



THURBER ENGINEERING LTD.

FOUNDATION INVESTIGATION AND DESIGN REPORT

**CUBERT STREET OVERPASS REPLACEMENT
HIGHWAY 401**

CITY OF OSHAWA, ONTARIO

SITE 22X-174/B1&B2

G.W.P. 2555-17-00

GEOCRES NO. 30M15-347

Latitude: 43.878673°

Longitude: -78.868774°

Client Name: Egis Canada Ltd.

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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual findings obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the proposed replacement of the existing Highway 401 Cubert Street overpass structures located in the City of Oshawa, 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 the data obtained from the present investigation, to describe the geotechnical conditions influencing design and construction of the foundations and approach embankments for the structures.

Thurber was retained by Egis Canada Ltd. (Egis) (formerly McIntosh Perry) to carry out this foundation investigation under the Ministry of Transportation Ontario (MTO) Agreement Number 2019-E-0076. The overall assignment includes replacement of the Highway 401 at Park Road South and Cubert Street underpass structures, new retaining walls and noise barrier walls on both sides of the highway, and overhead signs. This report addresses the proposed replacement of the Cubert Street underpass structures.

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

- Foundation Investigation Report for The Proposed Widening of the Existing Overpass

Structure at the Crossing of Hwy. 401 and Cubert Street, City of Oshawa, County of Ontario, District No. 6 (Toronto), Site No. 22-174, W.P. 44-71-07, prepared by Foundations Office, Design Services Branch, Ministry of Transportation and Communications Ontario, GEOCRES No.30M15-29 dated July 30, 1973 (Reference 1).

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

2. SITE DESCRIPTION

The existing Cubert Street overpass EBL and WBL structures are located approximately 1 km east of Stevenson Road in the City of Oshawa, Ontario. Cubert Street generally runs in a north-south direction and the two bridges carry the two directions of traffic on Highway 401 over the street. Each of the existing overpass bridges consists of a single-span concrete rigid frame structure supported on spread footings.

We understand that the original structures were constructed in 1941. Archive information indicates that the original bridge footings are about 1.07 m wide and founded at approximate Elevations 103.4 to 103.5. In 1977, the bridges were widened by approximately 2.5 m at the north and south sides. Archive information indicates that the widening footings are about 2.44 m wide and founded at the same elevations as the original footings. The highway grade at this location is at approximate Elevations 110.3 and 110.0 at the west and east abutments, respectively. The approach fills at the east and west abutments are in the order of 6.5 to 7 m above the original ground in this area. Further structural rehabilitation was completed in 2003.

It is understood that the existing structures are proposed to be replaced with twin structures, each to carry the Highway 401 WBL and EBL.

The overall surface topography in the vicinity of the site is relatively flat with the ground surface gently sloping towards the south. Beyond the highway right-of-way, all four quadrants of the bridge crossing are currently occupied by residential developments.

Based on published geological information, the site area is located within the Iroquois Plain physiographic region. This region extends around the western shores of Lake Ontario and consists of lakebed and beaches of the former glacial Lake Iroquois. The subsoils in this area are typically comprised of glacial tills and glaciolacustrine clays, silts and sands.

3. SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing program for the Cubert Street overpass was carried out between October 19 and December 5, 2022, and consisted of drilling and sampling ten (10) boreholes designated as Boreholes CS-01 to CS-10. The completed boreholes at this site were terminated at depths ranging from 6.4 m to 27.7 m (Elevations 104.4 to 82.1). The Record of Borehole sheets are provided in Appendix B.

The approximate locations of all the boreholes (previous 1973 and present investigations) are shown on the Borehole Location Plan and Stratigraphic Drawings in Appendix A.

Thurber obtained the co-ordinates of the as-drilled borehole locations in the field using Trimble R10 GPS equipment and forwarded them to MP, who then provided the ground surface elevations. It is understood that the horizontal and vertical accuracy of the survey results meet the MTO terms of reference requirements. The coordinates and elevations of the boreholes are given on the drawings and record of borehole sheets in Appendices A and B.

Lane closures and traffic control were implemented for drilling all of the boreholes that are located on Highway 401 or Cubert Street. Prior to commencement of drilling, utility clearances were obtained for all current borehole locations.

The current boreholes were advanced using track-mounted and truck-mounted drill rigs using hollow stem augers in conjunction with wash boring with tri-cone and PW casings at some locations. Soil samples were obtained at selected depth intervals using a 50 mm outside diameter split-spoon sampler driven in conjunction with the Standard Penetration Test (SPT) which was performed in accordance with ASTM D1586. Where encountered, rock coring was carried out using HQ core barrel in conjunction with HW casings.

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

Groundwater conditions in the open boreholes were observed throughout the current drilling operations. Two monitoring wells (50 mm diameter Schedule 40 PVC) were installed and enclosed in filter sand in Boreholes CS-01 and CS-04 to permit groundwater level monitoring. Details of the well installations are shown in Table 3.1.

Table 3.1: Borehole Completion Details

Foundation Unit	Borehole	Borehole Depth / Base Elevation (m)	Well Tip Depth / Elevation (m)	Completion Details
West Abutment (WBL bridge)	CS-01	18.3 / 87.1	17.1 / 88.3	Open borehole caved to 17.1 m, monitoring well with 1.5 m slotted screen installed within sand filter from 17.1 to 15.2 m, bentonite from 15.2 m to 0.25 m, then concrete to 0.15 m, then asphalt to ground surface.
East Abutment (EBL bridge)	CS-04	18.6 / 86.6	17.7 / 87.5	Monitoring well with 1.5 m slotted screen installed within sand filter from 18.6 to 15.8 m, bentonite from 15.8 to 0.25 m, then concrete from 0.25 to 0.13 m, then asphalt to ground surface.

3.1 Gas

The following summarizes factual information associated with the encountering and handling of gas in Borehole CS-04. It is noted that evidence of gas was not encountered during drilling, monitoring well installation and backfilling of this borehole during the field work.

- On April 14, 2023, some 5 months after initial well installation, gas odour and pressurization were noted in the wells installed in Boreholes CS-01 and CS-04. Bubbles and relatively higher pressure were noted inside the pipe in CS-04, while only slight pressure was noted in CS-01. After taking the water level readings, the well caps/J-plugs were put back into position. It is possible that the water level reading in CS-04 was affected by the gas pressure.
- On May 18, 2023, gas was noted while the well cap/J-plug was removed in an attempt to obtain a water level reading. Bubbling inside the pipe was observed and a smell of gas was also noted. After taking the water level reading, the well cap/J-plug was put back into position.
- On July 14, 2023, a second attempt was made to obtain water level reading. Similar occurrences regarding gas as before were noted. A levellogger was placed inside the pipe to allow a continual measurement of the water level.
- On September 15, 2023, a gastector was brought to site and recorded a hexane value of about 820 ppm above the pipe immediately after the J-plug was removed. No bubbling

sound and gas odour were noted. The hexane value decreased to zero shortly thereafter.

The pipe installation in Borehole CS-04 was decommissioned using a cement based grout.

