5	4 859 367.3	314 589.5
2	194.5	4 859 373.4	314 618.2
3	194.4	4 859 350.2	314 638.0
4	193.7	4 859 355.1	314 664.2
5	194.2	4 859 333.4	314 685.5
R-01	203.6	4 859 408.4	314 605.8
R-02	203.5	4 859 392.7	314 653.8
R-03	203.5	4 859 400.5	314 607.2
R-04	202.9	4 859 394.1	314 640.6
R-05	203.5	4 859 383.7	314 653.4
R-06	203.2	4 859 329.1	314 620.0
R-07	202.6	4 859 318.3	314 637.6
R-08	203.1	4 859 314.2	314 669.4
R-09	203.2	4 859 323.2	314 621.0
R-10	203.1	4 859 304.1	314 670.0
RR-1	202.9	4 859 313.0	314 655.4
RR-2	203.2	4 859 398.1	314 621.9

-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. 30M14-485

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	RPR	CHK	SKP	CODE	LOAD
DRAWN	AN	CHK	RPR	SITE	STRUCT

DATE JAN 2019
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METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
GWP No 2930-17-00

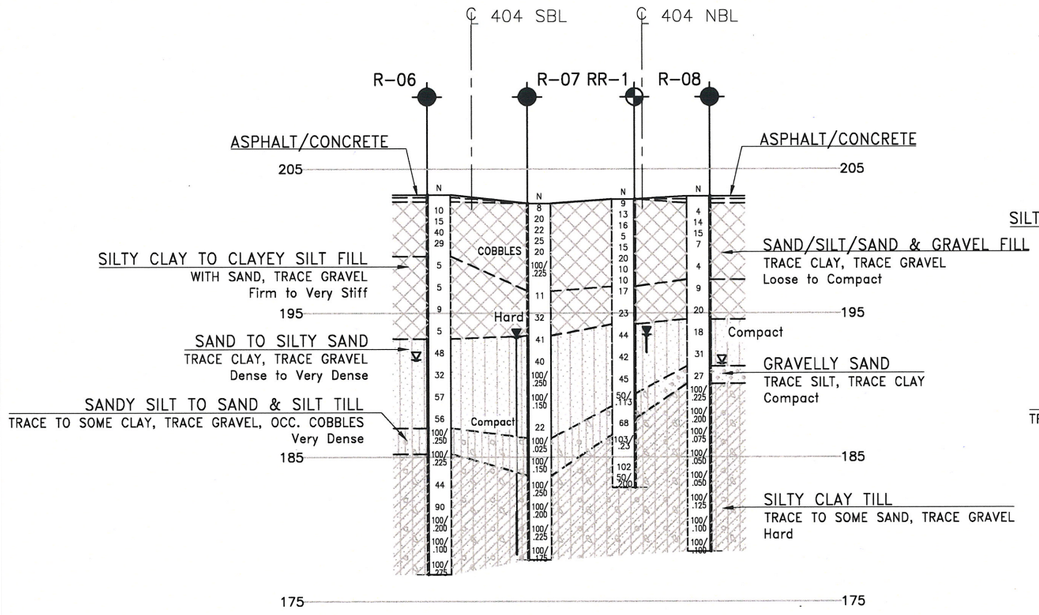
HIGHWAY 404
ROUGE RIVER BRIDGE REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

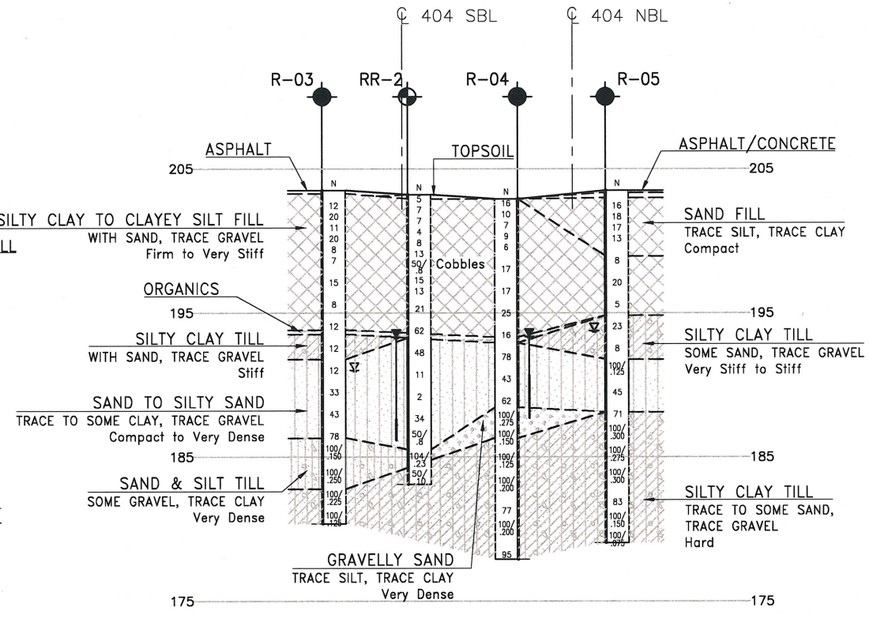
WSP

THURBER ENGINEERING LTD.

KEYPLAN



SECTION ALONG S. ABUT. BRGS



SECTION ALONG N. ABUT. BRGS

LEGEND

◆	Borehole (Current Investigation)
◈	Borehole (Previous Investigations)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
⧗	Water Level (Open Borehole)
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
1	194.5	4 859 367.3	314 589.5
2	194.5	4 859 373.4	314 618.2
3	194.4	4 859 350.2	314 638.0
4	193.7	4 859 355.1	314 664.2
5	194.2	4 859 333.4	314 685.5
R-01	203.6	4 859 408.4	314 605.8
R-02	203.5	4 859 392.7	314 653.8
R-03	203.5	4 859 400.5	314 607.2
R-04	202.9	4 859 394.1	314 640.6
R-05	203.5	4 859 383.7	314 653.4
R-06	203.2	4 859 329.1	314 620.0
R-07	202.6	4 859 318.3	314 637.6
R-08	203.1	4 859 314.2	314 669.4
R-09	203.2	4 859 323.2	314 621.0
R-10	203.1	4 859 304.1	314 670.0
RR-1	202.9	4 859 313.0	314 655.4
RR-2	203.2	4 859 398.1	314 621.9

20 0 20 40m H 1:1000

8 0 8 16m V 1:400

-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. 30M14-485

LICENSED PROFESSIONAL ENGINEER
S. PAINE
95814509
Jan 24/19
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P.K. CHATTERJI
Jan 24/19
PROVINCE OF ONTARIO

REVISIONS			
DATE	BY	DESCRIPTION	
DESIGN RPR	CHK SKP	CODE	LOAD
DRAWN AN	CHK RPR	SITE	STRUCT

DATE JAN 2019
DWG 3

FILENAME: H:\Drafting\15000\15786\TES-15786-PLPR-RougeRiver.dwg
PLOTDATE: 1/17/2019 2:17 PM

