



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT
ANNE STREET UNDERPASS
HIGHWAY 400
CITY OF BARRIE, ONTARIO
SITE 30-347
G.W.P. 2504-17-00**

GEOCRES NO. 31D-739

**Latitude: 44.385993°
Longitude: -79.707832°**

Report

to

McIntosh Perry

Date: June 9, 2020
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PART 1: FACTUAL INFORMATION

1.0 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the proposed replacement and widening of the existing Anne Street underpass structure located in the City of Barrie, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the proposed foundation locations, and based on the data obtained, to provide borehole location and soil strata drawings, records of boreholes, laboratory test results, and a written description of the subsurface conditions. A model of the subsurface conditions was developed for the site based on data obtained from the present investigation and selected data from previous investigations by others.

Thurber was retained by McIntosh Perry (MP) to carry out this foundation investigation under the Ministry of Transportation Ontario (MTO) Assignment Number 2017-E-0032. The assignment includes the reconstruction of Dunlop Street and Highway 400 interchange and replacement of the Highway 400 at Dunlop Street and Sunnidale Road underpass structures.. This report addresses the proposed replacement and widening of the Anne Street underpass structure.

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



- Preliminary Foundation Investigation Report, Anne Street Underpass, Structure Site 30-347, Highway 400 Widening, Ministry of Transportation Ontario, W.O. 06-20016 prepared by Golder Associates Ltd., GEOCREs No. 31D00-666, dated October 20, 2016 (Reference 1).
- Report on “Subsurface Exploration for Proposed Overpass at Anne Street and Highway 400, Barrie, Ontario”, GEOCREs No. 31D00-182, dated July 1957 (Reference 2).

2.0 SITE DESCRIPTION

The existing Anne Street underpass structure is located at the intersection of Highway 400 and Anne Street North in Barrie, Ontario. The underpass structure generally runs in a east-west direction and carries four lanes of Anne Street traffic over Highway 400. Based on the General Arrangement (GA) and archived design drawings, the existing underpass consists of a two-span reinforced concrete rigid frame supported on Frankie type (expanded base) caissons, although there is no construction record available for confirmation. The clear spans of the bridge are about 17.4 m each measured between the abutments and pier, and the deck width is about 17 m. The bridge is at an approximate 37° skew to the centerline of Highway 400. There is also a 1.8 m wide sidewalk with steel railing along the north and south sides of the structure. There are approach slabs at both ends of the structure. The length of the west and east approach slabs are 10.3 m and 6.5 m, respectively.

The overall surface topography in the vicinity of the site is relatively flat and consists of residential and commercial properties to the east and west of Highway 400. At the structure site, Anne Street has been constructed in fill with approach embankments up to approximately 7 m in height and the existing grade at approximate Elevations 240.7 m and 242.5 m adjacent to the east and west abutments, respectively. The existing grade of Highway 400 is approximately 5 to 7 m below Anne Street grade at about Elevation 236 m.

Selected photographs of the site are presented in Appendix D.

Based on published geological mapping, the study area is located within the Simcoe Lowlands physiographic region. This region borders Georgian Bay and Lake Simcoe and can generally be separated into two major divisions: the Nottawasaga basin to the west, consisting of plains draining into Nottawasaga Bay, and the Lake Simcoe basin to the east, consisting of the lowlands which surround Lake Simcoe. These two basins are connected at Barrie by a flat-floored valley through Barrie. The Simcoe Lowlands region is generally comprised of sand, silt and clay deposits of deltaic and lacustrine origin.



3.0 SITE INVESTIGATION AND FIELD TESTING

The current field investigation for Anne Street Underpass was carried out between February 4 and June 12, 2019, at which time five (5) boreholes were advanced at the structure site. The boreholes were advanced near the proposed abutment and pier locations to depths ranging from 9.8 m to 43.0 m (Elevations 194.7 to 231.9 m).

Three boreholes (numbered RW20-01 to RW20-03) were drilled for the proposed retaining wall to be constructed at the northeast corner of the new underpass. The three boreholes were drilled on January 8, 9 and 21, and February 14, 2020 at selected locations along the proposed retaining wall alignment. Boreholes RW20-02 and RW20-03 were terminated at 15.8 m and 9.8 depth (Elevations 219.6 and 221.1), respectively. Borehole RW20-01 was drilled near the bottom of the slope close to the northeast corner of Anne St. and Highway 400 underpass, and it was terminated at 2.7 m depth (Elevation 232.9) upon refusal. It is noted that portable drilling equipment was used to drill this borehole due to difficult sloping access and several attempts were made to further extend it without success. These records of borehole sheets are provided in Appendix A.

Boreholes AS1-1 and AS1-2, drilled during a previous investigation (Reference 1), were incorporated in this report. Boreholes AS1-1 and AS1-2 were terminated at 18.8 m and 18.1 m depth (Elevations 217.2 and 222.4), respectively. The Record of Borehole sheet of Boreholes AS1-1 and AS1-2 are included in Appendix C.

The approximate locations of all the boreholes (previous and present investigations) are shown on the Borehole Location Plan and Stratigraphic Drawings in Appendix E.

McIntosh Perry surveyed the boreholes of the present investigation in the field using a combination of GPS and total station equipment, and provided Thurber with the borehole coordinates and ground surface elevations. It is understood that the horizontal and vertical accuracy of the survey results meet the MTO terms of reference requirements of 0.5 m and 0.1m, respectively.

The boreholes were advanced using track and truck-mounted drill rigs with hollow stem augers, as well as wash boring with tri-cone and casing, except for the tripod used for RW20-01 as outlined above. Soil samples were obtained at selected intervals using a 50 mm outside diameter split-spoon sampler driven in conjunction with the Standard Penetration Test (SPT).

The field investigation was supervised on a full-time basis by a member of Thurber's technical staff who marked/staked the boreholes in the field, arranged for the clearance of subsurface



utilities, supervised the drilling, sampling and in-situ testing operations, logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Standpipe piezometers (25 mm diameter) were installed and enclosed in filter sand columns in selected boreholes to permit groundwater level monitoring. The details of the piezometers are shown in Table 3.1.

Table 3.1 – Piezometer Details

Borehole	Piezometer Tip		Slotted Screen Length (m)	Soil Types at Piezometer Screen
	Depth (m)	Elevation (m)		
ANN-03	42.7	197.9	3.0	Silty Sand
ANN-04	39.6	202.9	3.0	Silty Sand
RW20-03	9.1	226.8	4.1	Sand

All boreholes without standpipe piezometer were backfilled upon completion of drilling in general accordance with O. Reg. 903. The piezometers were decommissioned following groundwater monitoring as per O. Reg. 903 as amended by O.Reg.128/03.

4.0 LABORATORY TESTING

The recovered soil samples of the present investigation were subjected to visual identification (VI) and to natural moisture content determination. Selected samples were subjected to grain size distribution analyses (sieve and/or hydrometer), and Atterberg Limits testing. Geotechnical laboratory testing results are summarized on the Record of Borehole sheets included in Appendix A and are presented on the figures included in Appendix B.

Laboratory tests results from the previous investigation (Reference 1) are also included in Appendix C.

Selected soil samples were also submitted for analytical testing to assess the potential for soil corrosion on metals and the potential for sulphate action on concrete. The analyses were carried out by ALS Environmental, an independent Canadian Association for Laboratory Accreditation (CALA) accredited laboratory. The results of the analytical testing are presented in Appendix B.



5.0 DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix A and on the Borehole Locations and Soil Strata drawings in Appendix E. A general 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 and anticipated that soil conditions may vary between and beyond the borehole locations.

In general, the subsurface stratigraphy encountered at the site consists of a pavement structure overlying embankment fill which is underlain by a deposit of typically compact to dense silty sand to sand containing clayey silt and sandy silt interlayers. The silty sand to sand deposit overlies a hard silty clay to clayey silt deposit which is underlain by a lower layer of very dense silty sand. The groundwater level was measured to be at approximately 9 m to 10 m below the Anne Street grade and in the order of 4 m below the Highway 400 grade.

More detailed descriptions of the individual stratum are presented below.

5.1 Anne Street Underpass

5.1.1 Pavement Structure

Pavement structure consisting of approximately 100 mm to 130 mm of asphalt overlying 1.3 m of granular (sand and gravel fill) road base was encountered in the boreholes advanced through the Anne Street road platform (Boreholes ANN-01, ANN-03, ANN-04 and ANN-05).

Approximately 300 mm of asphalt overlying 1.1 m of granular (sand and gravel fill) road base was encountered in the borehole advanced through Highway 400 (Borehole ANN-02). An approximately 200 mm thick layer of asphalt was encountered at ground surface in Borehole AS1-2, drilled in close proximity to Highway 400 SBL.

SPT 'N' values recorded in the sand and gravel fill ranged from 27 to 36 blows per 0.3 m of penetration indicating a compact to dense condition. The natural moisture contents measured on samples of this fill ranged from 2 percent to 4 percent.

5.1.2 Embankment Fill

Embankment fill was encountered underlying the pavement structure in the boreholes advanced through the Anne Street grade (Boreholes ANN-01, ANN-03, ANN-04 and ANN-05) and through Highway 400 in Borehole AS1-2. Fill was contacted surficially in Borehole AS1-1.



The embankment fill generally consisted of silty sand to sand, trace silt, and contained trace to some gravel and clay, except for Boreholes AS1-1 and AS1-2 where it consisted of gravelly sand to sand and gravel containing trace silt and trace to some clay. The fill also contained occasional cobbles and/or boulders and some organic inclusions/pockets.

The thickness of the embankment fill ranged from 1.9 m to 8.1 m and the base of the fill was encountered at depths ranging from 6.5 m to 8.7 m (Elev. 235.8 m to 232.1 m).

The SPT 'N' values recorded in the embankment fill ranged from 8 blows per 0.3 m of penetration to greater than 100 blows for less than 0.3 m of penetration with most values ranging between 10 and 30 blows per 0.3 m of penetration indicating a typically compact condition. A higher SPT 'N' value of greater than 100 blows for less than 0.3 m penetration indicated the possible presence of cobbles and/or boulders in the fill. A loose zone of fill as indicated by 'N' values of 8 blows per 0.3 m penetration is present near the bottom of the fill in Borehole ANN-05. The natural moisture contents measured on samples of the fill generally ranged from 3 percent to 18 percent. Higher moisture contents of 77 and 108 percent were measured on samples of the fill in Boreholes ANN-01 and AS1-2 which are associated with the presence of organic inclusions.

The results of grain size analyses conducted on samples of the sand to silty sand fill and gravelly sand fill are provided on the Record of Borehole sheets in Appendices A and C, and illustrated on Figure B1 in Appendix B. The results are summarized as follows:

Soil Particle	Sand to Silty Sand Embankment Fill (Percent)	Gravelly Sand Fill (Percent)
Gravel	6 to 20	24
Sand	54 to 72	70
Silt	15	5
Clay	9	1
Silt + Clay	8 to 27	-

5.1.3 Silty Sand to Sand

In Boreholes ANN-01, ANN-03 to ANN-05, AS1-1 and AS1-2, a deposit of silty sand to sand, some silt, trace gravel was encountered underlying the embankment fill, whereas in Borehole ANN-02, the sand was encountered immediately below the pavement structure. In Boreholes ANN-02 and ANN-04, layers of gravelly sand, trace clay was encountered within the silty sand to sand.



Where fully penetrated in Boreholes ANN-02 to ANN-04, AS1-1 and AS1-2, the thickness of the silty sand to sand deposit ranged from 8.2 m to 12.1 m and the surface of the deposit was encountered at depths ranging between 1.4 m and 8.7 m. The base of the deposit was encountered at depths ranging between 10.2 m and 20.2 m (Elev. 225.9 and 220.9 m). Boreholes ANN-01 and ANN-05 were terminated within the silty sand to sand between 9.8 m and 10.4 m depths (Elev. 229.8 and 231.9 m).

The SPT 'N' values recorded in the silty sand to sand deposit ranged from 6 to 104 blows per 0.3 m of penetration, with most 'N' values lying between 15 and 75 blows, indicating compact to very dense conditions. There are some loose zones as indicated by 'N' values from 6 to 9 blows per 0.3 m penetration. Locally in Borehole AS1-1, an SPT 'N' value of 1 blow per 0.3 m of penetration was measured near elevation 231.0 in Borehole AS1-1. Occasional values of greater than 100 blows for less than 0.3 m of penetration indicated the possible presence of cobbles and/or boulders. The natural moisture contents measured on samples of the gravelly sand to silty sand ranged from 6 percent to 27 percent.

The results of grain size distribution analyses carried out on selected samples of the gravelly sand to sand are shown on Figure B2 in Appendix B.

The results are summarized as follows:

Soil Particle	Silty Sand to Sand (Percent)	Gravelly Sand (Percent)
Gravel	0 to 14	30 to 34
Sand	64 to 84	56 to 60
Silt	8 to 35	-
Clay	0 to 2	-
Silt + Clay	16	6 to 14

5.1.4 Clayey Silt/Silty Clay Interlayer

A clayey silt/silty clay interlayer, with sand, trace gravel, was encountered within the silty sand to sand deposit at 10.2 m depth in Borehole ANN-03, and within the silt in Borehole AS1-1 at 15.7 m depth. The thickness of this clayey silt/clayey silt interlayer was 4.6 m and 0.6 m in Boreholes ANN-03 and AS1-1, respectively.

The base of this deposit was encountered at 14.8 m and 16.3 m depth (Elevations 225.8 m and 219.7 m), in Boreholes ANN-03 and AS1-1, respectively.



The SPT 'N' values recorded in the clayey silt/silty clay interlayer ranged from 26 and 65 blows per 0.3 m penetration to greater than 100 blows for less than 0.3 m of penetration indicating a very stiff to hard consistency. The natural moisture contents measured on samples of the clayey silt ranged from 15 percent to 25 percent.

The results of grain size distribution analyses carried out on a sample of the clayey silt are shown on Figure B3 included in Appendix B and summarized as follows:

Soil Particle	Clayey Silt with sand (Percent)
Gravel	1
Sand	23
Silt	64
Clay	12

Atterberg limits testing carried out on a sample of the clayey silt measured a plastic limit of 14 percent and a liquid limit of 19 percent with a corresponding plasticity index of 5 percent. Atterberg limits testing carried out on a sample of the silty clay measured a plastic limit of 15 percent and a liquid limit of 40 percent with a corresponding plasticity index of 25 percent.

These results, which are plotted on Figure B6 in Appendix B, and also in Figure B3 in Appendix C, indicate that the clayey silt has a slight plasticity with a group symbol of CL-ML, and the silty clay has a medium plasticity with a group symbol of CI.

5.1.5 Silt/Sandy Silt

Layers of brown to grey silt/sandy silt containing trace to some sand and trace clay were contacted below the sand at 13.3 m and 16.5 m depths in Boreholes AS1-1 and AS2-1, respectively, which were terminated within the silt/sandy silt at 18.8 m and 17.5 m (Elevations 217.2 and 223.0).

SPT 'N' values recorded in the silt/sandy silt varied from 65 to 130 blows per 0.3 m of penetration indicating a very dense condition. The natural moisture contents measured on samples of the silty sand ranged from 22 percent to 26 percent.

The results of grain size distribution analyses carried out on selected samples of the silt/sandy silt are shown on Figure B2 in Appendix C and summarized as follows:



Soil Particle	Silt/Sandy Silt (Percent)
Gravel	0
Sand	5 to 22
Silt	78 to 90
Clay	0 to 8

5.1.6 Silty Clay to Clayey Silt

A deposit of silty clay to clayey silt, trace sand, was encountered in Boreholes ANN-02 to ANN-04 underlying the silty sand.

The thickness of this cohesive layer ranged from 13.5 m to 17.5 m and the top of the deposit was encountered at depths ranging between 10.2 m and 27.7 m (Elev. 225.9 m and 212.9 m). The base of this deposit was encountered at depths ranging from 27.7 m to 35.1 m (Elev. 208.8 m to 205.5 m).

The SPT 'N' values recorded in the cohesive deposit ranged from 22 blows per 0.3 m of penetration to greater than 100 blows for less than 0.3 m of penetration indicating a very stiff to hard consistency. The natural moisture contents measured on samples of the silty clay to clayey silt ranged from 18 percent to 37 percent.

The results of grain size distribution analyses carried out on selected samples of the silty clay are shown on Figures B3 and B4 included in Appendix B, and summarized as follows:

Soil Particle	Silty Clay (Percent)	Clayey Silt (Percent)
Gravel	0	0
Sand	1 to 8	2 to 5
Silt	36 to 50	78 to 82
Clay	49 to 63	16 to 17

Atterberg limits testing carried out on selected samples of the silty clay to clayey silt measured plastic limits of 15 to 21 percent, liquid limits of 22 to 34 percent and corresponding plasticity indices of 7 to 24 percent. These results, which are plotted on Figures B6 and B7 in Appendix B, indicate that the silty clay to clayey silt has low to intermediate plasticity (CL to CI).



5.1.7 Silty Sand (Lower)

A lower deposit of silty sand, trace clay, was encountered below the silty clay to clayey silt deposit in Boreholes ANN-02 to ANN-04.

The surface of the deposit was encountered at depths ranging from 27.7 m to 35.1 m. Boreholes ANN-02 to ANN-04 were terminated in this deposit at depths ranging from 41.4 m to 43.0 m (Elev. 201.1 m to 194.7 m). All the SPT 'N' values recorded in the silty sand were greater than 100 blows for less than 0.3 m of penetration indicating a very dense condition. Cobbles and boulders may be present in this deposit. The natural moisture contents measured on samples of the silty sand ranged from 18 percent to 26 percent.

The results of grain size distribution analyses carried out on selected samples of the silty sand are shown on Figure B5 in Appendix B and summarized as follows:

Soil Particle	Silty Sand (Percent)
Gravel	0
Sand	64 to 78
Silt	20 to 33
Clay	2 to 3

5.1.8 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 ANN-03 and ANN-04 to permit monitoring of groundwater levels. Water levels measured in the two installed standpipes and open boreholes from the current and past investigations are presented in Table 5.1 below.



Table 5.1 - Groundwater Level Measurements

Foundation Unit	Borehole	Date	Groundwater Level		Comments
			Depth (m)	Elev. (m)	
West Abutment	ANN-01	Jun. 6, 2019	7.0	235.3	Open borehole (caved to 7.0 m)
	ANN-04B	Jun. 12, 2019	Drill water	-	Open borehole
		Aug. 26, 2019	10.1	232.4	Piezometer
		Apr. 13, 2020	7.8	234.7	Piezometer
Pier	ANN-02	Feb. 14, 2019	5.3	230.8	Open borehole
	AS1-1	March 29, 2016	-	-	Borehole caved to 1.2 m
East Abutment	ANN-03	Jun. 4, 2019	9.1	231.5	Open borehole (caved to 7.9 m)
		Aug. 26, 2019	8.7	231.9	Piezometer
		Apr. 13, 2020	7.1	233.5	
	ANN-05	Jun. 12, 2019	6.4	233.2	Open borehole (caved to 6.7 m)
	AS1-2	April 20, 2016	8.6	231.9	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.

5.2 Retaining Wall - Northeast of Anne Street Underpass

5.2.1 Pavement Structure

Pavement structure consisting of approximately 75 mm of asphalt overlying sand fill was encountered surficially in Borehole RW20-02, drilled from Anne Street grade.

5.2.2 Topsoil

Topsoil with some roots and organics was encountered surficially in Borehole RW20-03. The thickness of the topsoil was 450 mm.

An SPT 'N' value recorded in the topsoil was 9 blows per 0.3 m of penetration indicating a loose condition. A natural moisture content measured on a sample of the topsoil was 29 percent.

The topsoil thickness may vary between and beyond the borehole locations, and the data is not intended for the purpose of estimating quantities.



5.2.3 Embankment Fill

Embankment fill was encountered in the Boreholes RW20-01 to RW20-03 drilled for the retaining wall below the pavement structure and topsoil. The fill consisted of layers of brown to grey sand, silty sand to sandy silt containing trace gravel to gravelly, trace to some silt, trace clay and occasional cobbles. A layer of brown silty clay with sand was encountered below the sand fill in Borehole RW20-03. A layer of sand mixed with organics was contacted at 3.2 m depth in Borehole RW20-02. Gasoline odour was noted within the silty sand fill in Borehole RW20-02. The thickness of the embankment fill was 5.7 m and 2.6 m in Boreholes RW20-02 and RW20-03, respectively. Borehole RW20-01 was terminated within the sand fill at 2.7 m depth (Elevation 232.9). A 0.6 m thick layer of sandy silt fill mixed with organics was encountered at ground surface in Borehole RW20-01.

The SPT 'N' values recorded in the embankment fill generally ranged from 18 to 70 blows per 0.3 m of penetration, with most values ranging between 20 and 39 blows per 0.3 m of penetration, indicating a compact to dense condition. SPT 'N' values of 92 blows per 0.3 m of penetration and 50 blows for less than 0.1 m penetration, were measured in Boreholes RW20-01 and RW20-02, indicating the possible presence of cobbles and/or boulders in the fill. A loose zone of fill as indicated by SPT 'N' values of 8 blows per 0.3 m penetration is present in Borehole RW20-03 within the upper 2.0 m of the fill. An SPT 'N' value of 10 blows per 0.3 m of penetration was measured in the silty clay fill indicating a stiff consistency. The natural moisture contents measured on samples of the fill generally ranged from 5 percent to 28 percent.

The results of grain size analyses conducted on samples of the silty sand fill and silty clay fill are provided on the Record of Borehole sheets in Appendices A, and illustrated on Figures B8 and B9 of Appendix B. The results are summarized as follows:

Soil Particle	Silty Sand to Sand Embankment Fill (Percent)	Silty Clay Embankment Fill (Percent)
Gravel	1 to 14	0
Sand	51 to 69	36
Silt	14 to 29	37
Clay	3 to 19	27

5.2.4 Gravelly Sand

A 1.0 m thick layer of grey gravelly sand was contacted below the fill in Borehole RW20-02 at 5.8 m depth.



An SPT 'N' value of 58 blows per 0.3 m of penetration, indicating a very dense state was measured in the gravelly sand. Moisture content in the gravelly sand was measured at 6 percent and 14 percent.

5.2.5 Sandy Silt to Sand

Layers brown to grey sandy silt to sand containing trace to some trace clay were contacted below the embankment fill and gravelly sand in Boreholes RW20-02 and RW20-03.

Boreholes RW20-02 and RW20-03 were terminated within the sandy silt and sand at 15.8 m and 9.8 m (Elevations 219.6 and 221.1), respectively.

SPT 'N' values recorded in the sandy silt to sand typically varied from 35 to 100 blows for 0.3 m of penetration indicating a dense to very dense condition. SPT 'N' values of 12 and 16 blows per 0.3 m of penetration, were measured in Borehole RW20-03 between approximate Elevations 225.0 and 222.5, indicating a compact zone. SPT 'N' values of 100 blows for less than 0.3 m of penetration were measured in Borehole RW20-02 indicating potential presence of cobbles and boulders. The natural moisture contents measured on samples of the sandy silt to sand ranged from 10 percent to 19 percent.

The results of grain size distribution analyses carried out on selected samples of the sandy silt to sand are shown on Figures B10 and B11 in Appendix B and summarized as follows:

Soil Particle	Sandy Silt (Percent)	Sand (Percent)
Gravel	0	0
Sand	28 to 34	88
Silt	56 to 58	10
Clay	10 to 14	2

5.2.6 Groundwater Conditions

Groundwater levels in the boreholes were observed during the drilling operations and measured upon completion of drilling. A standpipe piezometer was installed in Borehole RW20-03 to permit monitoring of groundwater levels. Water levels measured in the standpipe and open boreholes are presented in Table 5.2 below.



Table 5.2 - Groundwater Level Measurements

Borehole	Date	Groundwater Level		Comments
		Depth (m)	Elev. (m)	
RW20-01	January 9, 2020	Dry	-	Open borehole
RW20-02	January 21, 2020	4.6	230.8	Open borehole
RW20-03	March 2, 2020	4.6	226.3	Open borehole
		4.1	226.8	Piezometer
	April 13, 2020	3.6	227.3	Piezometer

5.3 Corrosivity Test Results

Selected soil samples were submitted for analytical testing of corrosivity parameters including sulphate content. The results of the analytical tests are shown in Table 5.3. The laboratory certificates of analysis are presented in Appendix B.

Table 5.3 – Analytical Corrosivity Test Results

Sample ID	Depth (m)	Soil Sample Description	Sulphide (percent)	Chloride (µg/g)	Sulphate (µg/g)	pH	Resist-ivity (ohm.cm)	Redox Potent-ial (mV)	Conduct-ivity (mS/cm)
ANN-03 SS#11	13.7 – 14.3	Clayey Silt	<0.2	51.3	48	7.9	4260	191	0.235
ANN-05 SS#7	7.6 – 8.2	Sand Fill	<0.2	681	69	8.0	689	180	1.45
ANN-04 SS#16	22.9 – 23.3	Silty Clay	<0.2	<5.0	111	8.1	3920	147	0.255
ANN-01 SS#5	4.6 – 5.2	Sandy Silt Fill	<0.2	1090	61	7.9	564	166	1.77
ANN-02 SS#4	3.0 – 3.7	Sand	<0.2	460	37	8.1	1180	174	0.848

6.0 MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. McIntosh Perry surveyed the boreholes in the field provided the borehole coordinates and ground surface elevations.

Walker Drilling of Utopia, Ontario supplied and operated the drilling and sampling equipment for the field program.



Full time supervision of the field activities was carried out by Messrs. Bryan Lui, Kevin Kweon and Jilesh Patel of Thurber. Overall supervision of the field program was performed by Messrs. Karel Furbacher, P.Eng. and Stephane Loranger, C.E.T. of Thurber.

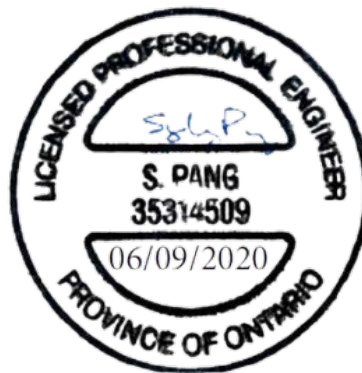
Interpretation of the field data and preparation of the report were carried out by Mr. Geoff Lay, P.Eng. and Ms. Rocio Palomeque Reyna, P.Eng. The report was reviewed by Dr. Sydney Pang, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



THURBER ENGINEERING LTD.



Rocio Palomeque Reyna, P.Eng.
Geotechnical Engineer



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



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



**FOUNDATION INVESTIGATION AND DESIGN REPORT
ANNE STREET UNDERPASS
HIGHWAY 400
CITY OF BARRIE, ONTARIO
SITES 30-347
G.W.P. 2504-17-00**

GEOCRE NO. 31D-739

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7.0 GENERAL

This report presents interpretation of the geotechnical data in the factual report and provides foundation recommendations to assist the design team in selecting and designing a suitable foundation system for the proposed Anne Street underpass structure. The proposed work is in support of the design associated with the Highway 400 project involving the replacement of underpass bridges at Dunlop Street, Anne Street and Sunnidale Road in Barrie, Ontario.

This foundation investigation and design report, with the interpretation and recommendations, is intended for the use of the Ministry of Transportation (MTO) and McIntosh Perry (MP), 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 archived design drawings dated February 1958 and the AECOM Structural Design Report (SDR) dated July 2017, the existing underpass structure is a two-span reinforced concrete rigid frame bridge structure supported on Franki Caisson Piles (expanded base). In Golder's preliminary foundation investigation report dated October 2016 (Reference 1), the existing structure is being described as supported on driven H-piles. There is no construction record available to confirm the foundation type of the existing structure. The clear spans of the bridge are 17.4 m each measured between the abutments and pier, and the deck width is about 17 m.



Based on the AECOM SDR (2017), the existing structure was originally constructed in 1959 under MTO Contract No. 58-162. The structure was rehabilitated in 1990, which consisted of the installation of a pancake anode cathodic protection system in a concrete overlay underlain by a conductive asphalt mix and asphalt wearing course. Miscellaneous concrete patch repairs to the remainder of the structure were also carried out at that time.

In 2009, extensive concrete patch repairs were carried out on the soffit as part of a holding strategy under Contract 2009-2044. A second holding strategy was completed in 2014 under Contract 2013-2052.

Visual observations of the existing structure did not reveal obvious signs of settlement or distress at the foundation elements. The adjacent approach fill slopes also appeared to be stable.

The General Arrangement (GA) drawings dated November 2018 and May 2019 show that the existing structure will be removed and Highway 400 will be widened by approximately 30 m to the west and 20 m to the east. The proposed replacement structures will consist of two-span precast concrete box girders with the abutments supported on driven H-piles. The bridge will have two clear spans each of approximately 45 m length and will have a deck width of about 27.6 m. The longer replacement structure will accommodate the proposed 10-lane widening configuration of Highway 400 beneath Anne Street South. The existing Anne Street South will also be widened to accommodate 4 lanes of traffic, two bike lanes, sidewalks, and a centre median. It is understood that there will be no change to the road grade on Highway 400. A grade raise of about 1.3 m is proposed at the approach embankment adjacent to the east abutment. Within the widening zones, up to 5 m and 7 m of new fill will be placed at the west and east abutments, respectively.

A retaining wall is proposed at the northeast quadrant of the Anne Street underpass near the east toe of the new east approach embankment. Available information indicates that the proposed wall height is up to about 6 m adjacent to the bridge, decreasing easterly to 2.5 m high. The length of the wall is approximately 118 m.

The discussion and recommendations presented in this report are based on the design information provided by McIntosh Perry, the factual data obtained during the course of the current investigation and selected data from a previous preliminary investigation by others.



8.0 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. As per CHBDC (2014) Clause 6.5.3, a typical degree of understanding is considered for this site.

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.

9.0 FOUNDATION DESIGN

In general, the subsurface stratigraphy encountered at the site consists of a pavement structure overlying silty sand to sand embankment fill at the abutments. The approach embankments and the pavement structure on Highway 400 are underlain by a deposit of typically compact to very dense silty sand to sand with lenses of very stiff to hard clayey silt and compact to dense gravelly sand. The silty sand to sand overlies a hard silty clay to clayey silt deposit which is underlain by very dense silty sand. The groundwater level was found to be at about 9 m to 10 m depth below the Anne Street grade, or about 3 m below the highway grade.

9.1 Foundation Alternatives

Based on the subsurface conditions at the site, consideration was given to supporting the new bridges using the following foundation types:

- Spread footings on native soil
- Driven steel H-piles
- Augered Caissons (Drilled Shafts)

A comparison of the technical advantages, disadvantages and relative risks and costs of the alternative foundation schemes is presented in Appendix F. Discussions on feasible foundation alternatives are presented in the following paragraphs. A preferred foundation scheme from a foundations perspective is then recommended.



Spread Footings on Native Soils

Spread footings founded on native soils are considered feasible to provide foundation support for the new bridge. The footings would likely be at or just below the groundwater table. Groundwater control systems will be required to facilitate footing construction in the dry. Such systems may include various means of dewatering supplemented by sump pumping. Temporary protection will also be required at various locations. This foundation option will preclude the use of integral abutments.

Driven Steel H-Piles

Steel H-piles driven to a specified geotechnical resistance into the underlying very dense silty sand deposit could be used to support the new bridge abutments and centre pier. This foundation option would permit integral abutment design should it be considered. The pile caps could either be perched within the approach embankments or founded in the native silty sand to sand deposit at shallow depths.

The driven pile option only requires limited groundwater control during pile cap construction. However, there are potential obstructions due to cobbles and boulders, and hard driving conditions are anticipated within the hard silty clay.

Vibrations due to pile driving into the hard silty clay could have adverse effects on the adjacent existing bridge foundations. A vibration and settlement monitoring program should be implemented to monitor the existing bridge while it remains operational.