Boreholes without monitoring well installations were backfilled upon completion of drilling in general accordance with O.Reg. 903. Borehole CS-04 has been decommissioned on September 15, 2023 as outlined above. Once the final readings are obtained, the remaining well in Borehole CS-01 will be decommissioned in general accordance with O.Reg. 903. The asphalt surface was reinstated in boreholes drilled on the highway or road platform.

4. LABORATORY TESTING

The recovered soil samples were subjected to visual identification (VI) and natural moisture content determination. Selected soil samples were subjected to grain size distribution analyses (sieve and/or hydrometer), and Atterberg Limits testing. Point Load Testing was carried out on selected rock cores for estimating the unconfined compressive strength of intact rock. Geotechnical laboratory testing results of the current investigation are summarized on the Record of Borehole sheets included in Appendix B and are presented on the figures included in Appendix C.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for metal corrosion associated with the below ground portion of the structure, selected samples of the soils were submitted to SGS, a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing for corrosivity parameters and sulphate content. The results of the analytical testing are summarized in Section 5.8 and are presented in Appendix C.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered subsurface stratigraphy are presented on the Record of Borehole sheets included in Appendices B and D, and on the Borehole Locations and Soil Strata drawings in Appendix A. 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 pavement structure overlying compact to occasionally dense embankment fill within the highway platform. Below the embankment fill and beyond the highway, the native soils consist of compact to very dense sand

and silt till which is underlain by typically hard clayey silt till. Within the northerly and westerly portions of the site, the clayey silt till is underlain by, or interlayered with, a deposit of very stiff to hard silty clay. Limestone bedrock with shale interbeds underlies the cohesive deposits. The groundwater level was observed to be at approximately 3 m to 5 m depths below the existing Cubert Street grade.

More detailed descriptions of the individual stratum are presented below.

5.1 Pavement Structure

On the highway platform, pavement structure consisting of approximately 100 mm to 305 mm of asphalt overlying granular (gravelly sand to sand, sand and silt) road base fill was encountered in Boreholes CS-05 to CS-10. On Cubert Street, pavement structure consisting of 75 mm to 150mm asphalt overlying granular road base fill was encountered in Boreholes CS-01 to CS-04. The granular fill ranged in thickness from 0.5 m to 1.3 m.

SPT 'N' values recorded in the granular fill typically ranged from 16 to 42 blows per 0.3 m of penetration indicating a compact to dense condition. A surface 'N' value in Borehole CS-02 was 100 blows for less than 0.3 m penetration. The moisture contents measured on samples of the granular fill ranged from approximately 2 percent to 7 percent.

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

Soil Particle	Gravelly Sand Fill (Percent)	
Gravel	30 to 34	
Sand	50 to 53	
Silt	15	16
Clay	2	

Results of grain size analyses conducted on a sample of the sand and silt fill are provided on the Record of Borehole sheets in Appendix B and illustrated on Figure C2 in Appendix C. The results are summarized as follows:

Soil Particle	Sand and Silt Fill (Percent)
Gravel	5
Sand	43
Silt	40
Clay	12

5.2 Embankment Fill

Embankment fill was encountered underlying the pavement structure in the boreholes advanced from the Highway 401 platform (Boreholes CS-05 to CS-10). This fill typically consisted of brown sand and silt, silty sand to sandy silt, trace gravel, trace to some clay. The embankment fill extended to 1.4 to 4.1 m depths below highway grade, or Elevations 109.4 to 105.8.

The SPT 'N' values recorded in the cohesionless fill typically ranged from 10 to 49 blows per 0.3m of penetration indicating a compact to dense condition. Some lower 'N' values between 4 and 9 blows per 0.3 m penetration indicated loose zones within the embankments. The natural moisture contents measured on samples of the cohesionless fill ranged from approximately 5 percent to 13 percent.

Results of grain size analyses conducted on samples of the sand and silt fill are provided on the Record of Borehole sheets in Appendix B and illustrated on Figure C3 in Appendix C. The results are summarized as follows:

Soil Particle	Cohesionless Embankment Fill (Percent)
Gravel	1 to 11
Sand	32 to 60
Silt	32 to 51
Clay	4 to 10

5.3 Sand and Silt to Sandy Silt Till

Sand and silt to sandy silt till containing trace to some gravel, trace to some clay with some cobbles and boulders was encountered below the fill at shallow depths in Boreholes CS-01, CS-02, CS-08, CS-09 and CS-10. Where fully penetrated, the base of this cohesionless till was encountered at 2.2 m to 8.5 m depths, or Elevation 103.2 to 101.2. Boreholes CS-09 was terminated within the sandy silt till at 6.4 m depth, or Elevation 104.4.

The SPT 'N' values recorded in this till typically ranged from 40 blows per 0.3 m of penetration to greater than 100 blows for less than 0.3 m penetration, indicating dense to very dense conditions. Some 'N' values of greater than 100 may be attributed to the presence of cobbles and boulders. An occasional 'N' value of 25 blows per 0.3 m of penetration recorded in Borehole CS-08 indicates a compact zone. The natural moisture contents measured on samples of the cohesionless till ranged from approximately 2 percent to 10 percent.

Results of grain size distribution analyses carried out on selected samples of the sand and silt to

sandy silt till are shown on Figure C4 in Appendix C. The results are summarized as follows:

Soil Particle	Sand and Silt to Sandy Silt Till (Percent)
Gravel	1 to 11
Sand	26 to 42
Silt	40 to 65
Clay	8 to 10

Glacial tills inherently contain cobbles and boulders. Cobbles and boulders were encountered at 3.4 m and 4.1 m depths in Borehole CS-01 during drilling and require coring to further advance the borehole. High resistance to split spoon sampler penetration were noted at various depths in the till in Boreholes CS-01, CS-08 and CS-09.

5.4 Clayey Silt Till

An extensive deposit of clayey silt till, with sand, trace gravel underlies the site. This cohesive till was encountered in all but Borehole CS-09 at depths ranging between 0.8 m and 8.5 m. Where fully penetrated, the depth to the base of the clayey silt till ranged between 8.7 m and 18.8 m (Elevations 99.5 to 86.6) in Boreholes CS-01, CS-02 and CS-05. Boreholes CS-07, CS-08 and CS-10 were terminated within the clayey silt till between 10.8 m and 14.6 m (Elevations 100.0 to 95.3). Boreholes CS-03, CS-04 and CS-06 were terminated in the clayey silt till on possible bedrock (see section below) at 18.4 m to 24.0 m depths, or Elevations 86.7 to 86.0. The thickness of the clayey silt till varied from 4.5 m to 19.9 m.

SPT 'N' values measured in the clayey silt till typically ranged from 35 blows per 0.3 m penetration to greater than 100 blows for less than 0.3 m of penetration indicating a hard consistency. Some higher N-values may be attributed to the presence of cobbles and boulders. In Boreholes CS-06, CS-08 and CS-10, lower SPT 'N' values ranging between 17 and 25 blows per 0.3 m penetration indicate some very stiff zones. A very low value of 3 blows recorded at about 9 m to 10 m depths in Borehole CS-06 indicates the presence of a soft zone or could be attributed to disturbance during the drilling operations.