THURBER

Appendix F

Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES

Spread Footings on Native Soils or Engineered Fill	Steel H-Piles Driven to Practical Refusal	Steel Pipe Piles Driven to Practical Refusal	Augered Caissons
Advantages: i. Generally less costly construction than deep foundation elements. ii. Relative ease of construction. ***Disadvantages:*** i. Relatively deep excavations (up to 10 m) would be required to bear footings on native competent soils. ii. Roadway protection and dewatering will be required iii. Foundations generally close to water/river requiring scour and erosion protection.	***Advantages:*** i. High geotechnical resistance may be developed by driving the piles into very dense/hard soils. ii. Suitable for integral abutment design. iii. Foundation construction requires less volume of excavation than footings. ***Disadvantages:*** i. Higher unit cost compared to footings. ii. Potential adverse effects on existing foundations due to vibrations associated with pile driving.	***Advantages:*** i. High geotechnical resistance can be developed by driving the piles into very dense/hard soils. ii. Foundation construction requires less volume of excavation than footings. ***Disadvantages:*** i. Higher unit cost compared to footings. ii. Suitability for integral abutment design should be assessed if required. iii. When driven into hard/very dense till deposits, pipe piles are more prone to pile tip damage in comparison to H-piles. iv. Potential adverse effects on existing foundations due to vibrations associated with pile driving.	***Advantages:*** i. High geotechnical resistance available for units founded on very dense/hard till. ii. Likely requires smaller work zone than other alternatives during construction. iii. Sub-excavation of fill and variable material not required. ***Disadvantages:*** i. Higher cost than spread footings ii. Specialized installation measures such as temporary liners and drilling slurry will be required to install caissons under the water table. iii. Potential loss of ground during installation could have adverse impacts on existing bridges. iv. Potential difficulties during augering to dislodge, remove or otherwise penetrate cobbles, boulders and hard/very dense zones within the tills.
RELATIVE COSTS			
MEDIUM	**MEDIUM**	**MEDIUM**	**HIGH**
RELATIVE RISKS			
MEDIUM	**LOW**	**MEDIUM**	**HIGH**
NOT RECOMMENDED	**RECOMMENDED**	**FEASIBLE**	**TECHNICALLY FEASIBLE BUT NOT PREFERABLE**

THURBER

Appendix G

Selected Slope Stability Output

Name: Embankment fill Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Compact to very dense sands and silts Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 33 ° Phi-B: 0 ° Piezometric Line
Name: Very dense sand and silt till Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 34 ° Phi-B: 0 ° Piezometric Line: 1
Name: Hard silt clay till Unit Weight: 20 kN/m³ Cohesion: 2 kPa Phi: 32 ° Phi-B: 0 ° Piezometric Line: 1
Name: Wall Unit Weight: 23 kN/m³ Cohesion: 300 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1

Project Number: 15786
Highway 404
Rouge River Bridge
Embankment height approximately 11.5 m high
Forward slope- normal operation
Drained Analysis

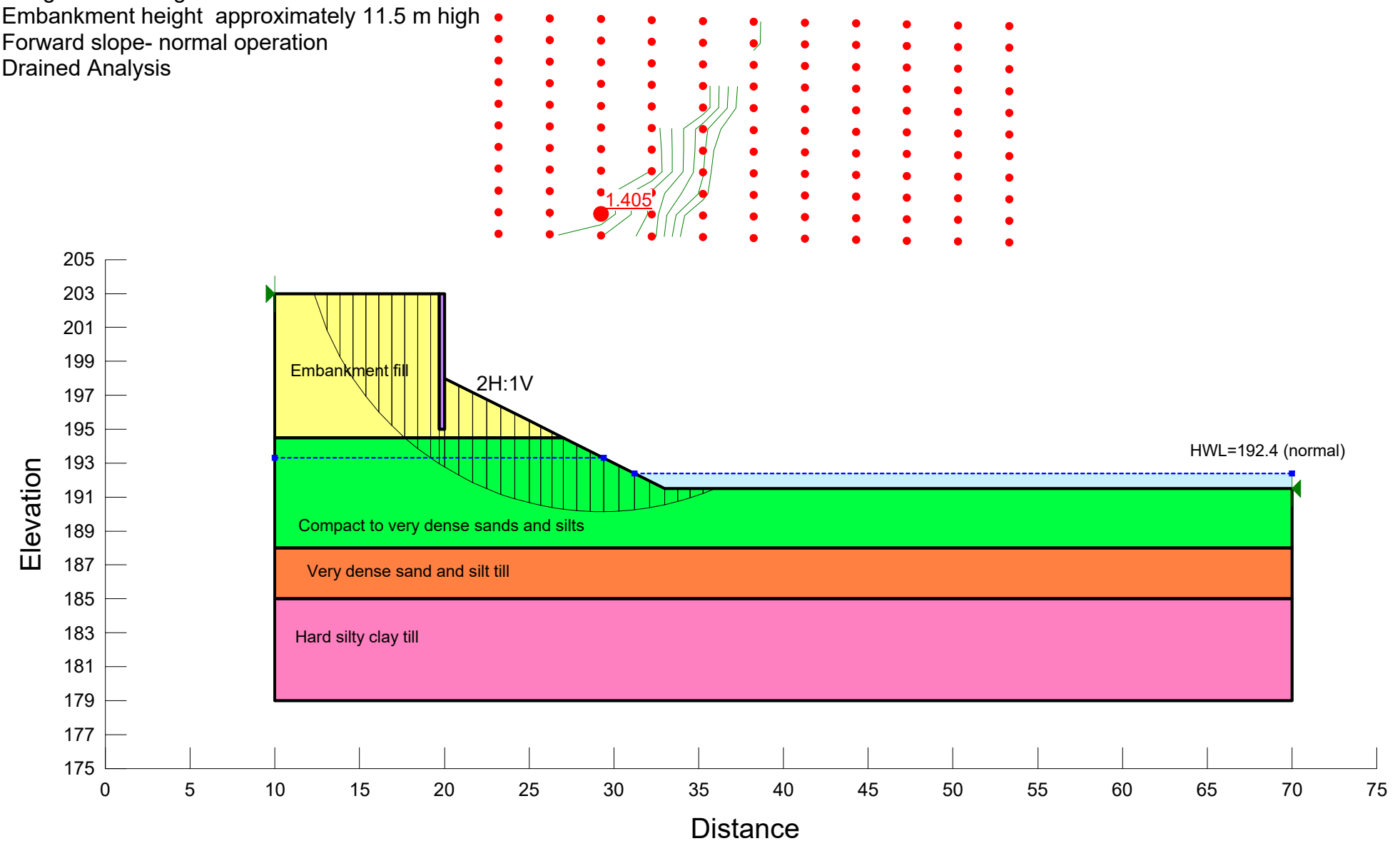


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Figure 1G

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Name: Very dense sand and silt till Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 34 ° Phi-B: 0 ° Piezometric Line: 1
Name: Hard silt clay till Unit Weight: 20 kN/m³ Cohesion: 200 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1
Name: Wall Unit Weight: 23 kN/m³ Cohesion: 300 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1