Augered Caissons (Drilled Shafts)

Augered caissons are feasible but carry a higher risk with respect to installation which would likely involve advancing the caisson holes through cohesionless, water-bearing sands and silts below the groundwater table. It is required to use temporary steel liners and a head of fluid (water or slurry) for stabilizing the sidewall and the base. The caissons may be founded within the hard silty clay to clayey silt deposit. It is understood that consideration is currently being given to using caissons for foundation support of the pier in order to eliminate the caisson cap due to lack of space for construction.

Preferred Foundation Alternative

From a foundation technical and cost effectiveness perspective, and taking into consideration the space restriction at the pier location, the preferred foundation alternatives for the new Anne Street bridge are driven piles for the abutments and caissons for the centre pier.

9.2 Spread Footings on Native Soil

9.2.1 Geotechnical Resistances

Based on the subsurface conditions encountered at this site, the new abutment footings may be founded below the embankment fill and frost depth on the native, undisturbed typically compact to dense silty sand to sand with gravelly sand lenses.

The founding levels and corresponding geotechnical resistances recommended at each foundation unit are presented in the following table.

The geotechnical resistances shown in the table below correspond to a minimum footing width of 4 m.

Table 9.1 – Spread Footing Founding Elevations

Foundation Unit	Reference Borehole	Highest Founding Elevation (m)	Founding Soil Type	Factored Geotechnical Resistance	
				ULS (kPa)	SLS (kPa)
West Abutment	ANN-01 ANN-04	233.5	Compact to Dense Sand to Gravelly Sand	400	200
Centre Pier	ANN-02 AS1-1	233.5	Compact Sand	400	175
East Abutment	ANN-03 ANN-05	232.0	Compact to Dense Silty Sand to Sand	400	200

The geotechnical resistances at SLS are based on an estimated settlement not exceeding 25 mm. This settlement should be essentially complete by the end of construction.

The above resistance values are for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance values used in design must be reduced in accordance with the CHBDC 2014 Clause 6.10.3 and Clause 6.10.4.

The lateral resistance developed along the base of cast-in-place concrete footings founded on the undisturbed, compact to dense silty sand to sand with gravelly sand lenses may be computed using an ultimate friction coefficient of 0.45. This is an “ultimate” value and requires a degree of sliding movement to occur to fully mobilize the resistance.

For frost protection purposes, all footing bases should have a minimum earth cover of 1.5 m or its thermal equivalent.



9.2.2 Footing Construction

The base of the footing excavation should be inspected by qualified foundation/geotechnical personnel to confirm that the footing subgrade is in the native, undisturbed compact to dense silty sand to sand with gravelly sand lenses conforming to the design requirements and has been adequately prepared to receive concrete. A concrete working slab should be placed within 4 hours following completion of excavation to prevent deterioration of the approved subgrade. The working slab should be at least 100 mm thick and formed with the same class of concrete as that of the footings. Where sub-excavation is required to remove unsuitable material from below the design founding level, the founding surface should be re-established using engineered fill or mass concrete of the same class as that of the footing. All footing construction procedures should follow the guidelines provided in OPSS 902.

The groundwater table is at, above or just below the recommended footing base level. The native silty sand to sand is prone to disturbance due to water seepage, accumulation of precipitation and surface runoff. The gravelly sand lenses, where exposed, will have a higher rate of water seepage. Feasible means of unwatering and dewatering will be required to facilitate dry excavations and to minimize subgrade disturbance for footing construction. Further details on groundwater control are provided in a later Section 13.

9.3 Driven Steel H-Piles

9.3.1 Axial Resistance

Conventional driven pile groups with pile caps are feasible for supporting the new bridge at this site. Should integral abutments be considered in the design, a single row of steel H-piles will be required to support the abutment walls.

It is recommended that the steel H-piles be driven to or below the elevations specified below to develop the required geotechnical resistance within the lower, very dense silty sand deposit with consistent “100-blow” material which was generally encountered below approximate Elevation 205 m.

For planning and design purposes, the pile tip elevations and recommended axial geotechnical resistances for steel HP 310 x 110 piles are provided in the table below.

Table 9.2 – Design Axial Geotechnical Resistances and Pile Tip Elevations

Location (Reference Boreholes)	Estimated Pile Tip Elevation (m)	Founding Stratum	Factored ULS (kN)	Factored SLS* (kN)
West Abutment (ANN-04)	205.0	Very Dense Silty Sand	1,600	1,400
Centre Pier (ANN-02)	205.0	Very Dense Silty Sand	1,600	1,400
East Abutment (ANN-03)	205.0	Very Dense Silty Sand	1,600	1,400

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 for axial compressive loading (typical degree of understanding of the subsurface conditions), as per CHBDC 2014. The SLS values correspond to a pile settlement up to 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 capacity of a pile must not be exceeded and should be confirmed by the structural designer. The actual pile embedment depth should also be established by the designer for structural stability and flexibility.

The pile tip elevations shown in Table 9.2 may be used for estimating purposes only. The actual pile tip elevations will be controlled during pile driving as indicated in Section 9.3.2.

Downdrag is not considered a pile design issue at this site.

9.3.2 Pile Installation

Pile installation shall be in accordance with OPSS.PROV 903.

Pile driving must be controlled by the use of the Hiley Formula for acceptance. An appropriate pile driving note is “Piles to be driven in accordance with Standard SS 103-11 using an ultimate geotechnical resistance of 3,200 kN per pile but must be driven to or below Elevation 205 m”. In addition, high strain dynamic testing (also commonly known as PDA testing) may be carried out for selected piles as required to confirm the pile resistance. A minimum of 10% of the total number of piles and not less than 2 piles per foundation element should be subjected to PDA testing.



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

Glacially derived soils inherently contain cobbles and boulders. At this site, the piles will have to be driven through very dense or hard soils and therefore hard driving conditions should be expected. In order to protect the piles while being driven through obstructions 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. Over-driving must be avoided to minimize the risk of damaging the pile.

The presence of boulders and cobbles, and the “100-blow” soils could prevent some piles from reaching the design pile tip elevations. An NSSP on pile installation is included in Appendix H with statements stipulating that the Contractor should inform the Contract Administrator if some piles cannot penetrate the obstructions to reach the design pile tip elevations.

Pile driving can induce pore pressure build-up within the silty soils immediately surrounding the pile resulting in reduction of the pile geotechnical resistance. Such resistance is anticipated to increase with time as the pore pressure dissipates after initial installation. It is recommended that a wait period of at least 7 days be specified before allowing retapping for confirmation of the pile geotechnical resistance.

9.3.4 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 pile cap under the abutment stems.

The geotechnical lateral resistance acting on a pile in cohesionless soil may be calculated using a coefficient of horizontal subgrade reaction (k_s) and ultimate lateral resistance (p_{ult}) as follows:

	k_s	=	$n_h z / B$	(kN/m ³)
	p_{ult}	=	$3 \gamma' z K_p$	(kPa)
Where	z	=	pile embedment depth (m)	
	B	=	pile width (m)	
	n_h	=	coefficient related to soil density (kN/m ³)	
	γ'	=	submerged unit weight (kN/m ³)	
	K_p	=	coefficient of passive lateral earth pressure	

The geotechnical lateral resistance acting on a pile in cohesive soils may be calculated using a value for the coefficient of horizontal subgrade reaction (k_s) and ultimate lateral resistance (p_{ult}) as follows:



$$\begin{aligned}
 k_s &= 67 C_u / B \quad (\text{kN/m}^3) \\
 p_{ult} &= 9 C_u \quad (\text{kPa}) \\
 \text{Where } C_u &= \text{undrained shear strength (kPa)} \\
 B &= \text{pile width (m)}
 \end{aligned}$$

The above equations and recommended parameters in Table 9.3 below may be used to analyse the interaction between a pile and the surrounding soil. The lateral pressures obtained from the analysis must not exceed the ultimate lateral resistance.

Lateral soil-pile interaction analyses may be carried out using the coefficient of horizontal subgrade reaction values provided in Table 9.3 below.

Table 9.3 – Soil Parameters for Lateral Pile Resistance

Foundation Unit	Soil Type	Elevation (m)		γ (kN/m ³)	γ'^{**} (kN/m ³)	n_h (kN/m ³)	K_p	C_u (kPa)
		Top	Bottom					
West Abutment	Gravelly Sand to Silty Sand - dense	232*	230	-	11	5,500	3.5	-
	Silty Sand to Sand - v. dense	230	224	-	12	8,000	3.9	-
	Silty Clay to Clayey Silt - hard	224	209	21	-	-	-	200
	Silty Sand - v. dense	209	205	-	12	10,000	4.0	-
	Groundwater level – Elevation 233 m							
Centre Pier	Silty Sand to Sand - compact	232*	226	-	11	4,000	3.2	-
	Silty Clay – v. stiff	226	224	20	-	-	-	150
	Silty Clay - hard	224	209	21	-	-	-	200
	Silty Sand - v. dense	209	205	-	12	10,000	4.0	-
	Groundwater level – Elevation 232 m							
East Abutment	Silty Sand to Sand - Compact	232*	230	-	11	2,500	3.0	-
	Clayey Silt – v. stiff	230	228	20	-	-	-	100
	Clayey Silt - hard	228	226	21	-	-	-	200
	Silty Sand to Sand - v. dense	226	221	-	12	11,000	4.2	-
	Clayey Silt to Silty Clay - hard	221	205	21	-	-	-	200
	Groundwater level – Elevation 233 m							



* Bottom of abutment wall.

** Submerged unit weight for cohesionless soils below groundwater level.

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/m³), 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.

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).

9.4 Augered Caissons

9.4.1 Axial Resistance

Caissons extending through the typically compact to dense silty sand to sand and founded within the hard silty clay to clayey silt may be considered to support the foundation elements. At the pier where space is limited for construction, it is understood that consideration is being given to using caissons to support the pier so that columns can be structurally connected and extended above ground without a cap.

It is recommended that the caissons be socketted within the hard silty clay to clayey silt ("100-blow" soil). Table 9.4 presents the recommended founding elevations and geotechnical resistances of typical caisson diameters for planning and design purposes.

Table 9.4 – Axial Geotechnical Resistances for Caisson Design

Foundation Unit	Highest Founding Elevation (m)	1.2 m Diameter		1.5 m Diameter		1.8 m Diameter	
		Factored ULS (kN)	Factored SLS (kN)	Factored ULS (kN)	Factored SLS (kN)	Factored ULS (kN)	Factored SLS (kN)
West Abutment	216.0	4,000	3,100	5,500	4,000	-	-
Centre Pier	216.0	4,300	3,200	6,500	4,200	9,700	7,200
	206.0	-	-	9,900	7,300	11,800	9,200
East Abutment	216.0	4,400	3,300	6,700	4,300	-	-

The SLS values above correspond up to 25 mm settlement.

The resistance values provided in Tables 9.4 above are based on shaft friction and a portion of end bearing, assuming that the walls and base of each caisson are free of loose, soft or otherwise disturbed material prior to placement of concrete.

Downdrag on the caissons is not an issue at this site.

9.4.2 Lateral Resistance

Lateral bridge loadings can be geotechnically resisted by the caissons through passive pressure developed along the embedded portion of the shaft. The methodology outlined in Section 9.3.4 above for driven piles may be used to estimate the lateral geotechnical resistance of the caissons by substituting the pile width, B, with the caisson diameter, D.

9.4.3 Caisson Installation

Caisson installation must be carried out in accordance with OPSS.PROV 903 where applicable.

The caisson installation equipment should be able to dislodge and remove any obstructions such as cobbles and boulders and to penetrate through the silty sand to sand into the hard silty clay to clayey silt. An NSSP addressing this issue must be included in the contract documents to alert the bidders. Suggested wording for such an NSSP is provided in Appendix H. Selection of the methods and equipment employed to install the caissons is the responsibility of the Contractor.

The caissons will extend below the groundwater table through the compact to dense silty sand to sand and will require temporary liners and drilling fluid (water or polymer slurry) to stabilize



the sidewall and the base. High volumes of seepage from the water-bearing sands and silts should be anticipated into the caisson excavations. Placement of concrete using pumped tremie methods may be required. The contractor must be alerted of these concerns and suggested texts for an NSSP are included in Appendix H to this effect.

9.5 Frost Cover

The design depth of frost penetration at this site is 1.5 m. The base of footings or pile caps must be provided with a minimum of 1.5 m of earth cover, or its thermal insulation equivalent, as protection against frost action.

10.0 RETAINED SOIL SYSTEMS (RSS) WALL

Design information provided by MP indicates that a RSS wall is proposed at the northeast quadrant of the Anne Street underpass near the east toe of the new east approach embankment. The proposed wall height is up to about 5.5 m to 6 m adjacent to the bridge, decreasing easterly to 2.5 m high. The length of the wall is approximately 118 m.

RSS walls used on this project must be specified to be “High Performance” and “High Appearance”. The soil conditions encountered near the wall alignment are generally suitable for the support of RSS walls. The contract drawings should include information on the longitudinal alignment of the wall in plan, the top and base elevations of the wall in profile, cross-sectional space constraints and NSSPs for the RSS wall. The underside of the RSS mass including the concrete levelling pads supporting the front panels may be stepped to accommodate topographic variations.

The performance of a RSS mass is dependent on, amongst other factors, the characteristics of its foundation. Failure to provide an adequate foundation may lead to settlement and distortion of the RSS and, in severe cases, to possible failure of the system. The foundation of the entire RSS mass must be considered, i.e. from the face of the wall to the furthest extent of the reinforcement. To provide acceptable foundation performance and based on Boreholes ANN-03 and RW20-01 to RW20-03, it is recommended that the RSS mass be founded at or below elevations presented in Table 10.1. The corresponding geotechnical resistances recommended are also presented in Table 10.1.



Table 10.1 – Retaining Wall Founding Elevations

Retaining Wall Station	Reference Borehole	Highest Founding Elevation (m)	Founding Soil Type	Factored Geotechnical Resistance	
				ULS (kPa)	SLS (kPa)
10+050	ANN-03	232.0	Compact sand	250	175
10+110	RW20-02	228.5	Very dense sandy silt	350	250
10+160	RW20-03	226.5	Very dense sand	350	250

The RSS mass should be founded on a minimum 0.5 m thick of engineered fill consisting of OPSS.PROV Granular A compacted to 100 percent of its Standard Proctor Maximum Dry Density (SPMDD) at a moisture content within 2 percent of optimum. The engineered pad must laterally extend at least 500 mm beyond the footprint of the RSS mass and levelling strip.

As per MTO RSS Design Guidelines, the top of the levelling pad should be placed at a depth below final grade not less than the larger of 0.8 m or 40% of frost depth (1.5 m), or 0.8 m in front of the wall.

The geotechnical resistances provided above are for concentric, vertical loading. The effects of load inclination and eccentricity need to be taken into account according to the CHBDC (2014) Clauses 6.10.3 and 6.10.4.

The entire block of reinforced earth must be designed against various modes of failure including sliding and overturning. Sliding resistance along the base of the wall may be estimated using an ultimate friction coefficient of 0.55 for an engineered granular fill subgrade and 0.45 for a compact to dense sand to silty sand subgrade. A Resistance Factor of 0.8 should be applied for the cohesionless soils as indicated in Table 6.2 of the CHBDC (2014).

Topsoil, organics, loose/soft, wet materials and debris must be stripped from the footprint of the RSS. It is noted that the subgrade level will be just above the groundwater level. The subgrade under the RSS foundation should be inspected and any loose/soft spots sub-excavated and replaced with compacted granular materials prior to placing fill. The subgrade preparation for the RSS wall, placement and compaction of the granular fill must be carried out in the dry.



The proprietary RSS system must meet the MTO's specifications for performance and appearance. The RSS supplier/designer may specify more stringent criteria or other requirements related to the particular design. The internal stability of the RSS wall should be analyzed by the supplier/designer of the proprietary product selected for this site.

RSS walls for bridge abutments must be selected from MTO DSM List 9.70.52.

RSS walls must be designed and constructed in accordance with MTO RSS SP 599S22 and SP 599S23.

10.1 Slope Stability of the Retaining Wall

Preliminary analysis of the global stability was conducted to assess stability of retaining wall founded on compact to very dense sandy silt and sand.

The global stability of the retaining walls must be analyzed after the final location and detail configurations of the walls are confirmed/finalized.

Global stability analyses were carried for the retaining walls. The analyses were carried out utilizing the commercially available slope stability analysis program Slope/W (Version 2019) of the GeoStudio software package developed by Geo-Slope International with the option for Morgenstern-Price method of slices for the limit equilibrium analyses. Analyses were completed for both static and seismic loading conditions.

The soil parameters used in the analyses were estimated from empirical correlations using the results of the in situ Standard Penetration Tests (SPTs) and geotechnical laboratory testing. The groundwater level in our analysis was based on readings obtained to date from standpipe piezometer.

The stability of the embankment was also checked under seismic loading assuming an acceleration of 0.032 g.

Results of the stability analyses are presented on Figures G1 and G2 in Appendix G. The results are also summarized in Table 10.2 below.

Table 10.2 - Computed Factors of Safety

Condition	Factor of Safety	Figure (Appendix G)
Retaining wall		
Static Drained	1.6	G1
Seismic = 0.032 g	1.5	G2



As per typical MTO requirements, a Factor of Safety (F.S.) of 1.5 is acceptable for long term (drained) conditions. Under the assumed seismic loading, the minimum acceptable factor of safety is 1.0. In the case of static loading, the factors of safety against global failure was 1.6 for drained condition and 1.5 for seismic condition. These factors of safety are considered to be acceptable for the proposed embankment bearing on the soils encountered at this site.

10.2 Settlement of the Retained soil system

The construction of the retaining walls, with heights of 5.5 m to 6.0 m and approximately 1.5 m (or less) of new fill will induce immediate (elastic) settlement in the underlying compact to very dense sandy silt/sand and very stiff to hard clayey silt.

The immediate settlements were assessed using elastic methods. Based on these analyses, the settlement is estimated to be in the order of 25 mm. This settlement will be immediate and essentially complete when construction of the retaining wall is completed.

Inspection of the retaining walls and placing of additional granular material to re-establish grades as necessary should be implemented during and after construction.

11.0 TEMPORARY EARTH CUTS

Earth cut is required for the proposed widening of Highway 400 and the corresponding lengthening and widening of the underpass structure. It is anticipated that a staged approach will be adopted during construction. Highway widening cut will be required towards the west and east of the existing bridge approaches. According to a GA drawing, the west cut and east cut will be in the order of 27 m and 20 m long, respectively. Existing boreholes indicate that up to 5 m to 7 m of silty sand to sand embankment fill will need to be excavated. The underlying native silty sand to sand may also be exposed at some locations. The cuts will largely be made above the groundwater table, although water seepage from water-bearing sands and silts, perched water from the fills, accumulation of surface runoff and precipitation should be expected.

Temporary open cut slopes at an inclination not steeper than 1H : 1V or flatter may be formed.

Temporary drainage of the cuts should be provided to maintain relatively dry and stable excavations. Surface runoff and precipitation should be diverted away from the excavations at all stages during construction. Permanent drainage will be required along the widened highway corridor. It is recommended that the water be controlled by means of permanent drains incorporated within the highway design.



Vegetative cover will be required on all exposed earth cut slopes to protect against surficial erosion. Reference may be made to OPSS.PROV 804.

Temporary protection (shoring) may be required at some locations during the earth cut operations. Recommendations for temporary protection (shoring) are presented in Section 15.0 of this report.

12.0 APPROACH FILLS

After the earth cuts, the west and east approach embankments will be widened to the north and south to accommodate the new, wider underpass structure. These widenings will require the placement of up to 7 m of new fill on the existing approach sideslopes. All sideslopes of the approach embankments should be designed for an inclination of 2H : 1V or flatter. There will also be a grade raise in the order of 1.2 m at the east approach.

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. All subgrade should be inspected and approved prior to placing fill.

Embankment widening should be carried out in accordance with OPSS.PROV 206 and OPSS.PROV 501 requirements. Materials used to construct the embankment widening should comprise granular materials or Select Subgrade Material (SSM) in compliance with OPSS.PROV 1010. Clayey earth material, especially those containing high plastic clay, is not recommended for embankment widening at this site due to potentially greater settlement after construction, difficulties in achieving the specified compaction and potential embankment stability issues. Where new embankment fill is placed against the existing embankment slopes, the existing fill slope must be benched in accordance with OPSD 208.010.

It is recommended that all exposed slope surfaces be vegetated and seeded in accordance with current MTO practice with reference to OPSS.PROV 804. Surface runoff and precipitation must be prevented from flowing perpendicularly down any slope surface. Erosion protection measures should be provided as necessary for the slopes.

13.0 APPROACH AND CUT SLOPES

Global stability analyses were carried out for the proposed embankment widenings and temporary earth cuts at the approaches. The analyses were carried out utilizing the commercially available slope stability analysis program Slope/W (Version 7) of the GeoStudio software package developed by Geo-Slope International with the option for Morgenstern-Price



method of slices for the limit equilibrium analyses. Analyses were completed for static conditions and seismic loading conditions where applicable.

The soil parameters used in the analyses were estimated from empirical correlations using the results of the in situ Standard Penetration Tests (SPTs) and geotechnical laboratory testing. The groundwater level in our analysis was based on readings obtained from standpipe piezometers.

13.1 Temporary Open Cuts

Analyses of global stability was carried out for open excavations through existing embankment fills overlying native, compact to dense silty sand to sand.

Selected graphical output of these analyses are presented on Figures G3 to G6 in Appendix G. The results are also summarized in Table 13.1 below.

**Table 13.1 Computed Factors of Safety
Temporary Earth Cuts**

Case	Factor of Safety	Figure (Appendix G)
Excavation Height (4.5 m) – Short Term Conditions		
Silty Sand to Sand Fill (1H : 1V)	1.3	G3
Silty Sand to Sand Fill (1.5H : 1V)	1.4	G4
Excavation Height (> 4.5 m) – Short Term Conditions		
Silty Sand to Sand Fill (1H : 1V)	1.1 to 1.2	G5, G7
Silty Sand to Sand Fill (1.5H : 1V)	1.2 to 1.3	G6, G8

As per typical MTO requirements, a Factor of Safety (F.S.) of 1.3 is acceptable for short term and total stress (undrained) conditions. Figures G3 and G4 indicate the F.S. are at or greater than 1.3 for 1H : 1V slopes that are up to 4.5 m high. Figure G4 shows that 1.5H : 1V slopes up to 5.5 m high can achieve a minimum F.S of 1.3.

Based on the above results, temporary cut slopes of 1H : 1V are generally acceptable for temporary cuts up to 4.5 m high. For cut heights exceeding 4.5 m, 1.5H : 1V slopes will be required to achieve the acceptable F.S. Surficial instability including sloughing should be anticipated especially for higher cuts. It is recommended that exposed cut slopes of any height

be temporarily covered with tarpaulin, or equivalent, for protection against adverse effects due to water seepage, surface runoff and precipitation during construction.

13.2 Forward Slope and Widened Embankment Stability

Based on results of the stability analyses, global stability of the embankments is not expected to be an issue if the grade raise and widening is constructed using granular materials or Select Subgrade Material (SSM) with side slopes not steeper than 2H : 1V.

Analyses of global stability was carried out for selected cases of embankment widening and the new forward slope configurations.

Selected graphical output of these analyses are presented on Figures G9 to G12 in Appendix G. The results are also summarized in Table 13.2 below. The east forward and approach slopes are considered representative as they have a height of up to 7 m including a grade raise of about 1.2 m. The new fill is assumed to be granular or Select Subgrade Material (SSM). Only the effective stress cases are analysed since all the soils considered have been identified as cohesionless.

**Table 13.2 Computed Factors of Safety
Forward Slope and Widened Embankment**

Case	Factor of Safety	Figure (Appendix G)
East Forward Slope (7 m max.)		
Effective Stress	2.2	G9
Seismic	2.0	G10
East Approach Side Slope (7 m max.)		
Effective Stress	1.45	G11
Seismic	1.35	G12

Figures G9 and G10 indicate that Factors of Safety (F.S.) in the order of 2 can be achieved for the static and seismic conditions at the proposed configuration of the east forward slope. These F.S. values for the static condition exceed 1.5 typically adopted for long term embankment design. Figure G11 indicates that a F.S. in the order of 1.45 can be achieved for the east approach side slope using Select Subgrade Material (SSM) and this F.S. is marginally acceptable. The use of granular materials will increase the F.S. The short term, total stress condition is not applicable at this site. The F.S. values of the seismic cases exceed 1.0.



Based on results of the stability analyses, global stability of the embankments is not expected to be an issue if the grade raise and widening is constructed using granular materials or Select Subgrade Material (SSM) with side slopes not steeper than 2H : 1V.

13.3 Settlement

Placement of new fill for the proposed embankment widening and the grade raise at the east approach will induce settlements within the fills and native soils. Based on the soil conditions at this site, it is estimated that not more than 25 mm of foundation settlement will occur beneath the newly constructed approach embankments. This settlement is expected to take place as the fill is placed and be completed by the end of construction.

14.0 SEISMIC CONSIDERATIONS

In accordance with the CHBDC 2014, the selection of the seismic site class is based on the soil conditions encountered in the upper 30 m of the stratigraphic profile. In general, the subsurface stratigraphy encountered at the site consists of a pavement structure overlying silty sand to sand embankment fill which is underlain by typically compact to dense, native silty sand to sand interlayered with clayey silt. The silty sand to sand deposit overlies hard silty clay to clayey silt which is, in turn, underlain by very dense silty sand.

As per Table 4.1, Clause 4.4.3.2 of the CHBDC (2014), the site may be classified as Seismic Site Class C.

Based on the National Building Code of Canada (NBCC 2015), the peak horizontal ground acceleration (PGA), corresponding to a design earthquake having a 2 percent probability of being exceeded in 50 years (i.e. 2,475 year return period) is 0.064 g at the site. Based on the site class and the PGA, the Site Coefficient is determined to be 1.00.

The new structure is classified to have a Seismic Performance Category of 1 based on Table 4.10 of the CHBDC (2014).

Based on review of the SPT data, seismically induced liquefaction of foundation soils is not anticipated under the design earthquake.

15.0 ABUTMENT WALL BACKFILL AND LATERAL EARTH PRESSURES

Backfill to the abutment walls should consist of free-draining granular material conforming to OPSS Granular A or B Type II specifications. The granular material should be placed to the



extents shown in OPSD 3101.150. Compaction should be carried out in accordance with OPSS.PROV 206 and OPSS.PROV 501.

Earth pressures acting on the structure may be assumed to impose a triangular distribution governed by the characteristics of the backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC (2014) but generally are given by the expression:

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

Where:

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

The earth pressure coefficients are dependent on the material used as backfill. Recommended unfactored values are shown in Table 15.1. The at-rest coefficients should be employed for restrained walls. Active pressures should be used for any wingwalls or unrestrained walls.

Table 15.1 – Lateral Earth Pressure Coefficients

Loading Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	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	3.7	-	3.2	-

The parameters in the table correspond to full mobilization of active and passive earth pressures and require certain relative movements between the wall and adjacent soil to produce these conditions. The values to be used in design can be assessed from Figure C6.16 of the Commentary to the CHBDC (2014).



In accordance with Clause 6.12.3 of the CHBDC (2014), a compaction surcharge should be added. The magnitude should be 12 kPa at the top of fill and decreasing to 0 kPa at a depth of 1.7 m for Granular B Type I, or 2.0 m for Granular A or Granular B Type II.

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

The design of the abutment walls must incorporate measures such as weep holes and/or subdrains to permit drainage of the backfill and avoid the potential build-up of hydrostatic pressures behind the walls.

16.0 EXCAVATION AND WATER CONTROL

All excavations must be carried out in accordance with OPSS.PROV 902 and the Occupational Health and Safety Act (OHSA). For the purposes of assessing excavation slope and temporary support requirements in compliance with the OHSA, the native silty sand to sand deposit is classified as Type 3 above the groundwater level and Type 4 below the groundwater level. The embankment fills are classified as Type 3 soils.

It is anticipated that bulk excavation of the earth cuts through existing embankment fill for highway widening will likely not require measures other than sump pumping and surface water diversion from the excavations.

It is anticipated that pile cap or spread footing construction will be carried out following the bulk excavation associated with the earth cuts for highway widening. Excavations for these foundation elements will extend to approximately 3 m below the existing grade of Highway 400 at both abutment and the centre pier locations. The excavations will extend through the pavement materials and sand to silty sand embankment fill into the typically compact to very dense, native silty sand to sand deposit.

Based on currently available water level readings, excavations for pile cap or spread footing construction are generally expected to extend up to the order of 2 m below the groundwater level. Flow of perched water from the embankment fill into the excavations should also be expected. In addition to effective pumping from filtered sumps and perimeter ditches, other measures of groundwater control including the use of interlocking sheetpiles may be required locally in order to maintain a reasonably dry subgrade for construction. Surface runoff and



precipitation must be diverted away from the excavations. All footings must be constructed in the dry.

The design of a dewatering system is the responsibility of the Contractor, and the Contract Documents must alert him to this responsibility. Filtered sumps must be properly designed to control loss of fines and ground loss.

Construction dewatering will be required to ensure that the work areas remain dry. McIntosh Perry advised that the anticipated volume of groundwater and stormwater to be pumped during construction will be in excess of 400,000 L/day. Therefore, an application for a Category 3 Permit to Take Water (PTTW) has been submitted to the MECP. It is understood that groundwater that seeps into the excavations, as well as any collected stormwater within the excavations, will be discharged down gradient of the work area as per OPSS 517.

Dewatering of all excavations should be carried out in accordance with OPSS.PROV 517, SP 517F01 Amendment to OPSS 517, OPSS.PROV 902 and NSSP FOUND0003. 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.

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. It is recommended that the excavations be inspected periodically to confirm stability at all stages. Provision must be made for the handling of potential obstructions in the existing fill materials. Suggested wording for an NSSP in this regard is included in Appendix H.

Where required, construction will need to be carried out in conjunction with temporary protection (shoring) which is discussed in more detail in the section below.

17.0 TEMPORARY PROTECTION SYSTEMS

Temporary protection (shoring) systems may be required to maintain live traffic lanes during construction of the new Anne Street bridge and to permit construction of the centre pier at the Highway 400 median.

An item titled "Temporary Protection System" as per OPSS.PROV 539 and SP105S09 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 temporary protection be specified on the contract drawings.

Client: McIntosh Perry

File No. 22424

E file: H:\20000-29999\22000-22999\22424 Hwy 400 Barrie 3 Bridges 2017-E-0032\Reports & Memos\ANNE STREET\FINAL\22424 Hwy 400 Anne St Underpass FINAL FIDR jun 20 text.doc

Date: June 9, 2020

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The selection and design of the temporary protection systems is the responsibility of the contractor. The design of such systems must incorporate traffic loading and surcharge loading due to construction equipment and operations.

For conceptual planning and costing purposes, a soldier pile and lagging wall and/or an interlocking sheetpile wall is considered suitable for temporary protection. These shoring walls 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)
	=	0.32 (native silty sand to sand)
	=	0.35 (native silty clay to clayey silt)
K_p	=	3.0 (approach fills)
	=	3.1 (native silty sand to sand)
	=	2.9 (native silty clay to clayey silt)

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. Filter fabric should be placed behind the lagging boards to minimize migration of fines. Full hydrostatic pressure will need to be incorporated for design of sheetpile walls if this type of protection system is used.

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.

18.0 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, new fills and associated works. Protection and/or relocation of utilities, if necessary, should be provided. Underground utilities should not be undermined or damaged during new foundation construction and fill placement.



If driven H-piles are used to support the proposed bridge abutments, the vibrations produced during pile driving could have adverse effects on the adjacent existing foundations and structures. A vibration and settlement monitoring program should be implemented to monitor the existing bridge while it remains operational. Suggested wording for an NSSP on vibration and settlement monitoring is included in Appendix H.