Moisture contents measured in the clayey silt till typically ranged from 2 percent to 10 percent in the boreholes drilled during the present investigation. Occasional values were up to the order of 18 percent and 22 percent.

Results of grain size distribution analyses carried out on selected samples of the clayey silt till are presented on the Record of Borehole sheets included in Appendix B. Grain size distribution curves

of samples tested are presented on Figures C5 to C7 in Appendix C. The results of the grain size distribution analyses are summarized below:

Soil Particle	Clayey Silt Till (Percent)
Gravel	0 to 8
Sand	34 to 47
Silt	35 to 51
Clay	10 to 24

Results of Atterberg Limits tests conducted on samples of the clayey silt till are presented on the Record of Borehole sheets in Appendix B and illustrated in Figures C9 and C11 of Appendix C. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	14 to 20
Plasticity Index	4 to 10

Results of the Atterberg Limits testing indicate that the clayey silt till is generally of low to slight plasticity with group symbols of CL to CL-ML.

Glacial tills inherently contain cobbles and boulders.

5.5 Silty Clay

A deposit of silt clay, trace sand was encountered below or interlayered with the clayey silt till in Boreholes CS-01, CS-02 and CS-05. The depth to the base of the silty clay ranged from 14.0 m to 23.2 m (Elevations 91.4 to 87.1). Borehole CS-01 was terminated in the silty clay upon contact with possible bedrock (see section below). The thickness of the silty clay varied from 2.3 m to 11.9 m where encountered.

SPT 'N' values measured in the silty clay ranged from 17 to 52 blows per 0.3 m penetration indicating a very stiff to hard consistency. Moisture contents measured in the silty clay ranged from 20 percent to 32 percent.

Results of grain size distribution analyses carried out on selected samples of the silty clay are presented on the Record of Borehole sheets included in Appendix B. Grain size distribution curves of samples tested are presented on Figure C8 in Appendix C. The results of the grain size distribution analyses are summarized below:

Soil Particle	Silty Clay (Percent)
Gravel	0
Sand	0 to 6
Silt	32 to 40
Clay	54 to 67

Results of Atterberg Limits tests conducted on samples of the silty clay are presented on the Record of Borehole sheets in Appendix B and illustrated in Figure C12 of Appendix C. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	44 to 50
Plasticity Index	25 to 31

Results of the Atterberg Limits testing indicate that the silty clay is of intermediate plasticity with a group symbol of CI.

5.6 Bedrock

Limestone bedrock was encountered underlying the clayey silt till and silty clay across the site. Bedrock was proven by coring in Boreholes CS-02 and CS-05, and inferred in Boreholes CS-01, CS-03, CS-04 and CS-06. The table below summarizes depths to top of bedrock and bedrock elevations encountered in these boreholes.

Table 5.1: Top of Bedrock

Foundation Element	Borehole Number	Approximate Top of Bedrock		
		Depth below highway grade or adjacent ground (m)	Elevation (m)	
WBL and EBL Replacement Bridges				
West Abutments	CS-01	18.3	87.1	Inferred
	CS-05	23.2	87.6	Proven
	CS-03	18.4	86.7	Inferred
East Abutments	CS-02	18.8	86.6	Proven
	CS-06	23.9	86.0	Inferred
	CS-04	18.6	86.6	Inferred

In general, the bedrock is described as moderately weathered becoming slightly weathered with

depth, grey limestone with shale interbeds. The joints are largely horizontal to sub-horizontal throughout the cores. There are fractured zones near the top of bedrock.

Total Core Recovery (TCR) in the core runs are at 100 percent. The Rock Quality Designation (RQD) values ranged from 51 percent to 95 percent indicating fair to excellent rock quality. The Fracture Index (FI) of the rock, expressed as number of fractures per 0.3 m of core, typically ranged from 0 to 6 except at the fractured zones where the FI is greater than 10.

The unconfined compressive strength (UCS) of the limestone, estimated from the results of point load tests, ranged from 45 to 94 MPa indicating a medium strong to strong rock. Results of these rock strength tests are included on the records of boreholes in Appendix B and presented in Appendix C.

5.7 Groundwater Conditions

Groundwater levels in the boreholes were observed during the drilling operations and measured upon completion of drilling. Monitoring wells were installed in Boreholes CS-01 and CS-04 to permit monitoring of groundwater levels. Water was added to Boreholes CS-01 to CS-06 in conjunction with tri-coning and rock coring for borehole advancement, and therefore the measured water levels may not represent stabilized groundwater levels.

Water levels measured in the monitoring wells and open boreholes from the current investigation are presented in Table 5.2 below.

Table 5.2: Groundwater Level Measurements

Borehole	Date	Groundwater Level		Comments
		Depth (m)	Elevation (m)	
CS-01	April 14, 2023	3.1	102.3	Monitoring Well
	May 18, 2023	5.0	100.4	
CS-02	December 2, 2022	0.0	105.4	Open borehole upon completion
CS-03	December 5, 2022	3.6	101.5	Open borehole upon completion
CS-04	April 14, 2023	10.5*	94.7*	Monitoring Well (levellogger used since July 2023)
	May 18, 2023	12.2*	93.0*	
	July 14, 2023	11.2*	94.0*	
	September 13, 2023	11.9*	93.3*	

Borehole	Date	Groundwater Level		Comments
		Depth (m)	Elevation (m)	
CS-05	October 27, 2022	15.0	95.8	Open borehole upon completion
CS-06	October 25, 2022	14.4	95.5	Monitoring Well (decommissioned after taking reading)
CS-07	October 20, 2022	-	-	Water level not recorded
CS-08	October 20, 2022	2.3	107.6	Open borehole upon completion
CS-09	November 7, 2022	dry	dry	Open borehole upon completion
CS-10	November 6, 2022	dry	dry	Open borehole upon completion

Note: * Possibly not stabilized due to influence from gas pressure present in the borehole.

The groundwater levels presented in Table 5.2 are short-term readings where seasonal fluctuations are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant or prolonged precipitation.

5.8 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 C.

Table 5.3: Analytical Corrosivity Test Results

Sample ID	Depth (m)	Soil Sample Description	Sulphide (percent)	Chloride (µg/g)	Sulphate (µg/g)	pH	Resistivity (ohm.cm)	Redox Potential (mV)	Electrical Conductivity (µS/cm)
CS-01 SS5	3.0 - 3.4	Sand and silt till	0.11	18	350.00	8.69	2,650	269	378
CS-02 SS5	3.0 - 3.3	Clayey silt with sand till	0.06	18	250	8.44	5,050	314	198
CS-03 SS3	1.5 - 2.1	Clayey silt with sand till	0.07	47	200.00	8.57	3,150	314	317
CS-04 SS4	2.3 - 2.9	Clayey silt with sand till	0.05	14	210	8.54	5,460	291	183

6. MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. Thurber surveyed the as-drilled boreholes in the field, and forwarded the borehole coordinates to Egis who provided the ground surface elevations.