Project Number: 15786
Highway 404
Rouge River Bridge
Embankment height approximately 11.5 m high
Forward slope- normal operation
Undrained Analysis

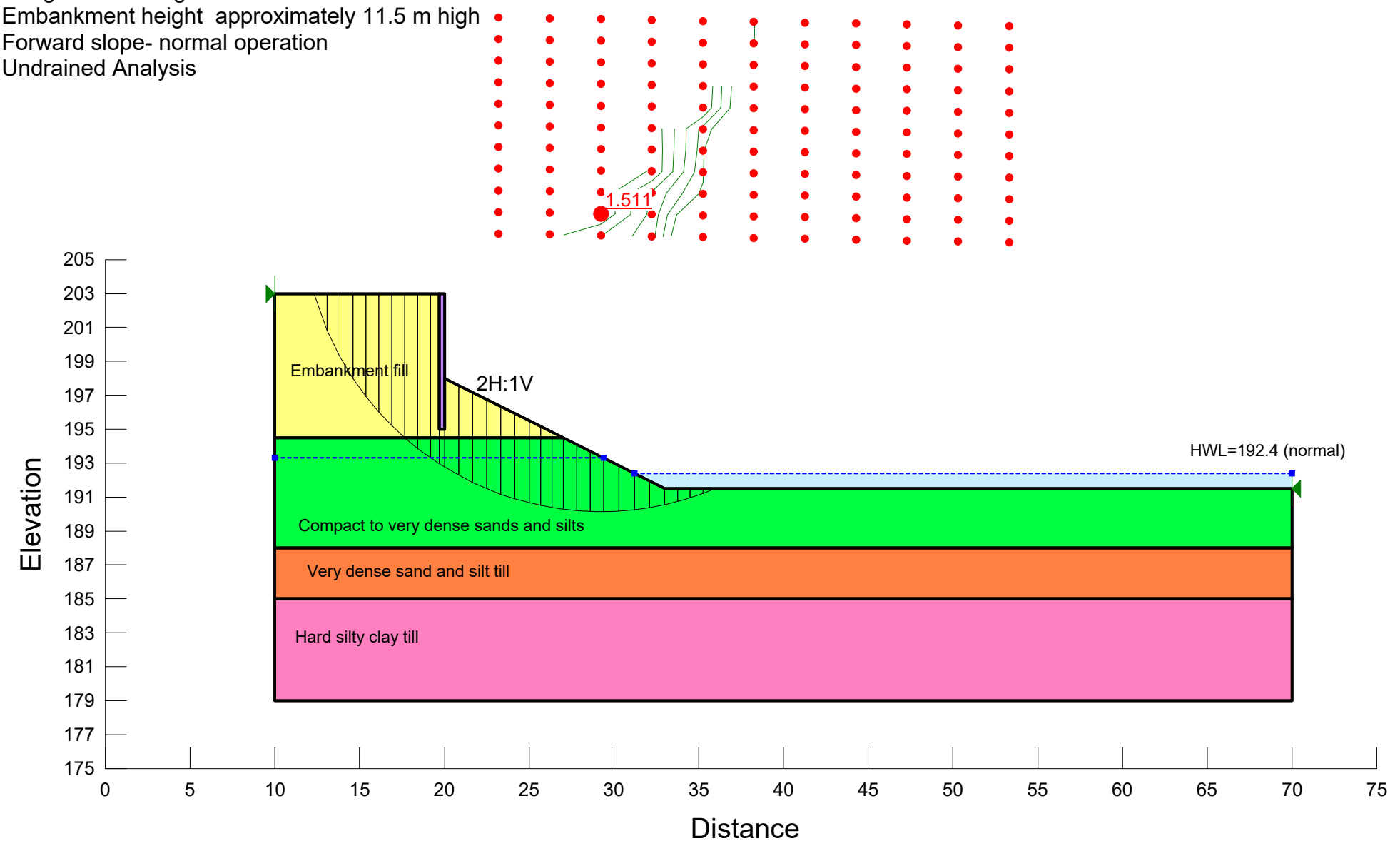

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Figure 2G

Name: Embankment fill Unit Weight: 19 kN/m³ Cohesion: 40 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1
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Name: Hard silt clay till Unit Weight: 20 kN/m³ Cohesion: 200 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1
Name: Wall Unit Weight: 23 kN/m³ Cohesion: 300 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1

Project Number: 15786
Highway 404
Rouge River Bridge
Embankment height approximately 11.5 m high
Forward slope- normal operation
Seismic Analysis PGA=0.13g