19.0 SOIL CORROSION POTENTIAL

The results of corrosivity analytical tests including sulphate tests conducted on selected soil samples indicate the following conditions at the test locations:

- The potential for sulphate attack on concrete foundations from the fill and native soils is considered to be low.
- The potential for soil corrosion on metal is considered to be moderate to severe for the fill based on the relatively low resistivity and slightly elevated chloride values.
- The effects of road de-icing salts should also be considered when selecting the class of concrete and corrosion mitigation measures.

20.0 CONSTRUCTION CONCERNS

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

- Staging of the earth cuts and bridge replacement must be carried out in a manner that minimizes the potential for disturbance of the existing bridge foundations adjacent to the work area. Currently available information indicates that the existing foundations are supported on deep foundations. However, there has been conflicting information on whether the deep foundations consist of Franki type (expanded base) caissons or driven H-piles. The founding depths of these caissons or piles are also unknown. Construction activities must avoid undermining the existing foundations.
- The existing fills may contain obstructions including cobbles, boulders or debris. The Contractor must be equipped and prepared to remove, penetrate or otherwise handle these obstructions during construction.
- Based on water levels measured in the piezometers, pile cap or footing excavations within the silty sand to sand will extend below the groundwater level. In addition to effective sump pumping, other measures of groundwater control may be required to maintain a reasonably dry excavation base for construction. A dewatering specialist should be consulted to provide input on the required dewatering system.



21.0 CLOSURE

Engineering analysis and preparation of the foundation design report were carried out by Mr. Geoff Lay, P.Eng and Ms. Rocio 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.



THURBER ENGINEERING LTD.



Rocio Palomeque Reyna, P.Eng.
Geotechnical Engineer



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



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

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Site: 44.386N 79.708W

User File Reference: Hwy 400, Anne St. Underpass

2020-02-04 19:16 UT

Requested by: Thurber Engineering Ltd.

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.080	0.050	0.032	0.011
Sa (0.1)	0.111	0.071	0.047	0.017
Sa (0.2)	0.108	0.071	0.049	0.018
Sa (0.3)	0.093	0.062	0.043	0.017
Sa (0.5)	0.077	0.052	0.036	0.013
Sa (1.0)	0.047	0.031	0.021	0.006
Sa (2.0)	0.024	0.016	0.010	0.003
Sa (5.0)	0.006	0.004	0.002	0.001
Sa (10.0)	0.003	0.002	0.001	0.000
PGA (g)	0.064	0.041	0.027	0.009
PGV (m/s)	0.063	0.040	0.026	0.008

Notes: Spectral ($S_a(T)$, where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s . Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. **These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.**

References

National Building Code of Canada 2015 NRCC no. 56190; Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information



Natural Resources
Canada

Ressources naturelles
Canada

Canada



Appendix A
Record of Borehole Sheets
Current Investigation

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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


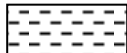



 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (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

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

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	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

<u>TERMS</u>	
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.

RECORD OF BOREHOLE No ANN-01

1 OF 2

METRIC

GWP# 2504-17-00 LOCATION Anne Street Underpass N 4 916 266.6 E 288 202.1 ORIGINATED BY BL
 DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2019.06.05 - 2019.06.05 LATITUDE 44.386216 LONGITUDE -79.708317 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
242.3	GROUND SURFACE													
0.0	ASPHALT: (100mm)													
0.1	SAND and GRAVEL Dense Brown Moist (FILL)		1	GS			242							
			1	SS	35		241							
240.8														
1.4	Silty SAND, some gravel Compact Brown Moist (FILL)		2	SS	26		240							
			3	SS	23		239							
			4	SS	25		238							
238.2														
4.1	Silty SAND, some gravel Compact Brown Moist (FILL)		5	SS	16		237							
							236							
	Trace organics		6	SS	10		235							
235.8							234							
6.5	SAND, some silt, trace clay, trace gravel Compact Brown Moist to Wet		7	SS	19		233							
			8	SS	19									

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No ANN-01

2 OF 2

METRIC

GWP# 2504-17-00 LOCATION Anne Street Underpass N 4 916 266.6 E 288 202.1 ORIGINATED BY BL
 DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2019.06.05 - 2019.06.05 LATITUDE 44.386216 LONGITUDE -79.708317 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)	
	Continued From Previous Page		9	SS	18			20	40	60	80	100	20	40	60		
231.9							232										
10.4	END OF BOREHOLE AT 10.4m. BOREHOLE CAVED TO 7.0m AND WATER LEVEL AT 7.0m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.1m, THEN ASPHALT PATCH TO SURFACE.																

ONTMT4S2 MTO-22424.GPJ 2017TEMPLATE(MTO).GDT 4/29/20

RECORD OF BOREHOLE No ANN-02

1 OF 5

METRIC

GWP# 2504-17-00 LOCATION Anne Street Underpass N 4 916 236.2 E 288 230.3 ORIGINATED BY KK
 DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN
 DATUM Geodetic DATE 2019.02.04 - 2019.02.14 LATITUDE 44.385943 LONGITUDE -79.707962 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
236.1	GROUND SURFACE													
0.0	ASPHALT						236							
235.8			1	GS										
0.3	SAND and GRAVEL Dense Brown Moist to Wet (FILL)													
			1	SS	33		235							
234.7														
1.4	SAND, some gravel, trace silt Loose to Compact Brown Moist													
			2	SS	9		234							
			3	SS	15		233							
			4	SS	19		232							
232.0														
4.1	Gravelly SAND, trace silt Compact to Dense Brown Moist													
			5	SS	21		231							34 60 6 (SH+CL)
							230							
			6	SS	35		229							
228.9														
7.2	Silty SAND, trace gravel Compact Grey Moist													
			7	SS	28		228							1 77 22 0
			8	SS	20		227							

Continued Next Page

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

RECORD OF BOREHOLE No ANN-02

2 OF 5

METRIC

GWP# 2504-17-00 LOCATION Anne Street Underpass N 4 916 236.2 E 288 230.3 ORIGINATED BY KK
 DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN
 DATUM Geodetic DATE 2019.02.04 - 2019.02.14 LATITUDE 44.385943 LONGITUDE -79.707962 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
225.9	Continued From Previous Page						226							
10.2	Silty CLAY , trace sand Very Stiff to Hard Grey Moist		9	SS	22		225							
							224							
			10	SS	67		223							
							222							
			11	SS	100/ 0.275		221							
							220							
			12	SS	100/ 0.225		219							
							218							
			13	SS	100/ 0.125		217							
			14	SS	100/ 0.200									

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No ANN-02

3 OF 5

METRIC

GWP# 2504-17-00 LOCATION Anne Street Underpass N 4 916 236.2 E 288 230.3 ORIGINATED BY KK
 DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN
 DATUM Geodetic DATE 2019.02.04 - 2019.02.14 LATITUDE 44.385943 LONGITUDE -79.707962 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
Continued From Previous Page														
	Silty CLAY , trace sand Hard Grey Moist		15	SS	101/ 0.275		216							0 1 52 47
							215							
							214							
							213							
			16	SS	89									
							212							
							211							
							210							0 8 38 54
			17	SS	79									
							209							
							208							
							207							
			18	SS	100/ 0.125									
208.4 27.7	Silty SAND , trace clay Very Dense Grey Wet													

Continued Next Page

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

RECORD OF BOREHOLE No ANN-02

4 OF 5

METRIC

GWP# 2504-17-00 LOCATION Anne Street Underpass N 4 916 236.2 E 288 230.3 ORIGINATED BY KK
 DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN
 DATUM Geodetic DATE 2019.02.04 - 2019.02.14 LATITUDE 44.385943 LONGITUDE -79.707962 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100					
Continued From Previous Page							206								
	Silty SAND , trace clay Very Dense Grey Moist						205								
			19	SS	100/ 0.100		204								0 64 33 3
							203								
							202								
			20	SS	100/ 0.100		201								
							200								
							199								
			21	SS	100/ 0.200		198								
							197								
			22	SS	100/ 0.100										

Continued Next Page

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

RECORD OF BOREHOLE No ANN-02

5 OF 5

METRIC

GWP# 2504-17-00 LOCATION Anne Street Underpass N 4 916 236.2 E 288 230.3 ORIGINATED BY KK
 DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN
 DATUM Geodetic DATE 2019.02.04 - 2019.02.14 LATITUDE 44.385943 LONGITUDE -79.707962 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							PLASTIC LIMIT w _p NATURAL MOISTURE CONTENT w LIQUID LIMIT w _L	
	Continued From Previous Page				0.175			20	40	60	80	100	20	40	60	
	Silty SAND , trace clay Very Dense Grey Moist						196									
194.7			23	SS	100/		195						○			
41.4	END OF BOREHOLE AT 41.4m. BOREHOLE OPEN AND WATER LEVEL AT 5.3m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.6m, CEMENT TO 0.2m, THEN ASPHALT TO SURFACE.				0.075											

ONTMT4S2 MTO-22424.GPJ 2017TEMPLATE(MTO).GDT 4/29/20

RECORD OF BOREHOLE No ANN-03

1 OF 5

METRIC

GWP# 2504-17-00 LOCATION Anne Street Underpass N 4 916 191.4 E 288 249.2 ORIGINATED BY KK/BL
 DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Augers/Wash Boring with Casing COMPILED BY AN
 DATUM Geodetic DATE 2019.05.29 - 2019.06.04 LATITUDE 44.385540 LONGITUDE -79.707724 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
240.6	GROUND SURFACE							20 40 60 80 100					
0.0	ASPHALT: (100mm)												
0.1	SAND and GRAVEL Compact Brown Moist (FILL)		1	SS	27								
239.2													
1.4	SAND, some gravel Compact Brown Moist (FILL)		2	SS	26								
			3	SS	11								
			4	SS	26								
236.4													
4.1	Silty SAND, trace to some clay, some gravel Dense Brown Moist (FILL)		5	SS	45								
			6	SS	30								
232.9													
7.6	SAND, some gravel, some silt Loose to Compact Brown/Grey Moist to Wet		7	SS	6								
			8	SS	28								

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No ANN-03

2 OF 5

METRIC

GWP# 2504-17-00 LOCATION Anne Street Underpass N 4 916 191.4 E 288 249.2 ORIGINATED BY KK/BL
 DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Augers/Wash Boring with Casing COMPILED BY AN
 DATUM Geodetic DATE 2019.05.29 - 2019.06.04 LATITUDE 44.385540 LONGITUDE -79.707724 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					
Continued From Previous Page							20 40 60 80 100	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w _P w w _L WATER CONTENT (%)					
230.3													
10.2	Clayey SILT , with sand, trace gravel Very Stiff to Hard Grey Moist		9	SS	26		230						1 23 64 12
							229						
			10	SS	100/ 0.225		228						
							227						
			11	SS	69		226						
225.8							225						2 84 12 2
14.8	SAND , some silt, trace clay, trace gravel Very Dense Grey Wet		12	SS	85		224						
							223						
			13	SS	73		222						
			14	SS	100/ 0.275		221						
220.9													
19.7	Clayey SILT , trace sand Hard												

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

METRIC

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _P W W _L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			"N" VALUES	20				40	60
	Continued From Previous Page						SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100						

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No ANN-03

4 OF 5

METRIC

GWP# 2504-17-00 LOCATION Anne Street Underpass N 4 916 191.4 E 288 249.2 ORIGINATED BY KK/BL
 DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Augers/Wash Boring with Casing COMPILED BY AN
 DATUM Geodetic DATE 2019.05.29 - 2019.06.04 LATITUDE 44.385540 LONGITUDE -79.707724 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	w _p w w _L						
	Continued From Previous Page						20	40	60	80	100	20	40	60	
	Silty CLAY , trace sand Hard Grey Moist														
							210								
							209								
			19	SS	82		208								
							207								
							206								
205.5							205								
35.1	Silty SAND , trace clay Very Dense Grey Wet		20	SS	100/ 0.200		205								
							204								
							203								
			21	SS	100/ 0.175		202								
							201								
			22	SS	100/										

Continued Next Page

+³ × 3³ : Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No ANN-03

5 OF 5

METRIC

GWP# 2504-17-00 LOCATION Anne Street Underpass N 4 916 191.4 E 288 249.2 ORIGINATED BY KK/BL
 DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Augers/Wash Boring with Casing COMPILED BY AN
 DATUM Geodetic DATE 2019.05.29 - 2019.06.04 LATITUDE 44.385540 LONGITUDE -79.707724 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
	Continued From Previous Page				0.200									
	Silty SAND, trace clay Very Dense Grey Wet		23	SS	100/		200							
					0.100		199							
197.6			24	SS	100/		198							
43.0	END OF BOREHOLE AT 43.0m. BOREHOLE CAVED TO 7.9m UPON RETRIEVAL OF CASING. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2019.08.27 8.7 231.9 2020.04.13 7.1 233.5				0.175									

RECORD OF BOREHOLE No ANN-04A

1 OF 1

METRIC

GWP# 2504-17-00 LOCATION Anne Street Underpass N 4 916 251.5 E 288 198.8 ORIGINATED BY BL
 DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Augers/Wash Boring with Casing COMPILED BY AN
 DATUM Geodetic DATE 2019.06.08 - 2019.06.12 LATITUDE 44.386080 LONGITUDE -79.708358 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%) w _p w w _L						
242.5	GROUND SURFACE							20	40	60	80	100		20	40	60		
0.0	ASPHALT: (100mm)																	
0.1	SAND and GRAVEL Dense Brown Moist (FILL)		1	GS			242											
			1	SS	36													
241.0							241											
1.4	SAND, some gravel, trace silt Compact to Dense Brown Moist (FILL)		2	SS	23													
			3	SS	32		240											
			4	SS	29		239											
238.4																		
4.1	Silty SAND, some clay, trace gravel Compact Grey Moist (FILL)		5	SS	14		238											
							237											
236.2	Inferred cobbles and/or boulders		6	SS	100/													
6.3	END OF BOREHOLE AT 6.3m. SPLIT SPOON BOUNCING. CASING COULD NOT BE ADVANCED. BOREHOLE MOVED TO 3.0m SOUTH.				0.075													

ONTM14S2 MTO-22424.GPJ 2017TEMPLATE(MTO).GDT 4/29/20

METRIC

[illegible]

CONTMT4S2 MTO-22424.GPJ 2017TEMPLATE(MTO).GDT 4/29/20

RECORD OF BOREHOLE No ANN-04B

2 OF 5

METRIC

GWP# 2504-17-00 LOCATION Anne Street Underpass N 4 916 249.9 E 288 196.3 ORIGINATED BY BL
DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Augers/Wash Boring with Casing COMPILED BY AN
DATUM Geodetic DATE 2019.06.08 - 2019.06.12 LATITUDE 44.386066 LONGITUDE -79.708389 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								20 40 60 80 100					
	Continued From Previous Page												
230.8	Gravelly SAND , some silt Dense Grey Moist		9	SS	41								
11.7	Silty SAND , trace clay Very Dense Grey Moist to Wet		10	SS	75								
			11	SS	100/ 0.200								
			12	SS	72								
			13	SS	72								
224.7	Clayey SILT , trace sand Hard Grey Moist		14	SS	68								
17.8													
223.1	Sandy SILT Very Dense Grey Moist												
19.4													

Continued Next Page

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

METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	UNIT WEIGHT γ KN/M ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
								20 40 60 80 100	W _P W W _L			
	Continued From Previous Page						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	20 40 60 80 100	W _P W W _L			
								20 40 60 80 100	20 40 60			GR SA SI CL

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No ANN-04B

4 OF 5

METRIC

GWP# 2504-17-00 LOCATION Anne Street Underpass N 4 916 249.9 E 288 196.3 ORIGINATED BY BL
 DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Augers/Wash Boring with Casing COMPILED BY AN
 DATUM Geodetic DATE 2019.06.08 - 2019.06.12 LATITUDE 44.386066 LONGITUDE -79.708389 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
Continued From Previous Page														
208.8	Silty CLAY , trace sand Hard Grey Moist													
			19	SS	100/ 0.275									
33.7	Silty SAND , trace clay Very Dense Grey Wet													
			20	SS	100/ 0.225									
			21	SS	100/ 0.300									
			22	SS	100/ 0.300									

Continued Next Page

+³ × 3³ : Numbers refer to
Sensitivity

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15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No ANN-04B

5 OF 5

METRIC

GWP# 2504-17-00 LOCATION Anne Street Underpass N 4 916 249.9 E 288 196.3 ORIGINATED BY BL
 DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Augers/Wash Boring with Casing COMPILED BY AN
 DATUM Geodetic DATE 2019.06.08 - 2019.06.12 LATITUDE 44.386066 LONGITUDE -79.708389 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
Continued From Previous Page							20	40	60	80	100	W P	W	W L			
201.1	Silty SAND , trace clay Very Dense Grey Wet				0.360												
23			23	SS	100/												
41.4	END OF BOREHOLE AT 41.4m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2019.08.27 10.1 232.4 2020.04.13 7.8 234.7				0.050												

RECORD OF BOREHOLE No ANN-05

1 OF 2

METRIC

GWP# 2504-17-00 LOCATION Anne Street Underpass N 4 916 174.0 E 288 246.5 ORIGINATED BY BL
DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2019.06.12 - 2109.06.12 LATITUDE 44.385384 LONGITUDE -79.707757 CHECKED BY GRL

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

ONTMT4S2 MTO-22424.GPJ 2017TEMPLATE(MTO).GDT 4/29/20

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No ANN-05

2 OF 2

METRIC

GWP# 2504-17-00 LOCATION Anne Street Underpass N 4 916 174.0 E 288 246.5 ORIGINATED BY BL
DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2019.06.12 - 2109.06.12 LATITUDE 44.385384 LONGITUDE -79.707757 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20	40	60	80	100	W P	W	W L			
	Continued From Previous Page																
	BOREHOLE CAVED TO 6.7m AND WATER LEVEL AT 6.4m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.1m, THEN ASPHALT PATCH TO SURFACE.																

RECORD OF BOREHOLE No RW20-01

1 OF 1

METRIC

GWP# 2504-17-00 LOCATION Anne Street N 4 916 198.4 E 288 261.8 ORIGINATED BY SB
 DIST HWY 400 BOREHOLE TYPE Tripod/NW Casing COMPILED BY BH
 DATUM Geodetic DATE 2020.01.08 - 2020.01.09 LATITUDE 44.385571 LONGITUDE -79.707547 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
235.6	GROUND SURFACE													
0.0	SILT , sandy, trace clay, mixed with organics Loose Dark Brown Moist (FILL) SAND , some gravel, some silt, trace clay Compact to Very Dense Brown to Grey Moist (FILL) occasional cobbles, wet		1	SS	8		235							
235.0			2	SS	24									
0.6			3	SS	50/		234							
			4	SS	29									
			5	SS	92		233							
232.9														14 69 14 3
2.7	END OF BOREHOLE AT 2.7m. ORIGINAL BOREHOLE MET REFUSAL AT 1.47m DUE TO OBSTRUCTION (POSSIBLY COBBLE). MOVED NORTHWEST (DOWNSLOPE) FOR ABOUT 0.6m AND CONTINUED ADVANCING TO 2.7m BEFORE REFUSAL TO FURTHER ADVANCE WAS ENCOUNTERED. BOREHOLE BACKFILLED WITH AUGER CUTTINGS AND HOLEPLUG TO SURFACE.													

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

RECORD OF BOREHOLE No RW20-02

1 OF 2

METRIC

GWP# 2504-17-00 LOCATION Anne Street N 4 916 131.5 E 288 287.0 ORIGINATED BY JM
 DIST HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY BH
 DATUM Geodetic DATE 2020.01.21 - 2020.01.21 LATITUDE 44.385014 LONGITUDE -79.707234 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
235.4	GROUND SURFACE													
0.0	ASPHALT (75mm)													
0.1	SAND, some gravel to gravelly, trace to some silt, trace clay Very Dense to Compact Brown to Grey Moist (FILL)		1	SS	70		235							
			2	SS	22		234							
			3	SS	20		233							
			4	SS	21		232							
232.2	occasional cobbles						231							
3.2	SAND mixed with organics, some silt, trace gravel Compact Black Moist (FILL)		5	SS	21		230							
231.3							229							
4.1	Silty SAND, trace gravel, some clay, gasoline odour Compact Brown to Grey Moist to Wet (FILL)		6	SS	18		228							
229.7	Gravelly SAND, some silt, occasional cobbles Very Dense Grey Wet		7	SS	58		227							
228.6	Sandy SILT, some clay, sand lenses Very Dense Grey Moist to Wet		8	SS	100/ 0.250		226							
			9	SS	94									

Continued Next Page

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

ONTM14S2 MTO-22424.GPJ 2017TEMPLATE(MTO).GDT 4/29/20

RECORD OF BOREHOLE No RW20-02

2 OF 2

METRIC

GWP# 2504-17-00 LOCATION Anne Street N 4 916 131.5 E 288 287.0 ORIGINATED BY JM
DIST HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY BH
DATUM Geodetic DATE 2020.01.21 - 2020.01.21 LATITUDE 44.385014 LONGITUDE -79.707234 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
	Continued From Previous Page													
	Sandy SILT , some clay Very Dense Grey Moist Layer of sand at 10.7m (300mm)		10	SS	76		225							
							224							
	Wet		11	SS	75		223							
							222							
			12	SS	50/ 0.150		221							0 34 56 10
							220							
219.6			13	SS	100									
15.8	END OF BOREHOLE AT 15.8m. BOREHOLE CAVED TO 4.8m. WATER LEVEL AT 4.6m. BOREHOLE BACKFILLED WITH HOLEPLUG TO 1.2m, SAND TO 0.5m, THEN COLD PATCH ASPHALT TO SURFACE													







ONTMT4S2 MTO-22424.GPJ 2017TEMPLATE(MTO).GDT 4/29/20

RECORD OF BOREHOLE No RW20-03

1 OF 2

METRIC

GWP# 2504-17-00 LOCATION Anne Street N 4 916 089.5 E 288 332.9 ORIGINATED BY AA
 DIST HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY BH
 DATUM Geodetic DATE 2020.02.14 - 2020.02.14 LATITUDE 44.384625 LONGITUDE -79.706670 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa												
230.9	GROUND SURFACE							20	40	60	80	100								
0.0	TOPSOIL (450mm)		1	SS	9															
230.4																				
0.5	SAND, trace to some gravel Loose Dark Brown to Brown Moist to Wet (FILL)																			
			2	SS	8															
			3	SS	8															
228.7																				
2.2	Silty CLAY, with sand Stiff Brown Wet (FILL)																			
			4	SS	10															
227.7																				
3.2	SAND, some silt, trace clay Compact to Very Dense Brown to Grey Moist																			
			5	SS	35															
												</								

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No RW20-03

2 OF 2

METRIC

GWP# 2504-17-00 LOCATION Anne Street N 4 916 089.5 E 288 332.9 ORIGINATED BY AA
 DIST HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY BH
 DATUM Geodetic DATE 2020.02.14 - 2020.02.14 LATITUDE 44.384625 LONGITUDE -79.706670 CHECKED BY RPR

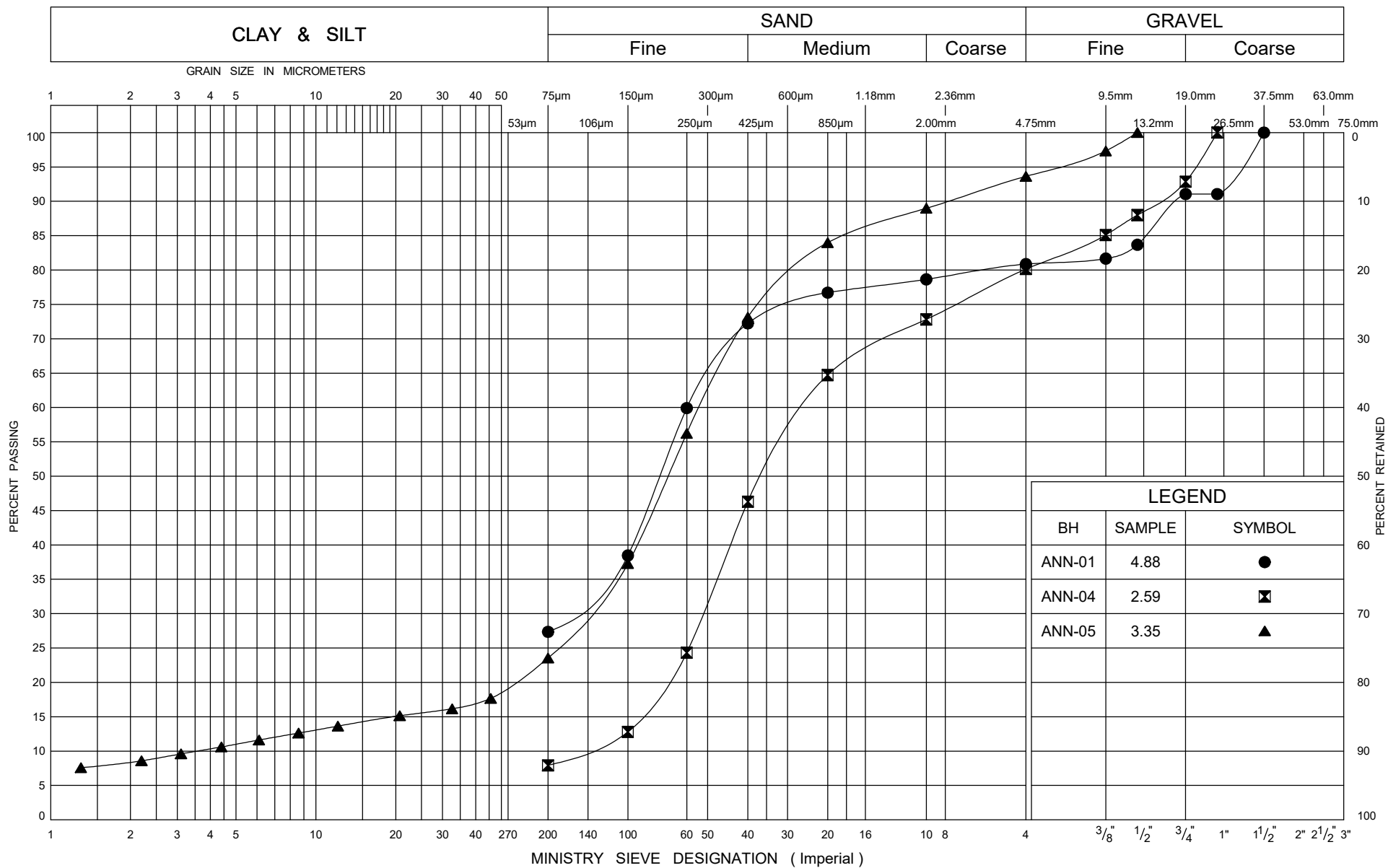
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W P	W	W L		
	Continued From Previous Page																
	WATER LEVEL AT 4.6M UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2020.03.02 4.1 226.8 2020.04.13 3.6 227.4																