Landshark Drilling of Brantford, Ontario supplied and operated the drilling and sampling equipment for the field program.

Full time supervision of the field activities was carried out by Mr. Sergey Gladkiy of Thurber. Overall supervision of the field program was performed by Messrs. Rod de Castro, P.Eng. and Cory Zanatta, P.Eng. of Thurber.

Interpretation of the field data and preparation of the report were carried out by Messrs. Rod de Castro, P.Eng. and Sydney Pang, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



THURBER ENGINEERING LTD.

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Date: **December 10, 2024**
File: **30915**



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**FOUNDATION INVESTIGATION AND DESIGN REPORT
CUBERT STREET OVERPASS REPLACEMENT
HIGHWAY 401
CITY OF OSHAWA, ONTARIO
SITE 22X-174/B1&B2
G.W.P. 2555-17-00**

GEOCRES NO. 30M15-347

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7. 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 Highway 401 Cubert Street overpass structure replacement in Oshawa, Ontario.

This foundation investigation and design report, with the interpretation and recommendations, is intended for the use of the Ministry of Transportation (MTO) and Egis Canada Ltd. (Egis) (formerly McIntosh Perry) 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.

Original Structure

Information provided by Egis indicates that the original overpass structures were built in 1941. The bridges are single-span concrete rigid frame structures with a clear span between abutment faces of about 13.9 m. The overall width encompassing the original WBL and EBL bridges was about 29.7 m. It is understood that the abutments are supported by spread footings in the order of 1.07m in width. Wingwalls extend for a length of about 9.3 m beyond the front faces of the abutments. There is no record available to confirm the founding elevation of the original structures.

Existing Structure

The original bridges were widened and rehabilitated in 1977 to form the existing structures. The structure widening was approximately 2.5 m to the north and south, resulting in an overall width of about 34.3 m. In addition, several aspects of structural rehabilitation were carried out.

Further minor rehabilitation works were undertaken in 2003 and 2008.

Visual observations of the existing bridge did not reveal obvious signs of settlement or distress at the foundation elements. The approach slopes appeared to be stable with no obvious signs of instability.

Proposed Replacement Structures

A 90% general arrangement (GA) drawing provided by Egis shows that the existing overpasses will be replaced by longer and wider WBL and EBL single span structures. The new clear span between abutment faces will be approximately 18.3 m. The WBL and EBL bridge decks will be approximately 28.4 m and 28.7 m, respectively. The new structures comprise welded steel plate girders resting on conventional concrete abutment walls supported on spread footings. Foundation alternatives for the new structures are discussed below.

The new structures will accommodate four Highway 401 WB lanes and three EB lanes for a total of seven lanes. Cubert Street will also be widened and carry one lane of traffic in each of the north and south directions with wider shoulders on both sides.

In order to accommodate the widened structures, the Cubert Street profile will be lowered up to about 1.5 m below the existing road grade. The new road grade will be at approximate Elevation 103.2 at its lowest point (below the Highway 401 centreline). It is understood that there will be no change to the Highway 401 grade.

New fill will be required on both the north (WBL) and south (EBL) sides for widening of Highway 401. Within the widenings, the new approach fill will be in the order of 6.5 to 7 m in height. Assuming a lowest grade at approximate Elevation 103.2, the approach embankment height will be up to the order of 7.5 m below highway grade.

The preliminary GA drawing also indicates that RSS walls are proposed beyond the wingwalls at each of the four corners of the overpass structures for retaining the widened Highway 401 embankments. These walls will be parallel to Cubert Street and range from 10.6 to 12.6 m in length.

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

8. STRUCTURE CLASSIFICATION

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

For the purpose of reporting, this structure has been classified as a Major-Route Bridge with Typical Consequence based on CHBDC S6-19 Sections 4.4.2 and 6.5.2, respectively. As per CHBDC (2019) 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. BRIDGE FOUNDATION DESIGN

In general, the subsurface stratigraphy encountered at the site consists of pavement structure overlying compact to occasionally dense embankment fill within the highway platform. Below the embankment fill and beyond the highway, the native soils consist of surficial compact to very dense sand and silt till which is underlain by typically very stiff to hard clayey silt till. Within the northerly and westerly portions of the site, the clayey silt till is underlain by, or interlayered with, a deposit of very stiff to hard silty clay. Limestone bedrock with shale interbeds underlies the cohesive deposits. The groundwater level was observed to be at approximately 3 m to 5 m depths below the existing Cubert Street grade beyond the Highway 401 platform.

9.1 Foundation Alternatives

Based on the subsurface conditions and project requirements, consideration was given to supporting the new bridge using the following foundation types:

- Spread footings on native soils
- Driven steel H-piles
- Drilled shafts (caissons)

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. Preferred foundation scheme from a foundation engineering perspective is then recommended.

Spread Footings on Native Soils

Spread footings founded on native very stiff to hard clayey silt till are feasible to support the new bridge abutments and new retaining walls associated with the bridges. This foundation option will preclude the use of integral abutments. Given that the Cubert Street profile will be lowered up to 1.5 m and the footings will have to be founded at a minimum 1.2 m below the final road grade to account for frost penetration, the footing founding levels would likely be at or slightly below the groundwater table during construction. Adequate groundwater control in conjunction with temporary protection will be required for footing construction in the dry. The required temporary protection system and excavation within the Highway 401 embankment will be extensive. These measures will have to be well co-ordinated as part of staged construction to minimize impact on the travelled lanes on Highway 401.

Driven Steel H-Piles

The presence of “100-blow” hard clayey silt till is within 2 m to 3 m depths below the proposed final Cubert Road grade. These hard soils with cobbles and boulders may pose difficulties for driven piles to reach the desired tip elevations. Pre-augering prior to pile driving may be required. This foundation alternative has not been further developed. Should driven piles be considered for foundation support, foundation recommendations will be provided in support of the design.

Drilled Shafts (Caissons)

If integral abutments are not used, augered caisson foundations founded within the very stiff to hard clayey silt till or silty clay are feasible for foundation support of the proposed bridges at this site. Construction of caissons through these soils will require use of a temporary steel liner in conjunction with maintaining a water head to control the ingress of groundwater from water-bearing interlayers and maintaining sidewall and basal stability. Caisson construction will require equipment that is capable of penetrating hard soils and dislodging, handling and removing obstructions such as cobbles and boulders where required.

Recommended Foundations

From a foundation technical perspective, the preferred foundation alternative for the new bridges at this site is spread footings. Alternatively, drilled shafts (augered caissons) may be used as bridge foundation support. The choice of foundation types would depend on the relative cost effectiveness between the two alternatives and preference in structural design considerations.

9.2 Spread Footings

9.2.1 Geotechnical Resistance

Given that the Cubert Street profile will be lowered up to 1.5 m, the new abutments may be supported by spread footings with founding levels at or below the design frost depth of 1.2 m below final grade on undisturbed, native very stiff to hard clayey silt till. Borehole CS-06, located near the Highway 401 median, reveals what appeared to be a localized presence of soft to firm zone within the till. Sub-excavation, backfilling and subgrade preparation for such scenarios are discussed in Section 9.2.2 below.