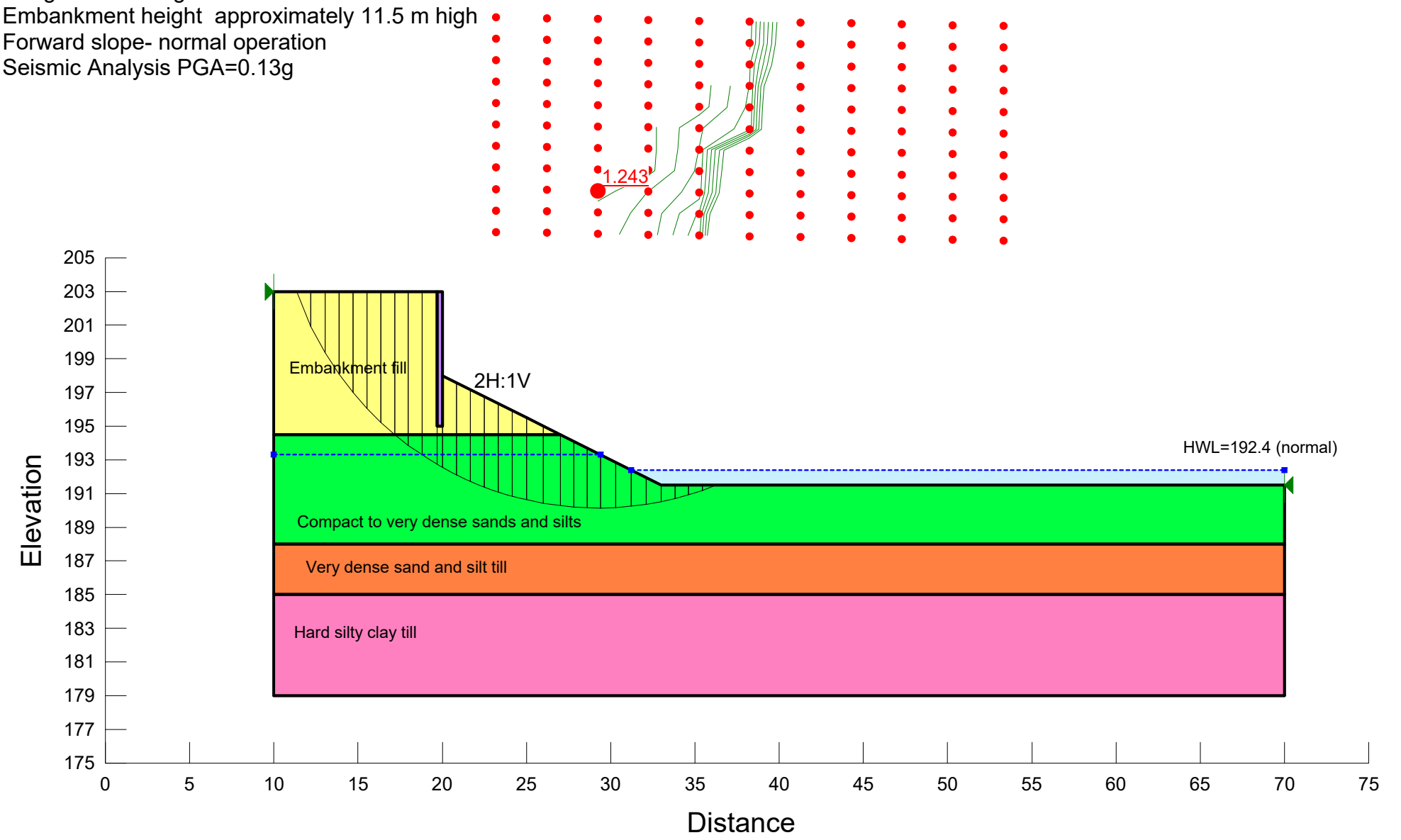

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Figure 3G

Name: Embankment fill Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
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Name: Hard silt clay till Unit Weight: 20 kN/m³ Cohesion: 2 kPa Phi: 32 ° Phi-B: 0 ° Piezometric Line: 1
Name: Wall Unit Weight: 23 kN/m³ Cohesion: 300 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1

Project Number: 15786
Highway 404
Rouge River Bridge
Embankment height approximately 11.5 m high
Forward slope-high water level
Drained Analysis

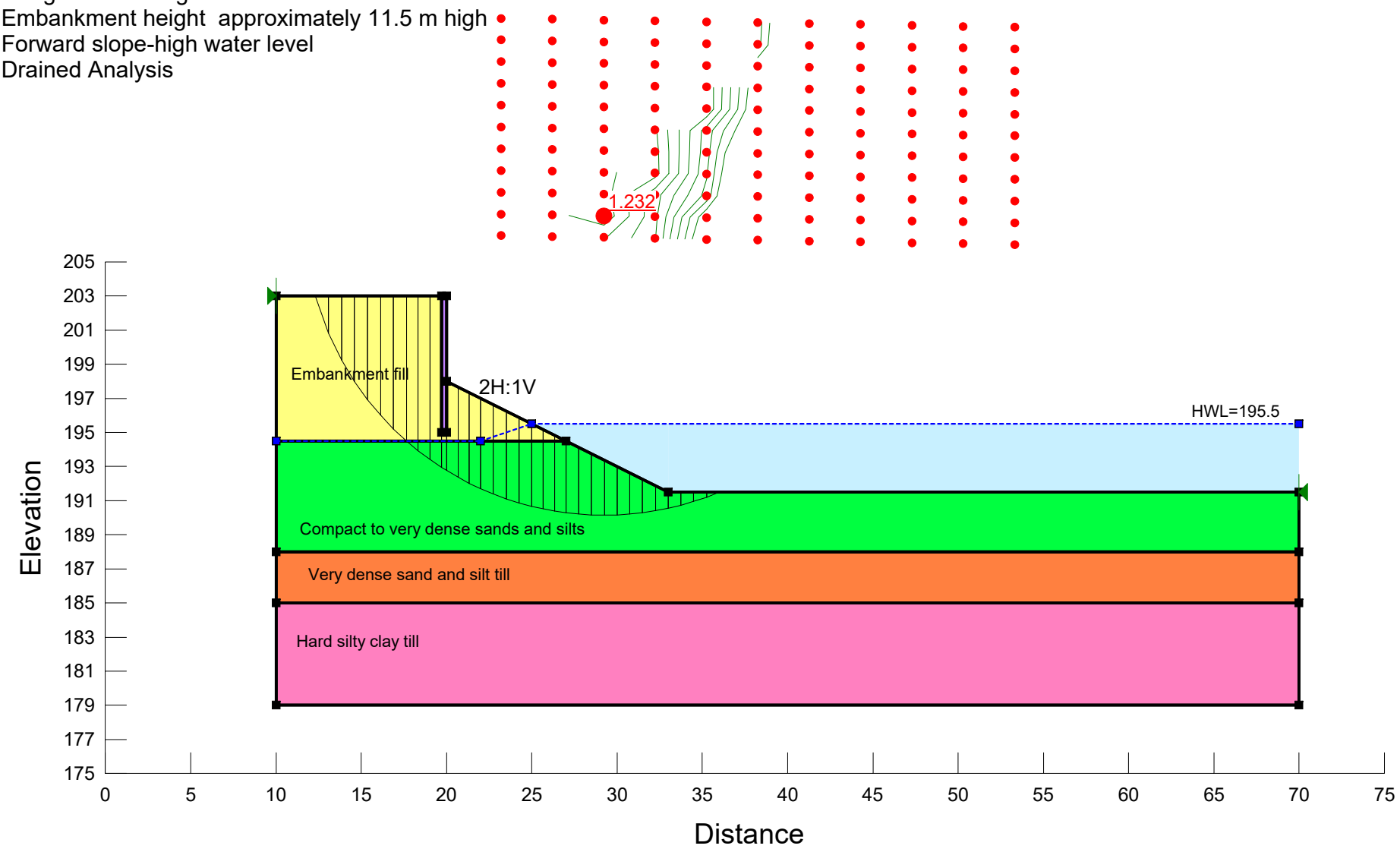

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Figure 4G

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Name: Hard silt clay till Unit Weight: 20 kN/m³ Cohesion: 200 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1
Name: Wall Unit Weight: 23 kN/m³ Cohesion: 300 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1

Project Number: 15786
Highway 404
Rouge River Bridge
Embankment height approximately 11.5 m high
Forward slope-high water level
Unrained Analysis