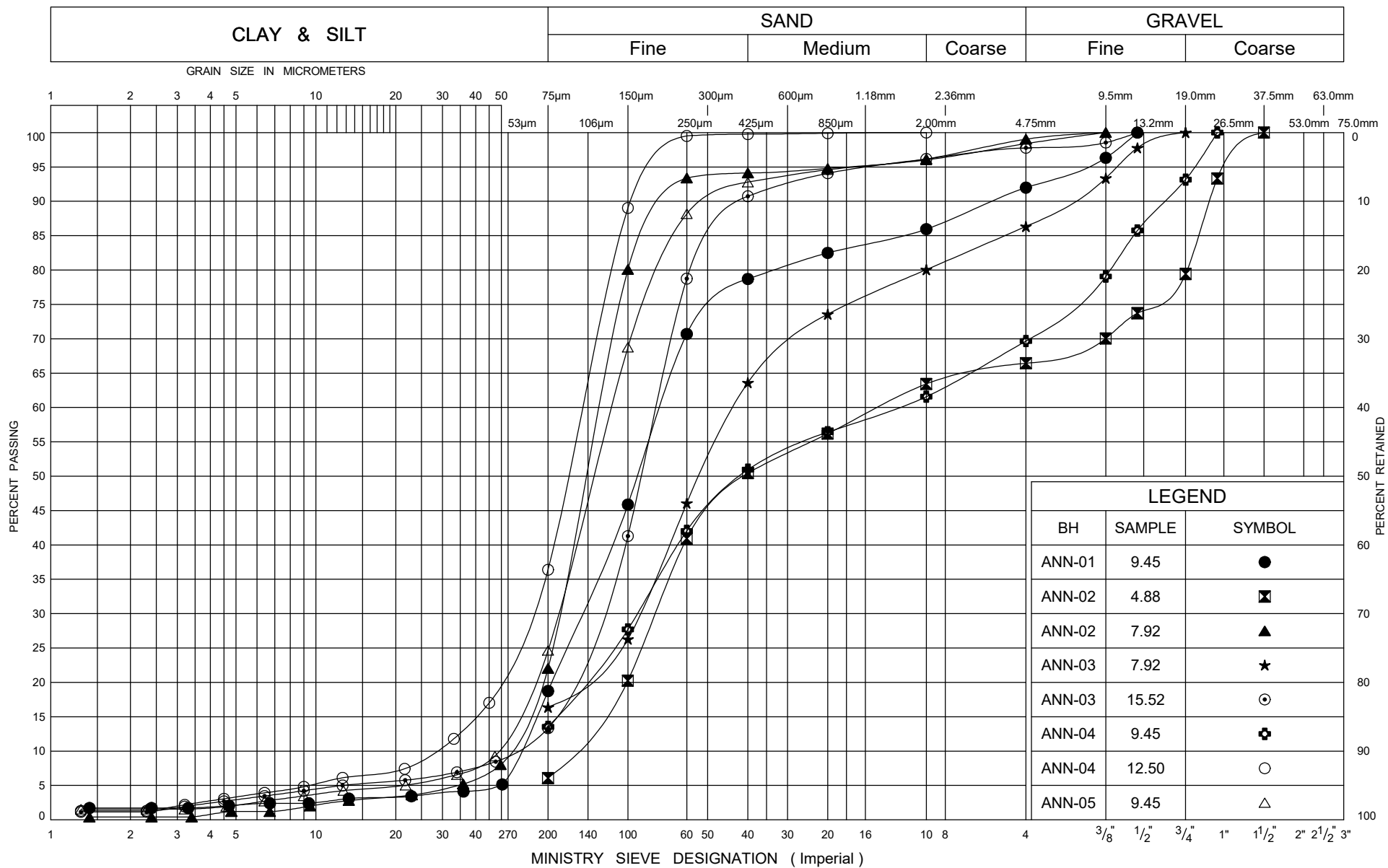


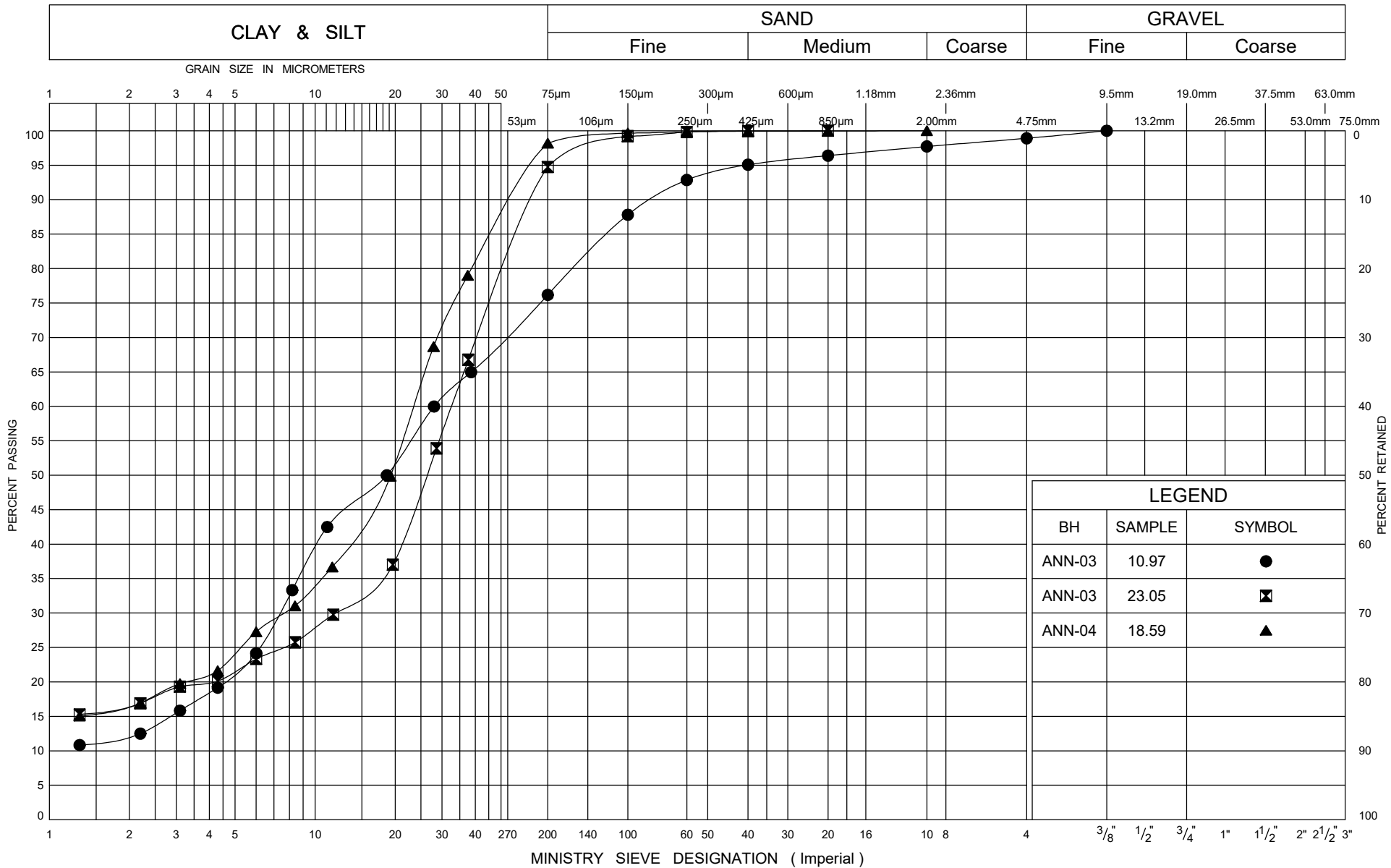
Appendix B

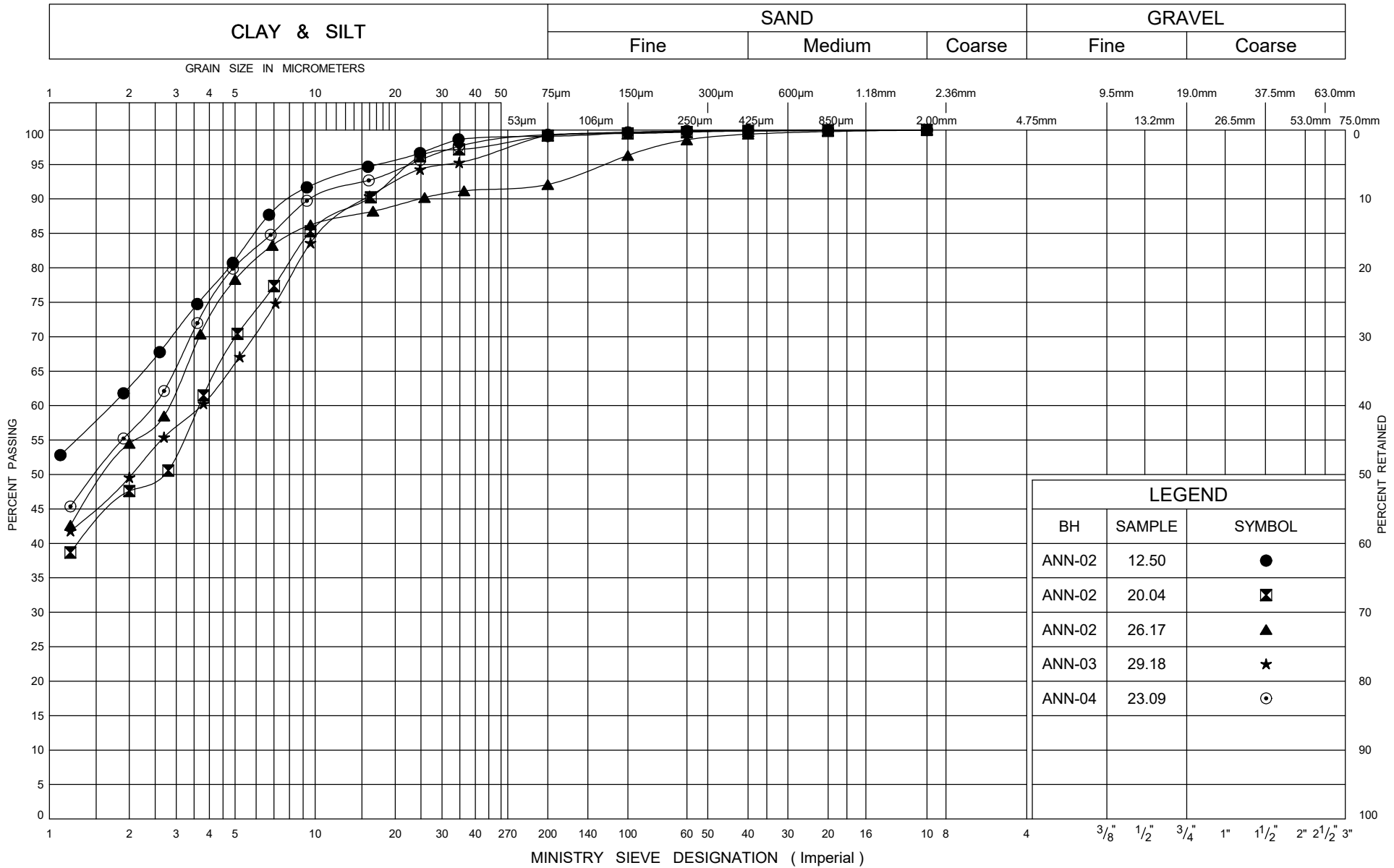
Geotechnical and Analytical Laboratory Test Results

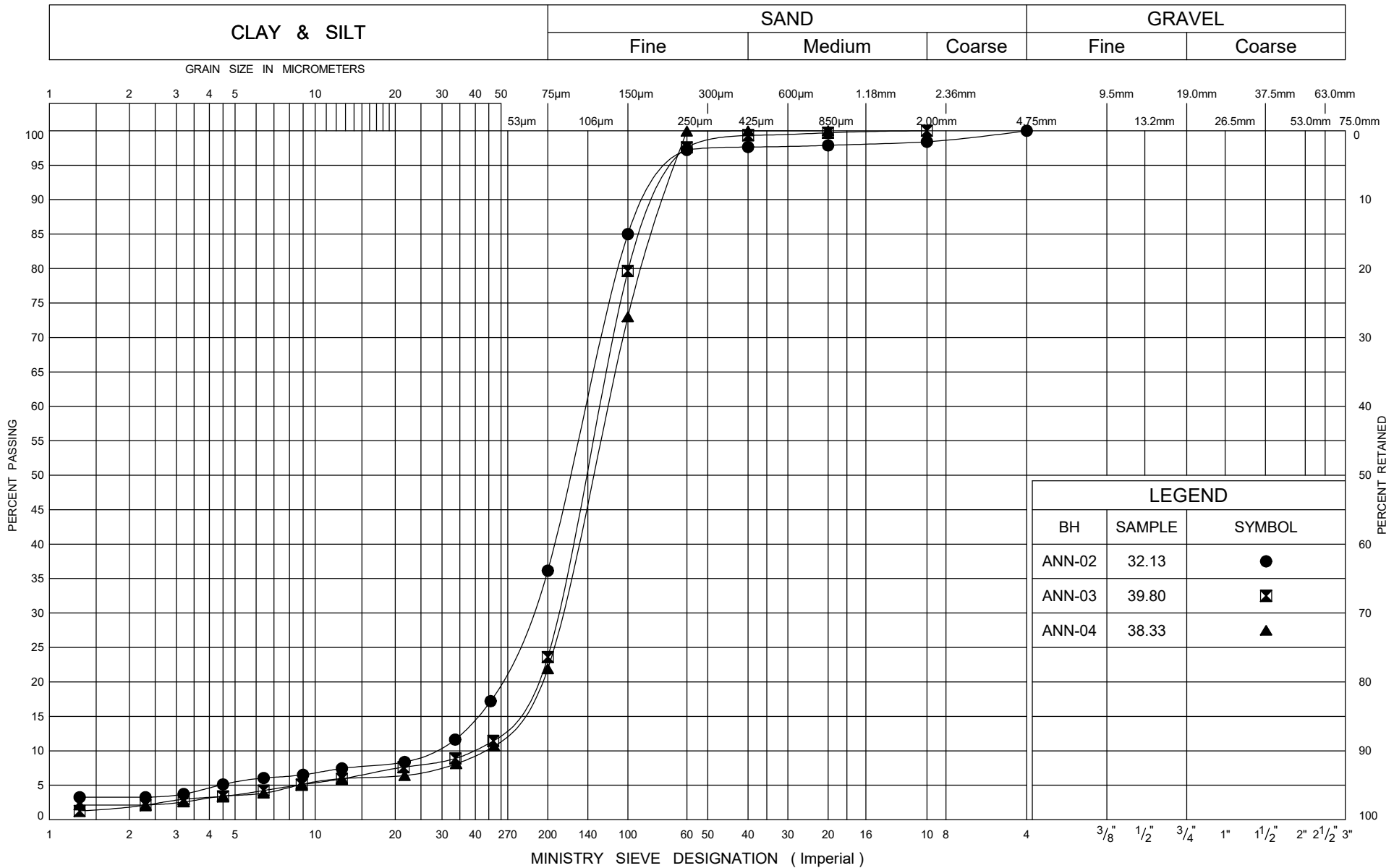
Current Investigation

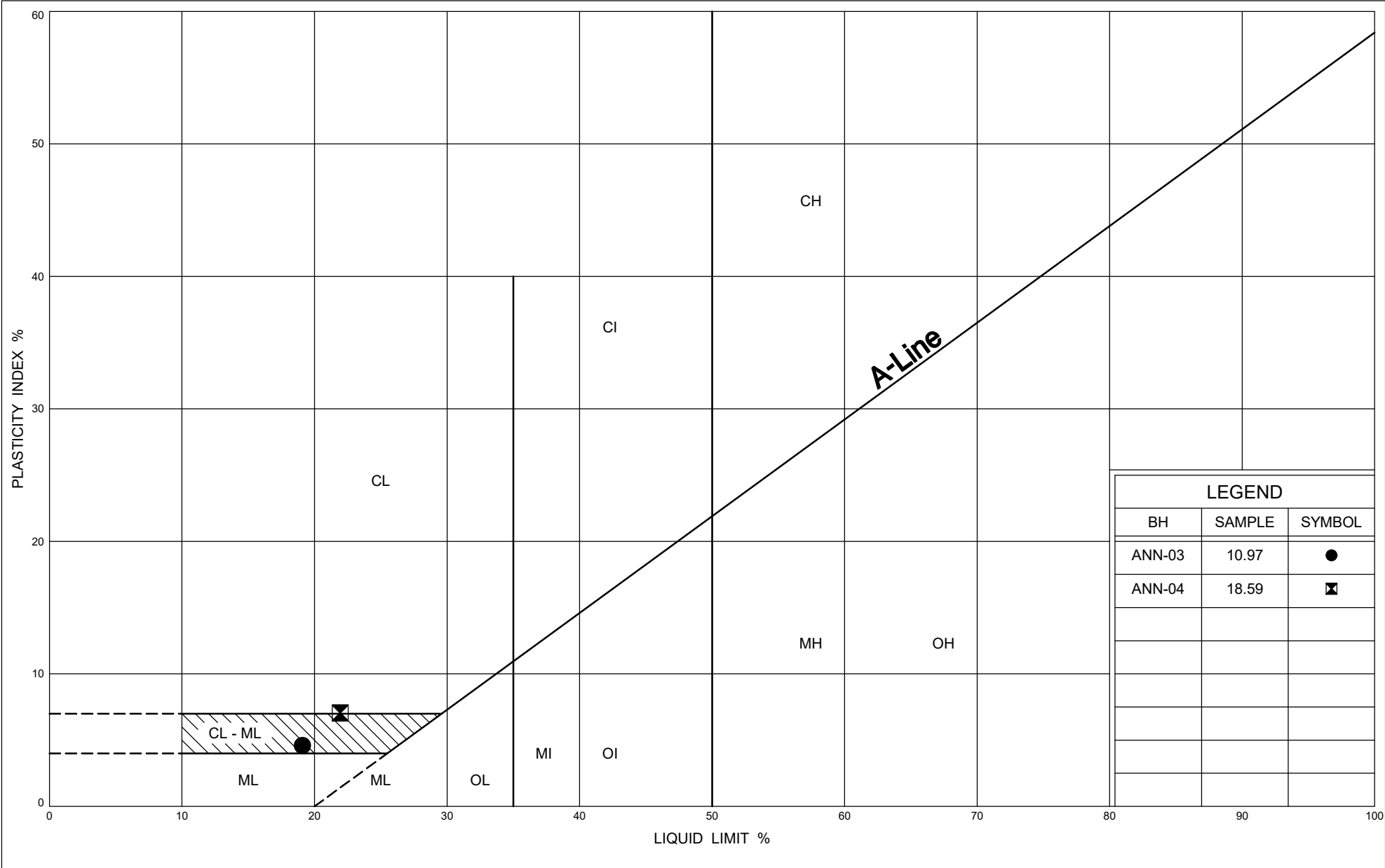


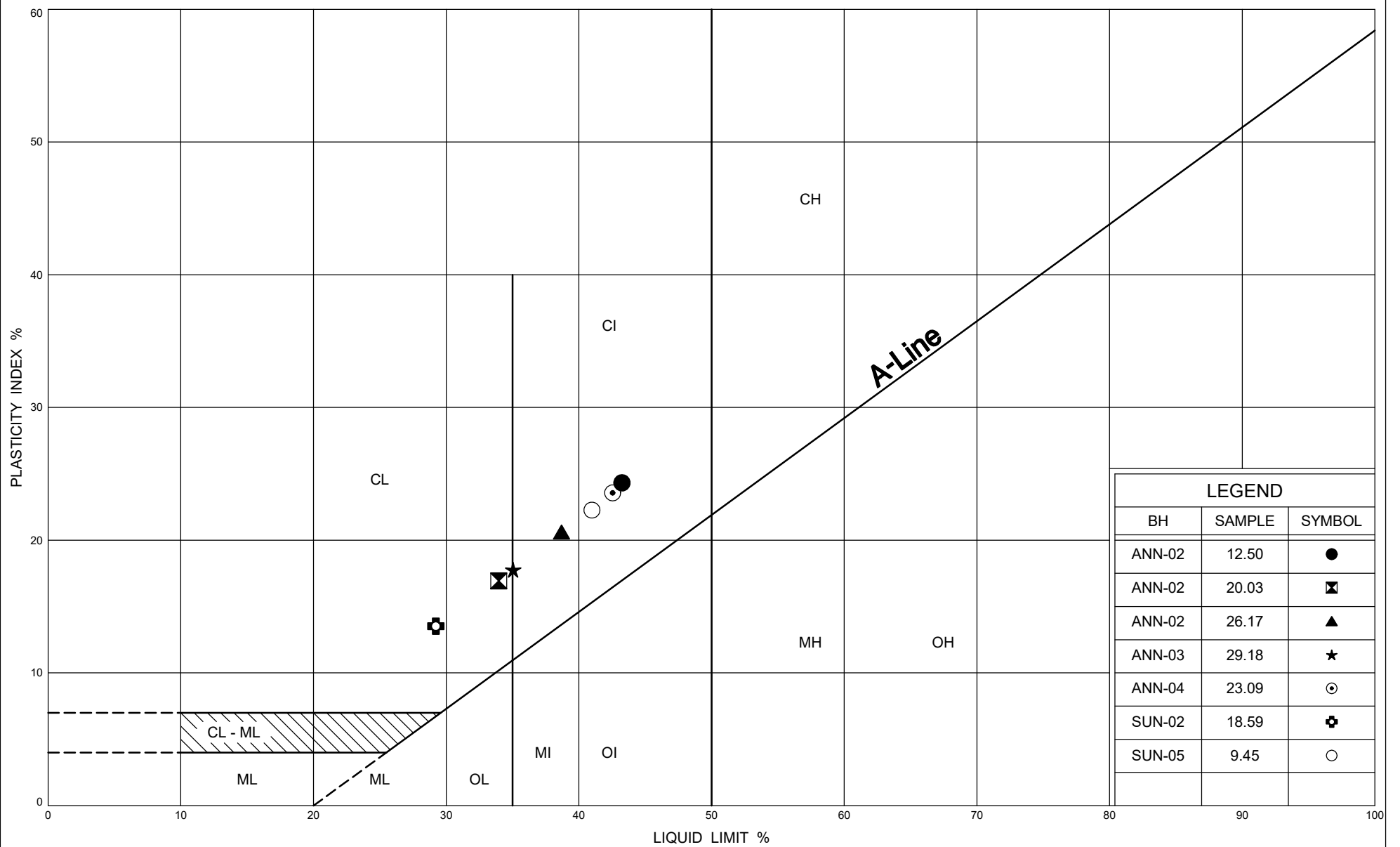












PLASTICITY CHART Silty CLAY

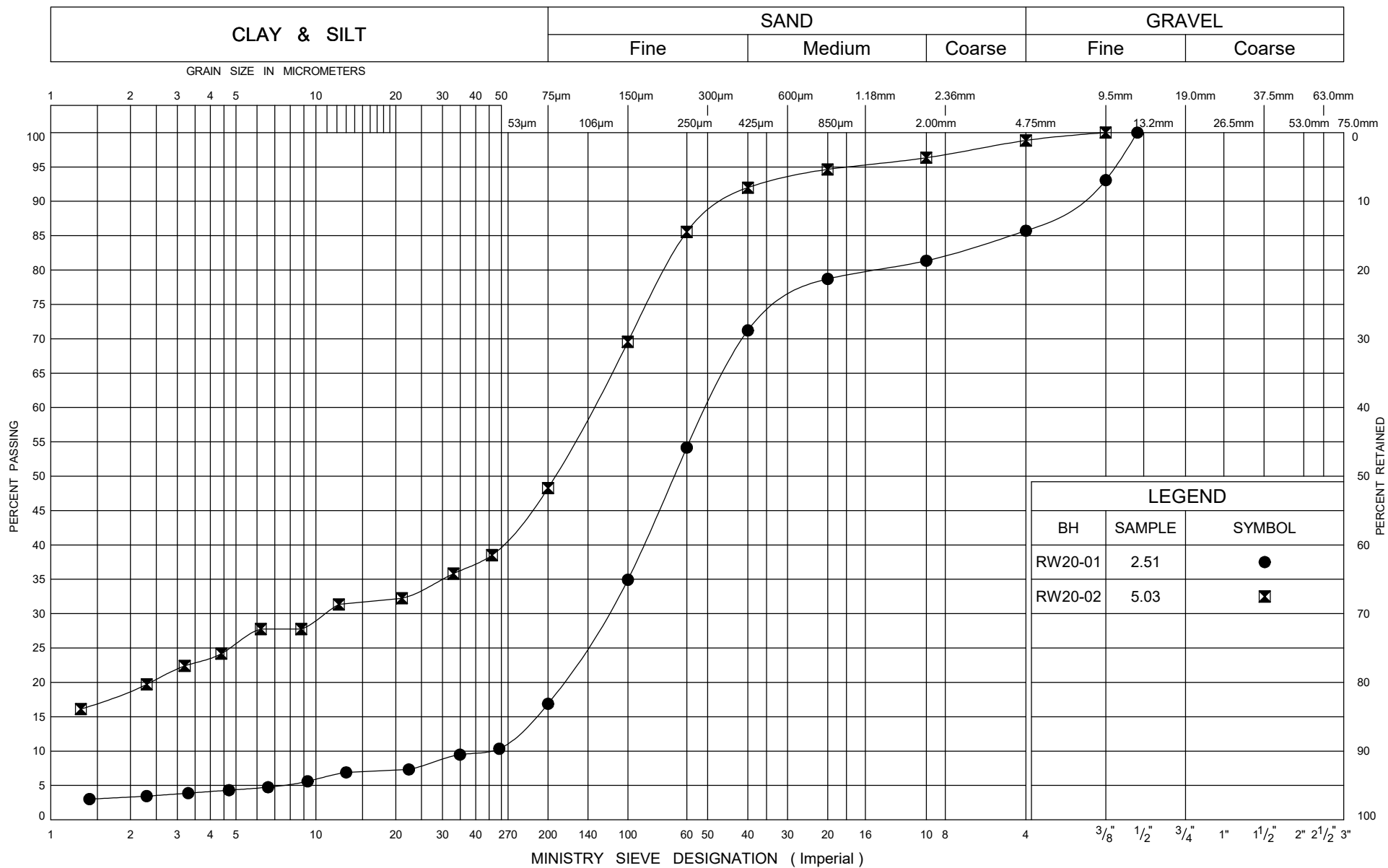
FIG No B7

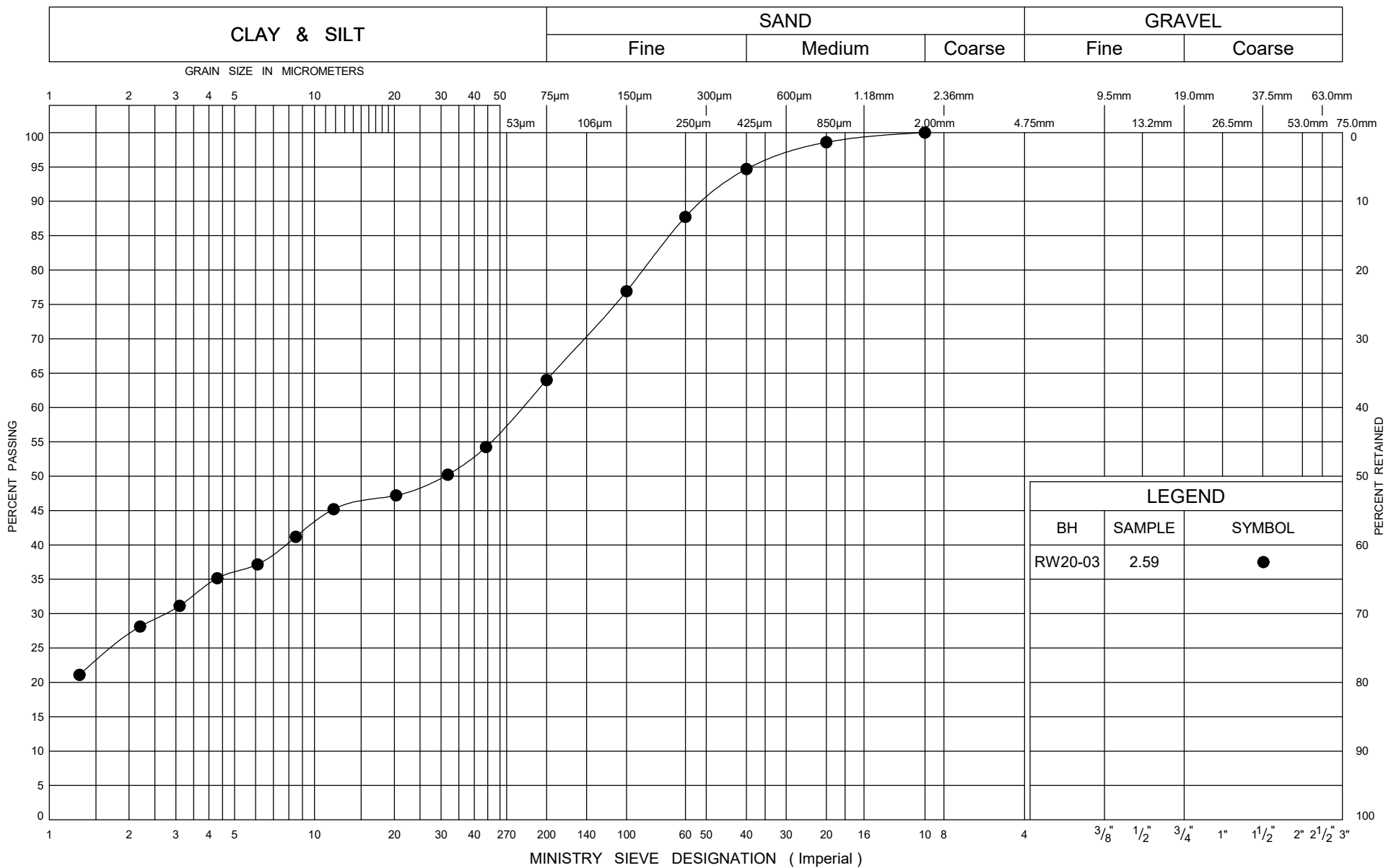
W P 2445-15-00



Ministry of
Transportation

Ontario





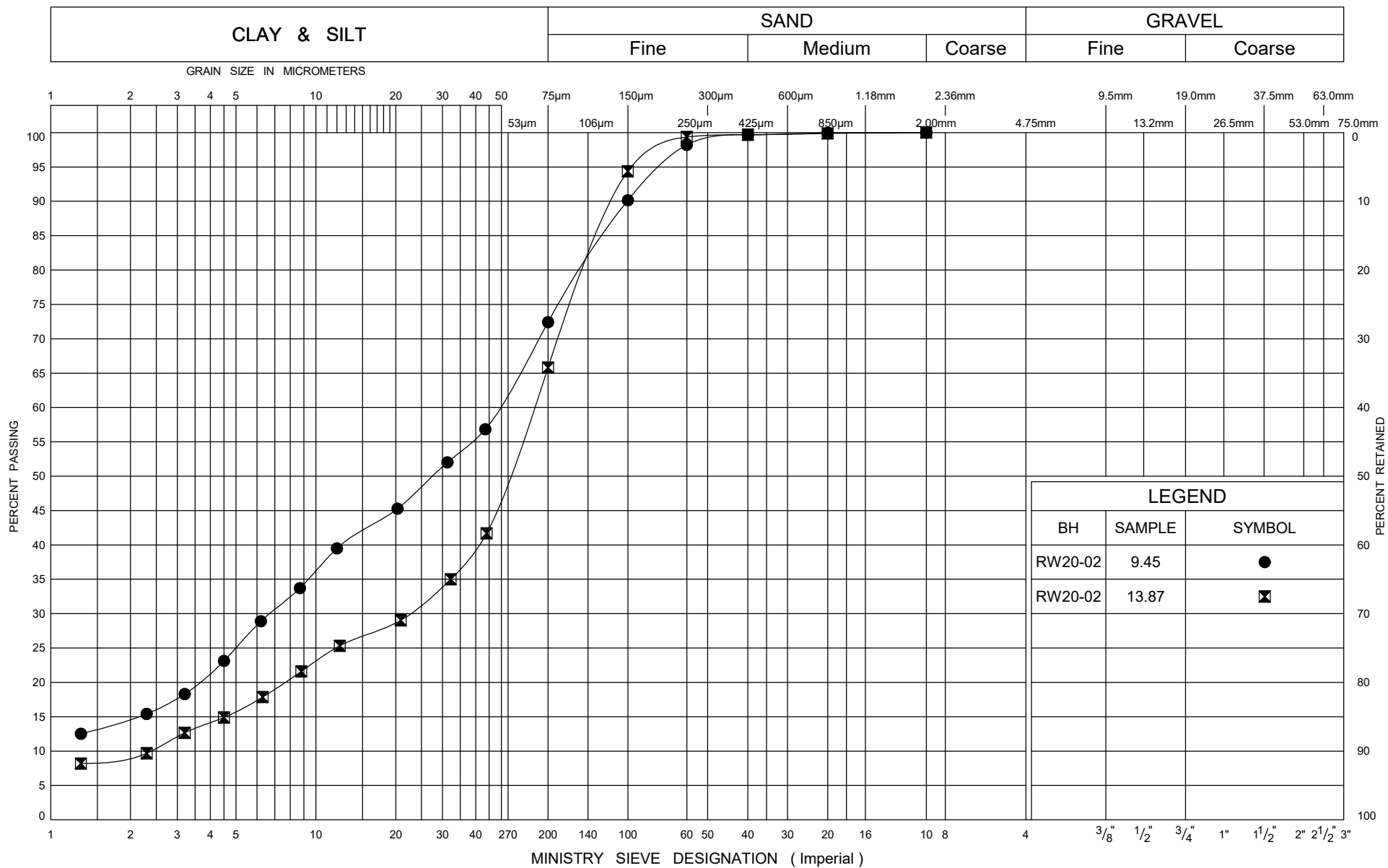




FIG No B11
W P
Anne Street



Thurber Engineering Ltd. (Oakville)
ATTN: Geoff Lay
2010 Winston Park Drive
Unit 103
Oakville ON L6H 5R7

Date Received: 28-JUN-19
Report Date: 05-JUL-19 14:32 (MT)
Version: FINAL

Client Phone: 905-829-8666

Certificate of Analysis

Lab Work Order #: L2301373
Project P.O. #: NOT SUBMITTED
Job Reference: 22424
C of C Numbers:
Legal Site Desc:

Amanda Fazekas
Account Manager

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ADDRESS: 5730 Coopers Avenue, Unit #26, Mississauga, ON L4Z 2E9 Canada | Phone: +1 905 507 6910 | Fax: +1 905 507 6927
ALS CANADA LTD Part of the ALS Group An ALS Limited Company

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2301373-1 ANN-03 SS#11 Sampled By: CLIENT on 30-MAY-19 Matrix: SOIL								
Physical Tests								
Conductivity		0.235		0.0040	mS/cm		02-JUL-19	R4691844
% Moisture		12.4		0.10	%	02-JUL-19	02-JUL-19	R4692329
pH		7.91		0.10	pH units		03-JUL-19	R4693084
Redox Potential		191		-1000	mV		04-JUL-19	R4694159
Resistivity		4260		1.0	ohm*cm		02-JUL-19	
Leachable Anions & Nutrients								
Chloride		51.3		5.0	ug/g	02-JUL-19	02-JUL-19	R4692459
Anions and Nutrients								
Sulphate		48		20	mg/kg	04-JUL-19	04-JUL-19	R4694474
Inorganic Parameters								
Acid Volatile Sulphides		<0.20	PEHR	0.20	mg/kg	03-JUL-19	03-JUL-19	R4693314
L2301373-2 ANN-05 SS#7 Sampled By: CLIENT on 12-JUN-19 Matrix: SOIL								
Physical Tests								
Conductivity		1.45		0.0040	mS/cm		04-JUL-19	R4694048
% Moisture		13.5		0.10	%	02-JUL-19	02-JUL-19	R4692329
pH		8.00		0.10	pH units		04-JUL-19	R4693744
Redox Potential		180		-1000	mV		04-JUL-19	R4694159
Resistivity		689		1.0	ohm*cm		04-JUL-19	
Leachable Anions & Nutrients								
Chloride		681		5.0	ug/g	02-JUL-19	02-JUL-19	R4692459
Anions and Nutrients								
Sulphate		69		20	mg/kg	04-JUL-19	04-JUL-19	R4694474
Inorganic Parameters								
Acid Volatile Sulphides		<0.20	PEHR	0.20	mg/kg	03-JUL-19	03-JUL-19	R4693314
L2301373-3 ANN-04 SS#16 Sampled By: CLIENT on 10-JUN-19 Matrix: SOIL								
Physical Tests								
Conductivity		0.255		0.0040	mS/cm		04-JUL-19	R4694048
% Moisture		17.2		0.10	%	02-JUL-19	02-JUL-19	R4692329
pH		8.06		0.10	pH units		04-JUL-19	R4693744
Redox Potential		147		-1000	mV		04-JUL-19	R4694159
Resistivity		3920		1.0	ohm*cm		04-JUL-19	
Leachable Anions & Nutrients								
Chloride		<5.0		5.0	ug/g	02-JUL-19	02-JUL-19	R4692459
Anions and Nutrients								
Sulphate		111		20	mg/kg	04-JUL-19	04-JUL-19	R4694474
Inorganic Parameters								
Acid Volatile Sulphides		<0.20	PEHR	0.20	mg/kg	03-JUL-19	03-JUL-19	R4693314
L2301373-4 ANN-01 SS#5 Sampled By: CLIENT on 05-JUN-19 Matrix: SOIL								