Table 9.1 below presents the recommended founding level and anticipated founding soils at the footing locations.

Table 9.1: Recommended Founding Conditions for Spread Footings

Foundation Element	Foundation Location	Reference Boreholes	Highest Founding Elevation (m)	Predominant Subgrade Soil Type
WBL (North) Bridge	West Abutment	CS-01* CS-07 CS-05	102.0	Hard Clayey Silt Till overlying Very stiff to hard Silty Clay
	East Abutment	CS-02 CS-08 CS-06**	102.0	Very dense Sand and Silt Till overlying Very stiff to hard Clayey Silt Till
EBL (South) Bridge	West Abutment	CS-05 CS-09 CS-03	102.0	Hard Clayey Silt Till overlying (north side) Very stiff to hard Silty Clay
	East Abutment	CS-06** CS-10 CS-04	102.0	Very stiff to hard Clayey Silt Till

* Cobbles and boulders are present within the glacial tills.

** May require local sub-excavation to below Elevation 100 to expose the very stiff to hard clayey silt till.

Table 9.2 below provides recommended geotechnical resistances for footing design.

Table 9.2: Recommended Geotechnical Resistances for Footing Design

Foundation Element	Foundation Location	Footing Width (m)	Factored Geotechnical Resistances	
			At ULS (kPa)	At SLS (kPa)
WBL (North) Bridge	West Abutment	4 to 5	500	350
	East Abutment			
EBL (South) Bridge	West Abutment	4 to 5	500	350
	East Abutment			

The values of the Factored Geotechnical Resistance at ULS were assessed assuming a Consequence Factor equal to 1 (Typical), and a Resistance Factor equal to 0.5 (Typical degree of understanding of the subsurface conditions), as per CHBDC 2019. The Factored Geotechnical Resistance at SLS was assessed assuming a factor of 0.8 for typical degree of understanding of the subsurface conditions. The founding subgrade may be considered as a cohesive soil for footing design purposes.

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 2019 Clause 6.10.2 and Clause 6.10.3.

The factored geotechnical SLS values given above are based on an estimated total settlement not exceeding 25 mm. This settlement is expected to be substantially complete by the end of construction. Differential settlement is not expected to exceed 20 mm across the width of the structure or between foundation elements.

The sliding resistance of cast-in-place concrete placed on the native, undisturbed very stiff to hard clayey silt till may be computed based on an ultimate coefficient of friction, $\tan \delta$, of 0.4.

For frost protection purposes, all footing bases should have a minimum earth cover of 1.2 m or its thermal equivalent.

9.2.2 Footing construction

The base of the footing excavation should be inspected by a Foundation Engineering Specialist to confirm that the footing subgrade is the native, undisturbed very stiff to hard clayey silt till

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.

In the vicinity of Borehole CS-06 on the east side or elsewhere along the footing alignments, the exposed subgrade at footing level may contain soft to firm soils. Once identified by subgrade inspection, sub-excavation up to 2 m depth or deeper may be required to remove these unsuitable materials from below the design founding level and expose the underlying very stiff to hard clayey silt till. The founding surface should be re-established using mass concrete.

All footing construction procedures should follow the guidelines provided in OPSS 902. Suggested wordings for an NSSP outlining the above are included in Appendix H.

Depending on location along the lowered street profile, the current groundwater table is at or slightly below the highest recommended footing base level. For permanent conditions, the lowered profile of Cubert Street with its long term drainage system would slightly drawdown the surrounding groundwater table. The proportion of clay particles within the clayey silt till would impede water seepage. During construction, dewatering in conjunction with temporary protection (shoring) will be required for groundwater control due to seepage from water-bearing interlayers, and accumulation of precipitation and surface runoff to facilitate dry excavations for footing construction.

Feasible means of groundwater control may include sheetpile in conjunction with sump pumping and well pointing where required. Further details on groundwater control are provided in a later Section 15.0.

Further discussions on groundwater control and temporary protection design are presented in Sections 15 and 16.

9.3 Drilled Shafts (Augered Caissons)

Augered caissons founded through the very stiff to hard clayey silt till and silty clay into the underlying limestone bedrock are feasible to provide foundation support to the replacement bridges.

Borehole information indicates that the limestone bedrock with shale interbeds is in a slightly weathered state overall with moderately weathered joints. Fractured zones exist within the upper 1 m below the top of bedrock. A minimum rock socket depth of 1 m within the sound bedrock is recommended to confirm full contact with the underlying intact limestone. However, the required

depth of rock socket should be determined by the designer to satisfy base fixity, lateral load resistance and any other structural requirements.

9.3.1 Axial Geotechnical resistance

For planning and design purposes, Table 9.3 presents the recommended founding depths and elevations for the caissons at both abutments, as well as geotechnical resistances recommended for typical caisson diameters.

Table 9.3: Recommended Augered Caisson Founding Levels and Geotechnical Resistances

Foundation Element	Foundation Location	Reference Borehole	Highest Caisson Tip Elevation (m)	Caisson Diameter D (m)	Factored Geotechnical Resistance at ULS (kN)
WBL (North) Bridge	West Abutment	CS-01	85.0	0.9	4,000
		CS-05	85.5	1.2	6,000
				1.5	9,000
	East Abutment	CS-02	84.5	0.9	4,000
		CS-06	84.0	1.2	6,000
				1.5	9,000
EBL (South) Bridge	West Abutment	CS-05	85.5	0.9	4,000
		CS-03	84.5	1.2	6,000
				1.5	9,000
	East Abutment	CS-06	84.0	0.9	4,000
		CS-04	84.5	1.2	6,000
				1.5	9,000

The SLS condition does not govern design of caissons socketted into bedrock.

The minimum spacing between adjacent caissons should be as per the CHBDC 2019. The vertical resistance will not be significantly affected by the spacing for caissons socketted within bedrock.

9.3.2 Lateral Geotechnical Resistance

Lateral bridge loadings can be geotechnically resisted by the augered caissons through passive pressure developed along the embedded portion of the shafts.

The geotechnical lateral resistance acting on a caisson 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:

$$\begin{aligned}
 k_s &= 67 C_u / D \quad (\text{kPa/m}) \\
 p_{ult} &= 9 C_u \quad (\text{kPa}) \\
 \text{Where } C_u &= \text{undrained shear strength (kPa)} \\
 D &= \text{caisson diameter in metres}
 \end{aligned}$$

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

$$\begin{aligned}
 k_s &= n_h z / D \quad (\text{kPa/m}) \\
 p_{ult} &= 3 \gamma' z K_p \quad (\text{kPa}) \\
 \text{Where } z &= \text{depth of embedment along pile (m)} \\
 D &= \text{caisson diameter (m)} \\
 n_h &= \text{coefficient related to soil density (kPa/m)} \\
 \gamma' &= \text{submerged unit weight (kN/m}^3\text{)} \\
 K_p &= \text{coefficient of passive lateral earth pressure}
 \end{aligned}$$

The above equations and recommended parameters in Table 9.4 below may be used to analyse the interaction between a caisson and the surrounding soils. The lateral pressures obtained from the analysis must not exceed the ultimate lateral resistance.