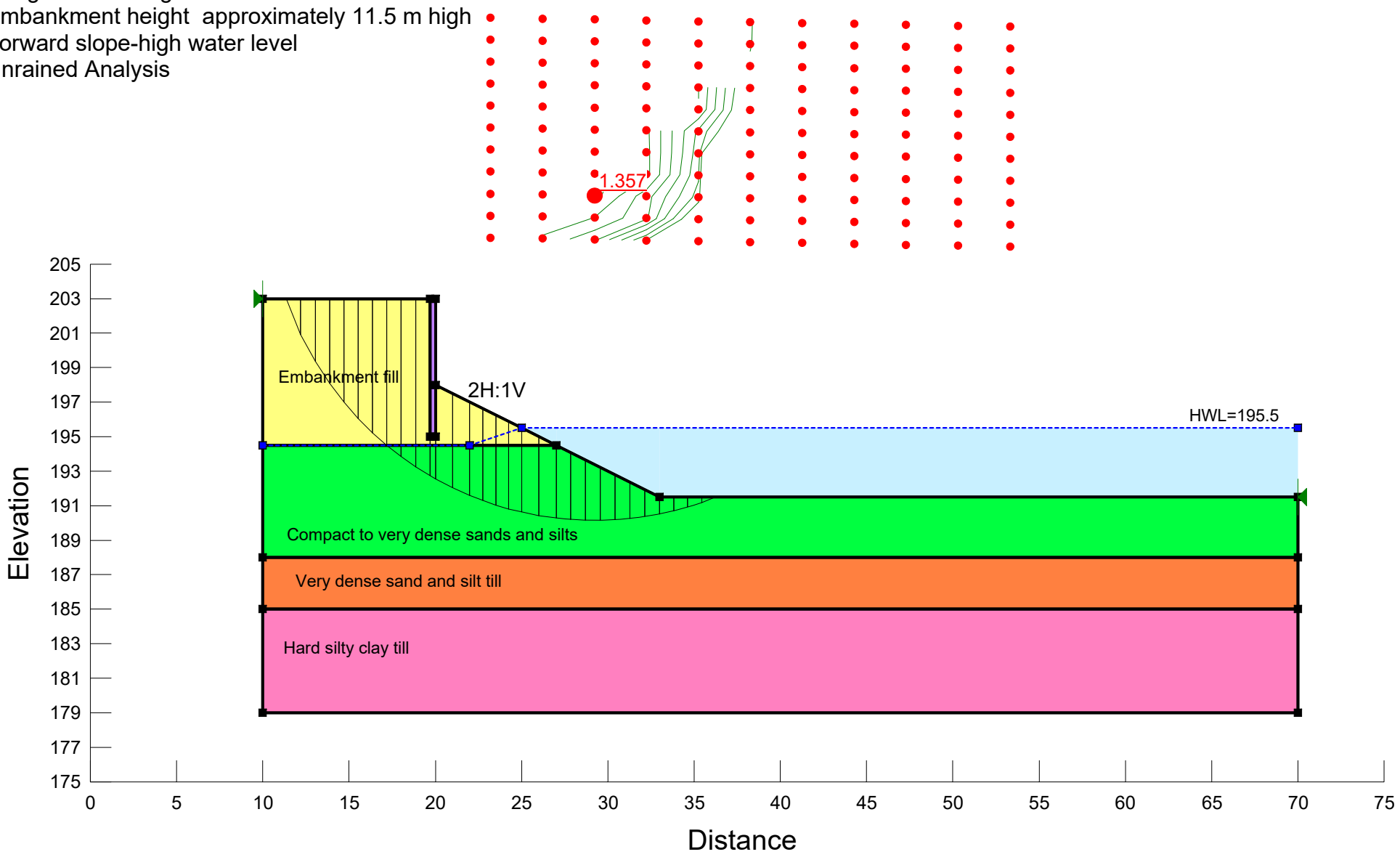

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Figure 5G

Name: Embankment fill Unit Weight: 19 kN/m³ Cohesion: 40 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1
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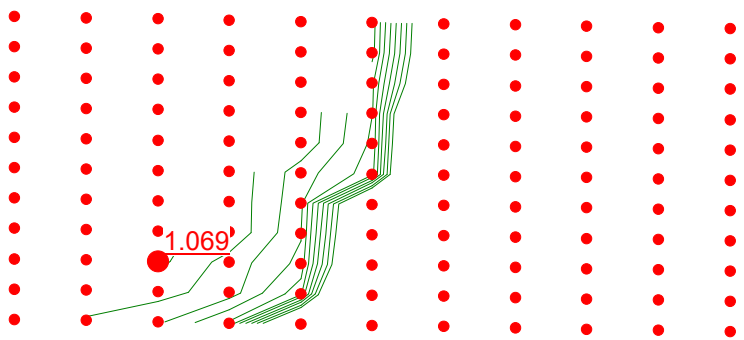
Name: Very dense sand and silt till Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 34 ° Phi-B: 0 ° Piezometric Line: 1
Name: Hard silt clay till Unit Weight: 20 kN/m³ Cohesion: 200 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1
Name: Wall Unit Weight: 23 kN/m³ Cohesion: 300 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1

Project Number: 15786
Highway 404
Rouge River Bridge
Embankment height approximately 11.5 m high
Forward slope-high water level
Seismic Analysis PGA=0.13g