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2301373-4 ANN-01 SS#5 Sampled By: CLIENT on 05-JUN-19 Matrix: SOIL								
Physical Tests								
Conductivity		1.77		0.0040	mS/cm		03-JUL-19	R4693077
% Moisture		9.35		0.10	%	02-JUL-19	02-JUL-19	R4692329
pH		7.91		0.10	pH units		03-JUL-19	R4693084
Redox Potential		166		-1000	mV		04-JUL-19	R4694159
Resistivity		564		1.0	ohm*cm		03-JUL-19	
Leachable Anions & Nutrients								
Chloride		1090		5.0	ug/g	02-JUL-19	02-JUL-19	R4692459
Anions and Nutrients								
Sulphate		61		20	mg/kg	04-JUL-19	04-JUL-19	R4694474
Inorganic Parameters								
Acid Volatile Sulphides		<0.20	PEHR	0.20	mg/kg	03-JUL-19	03-JUL-19	R4693314
L2301373-5 ANN-02 SS#4 Sampled By: CLIENT on 04-FEB-19 Matrix: SOIL								
Physical Tests								
Conductivity		0.848		0.0040	mS/cm		04-JUL-19	R4694048
% Moisture		12.0		0.10	%	02-JUL-19	02-JUL-19	R4692329
pH		8.13		0.10	pH units		04-JUL-19	R4693744
Redox Potential		174		-1000	mV		04-JUL-19	R4694159
Resistivity		1180		1.0	ohm*cm		04-JUL-19	
Leachable Anions & Nutrients								
Chloride		460		5.0	ug/g	02-JUL-19	02-JUL-19	R4692459
Anions and Nutrients								
Sulphate		37		20	mg/kg	04-JUL-19	04-JUL-19	R4694474
Inorganic Parameters								
Acid Volatile Sulphides		<0.20	PEHR	0.20	mg/kg	03-JUL-19	03-JUL-19	R4693314

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Sample Parameter Qualifier key listed:

Qualifier	Description
PEHR	Parameter Exceeded Recommended Holding Time On Receipt: Proceed With Analysis As Requested.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
CL-R511-WT	Soil	Chloride-O.Reg 153/04 (July 2011)	EPA 300.0
5 grams of dried soil is mixed with 10 grams of distilled water for a minimum of 30 minutes. The extract is filtered and analyzed by ion chromatography.			
Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).			
EC-WT	Soil	Conductivity (EC)	MOEE E3138
A representative subsample is tumbled with de-ionized (DI) water. The ratio of water to soil is 2:1 v/w. After tumbling the sample is then analyzed by a conductivity meter.			
Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).			
MOISTURE-WT	Soil	% Moisture	CCME PHC in Soil - Tier 1 (mod)
PH-WT	Soil	pH	MOEE E3137A
A minimum 10g portion of the sample is extracted with 20mL of 0.01M calcium chloride solution by shaking for at least 30 minutes. The aqueous layer is separated from the soil and then analyzed using a pH meter and electrode.			
Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).			
REDOX-POTENTIAL-WT	Soil	Redox Potential	APHA 2580
This analysis is carried out in accordance with the procedure described in the "APHA" method 2580 "Oxidation-Reduction Potential" 2012. Samples are extracted at a fixed ratio with DI water. Results are reported as observed oxidation-reduction potential of the platinum metal-reference electrode employed, in mV.			
RESISTIVITY-CALC-WT	Soil	Resistivity Calculation	APHA 2510 B
Resistivity are calculated based on the conductivity using APHA 2510B where Conductivity is the inverse of Resistivity.			
RESISTIVITY-CALC-WT	Soil	Resistivity Calculation	MOECC E3138
Resistivity are calculated based on the conductivity using APHA 2510B where Conductivity is the inverse of Resistivity.			
SO4-WT	Soil	Sulphate	EPA 300.0
5 grams of soil is mixed with 50 mL of distilled water for a minimum of 30 minutes. The extract is filtered and analyzed by ion chromatography.			
SULPHIDE-WT	Soil	Sulphide, Acid Volatile	APHA 4500S2J
This analysis is carried out in accordance with the method described in APHA 4500 S2-J. Hydrochloric acid is added to sediment samples within a purge and trap system. The evolved hydrogen sulphide (H2S) is carried into a basic solution by inert gas. The acid volatile sulfide is then determined colourimetrically.			

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA

Chain of Custody Numbers:

Reference Information

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.

- mg/kg - milligrams per kilogram based on dry weight of sample*
- mg/kg ww - milligrams per kilogram based on wet weight of sample*
- mg/kg lwt - milligrams per kilogram based on lipid weight of sample*
- mg/L - unit of concentration based on volume, parts per million.*
- < - Less than.*
- D.L. - The reporting limit.*
- N/A - Result not available. Refer to qualifier code and definition for explanation.*

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

MOISTURE-WT Soil

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MOISTURE-WT		Soil						
Batch	R4692329							
WG3093212-3	DUP	L2301503-31						
% Moisture		32.2	31.0		%	3.6	20	02-JUL-19
WG3093212-2	LCS							
% Moisture			98.8		%		90-110	02-JUL-19
WG3093212-1	MB							
% Moisture			<0.10		%		0.1	02-JUL-19
PH-WT		Soil						
Batch	R4693084							
WG3091951-1	DUP	L2300993-13						
pH		7.24	7.26	J	pH units	0.02	0.3	03-JUL-19
WG3093147-1	LCS							
pH			7.02		pH units		6.9-7.1	03-JUL-19
Batch	R4693744							
WG3095046-1	DUP	L2302187-2						
pH		7.93	7.96	J	pH units	0.03	0.3	04-JUL-19
WG3095316-1	LCS							
pH			6.99		pH units		6.9-7.1	04-JUL-19
REDOX-POTENTIAL-WT		Soil						
Batch	R4694159							
WG3095677-1	CRM	WT-REDOX						
Redox Potential			98.1		%		80-120	04-JUL-19
WG3095056-1	DUP	L2303375-1						
Redox Potential		260	233		mV	11	25	04-JUL-19
SO4-WT		Soil						
Batch	R4694474							
WG3095060-4	CRM	AN-CRM-WT						
Sulphate			97.7		%		60-140	04-JUL-19
WG3095060-3	DUP	L2303375-1						
Sulphate		26	27		mg/kg	4.0	30	04-JUL-19
WG3095060-2	LCS							
Sulphate			103.3		%		80-120	04-JUL-19
WG3095060-1	MB							
Sulphate			<20		mg/kg		20	04-JUL-19
SULPHIDE-WT		Soil						



Environmental

Quality Control Report

Workorder: L2301373

Report Date: 05-JUL-19

Page 3 of 5

Client: Thurber Engineering Ltd. (Oakville)
2010 Winston Park Drive Unit 103
Oakville ON L6H 5R7

Contact: Geoff Lay

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
SULPHIDE-WT	Soil							
Batch	R4693314							
WG3094278-3	DUP	L2301165-8						
Acid Volatile Sulphides		<0.20	<0.20	RPD-NA	mg/kg	N/A	30	03-JUL-19
WG3094278-2	LCS							
Acid Volatile Sulphides			78.6		%		70-130	03-JUL-19
WG3094278-1	MB							
Acid Volatile Sulphides			<0.20		mg/kg		0.2	03-JUL-19

Quality Control Report

Workorder: L2301373

Report Date: 05-JUL-19

Client: Thurber Engineering Ltd. (Oakville)
2010 Winston Park Drive Unit 103
Oakville ON L6H 5R7

Page 4 of 5

Contact: Geoff Lay

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
J	Duplicate results and limits are expressed in terms of absolute difference.
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Quality Control Report

Workorder: L2301373

Report Date: 05-JUL-19

Client: Thurber Engineering Ltd. (Oakville)
2010 Winston Park Drive Unit 103
Oakville ON L6H 5R7

Page 5 of 5

Contact: Geoff Lay

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Physical Tests							
% Moisture	1	30-MAY-19	02-JUL-19 12:03	14	33	days	EHTR
	2	12-JUN-19	02-JUL-19 12:04	14	20	days	EHTR
	3	10-JUN-19	02-JUL-19 12:05	14	22	days	EHTR
	4	05-JUN-19	02-JUL-19 12:06	14	27	days	EHTR
	5	04-FEB-19	02-JUL-19 12:07	14	148	days	EHTR
Conductivity (EC)	1	30-MAY-19	02-JUL-19 03:00	30	33	days	EHTL
	5	04-FEB-19	03-JUL-19 14:00	30	149	days	EHTR
pH	5	04-FEB-19	03-JUL-19 23:00	30	149	days	EHTR
Leachable Anions & Nutrients							
Sulphide, Acid Volatile	1	30-MAY-19	03-JUL-19 10:00	14	34	days	EHTR
	2	12-JUN-19	03-JUL-19 10:00	14	21	days	EHTR
	3	10-JUN-19	03-JUL-19 10:00	14	23	days	EHTR
	4	05-JUN-19	03-JUL-19 10:00	14	28	days	EHTR
	5	04-FEB-19	03-JUL-19 10:00	14	149	days	EHTR

Legend & Qualifier Definitions:

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR: Exceeded ALS recommended hold time prior to sample receipt.
EHTL: Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT: Exceeded ALS recommended hold time prior to analysis.
Rec. HT: ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L2301373 were received on 28-JUN-19 16:40.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.



L2301373-COFC

COC Number: 17 -

Page of

Canada Toll Free: 1 800 668 9878

[illegible]

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.


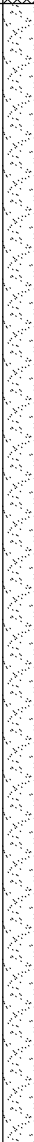

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Appendix C

Record of Borehole Sheets and Laboratory Test Results Previous Investigations


PROJECT <u>14-1111-0002</u>		RECORD OF BOREHOLE No AS1-1		SHEET 1 OF 2		METRIC	
G.W.P. <u>06-20016</u>		LOCATION <u>N 4916217.8 ; E 288209.9</u>		ORIGINATED BY <u>ML</u>			
DIST <u>Central</u> HWY <u>400</u>		BOREHOLE TYPE <u>Truck - Mounted D-50 108 mm I.D., 194 mm O.D. Hollow Stem Auger</u>		COMPILED BY <u>MCK</u>			
DATUM <u>Geodetic</u>		DATE <u>March 29, 2016</u>		CHECKED BY <u>CN</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20	40	60	80	100	W _p	W	W _L		
236.0	GROUND SURFACE																
0.0	Gravelly sand, trace to some clay, containing wood fragments (FILL) Loose to compact Brown to grey Moist		1	SS	8												
			2	SS	4												
			3A														
234.1			3B	SS	10												
1.9	SAND, trace to some gravel, trace to some silt Very loose to very dense Brown to grey Wet		4	SS	22											16 74 8 2	
			5	SS	32												
			6	SS	1												
			7	SS	48												4 75 19 2
			8	SS	78												
			9	SS	45												
		10	SS	72													
		11	SS	65													
222.7																	
13.3	SILT, trace to some sand, trace clay Very dense Brown to grey Wet		12	SS	130											0 6 90 4	

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GTA-MTO 001 S:\CLIENTS\MT\TOHWY_400_BARRIER02_DATA\GINT\1411110002.GPJ GAL-GTA.GDT 10/19/16

PROJECT 14-1111-0002			RECORD OF BOREHOLE No AS1-1			SHEET 2 OF 2			METRIC								
G.W.P. 06-20016			LOCATION N 4916217.8 ; E 288209.9			ORIGINATED BY ML											
DIST Central HWY 400			BOREHOLE TYPE Truck - Mounted D-50 108 mm I.D., 194 mm O.D. Hollow Stem Auger			COMPILED BY MCK											
DATUM Geodetic			DATE March 29, 2016			CHECKED BY CN											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100					
220.3	SILT, trace to some sand, trace clay Very dense Brown to grey Wet		13A	SS	65												
15.7			13B														
219.7	SILTY CLAY Hard Grey Wet																
16.3																	
	SILT, trace to some sand, trace clay Very dense Brown to grey Wet		14	SS	103												0 5 87 8
217.2	END OF BOREHOLE		15	SS	89												
18.8	NOTE: 1. Borehole caved to a depth of 1.2 m.																

PROJECT <u>14-1111-0002</u>		RECORD OF BOREHOLE No AS1-2		SHEET 1 OF 2		METRIC	
G.W.P. <u>06-20016</u>		LOCATION <u>N 4916185.3; E 288241.7</u>		ORIGINATED BY <u>ML</u>			
DIST <u>Central</u> HWY <u>400</u>		BOREHOLE TYPE <u>Truck - Mounted D-90, 108 mm I.D. 194 mm O.D. Hollow Stem Auger</u>		COMPILED BY <u>MK</u>			
DATUM <u>Geodetic</u>		DATE <u>April 20 and 21, 2016</u>		CHECKED BY <u>CN</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)				
								20	40	60	80	100	20		
240.5	GROUND SURFACE														
0.0	ASPHALT														
0.2	Gravelly sand to sand and gravel, trace silt (FILL) Compact to dense Brown Moist		1	SS	31										
			2	SS	25										
			3	SS	26										
236.4															
4.1	Silty sand, trace to some gravel, trace clay, containing black organic silt pockets (FILL) Compact Grey Moist		4A	SS	26										
235.6			4B												
4.9	Sand, some silt, trace gravel to gravelly, trace organics (FILL) Compact Grey to brown Moist to wet														
			5	SS	17										
			6A												
			6B	SS	12										
	- 130 mm organic silt pocket encountered at a depth of about 7.1 m - 80 mm clayey silt pocket encountered at a depth of about 7.3 m														
			7	SS	29										
232.2															
8.3	SAND, trace gravel, trace to some silt Compact to very dense Brown Wet		8	SS	11										
			9	SS	55										
			10	SS	55										
			11	SS	53										
			12	SS	104										

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GTA-MTO 001 S:\CLIENTS\MTOWHY_400_BARRE02_DATA\GINT\141110002.GPJ GAL-GTA.GDT 10/19/16

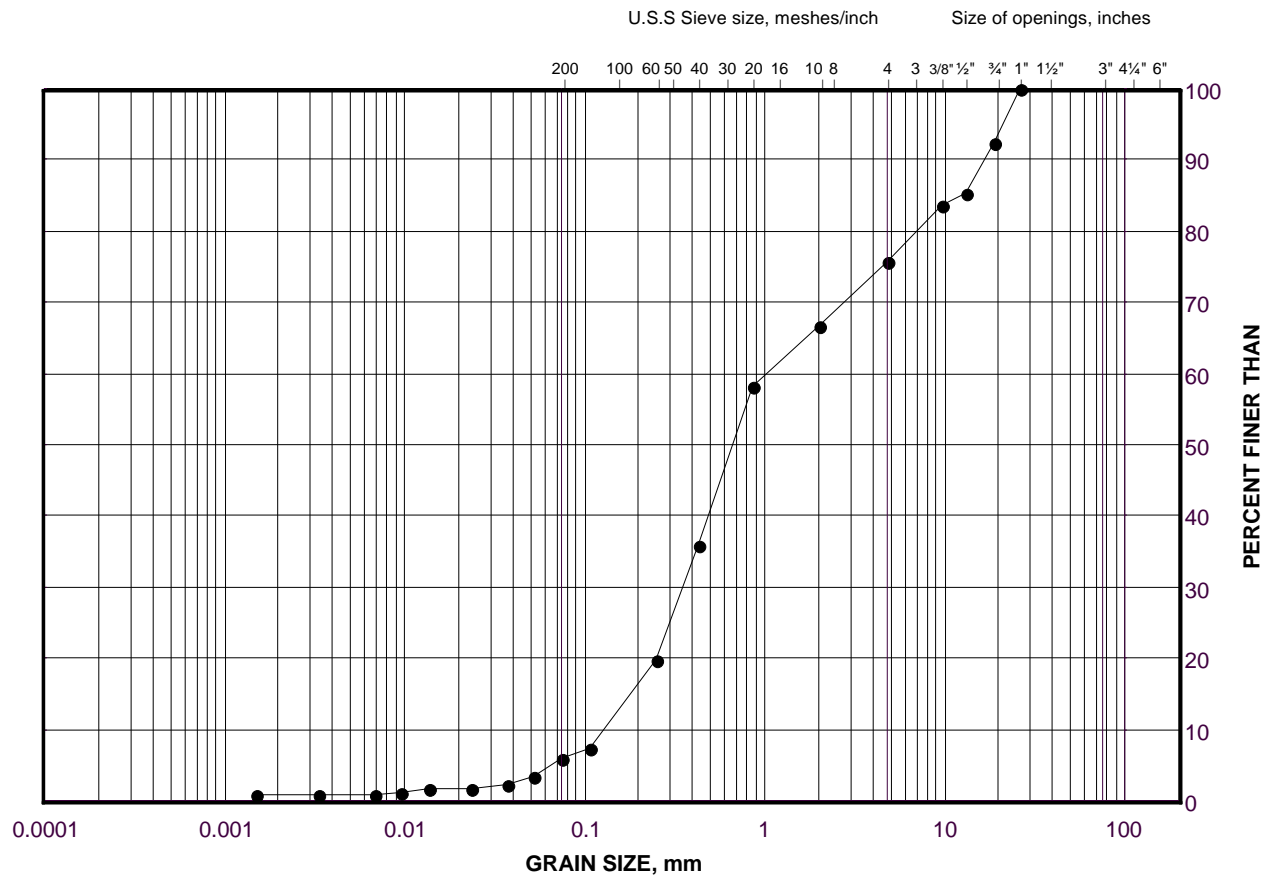
PROJECT 14-1111-0002			RECORD OF BOREHOLE No AS1-2			SHEET 2 OF 2			METRIC								
G.W.P. 06-20016			LOCATION N 4916185.3 ; E 288241.7			ORIGINATED BY ML											
DIST Central HWY 400			BOREHOLE TYPE Truck - Mounted D-90, 108 mm I.D., 194 mm O.D. Hollow Stem Auger			COMPILED BY MK											
DATUM Geodetic			DATE April 20 and 21, 2016			CHECKED BY CN											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100					
224.0	SAND, trace gravel, trace to some silt Compact to very dense Brown Wet		13	SS	88		225										
16.5	Sandy SILT Very dense Brown Wet						224										
223.0			14	SS	117		223										0 22 78 0
17.5	Start of Dynamic Cone Penetration Test (DCPT)																
222.4																	
18.1	END OF BOREHOLE																
	NOTES: 1. Water level at a depth of about 8.6 m below ground surface (Elev. 231.9 m) upon completion of drilling. 2. Borehole caved to a depth of about 4.0 m.																

GTA-MTO 001 S:\CLIENTS\MTOWHY_400_BARRE\02_DATA\GINT\1411110002.GPJ GAL-GTA.GDT 10/19/16

GRAIN SIZE DISTRIBUTION

Gravelly Sand (Fill)

FIGURE B1



SILT AND CLAY SIZES				FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED				SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
•	AS1-2	2	238.7

Project Number: 14-1111-0002

Checked By: CN

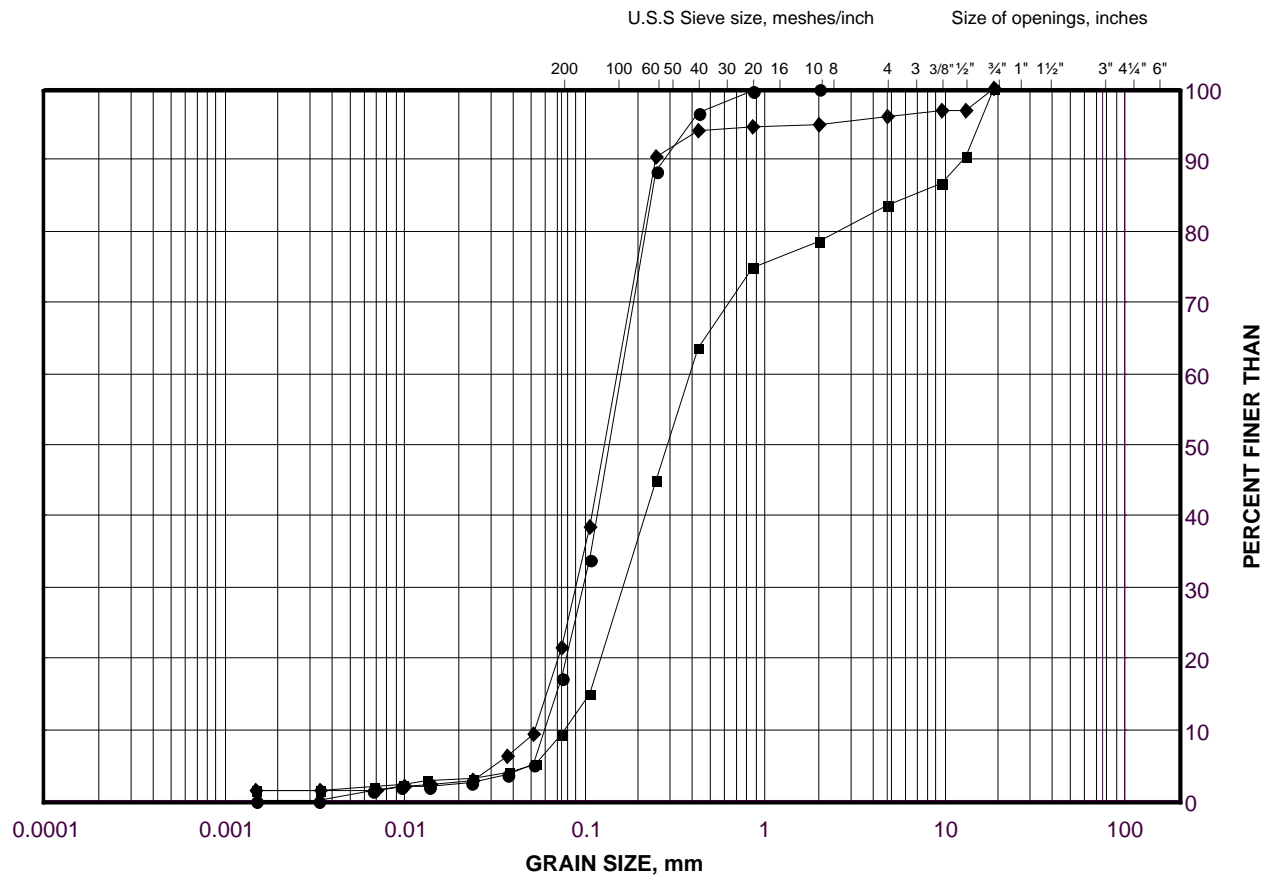
Golder Associates

Date: 21-Jul-16

GRAIN SIZE DISTRIBUTION

Sand

FIGURE B2-1



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	AS1-2	11	228
■	AS1-1	4	233.4
◆	AS1-1	7	229.7

Project Number: 14-1111-0002

Checked By: _____ CN _____

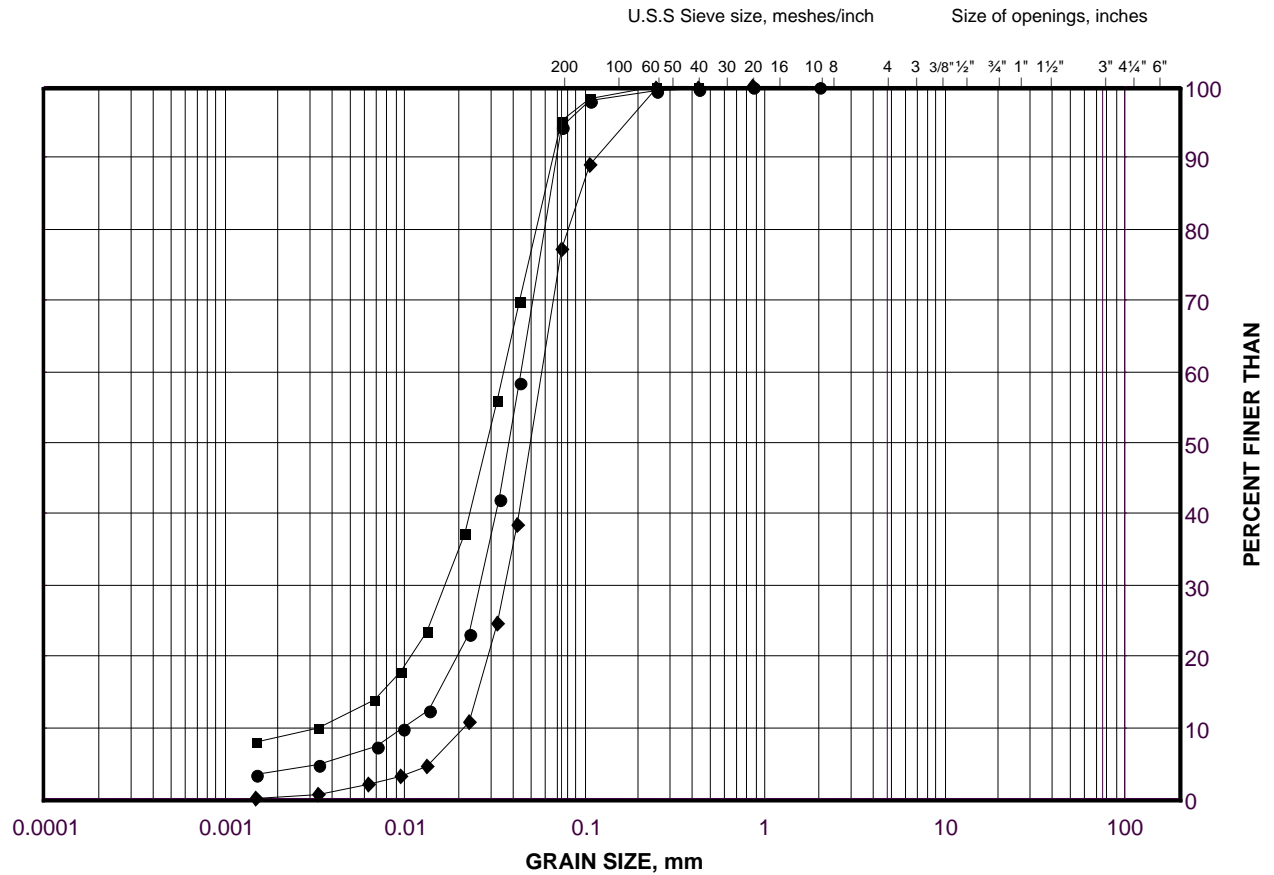
Golder Associates

Date: 22-Jul-16

GRAIN SIZE DISTRIBUTION

Silt to Sandy Silt

FIGURE B2-2



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

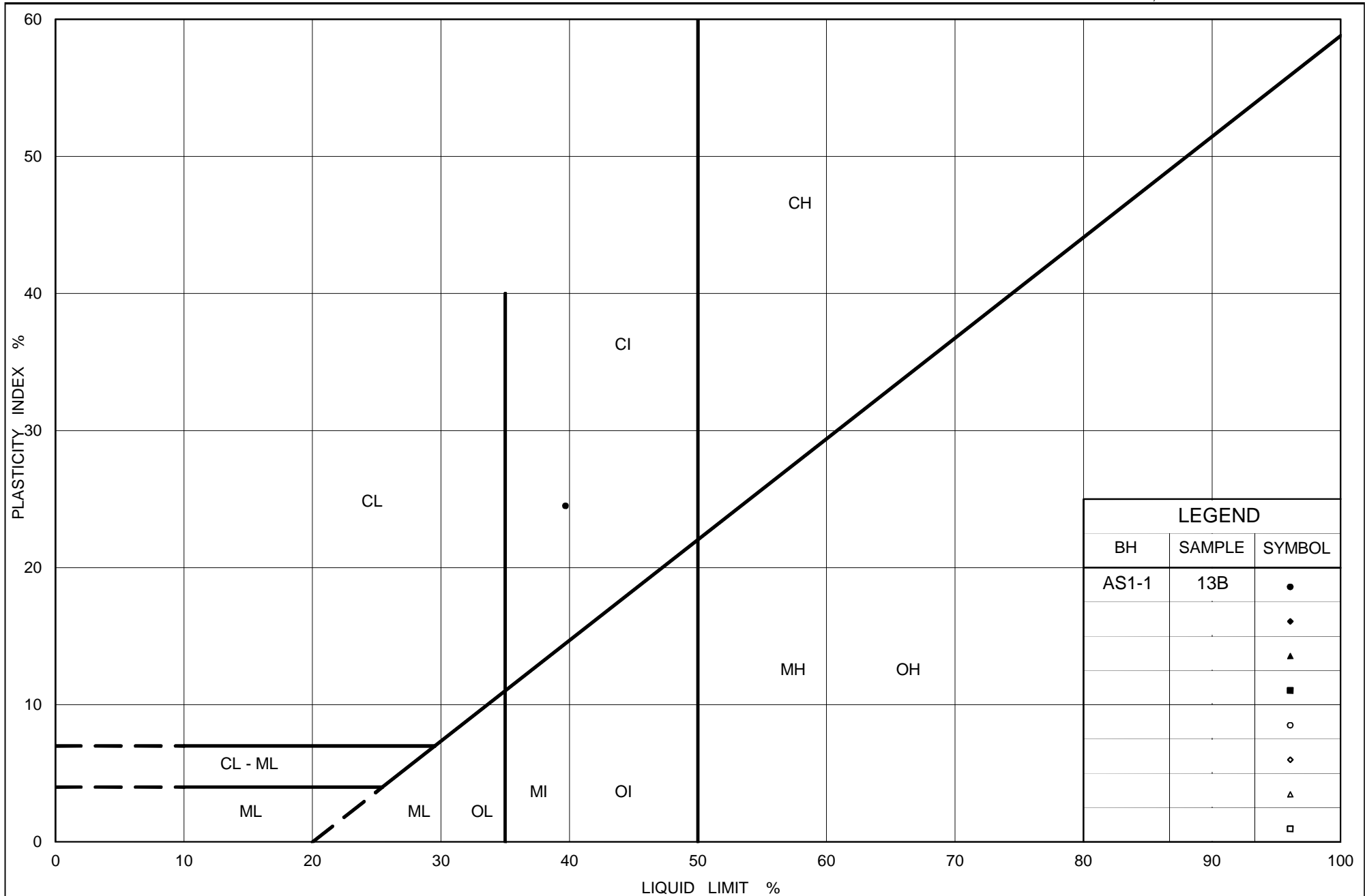
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	AS1-1	12	222
■	AS1-1	14	219
◆	AS1-2	14	223.2

Project Number: 14-1111-0002

Checked By: _____ CN _____

Golder Associates

Date: 22-Jul-16



Ministry of Transportation

Ontario

PLASTICITY CHART Silty Clay

Figure No. B3

Project No. 14-1111-0002

Checked By: CN

UNIVERSAL GEOTECHNIQUE LIMITED
SOIL MECHANICS LABORATORY
BOREHOLE LOG

PRO Anne Street Overpass, Barrie, Ontario. ORDER NO. I.277/57
 CLIENT Department of Highways, Ontario.
 BOREHOLE NO. BH.1 DIAMETER 2-1/2" CASING 2-1/2"
 BOREHOLE LOCATION See Plan INCLINATION Vertical BEARING

DESCRIPTION OF STRATA	ELEVATION	LEGEND	SAMPLE	DEPTH	THICKNESS	N	REMARKS
Firm brown to gray clayey sand with some organic matter and fine to medium gravel. Probably FILL.	771.82 235.3m		• 1	Zero	0.0m	12	Moist Low to medium dry strength.
Loose brown to gray sand with fine to medium gravel and some organic matter. Probably FILL.			• 2	Free Water		9	Moist Low dry strength.
Dense brown to gray fine to coarse SAND with generally subrounded fine to medium gravel.			• 3			30	do
Dense brown gray generally fine calcareous SAND with fine to medium subrounded gravel.			• 4			33	do
Firm do			• 5			22	do
Dense brown gray fine to medium calcareous SAND with fine to medium subrounded gravel.	227.7m		• 6	25'-1"	7.6m	37 (7")	do
				End of Borehole			

SCALE: 1" = 5'-0" • DISTURBED SAMPLE ■ UNDISTURBED SAMPLE

UNIVERSAL GEOTECHNIQUE LIMITED
SOIL MECHANICS LABORATORY
BOREHOLE LOG

PROJECT Anne Street Overpass, Barrie, Ontario.