Table 9.4: Recommended Geotechnical Parameters for Lateral Resistance Design

Foundation Element	Reference Boreholes	Approx. Elevation (m)	Undrained Shear Strength C_u (kPa)	Unit Weight γ (kN/m ³)	K_p	n_h (kN/m ³)	Soil Conditions
WBL and EBL Bridges (East Abutments)	CS-02 CS-04 CS-06 CS-08 CS-10	106 to 102	-	21	3.2	5,000	Compact to very dense Sand and silt till
		102 to 100	150	20	-	-	Very stiff Clayey silt till
		100 to 87	175	21	-	-	Very stiff to hard Clayey silt till
WBL Bridge (West Abutment)	CS-01 CS-05 CS-07	108 to 98	200	21	-	-	Hard Clayey silt till
		98 to 87	150	20	-	-	Very stiff (with hard zones) Silty Clay
EBL Bridge (West Abutment*)	CS-03 CS-05 CS-09	108 to 104	-	22	3.4	6,000	Very dense Sandy silt till
		104 to 98	200	21	-	-	Hard Clayey silt till
		98 to 87	175	21	-	-	Very stiff to hard Silty clay

* The transitions between silty clay and clayey silt till are not well defined. The recommended parameters are based on predominant silty clay.

The spring constant, K , for analysis may be obtained by the expression, $K = k_s \times d_z \times D$ (kN/m), where k_s is the coefficient of horizontal subgrade reaction (kPa/m), D is the caisson diameter (m), d_z is the length (m) of the caisson segment or element used in the analysis. The ultimate lateral resistance on any one segment of caisson, P_{ult} , may be obtained from the expression, $P_{ult} = p_{ult} \times d_z \times D$. This represents the ultimate load at the contact between the caisson and the surrounding soil above which any additional load will not be supported at greater displacements.

The group efficiency factors can be calculated based on side-by-side and line-by-line factors shown in Figures C6.22, C6.23, and C6.24 of the CHBDC 2019, S6.1.19 (Commentary).

9.3.3 Caisson Installation

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

For each caisson, a temporary steel liner should be available to support the caisson sidewalls and provide partial seepage cut-off where required.

The installation of caissons at this site must consider the following issues:

- Caisson installation equipment must be able to advance through cobbles, boulders and other obstructions within the fill and till deposits.
- Caisson installation equipment with rock drilling / coring capabilities must be used to penetrate the typically strong limestone for seating the caissons.

Selection of the construction methods and equipment employed to address the above issues is the responsibility of the Contractor. The contract documents must contain statements to alert bidders of the above conditions (see suggested NSSP wording in Appendix H). Once the caisson hole is inspected and approved, and the steel reinforcement cage is in place, concrete should be placed using tremie techniques without delay.

The Contractor should use appropriate means such as a cleanout bucket, air lift, hydraulic pump, or other approved devices, where appropriate, to clean the rock socket base and sidewalls of all shafts. The socket base should be inspected using a Shaft Inspection Device (SID), Shaft Quantitative Inspection Device (SQUID), down-hole camera, and/or an approved alternate to verify the socket cleanliness and base sediment thickness prior to concreting. Consideration should also be given to measuring the structural integrity of the caissons including the use of Crosshole Sonic Logging (CSL), Pile Integrity Testing (PIT) and Thermal Integrity Profiling (TIP).

9.4 Frost Cover

The design depth of frost penetration at this site is 1.2 m. The base of footings or caisson caps must be provided with a minimum of 1.2 m of earth cover, or its thermal insulation equivalent, as protection against frost action.

10. RETAINED SOIL SYSTEMS (RSS) WALLS

A 90% GA and wall layout drawings indicate that RSS walls are proposed beyond the wingwalls at each of the four corners of the overpass structures for retaining the widened Highway 401 embankments. A summary of RSS walls details is provided in Table 10.1.

Table 10.1: Summary of Proposed RSS Walls

RSS Wall Location	Length (m)	Skew relative to abutment centreline	Proposed Underside Approximate Elevation of Granular Pad (m)
Northwest	9.3	20° ⁽¹⁾	102.8 to 101.9
Northeast	8.2	20° ⁽²⁾	102.8 to 101.9
Southwest	10.4	20° ⁽¹⁾	102.8 to 101.9
Southeast	9.3	20° ⁽²⁾	102.8 to 101.9

⁽¹⁾ Relative to west abutment centreline.

⁽²⁾ Relative to east abutment centreline

The proposed wall height is anticipated to be up to the order of 5.5 m to 6 m adjacent to the bridges, and progressively decrease away from the bridges.

RSS walls used for 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-sections, 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 available borehole information, it is recommended that the RSS masses be founded at or below elevations presented in Table 10.1. The corresponding geotechnical resistances recommended are also presented in Table 10.1.

10.1 Geotechnical Resistance

Based on the subsurface conditions adjacent to the wall alignment, the wall footings should be founded at or below the design frost penetration depth of 1.2 m below the final grade. The proposed road profile is to be lowered up to 1.5 m. A 90% GA drawing indicates that the final grade at the new road centreline near the RSS locations would be at approximate Elevation 104.5. The founding elevations and geotechnical resistances recommended for these footings are presented in Table 10.2 below.

Table 10.2: Recommended Parameters for RSS Wall Foundation Design

RSS Wall	Reference Borehole	Highest Granular Pad Founding Elevation (m)	Founding Soil Type	Factored Geotechnical Resistance	
				ULS (kPa)	SLS (kPa)
Northwest	CS-01 CS-07	103.0	Very stiff to hard Clayey silt till overlying Very stiff to hard Silty clay	500	350
Northeast	CS-02 CS-08			500	350
Southwest	CS-03 CS-09	103.0	Very stiff to hard Clayey silt till	500	350
Southeast	CS-04 CS-10			500	350

The RSS mass should be founded on a minimum 0.5 m thick 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 2019 Clauses 6.10.2 and 6.10.3.

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 0.4 for a very stiff to hard clayey silt till subgrade. A Resistance Factor of 0.8 should be applied for the cohesionless soils as indicated in Table 6.2 of the CHBDC 2019.

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.

10.2 Global Stability at Retaining Wall

Preliminary global stability analyses were carried out for a representative proposed RSS wall utilizing the commercially available slope stability analysis program Slope/W (Version 2022) 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. These analyses should be revisited and confirmed after the final location and detail configurations of the walls are finalized.

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 piezometers. The stability of the embankment was checked for the seismic (pseudo-static) condition assuming a peak horizontal acceleration of 0.0845 g.

Results of the stability analyses are presented on Figures G1 to G3 in Appendix G. The results are also summarized in Table 10.3 below.