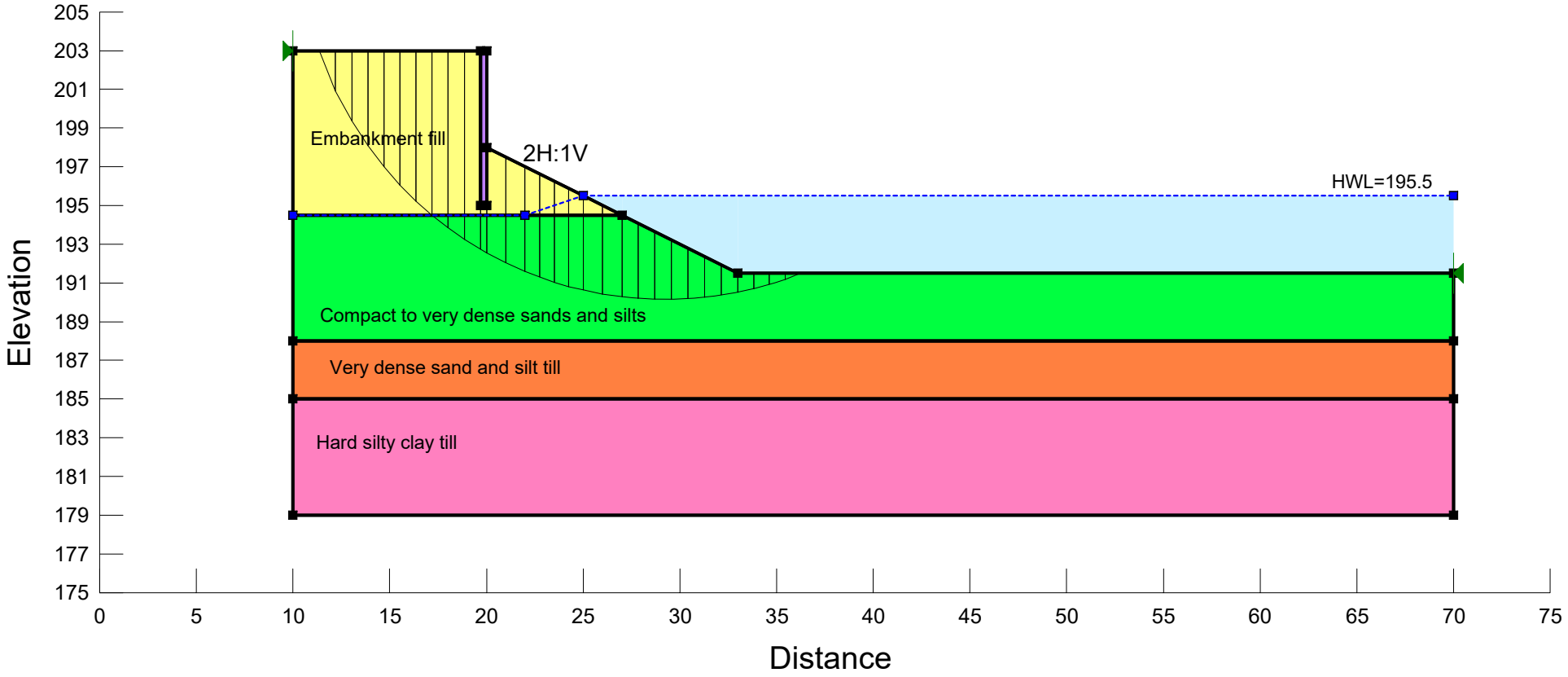


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Figure 6G

Name: Embankment fill Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
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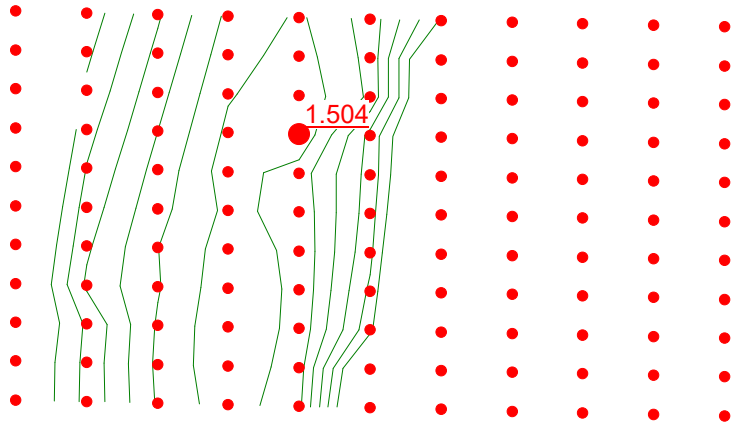
Name: Very dense sand and silt till Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 34 ° Phi-B: 0 ° Piezometric Line: 1
Name: Hard silty clay till Unit Weight: 20 kN/m³ Cohesion: 2 kPa Phi: 32 ° Phi-B: 0 ° Piezometric Line: 1

Project Number: 15786
Highway 404
Rouge River Bridge
Embankment Height approximately 11.5 m high
Side slope
Drained Analysis



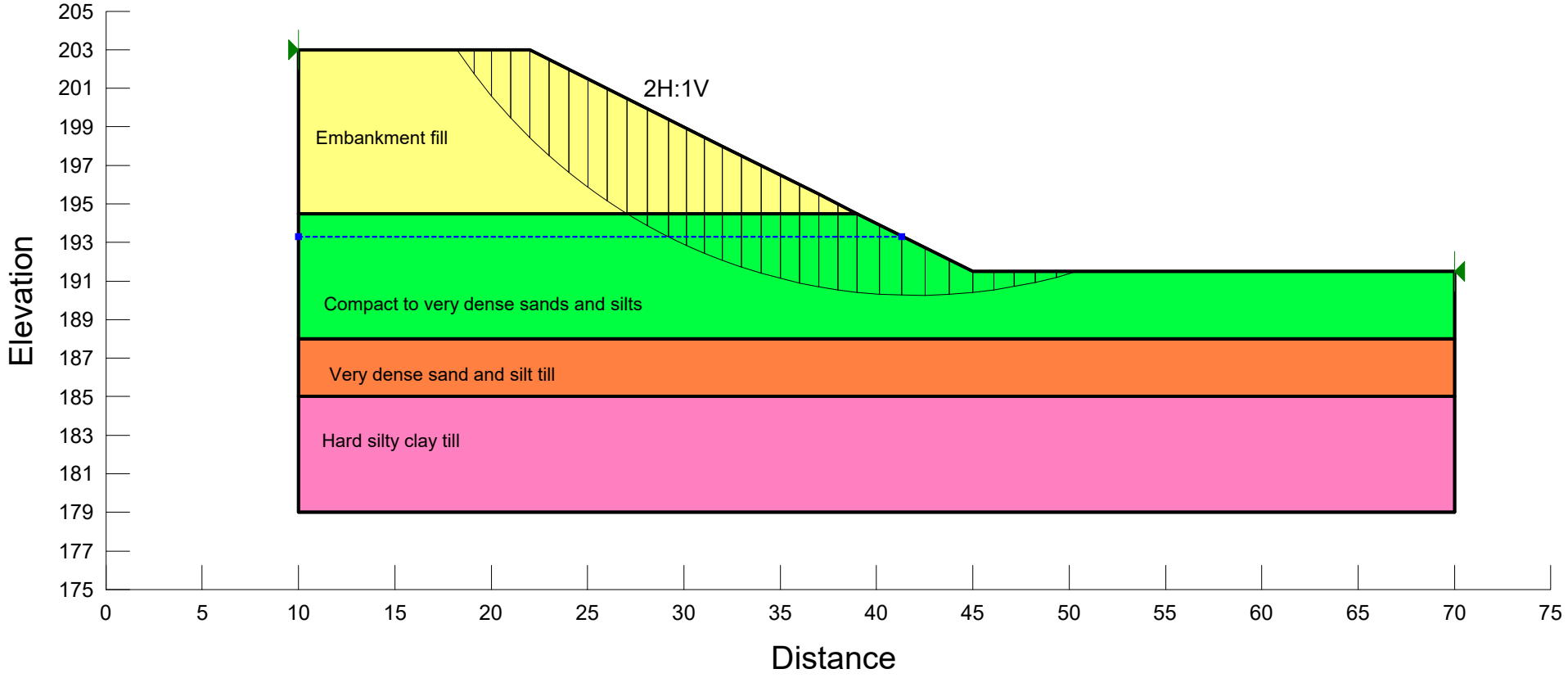


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Figure 7G

Name: Embankment fill Unit Weight: 19 kN/m³ Cohesion: 40 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1
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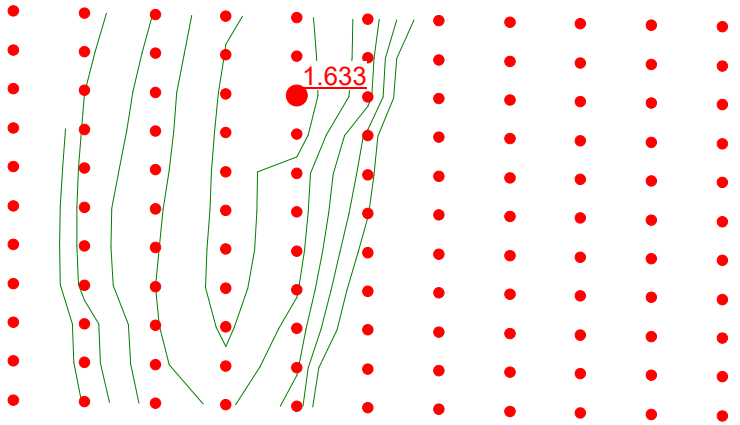
Name: Very dense sand and silt till Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 34 ° Phi-B: 0 ° Piezometric Line: 1
Name: Hard silty clay till Unit Weight: 20 kN/m³ Cohesion: 200 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1