ORDER NO. 1,227/57

CLIENT Department of Highways, Ontario.

BOREHOLE NO. BH.2

DIAMETER 2-1/2"

CASING 2-1/2"

BOREHOLE LOCATION See Plan

INCLINATION Vertical

BEARING

FORM G-1A 900-5-54
(UNITED STATES OF AMERICA)

DESCRIPTION OF STRATA	ELEVATION	LEGEND	SAMPLE	DEPTH	THICKNESS	N	REMARKS
Firm brown grey sand, clayey concentrations. Black organic matter. Probably FILL.	772.65		• 1	Zero	0.0m	20	Moist
Firm do	235.5m		• 2	Free Water		15	do
do			• 3			12	do
Iron staining							
Dense grey brown fine to coarse calcareous SAND and fine to medium generally subrounded GRAVEL.	232.9m		• 4	8'-6"	2.6m	32	Moist Low dry strength.
Dense brown sandy SILT with lenses of fine to medium SAND. Traces of bedding.	231.5m		• 5	13'-0"	4.0m	31	Moist, Low to medium dry strength.
do			• 6			48	do
Some Iron staining							
Firm brown grey fine to medium calcareous SAND. Lenses of fine subrounded to rounded gravel embedded in clay.	228.5m		• 7	23'-0"	7.0m	26	Moist Low dry strength.
Dense brown grey fine to medium calcareous SAND with fine to medium gravel, generally subrounded.			• 8			30	do
do			• 9			35	do
do			• 10			-	Wash Sample
Dense grey generally fine calcareous SAND.	221.2m		• 11	47'-0"	14.3m	47	Moist Low dry strength.

SCALE: 1" = 5'-0" • DISTURBED SAMPLE

■ UNDISTURBED SAMPLE

UNIVERSAL GEOTECHNIQUE LIMITED

SOIL MECHANICS LABORATORY

BOREHOLE LOG




PROJECT Anne Street Overpass, Barrie, Ontario, ORDER NO. T.227/57

CLIENT Department of Highways, Ontario.

BOREHOLE NO. BH.2 DIAMETER 2-1/2" CASING 2-1/2"

BOREHOLE LOCATION See Plan INCLINATION Vertical BEARING

FORM G-1-A BOREHOLE LOG

DESCRIPTION OF STRATA	ELEVATION	LEGEND	SAMPLE	DEPTH	THICKNESS	N	REMARKS
Dense gray generally fine calcareous SAND.	226.3m			50'-0"	15.2m		
Very stiff gray calcareous silty CLAY.	217.7m		• 12	58'-6"	17.8m	62	Molst. Sand: Low dry strength. Clay: High dry strength.
	216.8m			61'-6"	18.7m		
				End of Borehole			

SCALE: 1" = 5'-0" • DISTURBED SAMPLE

■ UNDISTURBED SAMPLE

UNIVERSAL

GEOTECHNIQUE

LIMITED

SOIL MECHANICS LABORATORY

BOREHOLE LOG

PROJECT Anne Street Overpass, Barrie, Ontario. ORDER NO. I.227/57CLIENT Department of Highways, Ontario.BOREHOLE NO. BH.3 DIAMETER 2-1/2" CASING 2-1/2"BOREHOLE LOCATION See Plan INCLINATION Vertical BEARING ---FORM G-1A 800-e-84
(UNIVERSITY/84)

DESCRIPTION OF STRATA	ELEVATION	LEGEND	SAMPLE	DEPTH	THICKNESS	N	REMARKS
	773.58			Zero	0.0m		
Firm brown sand, gravel, little clay and bits of wood. FILL.	235.8m		• 1			29	Moist
Firm brown sand and black organic matter. Probably FILL.			• 2			21	do
Firm grey to iron-stained yellow fine to medium SAND with fine to medium generally subrounded gravel.	233.8m		• 3	6'-7"	Free Water	27	Wet Low dry strength.
do			• 4	2.0m		33	Moist Low dry strength.
do			• 5			23	do
Dense grey generally fine calcareous silty SAND.	230.2m		• 6	18'-6"	5.6m	37	do
do			• 7			37	do
Slight iron staining.			• 8			22	Wet Low dry strength.
do			• 9				
No iron staining.	225.4m		• 10	34'-0"	10.4m		
Brown grey fine to medium calcareous SAND.			• 11			22	Moist Low dry strength.
Grey generally fine calcareous SAND.			• 12				
do	222.1m			45'-0"	13.7m		
Firm grey silty CLAY.							
Hard do	220.6m			50'-0"	15.2m	52	Last sample

SCALE: 1" = 5'-0" • DISTURBED SAMPLE End of Borehole ■ UNDISTURBED SAMPLE

UNIVERSAL GEOTECHNIQUE LIMITED

SOIL MECHANICS LABORATORY

BOREHOLE LOG


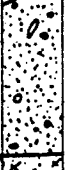

PROJECT Anne Street Overpass, Barrie, Ontario. ORDER NO. T.227/57

CLIENT Department of Highways, Ontario.

BOREHOLE NO. BH.4 DIAMETER 2-1/2" CASING 2-1/2"

BOREHOLE LOCATION See Plan INCLINATION Vertical BEARING

FORM G-1A 500-5-54
L. M. STANLEY CO.

DESCRIPTION OF STRATA	ELEVATION	LEGEND	SAMPLE	DEPTH	THICKNESS	IN	REMARKS
Firm grey brown fine to medium somewhat clayey sand with gravel. Probably FILL.	774.26		• 1	Zero	0.0m	22	Moist
do With traces of organic matter. Probably FILL.	236.0m		• 2	Free Water		17	Wet
Firm grey brown fine to coarse calcareous SAND and fine to medium generally subrounded GRAVEL.			• 3			22	Wet No dry strength.
	232.0m		• 4	13'-0"	4.0m	33	Damp Low to medium dry strength.
Dense brown sandy SILT with thin lenses of clay. Exhibits bedding.			• 5			34	Wash sample
Dense grey generally fine calcareous SAND.			• 6	25'-6"	7.8m	55	Moist. Low to medium dry strength.
Dense grey brown generally fine calcareous SAND with occasional fine gravel. Exhibits faint bedding and some iron staining.	228.2m			End of Borehole			

SCALE: 1" = 5'-0" • DISTURBED SAMPLE ■ UNDISTURBED SAMPLE

UNIVERSAL GEOTECHNIQUE LIMITED

SOIL MECHANICS LABORATORY

BOREHOLE LOG

PROJECT Anne Street Overpass, Barrie, Ontario.

ORDER NO. L227/57

CLIENT Department of Highways, Ontario.

BOREHOLE NO. BH-5

DIAMETER 2-1/2"









CASING 2-1/2"

BOREHOLE LOCATION See Plan

INCLINATION Vertical

BEARING

FORM G-11A 900-6-84
LIMITED LIABILITY

DESCRIPTION OF STRATA	ELEVATION	LEGEND	SAMPLE	DEPTH	THICKNESS	N	REMARKS
Firm grey brown sand, gravel and little clay. Probably FILL.	771.38 235.1m		• 1	Zero	0.0m	25	Moist
do With some organic matter.			• 2	Free Water		26	Moist
	233.0m			7'-0"	2.1m		
Firm grey brown fine to coarse SAND with fine to medium generally subrounded GRAVEL.			• 3			26	Wet No dry strength.
	231.4m			12'-0"	3.7m		
Firm brown sandy SILT with some gravel and clay bands.			• 4			24	Moist Low to medium dry strength.
			• 5			39	Moist Low dry strength.
Dense grey brown fine to medium calcareous SAND.							
do	227.5m		• 6	25'-1"	7.6m	39 (7")	Wet Low dry strength.
				End of Borehole			

SCALE: 1" = 5'-0" • DISTURBED SAMPLE

■ UNDISTURBED SAMPLE

UNIVERSAL GEOTECHNIQUE LIMITED
SOIL MECHANICS LABORATORY
BOREHOLE LOG

PROJECT Anne Street Overpass, Barrie, Ontario. ORDER NO. L227/57
 CLIENT Department of Highways, Ontario.
 BOREHOLE NO. BH.6 DIAMETER 2-1/2" CASING 2-1/2"
 BOREHOLE LOCATION See Plan INCLINATION Vertical BEARING

FORM G-1A 800-6-84
UNIVERSAL GEOTECHNIQUE

DESCRIPTION OF STRATA	ELEVATION	LEGEND	SAMPLE	DEPTH	THICKNESS	N	REMARKS
	772.48			Zero	0.0m		
Firm grey sand and black organic matter. Probably FILL.	235.5m		• 1			12	Moist
Firm grey and iron-stained yellow sand, little clay, Probably FILL.			• 2	Free Water		29	Moist
Dense medium to coarse calcareous SAND and fine to medium generally subrounded GRAVEL.			• 3			39	Wet No dry strength.
Very stiff brown sandy silty calcareous CLAY with fine to medium subangular to subrounded gravel.	231.5m		• 4	13'-0"	4.0m	30	Moist High dry strength.
Firm grey brown fine to coarse SAND and fine to medium subangular to subrounded GRAVEL.			• 5			25	Wet No dry strength.
Dense grey brown fine to medium calcareous SAND with gene. silty subrounded gravel.	227.7m		• 6	25'-6"	7.8m	37	Moist Low dry strength.
				End of Borehole			

SCALE: 1" = 5'-0" • DISTURBED SAMPLE

■ UNDISTURBED SAMPLE



Appendix D
Selected Site Photographs



Photograph 1 – West Approach and Borehole ANN-01, looking south



Photograph 2 – East Approach and Borehole ANN-05, looking north



Photograph 3 –Existing Bridge and Borehole ANN-03, looking west

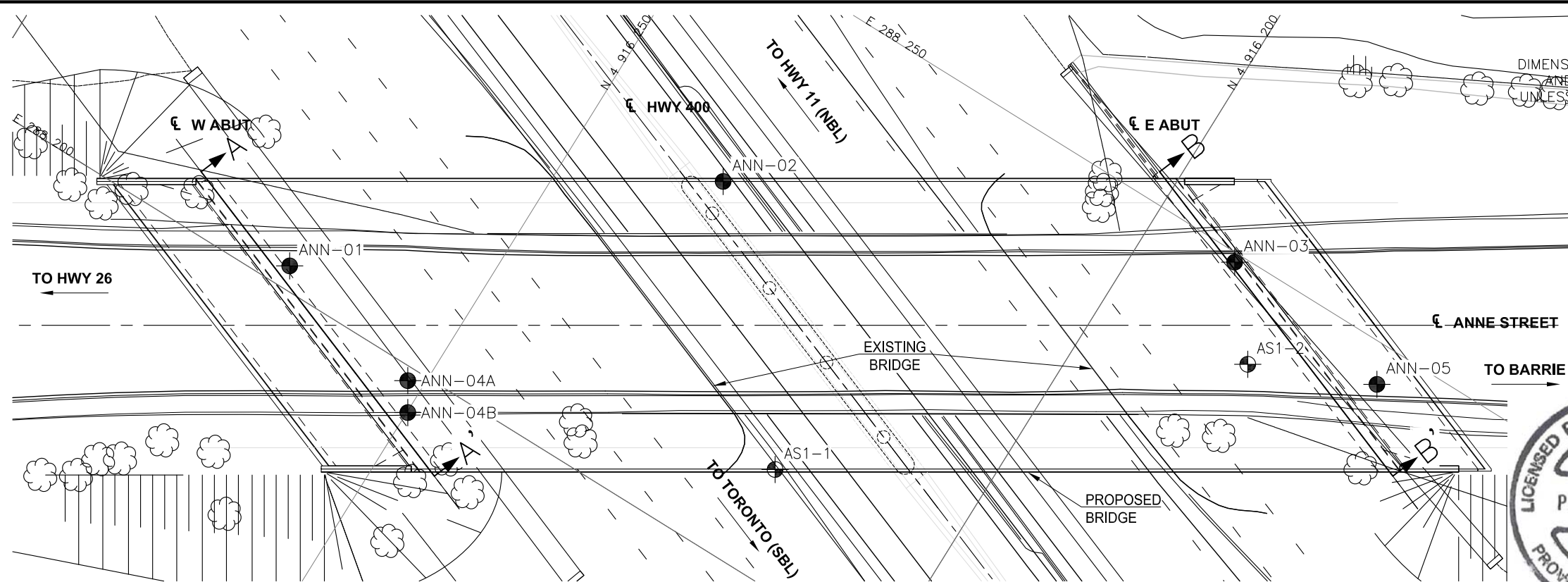


Photograph 4 –Existing Bridge and Drill Rig Setup at ANN-02, looking south

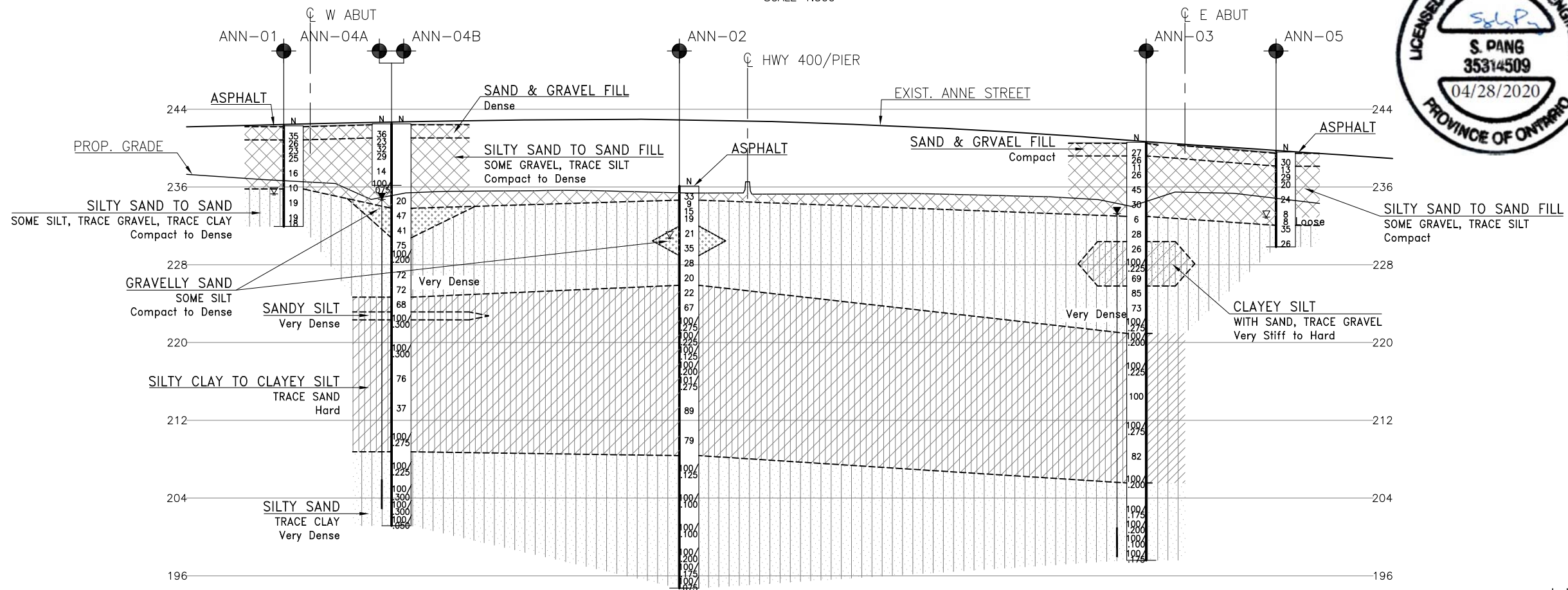


Appendix E

Borehole Locations and Soil Strata Drawings



PLAN



ANNE STREET CL PROFILE



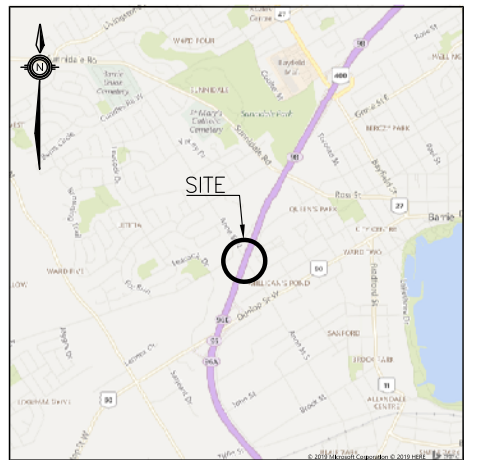
METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
GWP No 2504-17-00

HIGHWAY 400
ANNE STREET
UNDERPASS
BOREHOLE LOCATIONS AND SOIL STRATA

McINTOSH PERRY



KEYPLAN

LEGEND

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

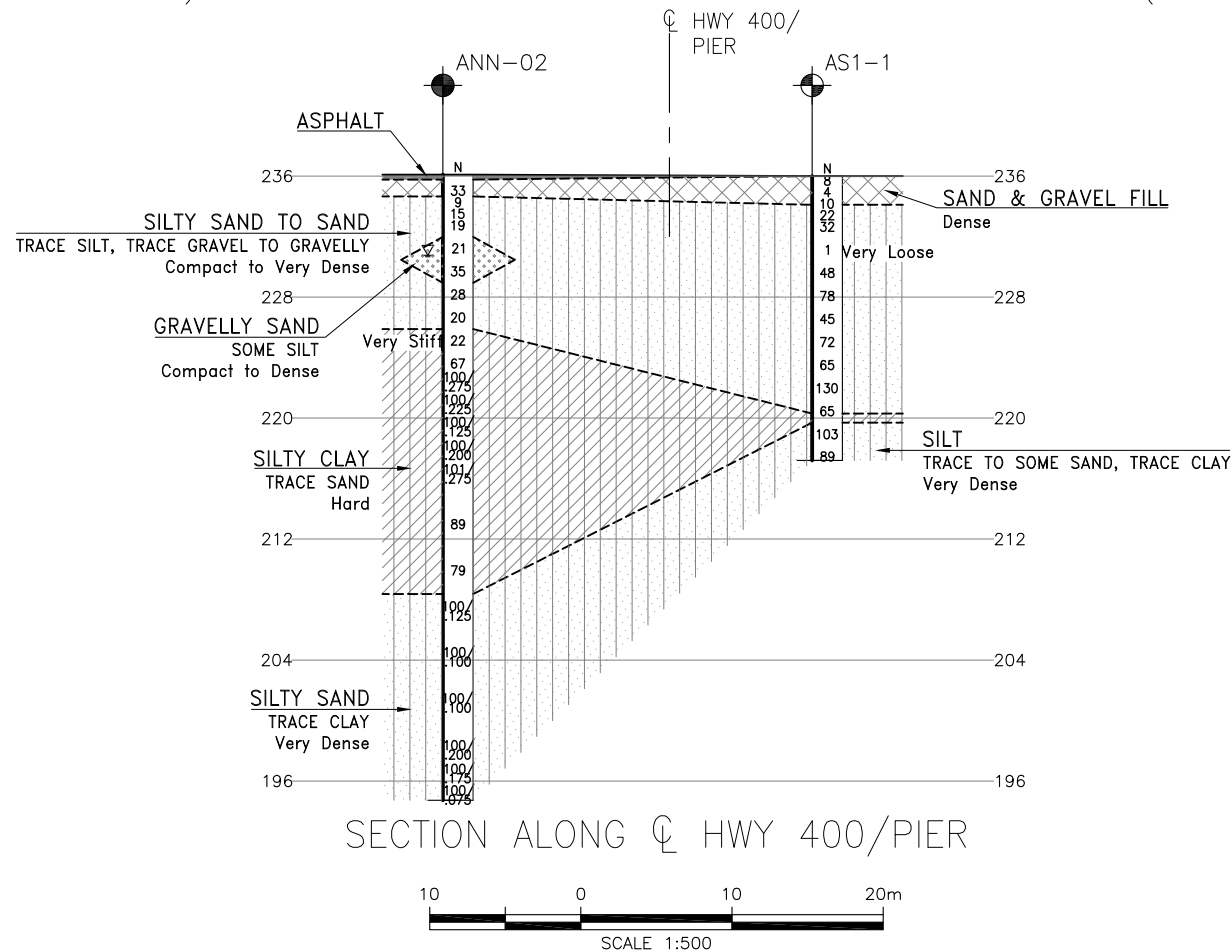
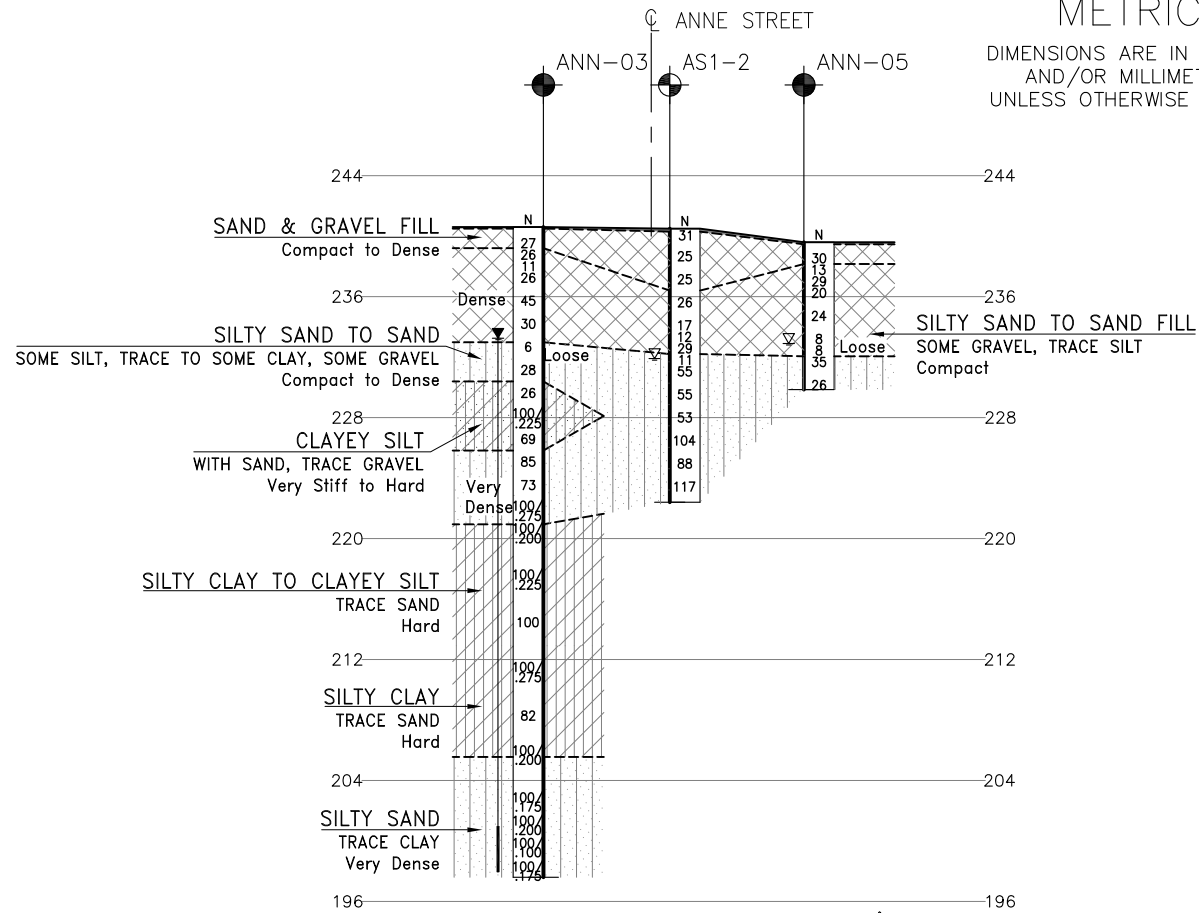
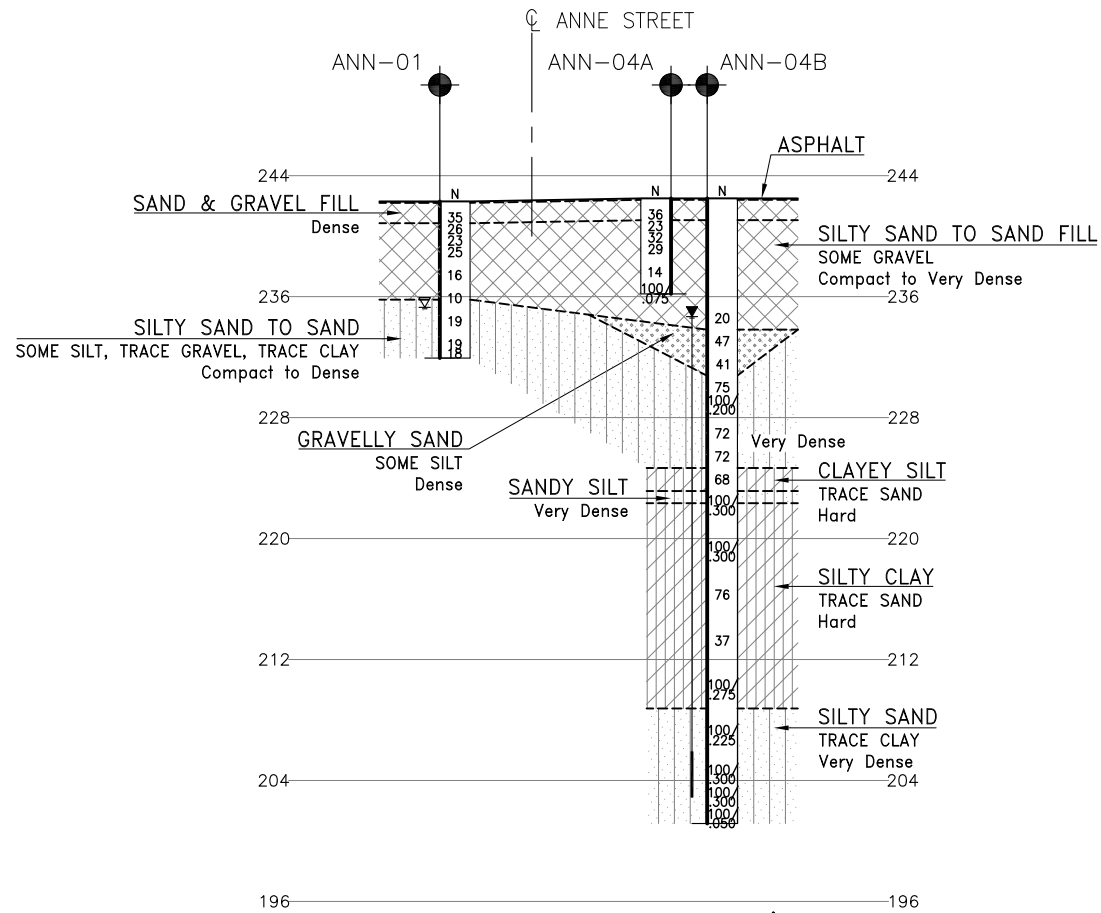
NO	ELEVATION	NORTHING	EASTING
ANN-01	242.3	4 916 266.6	288 202.1
ANN-02	236.1	4 916 236.2	288 230.3
ANN-03	240.6	4 916 191.4	288 249.2
ANN-04A	242.5	4 916 251.5	288 198.8
ANN-04B	242.5	4 916 249.9	288 196.3
ANN-05	239.6	4 916 174.0	288 246.5
AS1-1	236.0	4 916 217.8	288 209.9
AS1-2	240.5	4 916 185.3	288 241.7

-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 10.