Table 10.3: Computed Factors of Safety for RSS Walls

Condition	Factor of Safety	Figure (Appendix G)
Retaining wall beyond the West Abutment SW wingwall		
Static Drained	1.8	G1
Static Undrained	> 2	G2
Seismic (PGA 0.064g)	1.5	G3

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 F.S. is 1.1. The estimated F.S. values for global stability in the table above are acceptable for the proposed RSS walls.



11. EARTH CUTS

As part of construction of the longer and wider replacement structures and the proposed widening of Highway 401 on both sides, earth cuts will be required along Cubert Street to lower the entire road profile up to about 1.5 m below the existing grade. In the west and east abutment areas, earth cuts will be required to widen the roadway and to accommodate the larger replacement structures. The existing structures will be demolished and removed. It is our understanding that a staged approach will be adopted during construction, where highway widening (see section below) and the northerly and southerly portions of the new structures will be constructed first to be followed by the middle section below the highway.

Preliminary information provided by MP indicates that road cuts along Cubert Street, to the north and south of Highway 401, will be about 80 m and 120 m in length at the north and south approaches, respectively. The grade lowering would be up to about 1.5 m depth below existing road grade. The highway grade will remain unchanged. The cut will be formed through surficial fill into the very dense sand and silt till and/or very stiff to hard clayey silt till. The groundwater table is generally below the final road grade. As such, the cuts will largely be made above the groundwater table, although water seepage from water-bearing layers, perched water from the fills, accumulation of surface runoff and precipitation should be expected.

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

The inclination of permanent slopes may be designed for 2H : 1V, or flatter. Vegetative cover will be required on all exposed earth cut slopes to protect against surficial erosion. Reference may be made to OPSS.PROV 804. For temporary slopes, plastic sheetings or tarps may be used for covering where required to minimize slope erosion.

Temporary protection (shoring) will be required for the earth cut operations as part of staged construction. Recommendations for temporary protection (shoring) are presented in Section 16 of this report.

11.1 Earth Cut Stability

Analyses of global stability were conducted for the proposed earth cuts along Cubert Street near the bridge as part of the road deepening and highway widening.

Selected graphical output of the stability analyses are presented on Figures G4 to G6 in Appendix G. The results are also summarized in Table 11.1 below.

Table 11.1: Computed Factors of Safety for Earth Cuts

Condition	Cubert Street Deepening Cut	Factor of Safety	Figure (Appendix G)
Highway Embankment Side Slope 2H : 1V			
Static Drained	1.5 m	1.66	G4
Static Undrained	1.5 m	>2	G5
Seismic (PGA 0.0845g)	1.5 m	1.47	G6

As per typical MTO requirements, a Factor of Safety (F.S.) of 1.3 is acceptable for short term and total stress (undrained) conditions. A F.S. of 1.5 is acceptable for long term and effective stress (drained) conditions. Under the assumed seismic loading, the minimum acceptable F.S. is 1.1. Accordingly, the analysed cases satisfy global stability requirements.

12. EMBANKMENT WIDENING

Highway 401 will be widened to the north and south parallel to the highway in conjunction with the new and wider underpass structures. These widenings are in the order of 10 m to 12 m and will require placement of new fill up to the order of 5.5 m to 6 m adjacent to the bridges, and progressively decrease away from the bridges. There is no grade change for the highway.

Sideslopes of the widened embankments should be designed for an inclination of 2H : 1V or flatter.

Prior to fill placement, the subgrade must be adequately prepared to receive the new fill. All vegetation, topsoil, organics, soft/loosened, wet or otherwise disturbed 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 must be provided for the slopes.

12.1 Widened Embankment Stability

Analyses of global stability were conducted for the new highway embankment widening at the northeast and southeast quadrants where new fill will be placed.

Selected graphical output of the stability analyses are presented on Figures G4 to G7 in Appendix G. The results are also summarized in Table 12.1 below.

Table 12.1: Computed Factors of Safety for Sideslope

Condition	Embankment Widening Fill	Factor of Safety	Figure (Appendix G)
Highway Embankment Side Slope 2H : 1V			
Static Drained	Granular fill	1.82	G7
Static Undrained	Granular fill	1.38	G8
Seismic (PGA 0.0845g)	Granular fill	1.20	G9
Seismic (PGA 0.0845g)	Granular B Type I	1.28	G10

As per typical MTO requirements, a Factor of Safety (F.S.) of 1.3 is acceptable for short term and total stress (undrained) conditions. A F.S. of 1.5 is acceptable for long term and effective stress (drained) conditions. Under the assumed seismic loading, the minimum acceptable F.S. is 1.1. Accordingly, the analysed cases satisfy global stability requirements.

12.2 Settlement

Placement of new fill up to 5.5 m to 6 m in height for the embankment widening will induce settlements within the existing fills and native soils. The new fill will induce immediate (elastic) settlement in the cohesionless sands and silts and re-compression of the very stiff to hard clayey silt till. There should also be additional settlement due to self-compression of the new fill.

Based on the soil conditions at this site, it is estimated that not more than 25 mm of foundation settlement will occur beneath the new widened embankments. The majority of this settlement is

expected to take place as the fill is placed and be completed by the end of construction.

13. SEISMIC CONSIDERATIONS

In accordance with the CHBDC 2019, the selection of the seismic site class is based on the subsurface conditions encountered in the upper 30 m of the stratigraphic profile. In general, the subsurface stratigraphy at shallower depths at the site consists of a pavement structure overlying embankment fill on the highway, or native soils on Cubert Street. The native soils consist of surficial deposits of compact to very dense sand and silt till, which overlies an extensive deposit of typically very stiff to hard clayey silt till. To the west of Cubert Street, the clayey silt till is underlain by very stiff silty clay. The site is underlain by limestone bedrock at about 23 m to 24 m depths below highway grade. The groundwater level was recorded at 3 m to 5 m depths below the existing Cubert Street grade beyond the Highway 401 platform.

As per Table 4.1, Clause 4.4.3.2 of the CHBDC (2019), the site may be classified as Seismic Site Class C.

Based on the National Building Code of Canada (NBCC 2020), 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 0.169 g at the site. Based on the site class and the PGA, the Site Coefficient is determined to be 1.0.

The new structure is classified to have a Seismic Performance Category of 1 based on Table 4.10 of the CHBDC 2019.

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

14. WALL BACKFILL AND LATERAL EARTH PRESSURES

Backfill to the abutment and retaining walls should consist of free-draining granular material conforming to OPSS.PROV 1010 Granular A or B Type II specifications. The granular material should be placed to the extents shown in OPSD 3101.150 or OPSD 3121.150 where applicable. 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 2019 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 14.1. The at-rest coefficients should be employed for restrained walls. Active pressures should be used for any wingwalls or unrestrained walls.

Table 14.1: 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 C6.27 of the Commentary to the CHBDC 2019.

In accordance with Clause 6.12.3 of the CHBDC, 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 and 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 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.



15. 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 temporary excavation slope and temporary support requirements in compliance with the OHSA, embankment fill, compact to very dense sand and silt till are classified as a Type 3 soil above the groundwater level and a Type 4 soil below the groundwater level. The very stiff to hard clayey silt till is classified as a Type 3 soil.