Project Number: 15786
Highway 404
Rouge River Bridge
Embankment Height approximately 11.5 m high
Side slope
Undrained Analysis



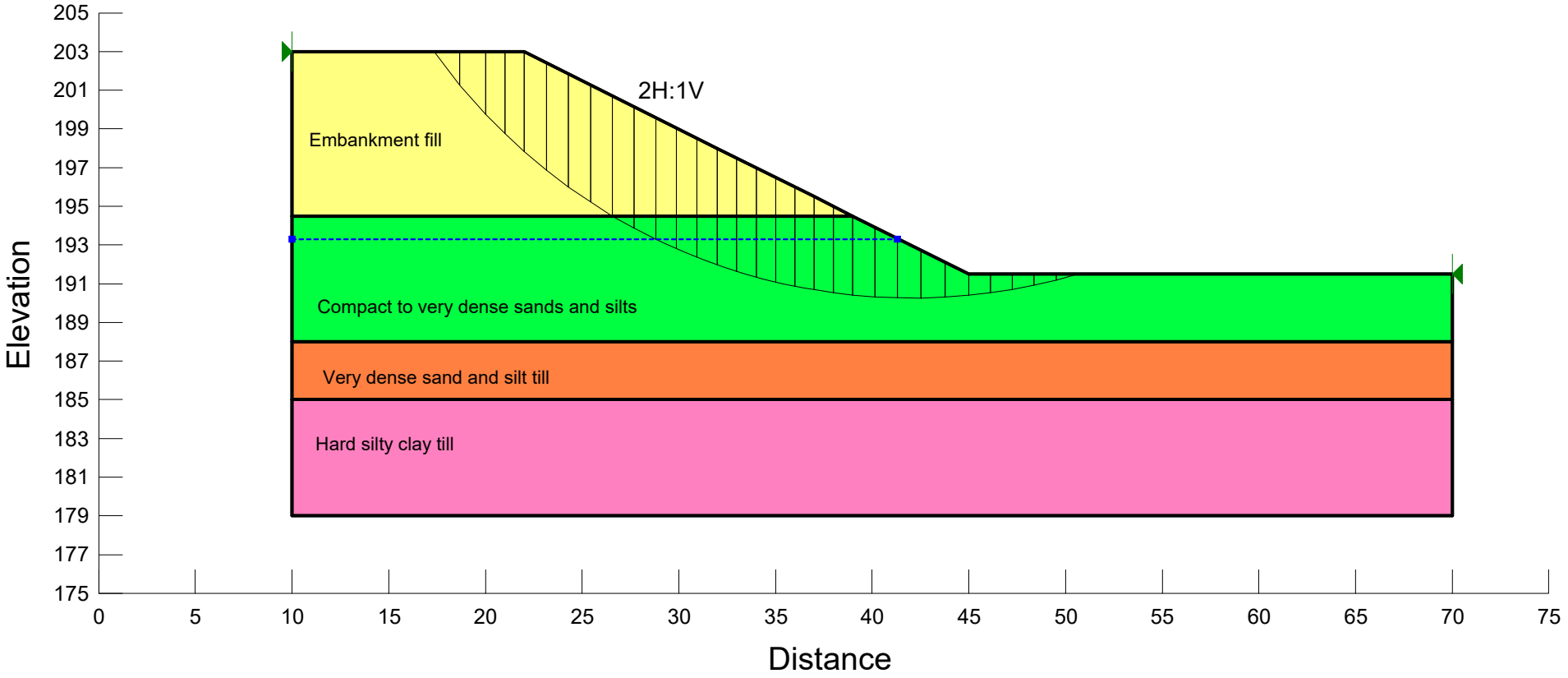


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Figure 8G

Name: Embankment fill Unit Weight: 19 kN/m³ Cohesion: 40 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1
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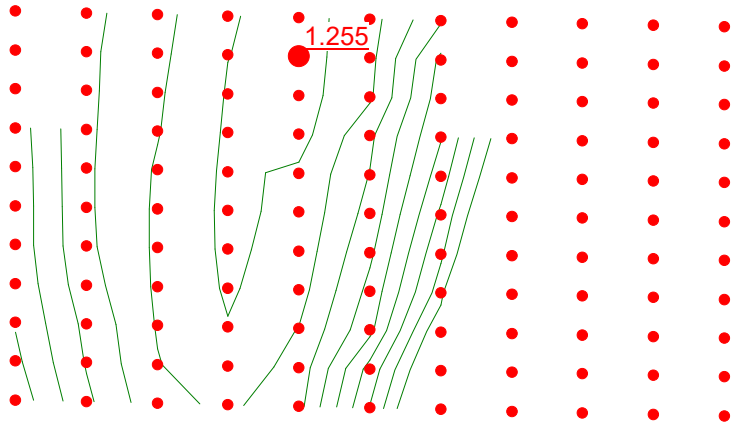
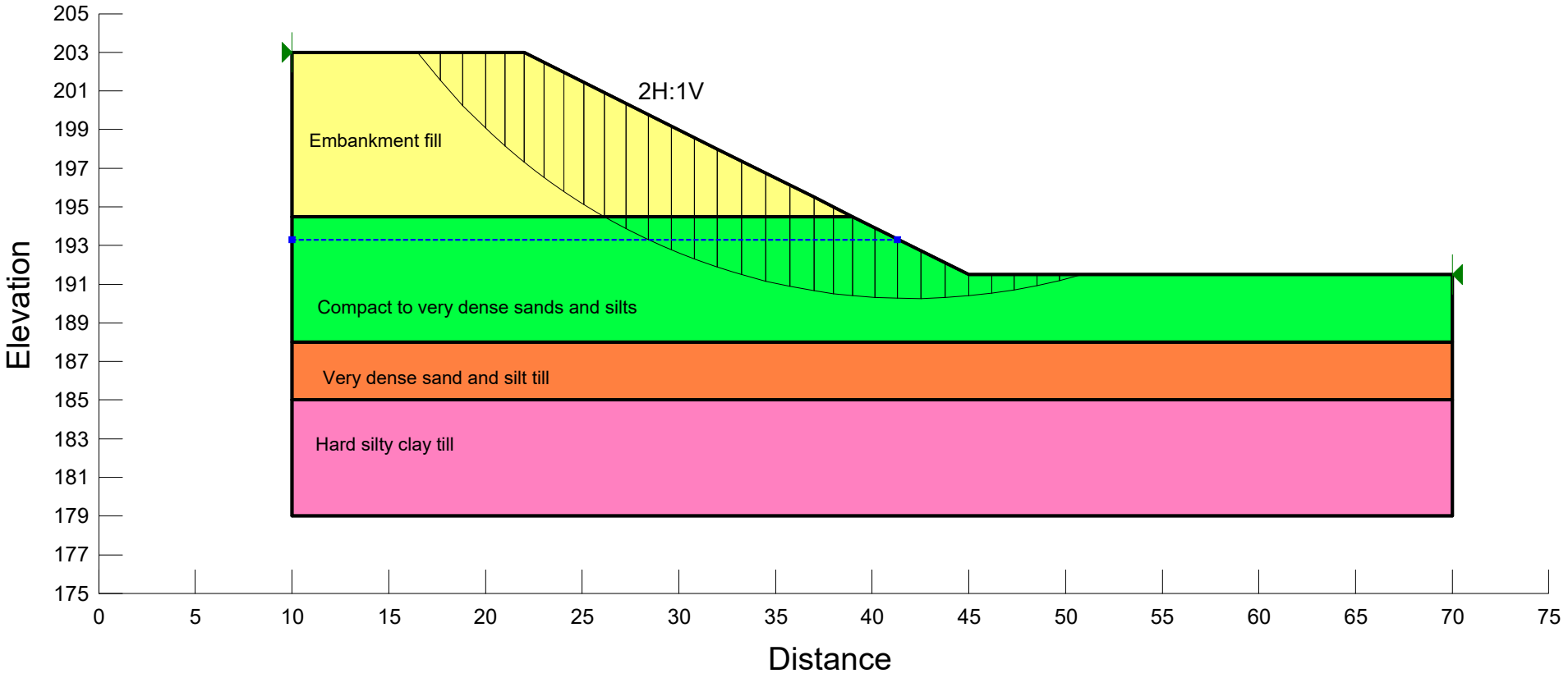
Name: Very dense sand and silt till Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 34 ° Phi-B: 0 ° Piezometric Line: 1
Name: Hard silty clay till Unit Weight: 20 kN/m³ Cohesion: 200 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1