GEOCRES No. 31D-739

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	CF	CHK SKP	CODE
DRAWN	AN	CHK GF	SITE
			LOAD
			DATE
			APR 2020
			STRUCT
			DWG 1

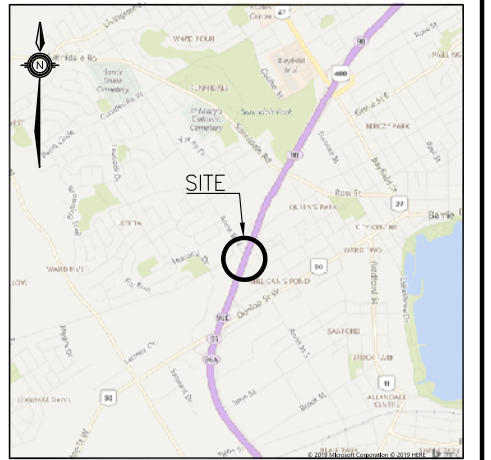


METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
GWP No 2504-17-00

HIGHWAY 400
ANNE STREET
UNDERPASS
BOREHOLE LOCATIONS AND SOIL STRATA

McINTOSH PERRY



KEYPLAN

LEGEND

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

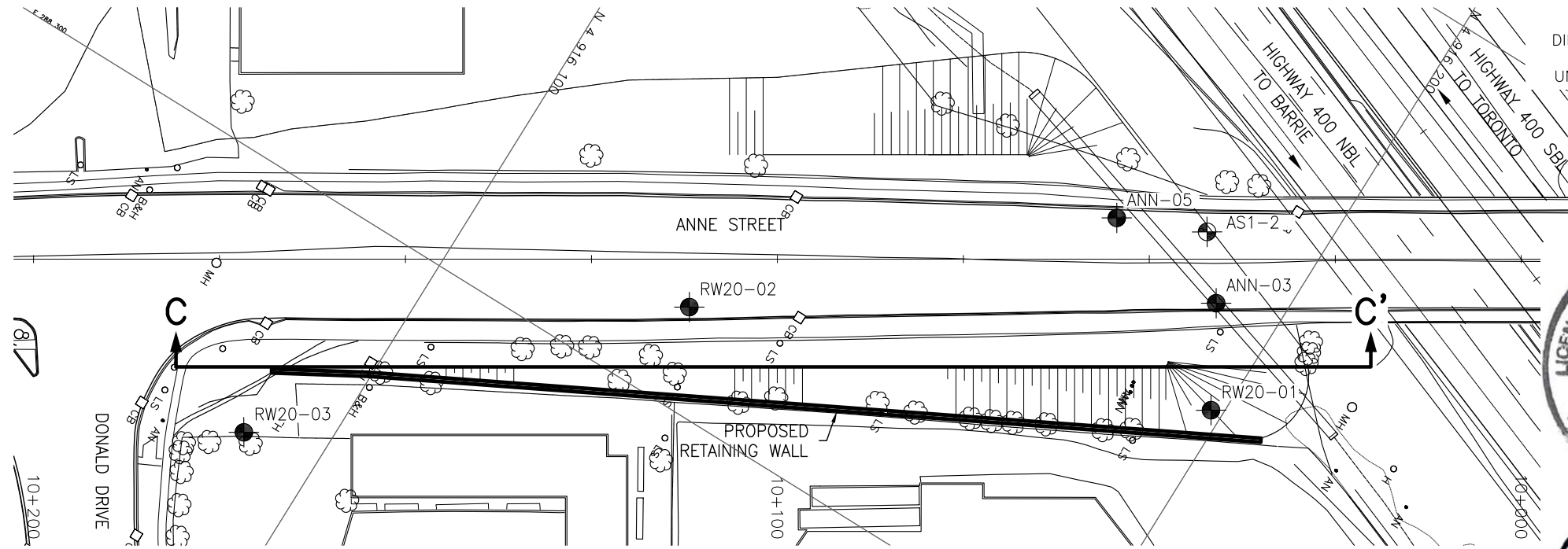
NO	ELEVATION	NORTHING	EASTING
ANN-01	242.3	4 916 266.6	288 202.1
ANN-02	236.1	4 916 236.2	288 230.3
ANN-03	240.6	4 916 191.4	288 249.2
ANN-04A	242.5	4 916 251.5	288 198.8
ANN-04B	242.5	4 916 249.9	288 196.3
ANN-05	239.6	4 916 174.0	288 246.5
AS1-1	236.0	4 916 217.8	288 209.9
AS1-2	240.5	4 916 185.3	288 241.7

-NOTES-

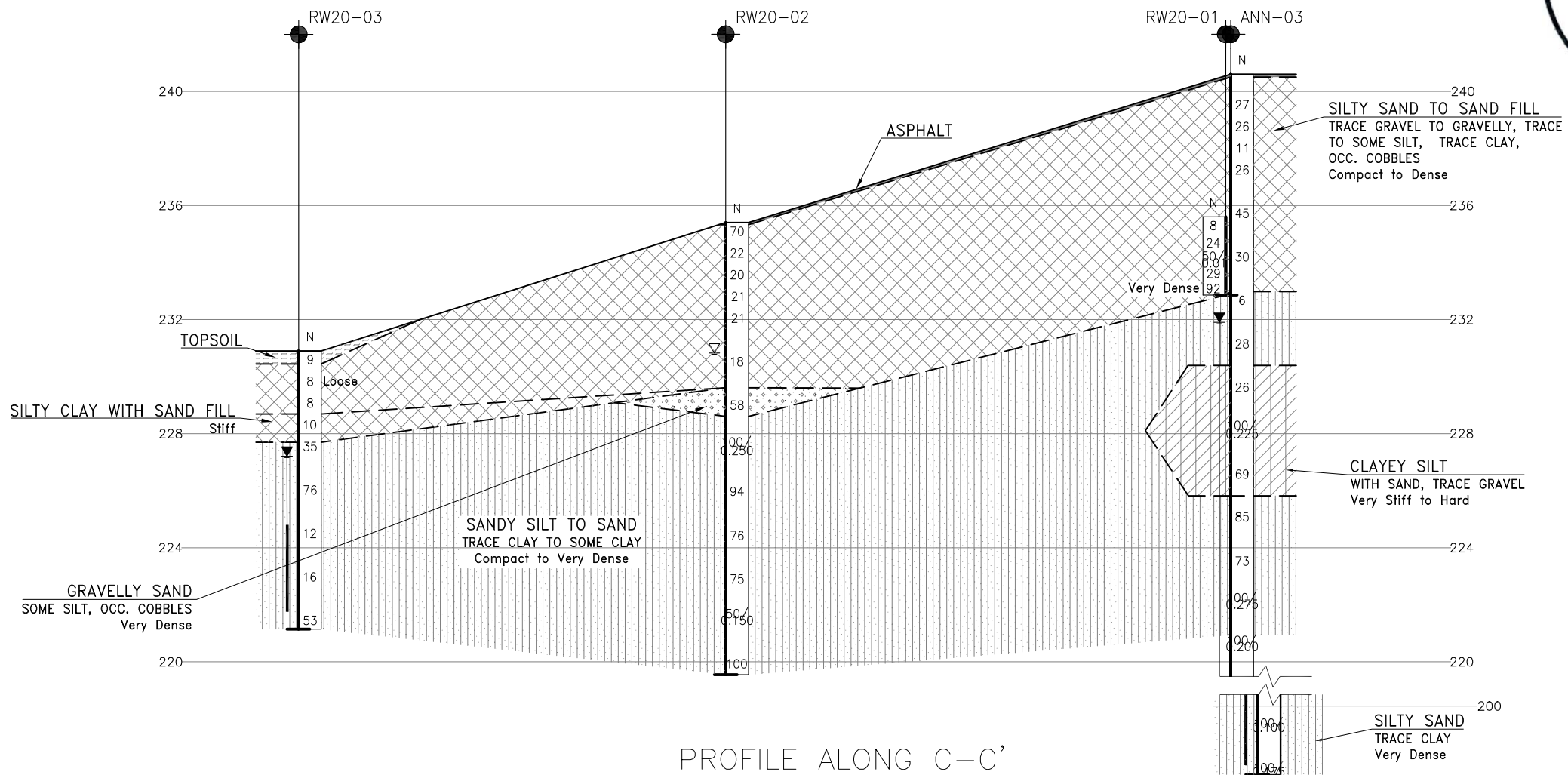
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 10.

GEOCRES No. 31D-739

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	CF	CHK SKP	CODE
DRAWN	AN	CHK GF	SITE
			LOAD
			DATE
			APR 2020
			STRUCT
			DWG 2



PLAN
SCALE 1:800



PROFILE ALONG C-C'

SCALE 1:800
SCALE 1:200

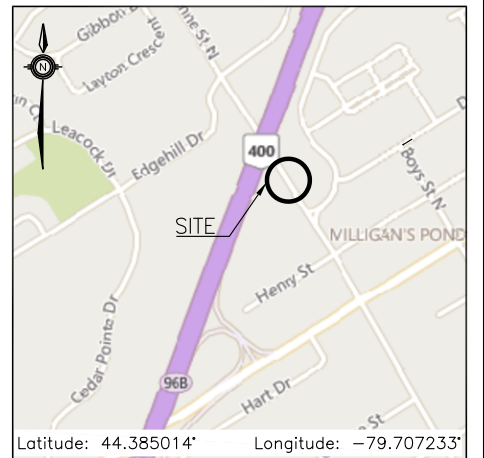
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



CONT No
GWP No 2504-17-00

HIGHWAY 400
ANNE STREET
NORTH EAST RETAINING WALL
BOREHOLE LOCATIONS AND SOIL STRATA

McINTOSH PERRY



KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
RW-01	235.6	4 916 198.4	288 261.8
RW-02	235.4	4 916 131.5	288 287.0
RW-03	230.9	4 916 089.5	288 332.9
ANN-03	240.6	4 916 191.4	288 249.2
AS1-2	240.5	4 916 185.3	288 241.7

-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 10.

GEOCRES No. 31D-739

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	RPR	CHK SKP	CODE
DRAWN	BH	CHK RPR	SITE
LOAD	DATE	APR 2020	
STRUCT	DWG	3	



Appendix F

Foundation Comparison



COMPARISON OF FOUNDATION ALTERNATIVES

Footings on Native Soil	Driven Piles	Caissons
<i>Advantages:</i> <ul style="list-style-type: none">i. Generally less costly than deep foundation elements.	<i>Advantages:</i> <ul style="list-style-type: none">i. Higher bearing capacity than spread footings.ii. Minimal excavation and dewatering required.iii. Construction could continue in freezing weather.iv. Allows integral abutment design.	<i>Advantages:</i> <ul style="list-style-type: none">i. High resistance is available for caissons founded within the hard silty clay deposit.ii. Minimal excavation and dewatering required.iii. Construction could continue in freezing weather.
<i>Disadvantages:</i> <ul style="list-style-type: none">i. Construction dewatering will be required.ii. Precludes integral abutment design.	<i>Disadvantages:</i> <ul style="list-style-type: none">i. Higher unit cost than footings.ii. Potential for varying pile lengths within a foundation unit.	<i>Disadvantages:</i> <ul style="list-style-type: none">i. Higher unit cost compared to other foundation options such as footings or driven piles.ii. Specialized installation measures such as temporary liners and drilling water/mud required to install caissons under the water table.iii. Potential difficulty in cleaning and inspecting bases.
FEASIBLE	RECOMMENDED	FEASIBLE RECOMMENDED FOR PIER DUE TO SPACE RESTRICTION



Appendix G

Selected Slope Stability Output

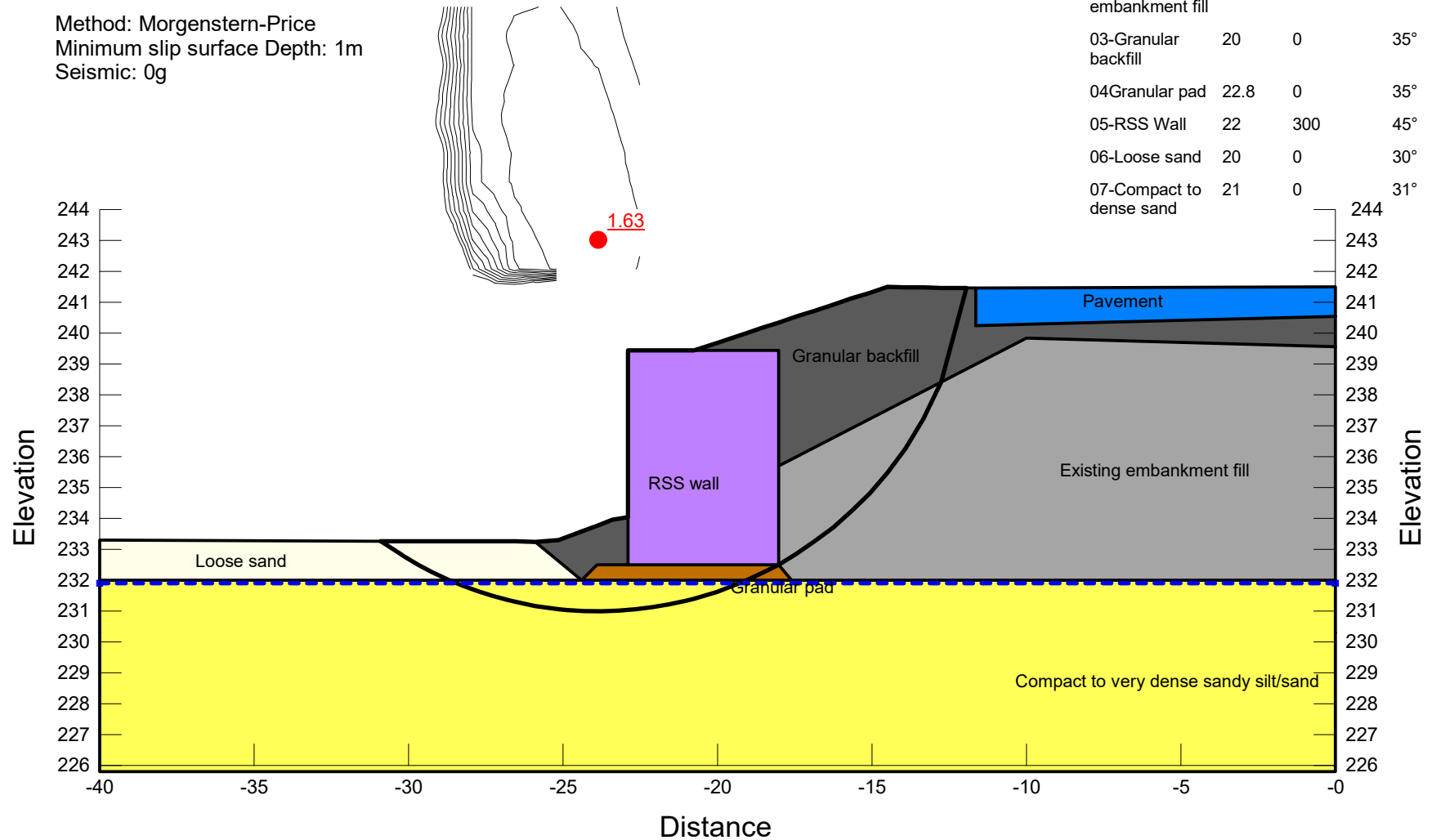
SOUTHEAST RETAINING WALL ANNE ST. AND HWY 400 UNDERPASS DRAINED ANALYSIS

FIGURE G1

File Name: NE RSS wall-10+050.gsz
Method: Morgenstern-Price
Date: 2020-02-24

Method: Morgenstern-Price
Minimum slip surface Depth: 1m
Seismic: 0g

Name	Unit Weight (kN/m³)	Cohesion' (kPa)'	Phi
01-Pavement	22.8	0	35°
02-Existing embankment fill	20	0	30°
03-Granular backfill	20	0	35°
04Granular pad	22.8	0	35°
05-RSS Wall	22	300	45°
06-Loose sand	20	0	30°
07-Compact to dense sand	21	0	31°



SOUTHEAST RETAINING WALL ANNE ST. AND HWY 400 UNDERPASS SEISMIC ANALYSIS

FIGURE G2

File Name: NE RSS wall-10+050- seismic.gsz
Method: Morgenstern-Price
Date: 2020-02-27

Method: Morgenstern-Price
Minimum slip surface Depth: 1m
Seismic: 0.032g

Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi
01-Pavement	22.8	0	35°
02-Existing embankment fill	20	0	30°
03-Granular backfill	20	0	35°
04Granular pad	22.8	0	35°
05-RSS Wall	22	300	45°
06-Loose sand	20	0	30°
07-Compact to dense sand	21	0	31°

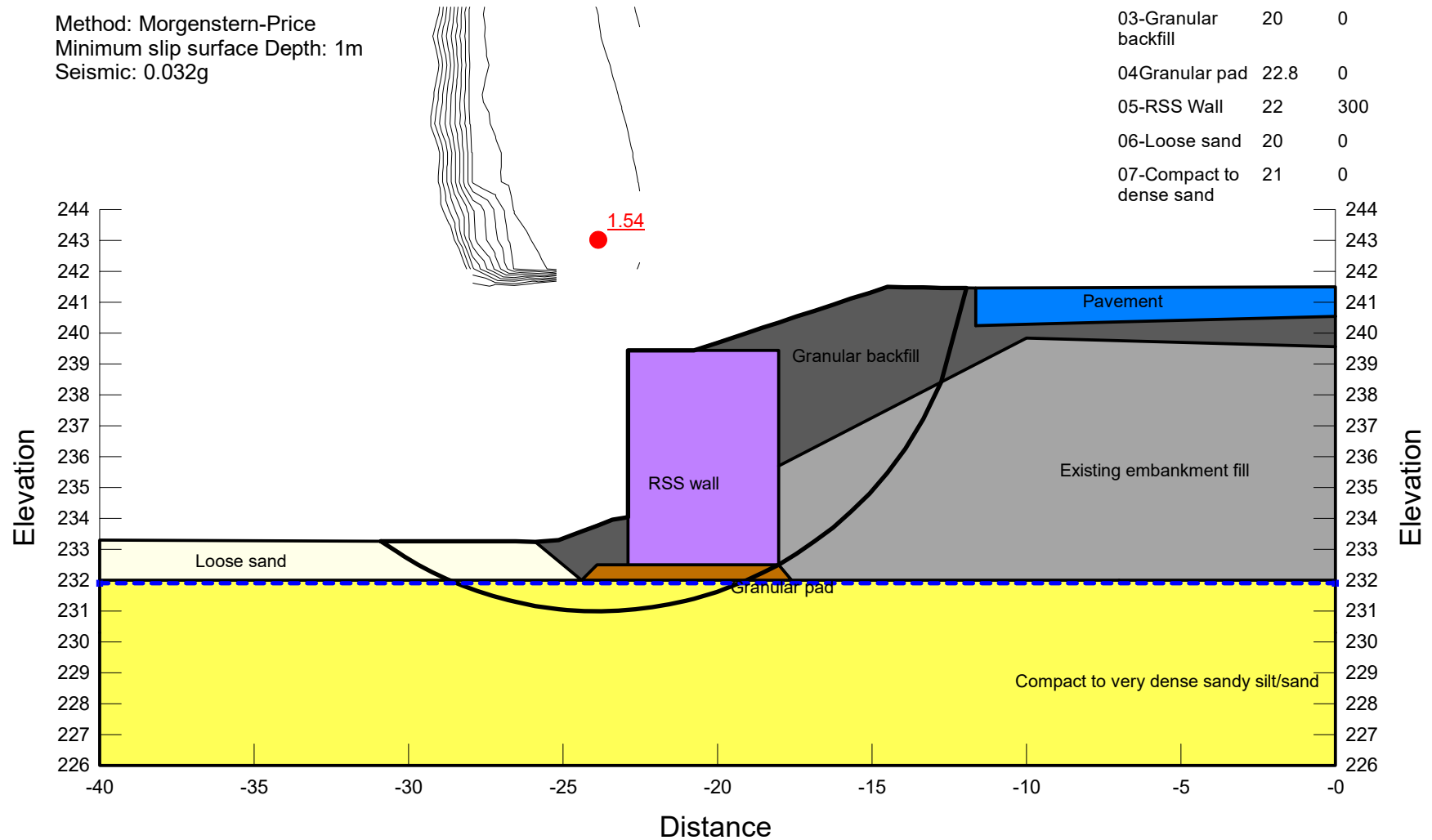


FIGURE G3

EAST ABUTMENT FORWARD SLOPE (4.5 M DEEP TEMPORARY CUT)

File Name: 22424 Anne Street - East Abutment_4.5 m Cut 1H-1V.gsz

Last Edited By: Geoff Lay

Date: 9/26/2019

Method: Morgenstern-Price

Minimum Slip Surface Depth: 1 m

Seismic: 0g

Existing Embankment Fill 20 kN/m³ 0 kPa 30 °

Pavement Structure 22.8 kN/m³ 0 kPa 35 °

Silty Sand to Sand - Compact to Dense 21 kN/m³ 0 kPa 31 °

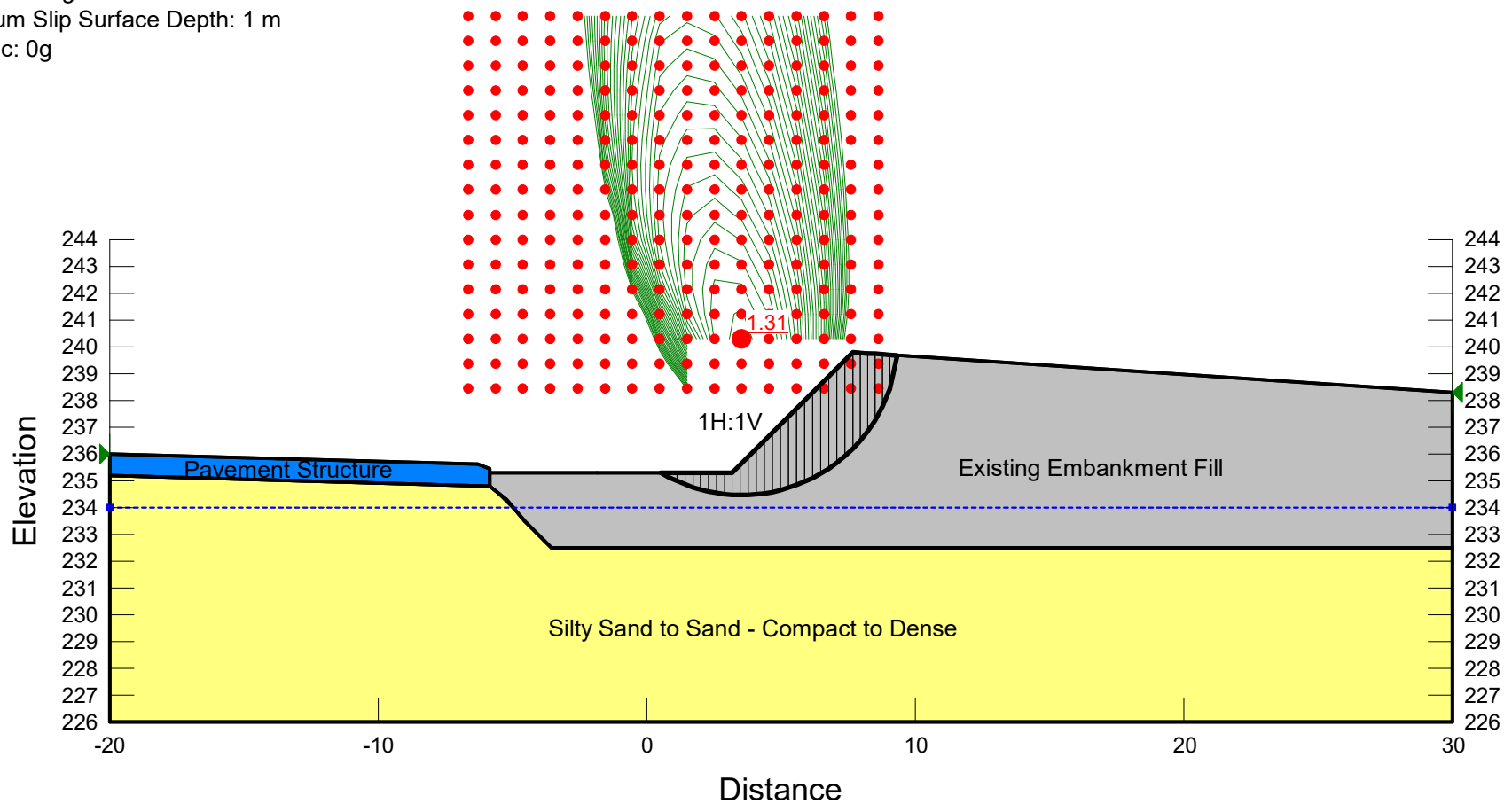


FIGURE G4

EAST ABUTMENT FORWARD SLOPE (4.5 M DEEP TEMPORARY CUT)

File Name: 22424 Anne Street - East Abutment_4.5 m Cut 1.5H-1V.gsz

Last Edited By: Geoff Lay

Date: 9/26/2019

Method: Morgenstern-Price

Minimum Slip Surface Depth: 1 m

Seismic: 0g

Existing Embankment Fill 20 kN/m³ 0 kPa 30 °

Pavement Structure 22.8 kN/m³ 0 kPa 35 °

Silty Sand to Sand - Compact to Dense 21 kN/m³ 0 kPa 31 °

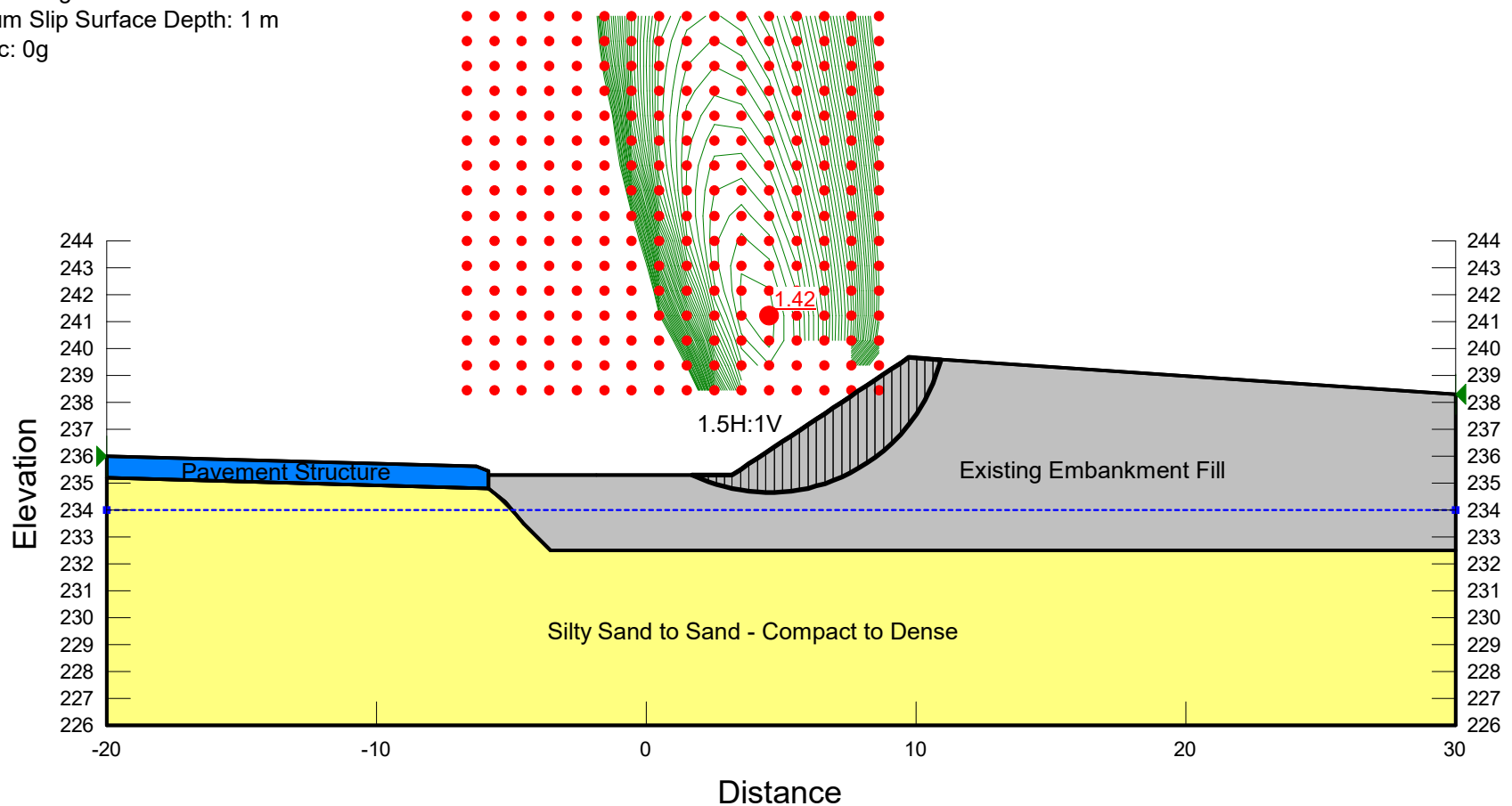


FIGURE G5

EAST ABUTMENT FORWARD SLOPE (5.5 M DEEP TEMPORARY CUT)

File Name: 22424 Anne Street - East Abutment_5.5 m Cut 1H-1V.gsz

Last Edited By: Geoff Lay

Date: 9/26/2019

Method: Morgenstern-Price

Minimum Slip Surface Depth: 1 m

Seismic: 0g

Existing Embankment Fill 20 kN/m³ 0 kPa 30 °

Pavement Structure 22.8 kN/m³ 0 kPa 35 °

Silty Sand to Sand - Compact to Dense 21 kN/m³ 0 kPa 31 °

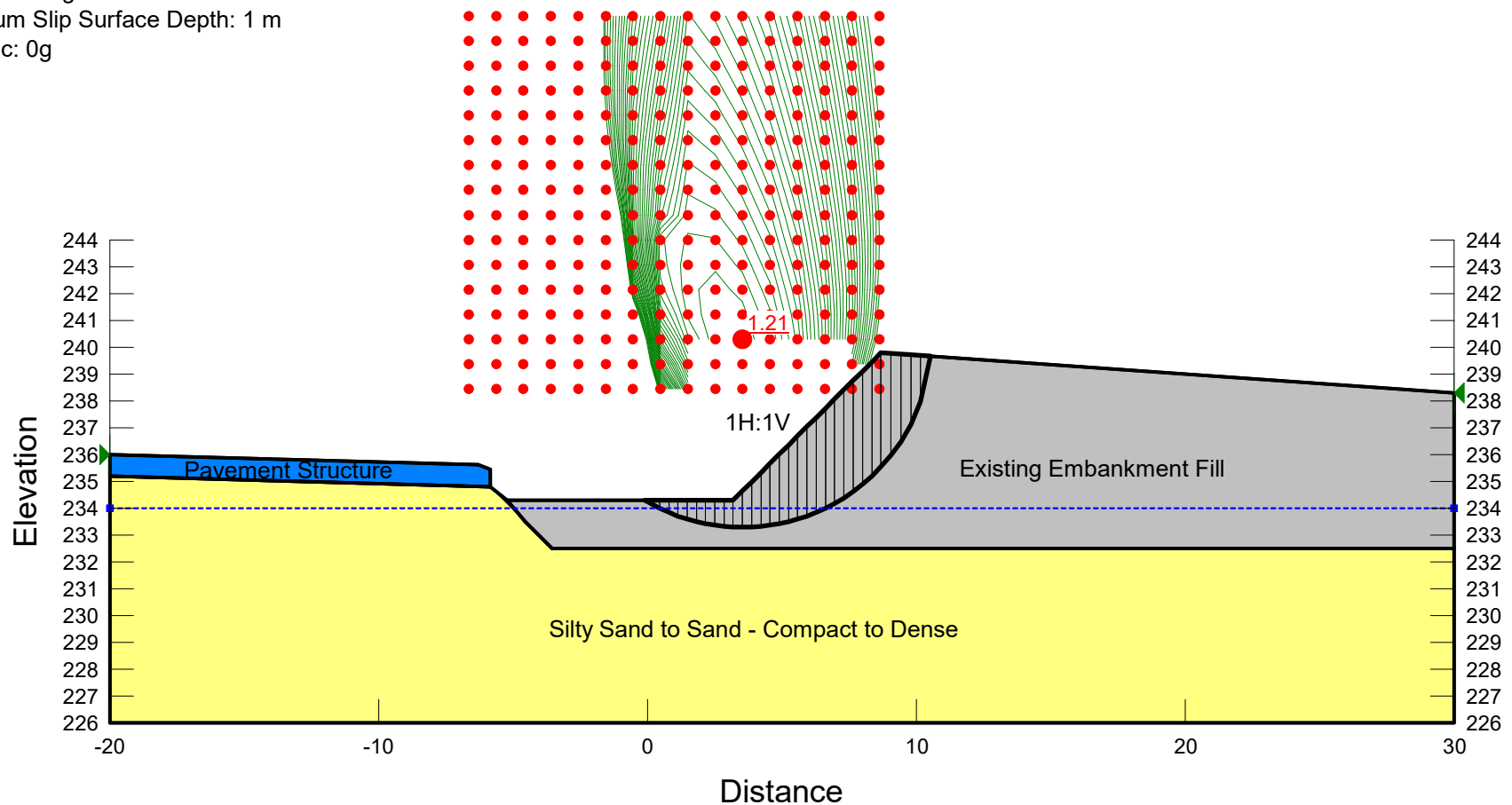


FIGURE G6

EAST ABUTMENT FORWARD SLOPE (5.5 M DEEP TEMPORARY CUT)