Project Number: 15786
Highway 404
Rouge River Bridge
Embankment Height approximately 11.5 m high
Side slope
Seismic Analysis PGA=0.13g





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Date: 2019-01-22 ,Time: 11:07:48 AM

Figure 9G

THURBER

Appendix H

List of Special Provisions
and
Suggested Wording for NSSP

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
- NSSP FOUN0003 Amendment to OPSS.PROV 902
- OPSS PROV 903 Construction specification for deep foundations
- OPSS PROV 1010 Material specification for aggregates - base, subbase, select subgrade, and backfill material
- 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

The Contractor is alerted that there are risks of encountering obstructions such as cobbles, boulders and other man-made debris within the embankment fill and native soils. Such obstructions and hard/very dense zones in the soils can impede pile penetration. 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 an 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.

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3. Suggested Text for NSSP on Groundwater Control

Water seepage due to perched water in the slope, random fill, surface runoff and precipitation should be expected. For temporary excavations for pile cap construction 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. It is also important to minimize disturbance of the exposed sand fill surfaces by limiting construction traffic.

4. Suggested Text for NSSP on "Impact on Adjacent Structure"

It is critical that the Contractor's excavation and construction activities do not undermine or have any adverse impact on the integrity and performance of the following adjacent structures:

- The operating lanes of the Highway 404 during excavation and foundation construction at the new north and south abutments.
- Protection of the existing structure foundations, back slopes at median, and utilities (if present at this site) during excavation and pile driving.
- Protection of existing approach fills.

5. Suggested Text for NSSP on "Vibration and Settlement Monitoring"

The Contractor shall monitor vibration levels on the existing structure during pile driving for the new structure. The vibration monitoring equipment shall be placed on the ground adjacent to the existing structure such that it will not be disturbed. The monitoring locations should be strategically selected to characterize vibration propagation at the site. Vibration levels due to pile driving are measured in peak particle velocity (ppv) and the monitoring criteria that have been established for this project are as follows:

a) For a vibration frequency of 30 Hz or less (typical of impact pile driver), a review ppv level of 9 mm/sec and an alert ppv level of 12 mm/sec shall be used. For a vibration frequency of greater than 30 Hz, a review ppv level of 12 mm/sec and an alert ppv level of 15 mm/sec shall be used.

b) Survey markers consisting of fluorescent paint marks shall be established as survey targets on bridge abutments located within 20 m of any pile to be driven. Two (2) survey markers shall be established on each wall face (abutment walls and wing walls). A minimum of two (2) survey markers (concrete nails may be used as substitution) shall be established on the pavement at each bridge immediate approach. Prior to commencement of pile driving, baseline elevation readings shall be established and the results submitted to the Contract Administrator (CA) for approval and record purposes.

c) The benchmark elevations at the survey markers shall be surveyed to an accuracy of ± 2 mm or better. An acceptable set of baseline readings shall consist of three (3) readings taken on three (3) consecutive days. All survey elevations must be established with reference to survey monuments located outside of the immediate vicinities of the piling operation and monitoring areas.

d) Upon commencement of pile driving, vibration monitoring, elevation surveys of survey markers, and visual field inspection shall be carried out by the Contractor on a continual basis.

As a minimum, all survey markers shall be surveyed once after the baseline readings and immediately prior to the commencement of pile driving. For the first day of piling at the site, each marker shall be surveyed three (3) times a day, say, morning before piling, mid-day and end of day. Assuming the readings do not show any sign of movement, then the monitoring frequency may be reduced to twice a day (say beginning and end of day). The monitoring frequency (more or less) may be changed when deemed necessary by the Contract Administrator during the course of the work.

g) Vibration monitoring shall be carried out by the Contractor, or its representatives, using vibration monitoring equipment such as the Instantel Blast Mate Monitors, or equal. These monitors shall be deployed at selected locations on site including the ground surfaces adjacent to bridge elements where survey monitoring is to be carried out.

h) At each site, continual monitoring shall be carried out for the first day to establish vibration patterns. Thereafter, vibration monitoring shall be carried out during the first 3 m of driving and during seating of each pile. In any case, the monitoring frequency shall not be less than that required for survey monitoring outlined above.

i) Any exceedance of the review or alert levels must be reported to the Contract Administrator immediately. Should the vibration level reach or exceed the review level as specified in Clause a), but less than the alert level, and provided that settlement or other forms of distress are not evident, the pile driving operation may proceed with caution and in conjunction with precautionary measures including more frequent survey of the survey markers. If the vibration and/or settlement monitoring readings are not acceptable, the Contractor must alter the pile driving procedures (including reduction of the hammer energy) until the measured vibrations are within acceptable limits.

j) Should there be any sign of potential adverse effect on the bridge elements and pavement surface as a result of visual inspections, or if the measured vibration level approaches the alert level, or if there is a change in the baseline elevations that indicate settlement or the development of a trend of settlement, the Contractor shall immediately stop the piling work. The Contract Administrator will then review the situation and in conjunction with the Contractor, come up with a plan for re-commencing any piling operation in the area.

k) All settlement and vibration monitoring results must be submitted to the Contract Administrator at the end of each day.