File Name: 22424 Anne Street - East Abutment_5.5 m Cut 1.5H-1V.gsz

Last Edited By: Geoff Lay

Date: 9/26/2019

Method: Morgenstern-Price

Minimum Slip Surface Depth: 1 m

Seismic: 0g

Existing Embankment Fill 20 kN/m³ 0 kPa 30 °

Pavement Structure 22.8 kN/m³ 0 kPa 35 °

Silty Sand to Sand - Compact to Dense 21 kN/m³ 0 kPa 31 °

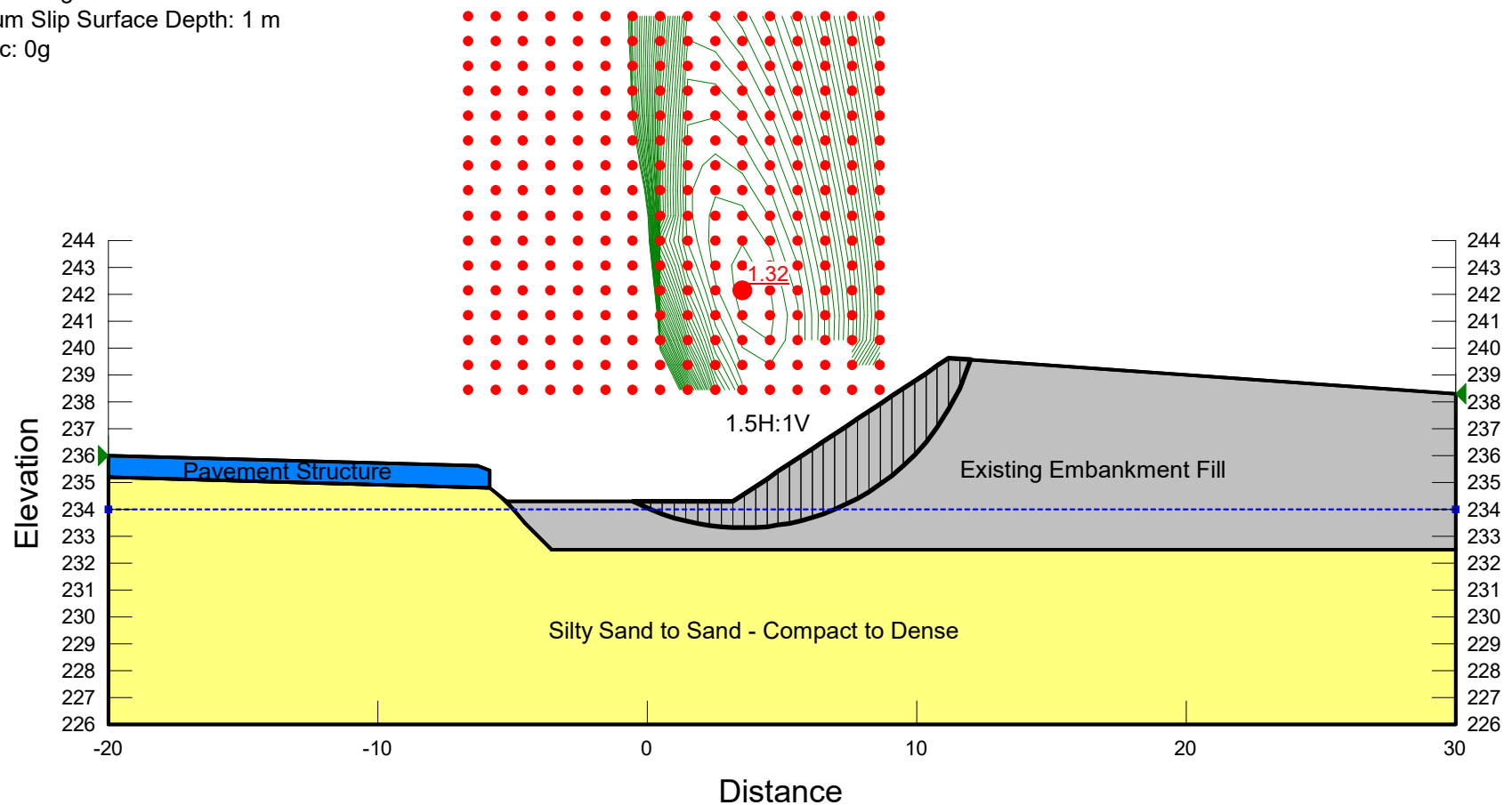


FIGURE G7

EAST ABUTMENT FORWARD SLOPE (6.3 M DEEP TEMPORARY CUT)

File Name: 22424 Anne Street - East Abutment_6.3 m Cut 1H-1V.gsz

Last Edited By: Geoff Lay

Date: 9/26/2019

Method: Morgenstern-Price

Minimum Slip Surface Depth: 1 m

Seismic: 0g

Existing Embankment Fill 20 kN/m³ 0 kPa 30 °

Pavement Structure 22.8 kN/m³ 0 kPa 35 °

Silty Sand to Sand - Compact to Dense 21 kN/m³ 0 kPa 31 °

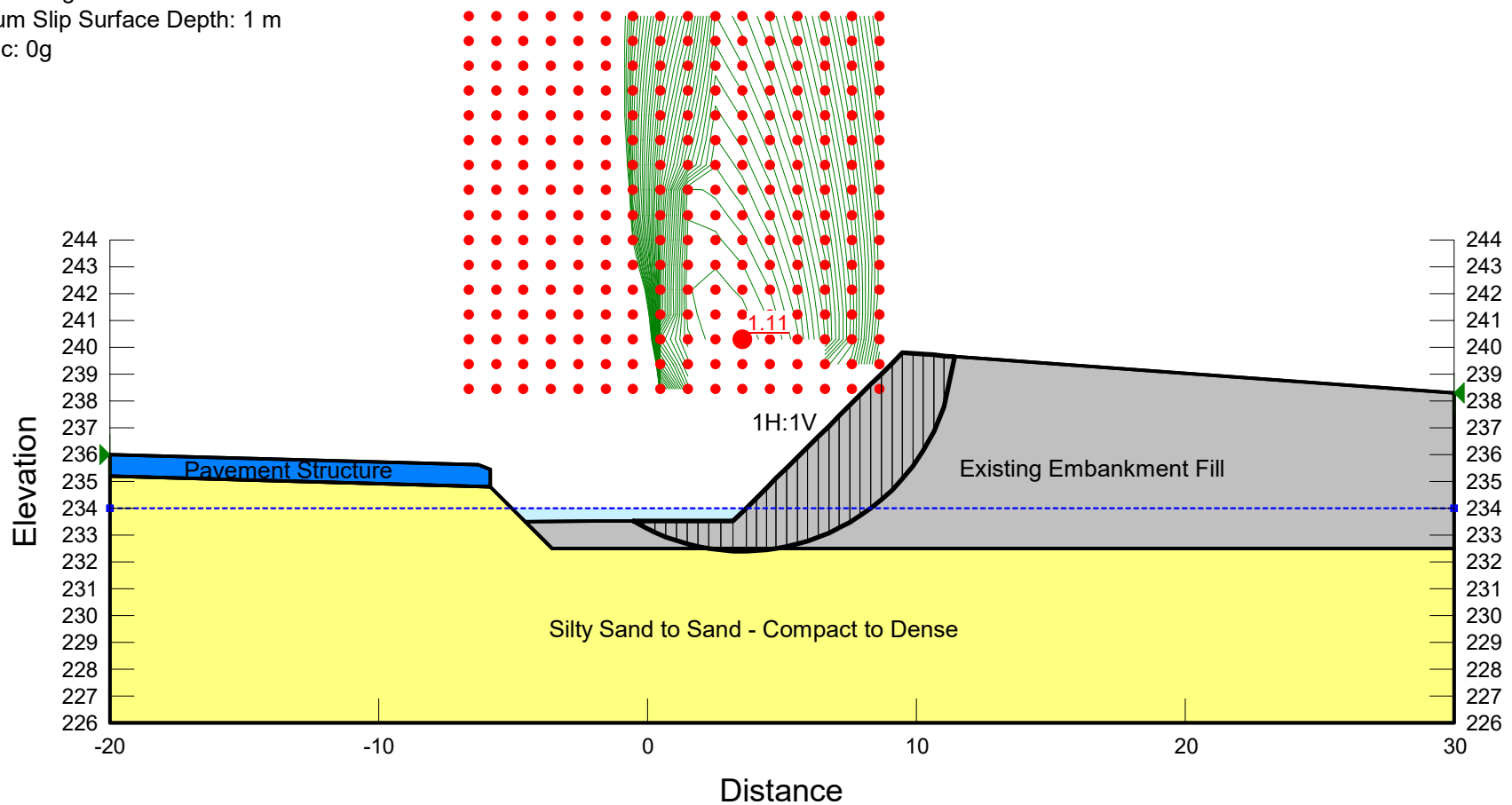


FIGURE G8

EAST ABUTMENT FORWARD SLOPE (6.3 M DEEP TEMPORARY CUT)

File Name: 22424 Anne Street - East Abutment_6.3 m Cut 1.5H-1V.gsz

Last Edited By: Geoff Lay

Date: 9/26/2019

Method: Morgenstern-Price

Minimum Slip Surface Depth: 1 m

Seismic: 0g

Existing Embankment Fill 20 kN/m³ 0 kPa 30 °

Pavement Structure 22.8 kN/m³ 0 kPa 35 °

Silty Sand to Sand - Compact to Dense 21 kN/m³ 0 kPa 31 °

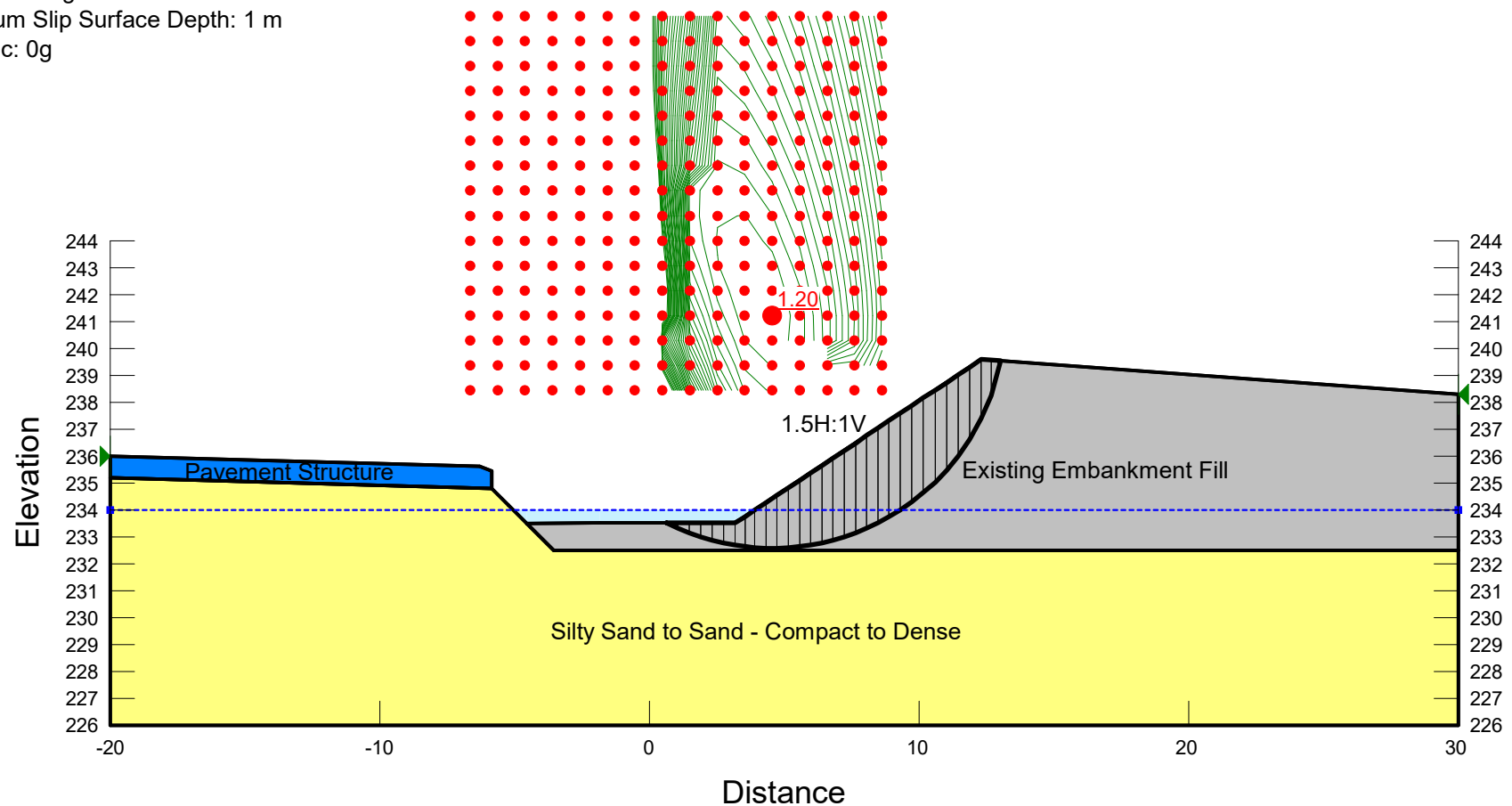


FIGURE G9

EAST ABUTMENT FORWARD SLOPE (EFFECTIVE STRESS)

File Name: 22424 Anne Street - East Abutment Forward_.gsz

Last Edited By: Geoff Lay

Date: 9/26/2019

Method: Morgenstern-Price

Minimum Slip Surface Depth: 1 m

Seismic: 0g

Granular Backfill 22.8 kN/m³ 0 kPa 35 °

Concrete 24 kN/m³ 30000 kPa 0 °

Fill 20 kN/m³ 0 kPa 30 °

Existing Embankment Fill 20 kN/m³ 0 kPa 30 °

Pavement Structure 22.8 kN/m³ 0 kPa 35 °

Silty Sand to Sand - Compact to Dense 21 kN/m³ 0 kPa 31 °

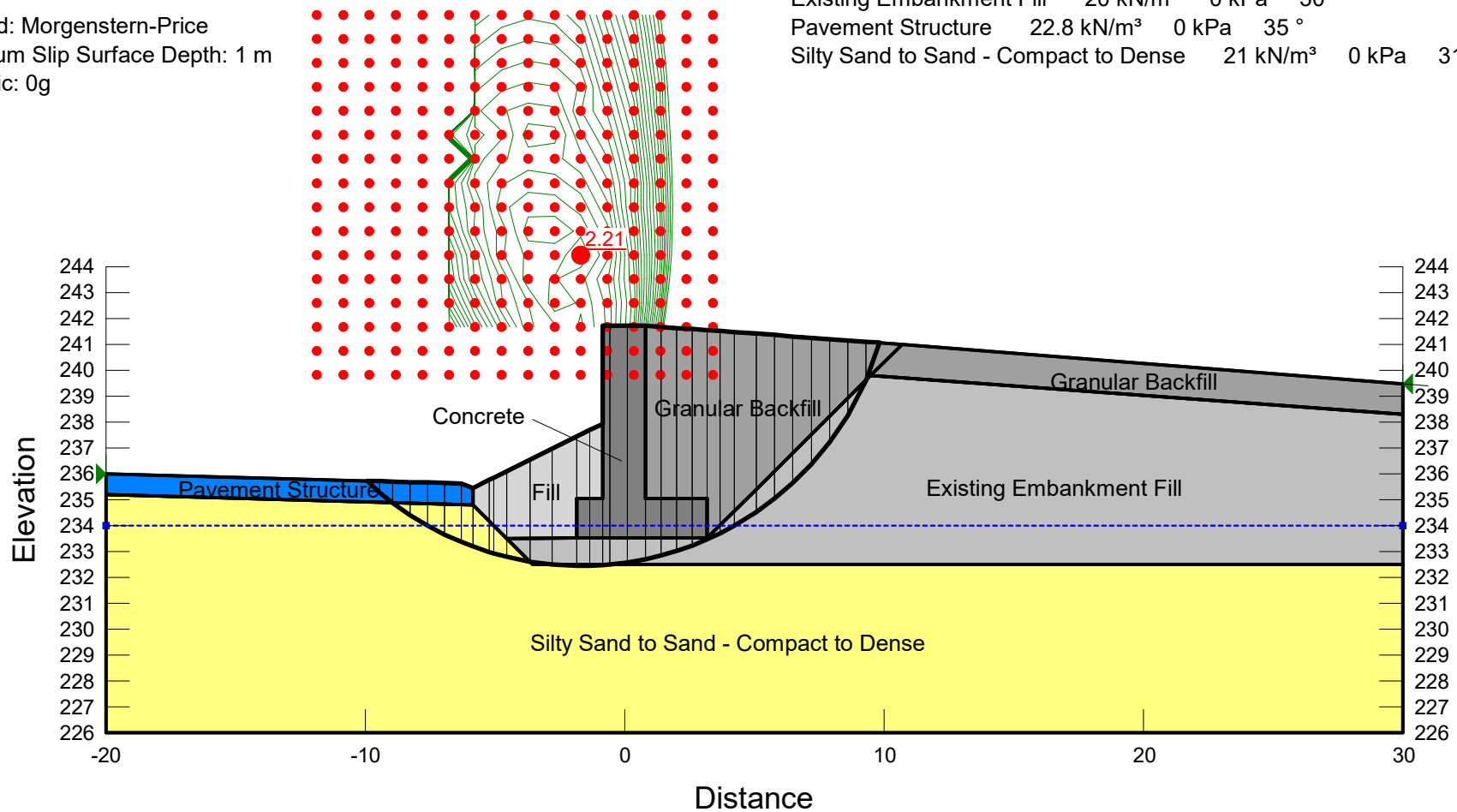


FIGURE G10

EAST ABUTMENT FORWARD SLOPE (SEISMIC)

File Name: 22424 Anne Street - East Abutment Forward Seismic_.gsz

Last Edited By: Geoff Lay

Date: 9/26/2019

Method: Morgenstern-Price

Minimum Slip Surface Depth: 1 m

Seismic: 0.032g

Granular Backfill 22.8 kN/m³ 0 kPa 35 °

Concrete 24 kN/m³ 30000 kPa 0 °

Fill 20 kN/m³ 0 kPa 30 °

Existing Embankment Fill 20 kN/m³ 0 kPa 30 °

Pavement Structure 22.8 kN/m³ 0 kPa 35 °

Silty Sand to Sand - Compact to Dense 21 kN/m³ 0 kPa 31 °

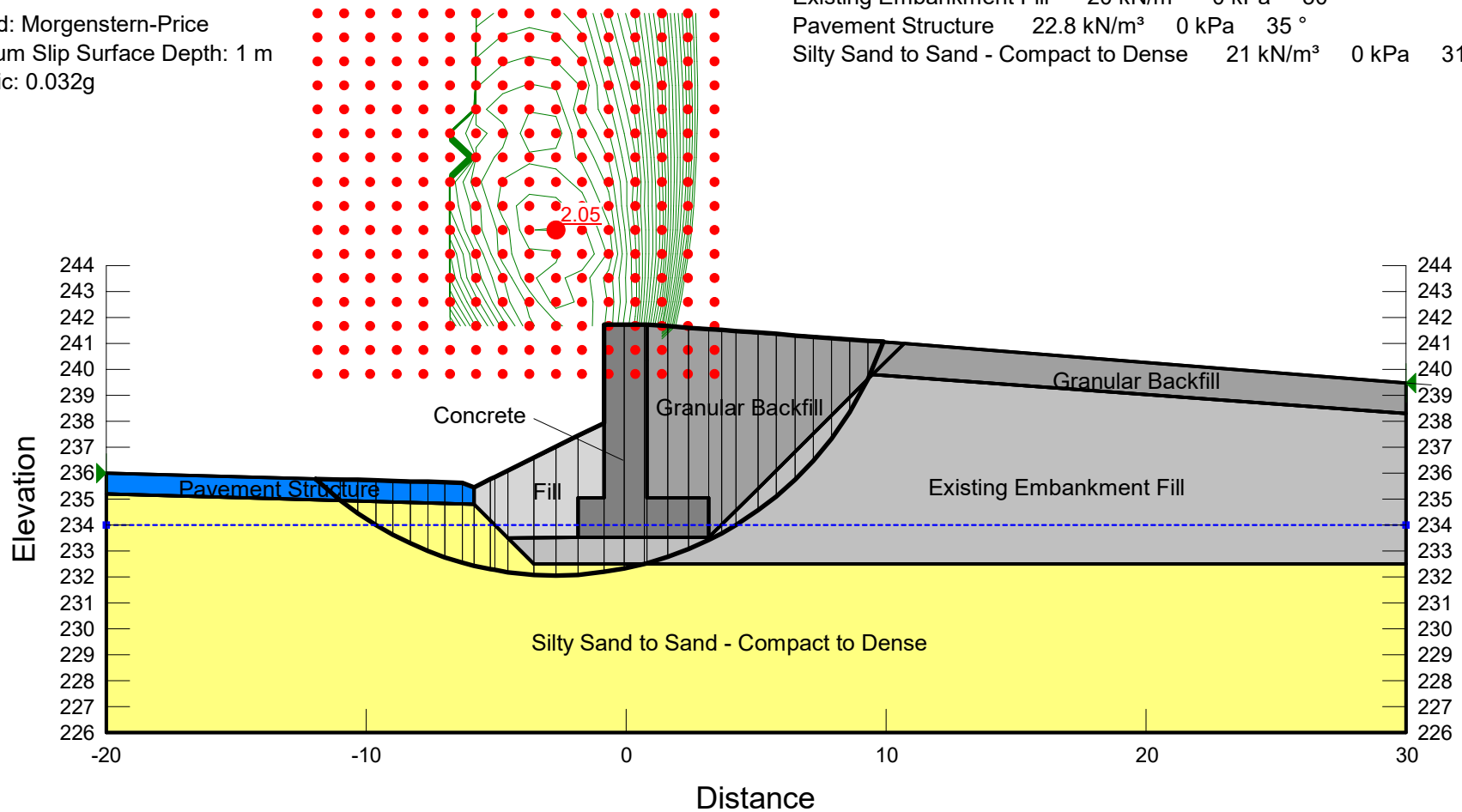


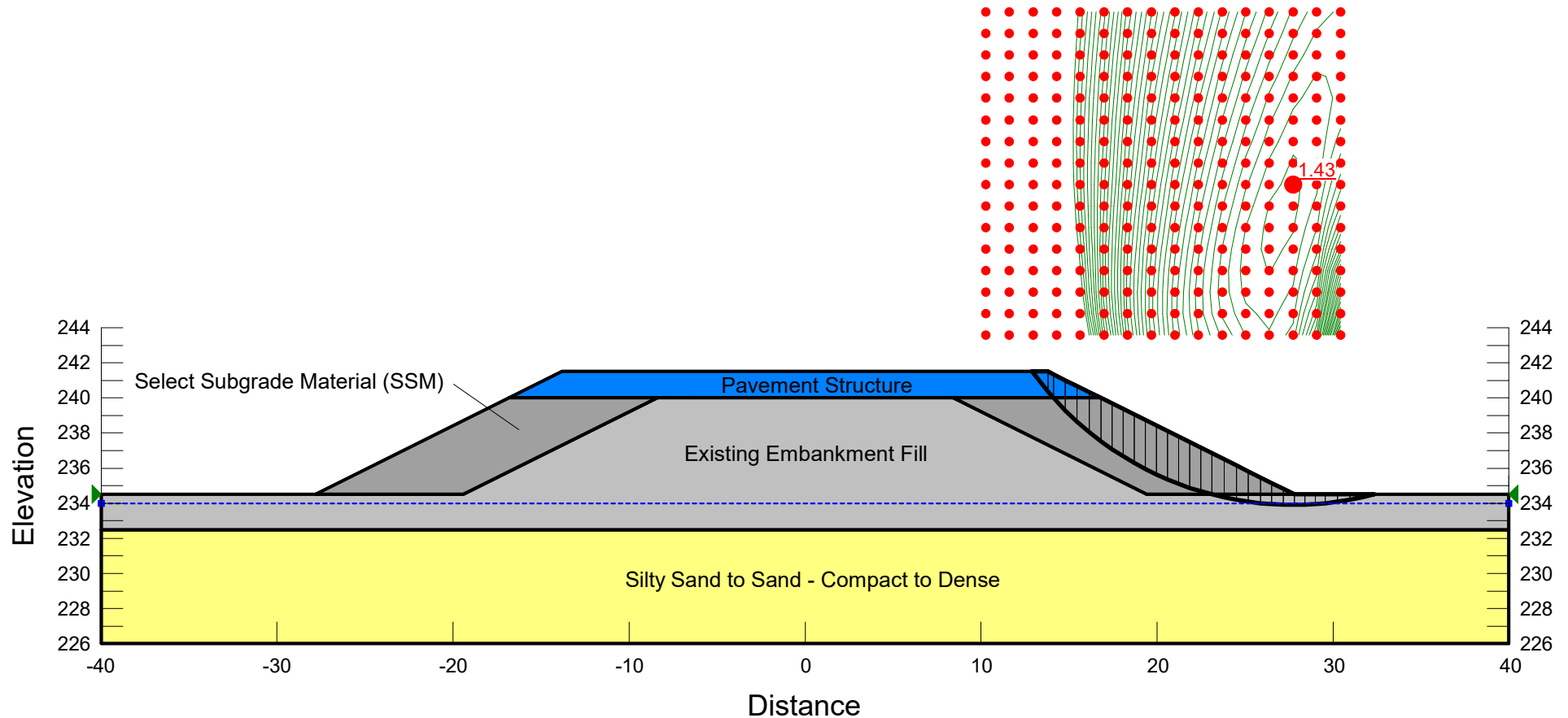
FIGURE G11

APPROACH FILL SIDE SLOPE EBL (EFFECTIVE STRESS)

File Name: 22424 Anne Street - East Abutment Side Slope_.gsz
Last Edited By: Geoff Lay
Date: 9/26/2019

Method: Morgenstern-Price
Minimum Slip Surface Depth: 1 m
Seismic: 0g

Pavement Structure	22.8 kN/m ³	0 kPa	35 °
Select Subgrade Material (SSM)	20 kN/m ³	0 kPa	30 °
Existing Embankment Fill	20 kN/m ³	0 kPa	30 °
Silty Sand to Sand - Compact to Dense	21 kN/m ³	0 kPa	31 °

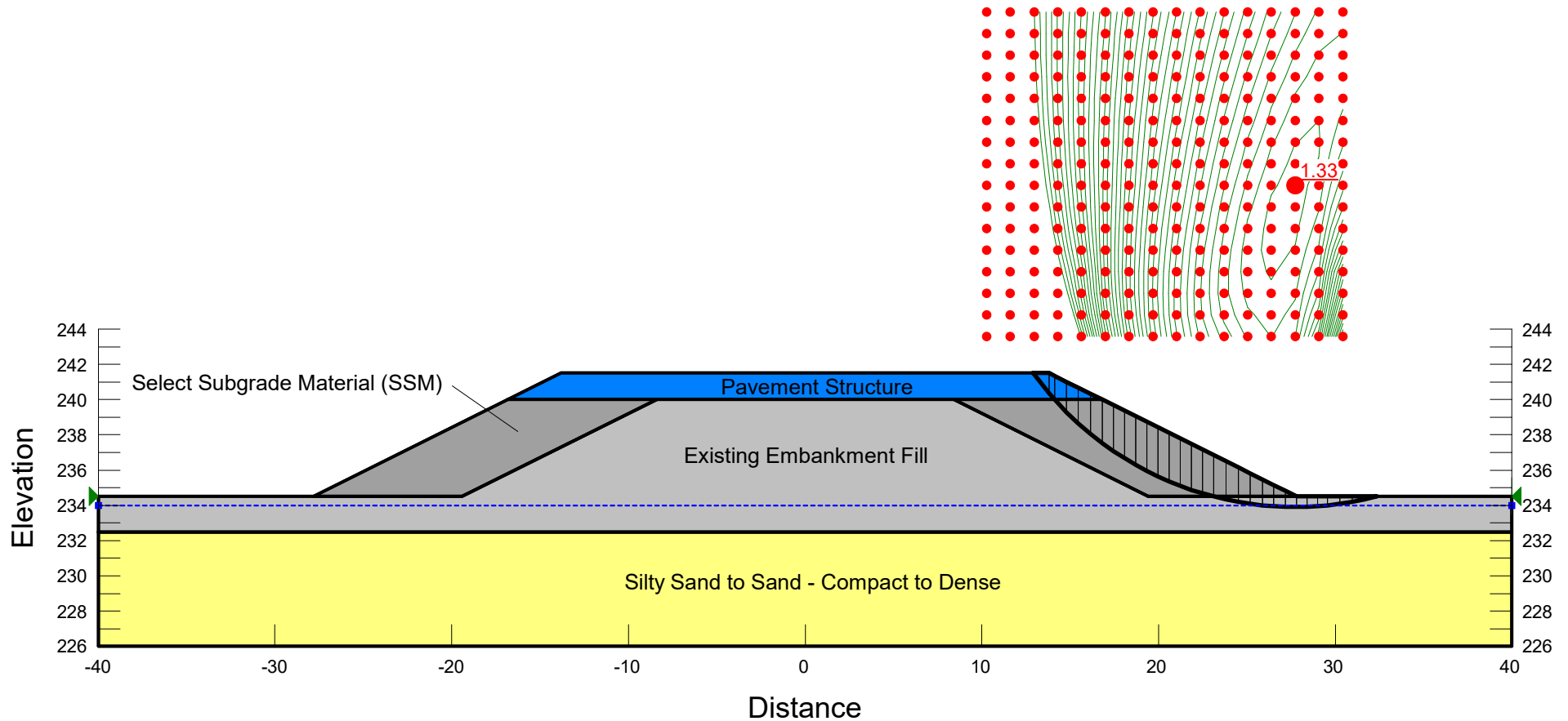


APPROACH FILL SIDE SLOPE EBL (SEISMIC)

File Name: 22424 Anne Street - East Abutment Side Slope Seismic_.gsz
 Last Edited By: Geoff Lay
 Date: 9/26/2019

Method: Morgenstern-Price
 Minimum Slip Surface Depth: 1 m
 Seismic: 0.032g

Pavement Structure	22.8 kN/m ³	0 kPa	35 °
Select Subgrade Material (SSM)	20 kN/m ³	0 kPa	30 °
Existing Embankment Fill	20 kN/m ³	0 kPa	30 °
Silty Sand to Sand - Compact to Dense	21 kN/m ³	0 kPa	31 °





Appendix H

List of OPSS Documents and NSSP Wording



1. List of OPSS and OPSD Referenced in this Report

- OPSS.PROV 206 (Construction Specification for Grading)
- OPSS.PROV 212 (Construction Specification for Earth Borrow)
- OPSS.PROV 501 (Construction Specification for Compacting)
- OPSS.PROV 539 (Construction Specification for Temporary Protection Systems)
- SP 105S09 (Amendment to OPSS 539)
- OPSS.PROV 804 (Construction Specification for Seed and Cover)
- OPSS 902 (Construction Specification for Excavating and Backfilling - Structures)
- OPSS.PROV 903 (Construction Specification for Deep Foundations)
- OPSS.PROV 1010 (Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill material)
- OPSD 208.010 (Benching of Earth Slopes)
- OPSD 3101.150 (Walls, Abutment, Backfill, Minimum Granular Requirement)

2. Suggested Text for NSSP on “Excavations”

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. It is noted that potential obstructions exist in the fill materials, and cobbles and boulders in the till. Laboured excavation should be anticipated in the very dense or hard native soils. The contractor's methods and equipment must be capable of dislodging, removing or otherwise penetrating the obstructions, cobbles or boulders. The excavations shall be inspected periodically to confirm stability at all stages.

3. Suggested text for a NSSP on Pile Installation

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

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



Subsequent to driving a pile to the estimated tip elevation, the Contractor shall wait for at least seven (7) days prior to retapping to confirm the pile geotechnical resistance.

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 400 during excavation and foundation construction at the new centre pier and 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 Highway 400 structure while it remains operational during construction. 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 temporary protection pile to be installed. 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 installation, 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 installation, 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. The monitoring frequency shall not be less than that required for survey monitoring outlined above.
- i) Any exceedance of the vibration 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 installation may proceed with caution and in conjunction with precautionary measures including more frequent survey of the survey markers. If the vibration monitoring readings are not acceptable, the Contractor must alter the pile installation procedures until the measured vibrations are within acceptable limits.
- j) All settlement readings must be submitted to the Contract Administrator in a timely manner for review.
- k) 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.
- l) All settlement and vibration monitoring results must be submitted to the Contract Administrator by the end of each day.