Earth cuts will be required for the Cubert Street lowering which will extend to approximately Elevation 103.2 at the deepest location. Bulk excavation within the highway embankment will also be required to accommodate the new bridges and roadway widening. It is anticipated that these bulk excavations will likely require water control measures such as sump pumping and surface water diversion from the excavations.

For spread footing construction, sub-excavation below the new Cubert Street grade will be required. Excavations for these foundation elements will extend to or just above the current groundwater level.

It is anticipated that the clay size particles contained in the subgrade soils will impede water seepage. However, flow of perched water from the embankment fill into the excavations and from water-bearing layers within the cohesive soils should be expected. In addition to effective pumping from filtered sumps and perimeter ditches, other measures of groundwater control including well points 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 as per OPSS.PROV 904.

The design of a dewatering system that may be required 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.

Dewatering of all excavations should be carried out in accordance with OPSS.PROV 517, SP 517F01 Amendment to OPSS 517, November 2016 (issued July 2017), and OPSS.PROV 902 and NSSP FOUN0003. A design engineer with a minimum five years of relevant experience will be required to design and implement a dewatering system.

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 fills and native tills. Suggested wording for an NSSP in this regard is included in Appendix H.

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

Hydrogeological aspects of this project are addressed by Egis separately. Egis advised that an assessment of water taking quantities has been completed and that an EASR will be required for this site.

16. TEMPORARY PROTECTION SYSTEMS

Temporary protection systems (TPS), or shoring, will be required as part of the staged construction for the new longer and wider bridges, widening of the highway and lowering of the road profile.

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.

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 the construction equipment and operations. It is anticipated that the TPS will need to be extended through the existing embankment fill, the surficial native compact to very dense sand and silt till, and into the cohesive clayey silt till. Installation of roadway protection should consider that the existing embankment fill and native tills contain oversize obstructions such as cobbles and boulders.

For conceptual planning and costing purposes, an augered soldier pile and wood lagging wall is considered suitable for temporary protection at this site. There may be difficulties in installing sheetpile walls due to the presence of very dense and hard soils containing cobbles and boulders. 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)
	=	0.31 (native sand and silt till)
	=	0.32 (native clayey silt till)
K_p	=	3.0 (approach fills)
	=	3.2 (native sand and silt till)
	=	3.1 (native clayey silt till)

It is recommended that lateral earth pressures acting on the wall be computed in accordance with the CHBDC 2019. 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. Dewatering will need to be considered as discussed in the section above.

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. Given the retained height and the permissible ground movements, the TPS will likely have to be supported by struts, internal bracings and anchors where space permits. All shoring systems should be designed by a Professional Engineer experienced in such designs.

Consideration should be given to leaving in place the TPS that is immediately adjacent to the bridge footings should be left in place. It is recommended that the TPS be decommissioned by cutting to at least 1.2 m below the final grade as per OPSS.PROV 539 requirements. Decommissioning procedures should be to minimize the risks of disturbance and damage to the finished works and the bridge. Any other TPS installed in close proximity to permanent works including buried utilities should also be left in place and similarly decommissioned. Suggested wording for an NSSP is included in Appendix H.

17. ADJACENT STRUCTURES AND BURIED UTILITIES

Construction of the new bridge footings will involve a relatively large excavation under Highway 401 as discussed above. It is recommended that designers of the bridges, highways/roadways and the affected utility owners co-ordinate to confirm that the anticipated staged construction will safely and effectively accommodate all aspects of the proposed works without adversely

impacting each other.

The potential presence of other 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 bridges, retaining walls, road cuts, new fills and associated works.

Protection and/or relocation of utilities, if necessary, should be implemented. Underground utilities should not be undermined or damaged during new foundation construction and fill placement.

18. SOIL CORROSION POTENTIAL

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

- The potential for sulphate attack on concrete from the surrounding native soils is considered negligible due to the low concentration of sulphate and slightly alkaline pH values.
- The overall potential for corrosion on metal is presented in Table 18.1.

Table 18.1: Potential for Corrosion on Metal

Sample ID	Depth (m)	Elevation (m)	Soil Sample Description	Degree of Corrosivity on metal
CS-01 SS5	3.0 - 3.4	102.4 – 102.0	Sand and silt till	Moderately corrosive
CS-02 SS5	3.0 - 3.3	102.4 – 102.1	Clayey silt with sand till	Mildly corrosive
CS-03 SS3	1.5 - 2.1	103.6 – 103.0	Clayey silt with sand till	Moderately corrosive
CS-04 SS4	2.3 - 2.9	102.9 – 102.3	Clayey silt with sand till	Mildly corrosive

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



19. CONSTRUCTION CONCERNS

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

- Staged construction of the new bridge footings requires deep excavations in the centre portion of the Highway 401 embankment with supported temporary protection (shoring) and associated dewatering. Construction activities must avoid undermining the highway and adversely affecting the live traffic during construction.
- Staged construction of the replacement bridges, RSS walls, road cut and highway widening must be carried out in a manner that would avoid undermining the existing bridge foundations while they remain operational.
- Foundation excavations and earth cuts will typically be carried out above the groundwater level. However, seepage from perched groundwater and water-bearing layers within the glacial tills will occur. Sump pumping, diversion of surface runoff, precipitation and other forms of temporary dewatering will be required to maintain a reasonably dry excavation during construction. A dewatering specialist should be consulted to provide input on the required dewatering system.
- Settlement monitoring of the existing bridge foundations during new bridge construction, displacement monitoring of the temporary protection systems and adjacent highway travel lanes adjacent to the work areas are recommended during construction.
- Daily visual inspection of the highway pavement surface must be carried out in the vicinity of the construction works. If cracks form in the pavement or settlement occurs, these observations must immediately be brought to the attention of the CA for determining if further action is required.
- Confirmation that the backfill to the abutments are adequately placed and compacted to specifications.
- The forward and side approach slopes and permanent cut slopes should be inspected after construction for surficial disturbance. Where necessary, remedial measures such as re-vegetation and/or placement of gravel sheeting may be required.

20. SIGNATURES/CLOSURE

Engineering analysis and preparation of the foundation design report were carried out by Sydney Pang, P.Eng. with the assistance of Rocio Reyna, P.Eng. This report was reviewed by P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



THURBER ENGINEERING LTD.

This report was issued before any final design or construction details had been prepared or issued. Therefore, differences may exist between the report recommendations and the final design, the contract documents, or conditions during construction. In such instances, Thurber Engineering Ltd. should be contacted immediately to address these differences. Designers and contractors undertaking or bidding the work should examine the factual results of the investigation, satisfy themselves as to the adequacy of the information for design and construction, and make their own interpretation of the data as it may affect their proposed scope of work, cost, schedules, safety, and equipment capabilities.

We trust this information meets your present needs. If you have any questions, please contact the undersigned at your convenience.

Thurber Engineering Ltd.



Rocio Reyna, P. Eng.
Associate, Senior Geotechnical Engineer



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



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

Date: **December 10, 2024**
File: **30915**

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

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3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

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- a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.
- b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.
- c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.
- d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

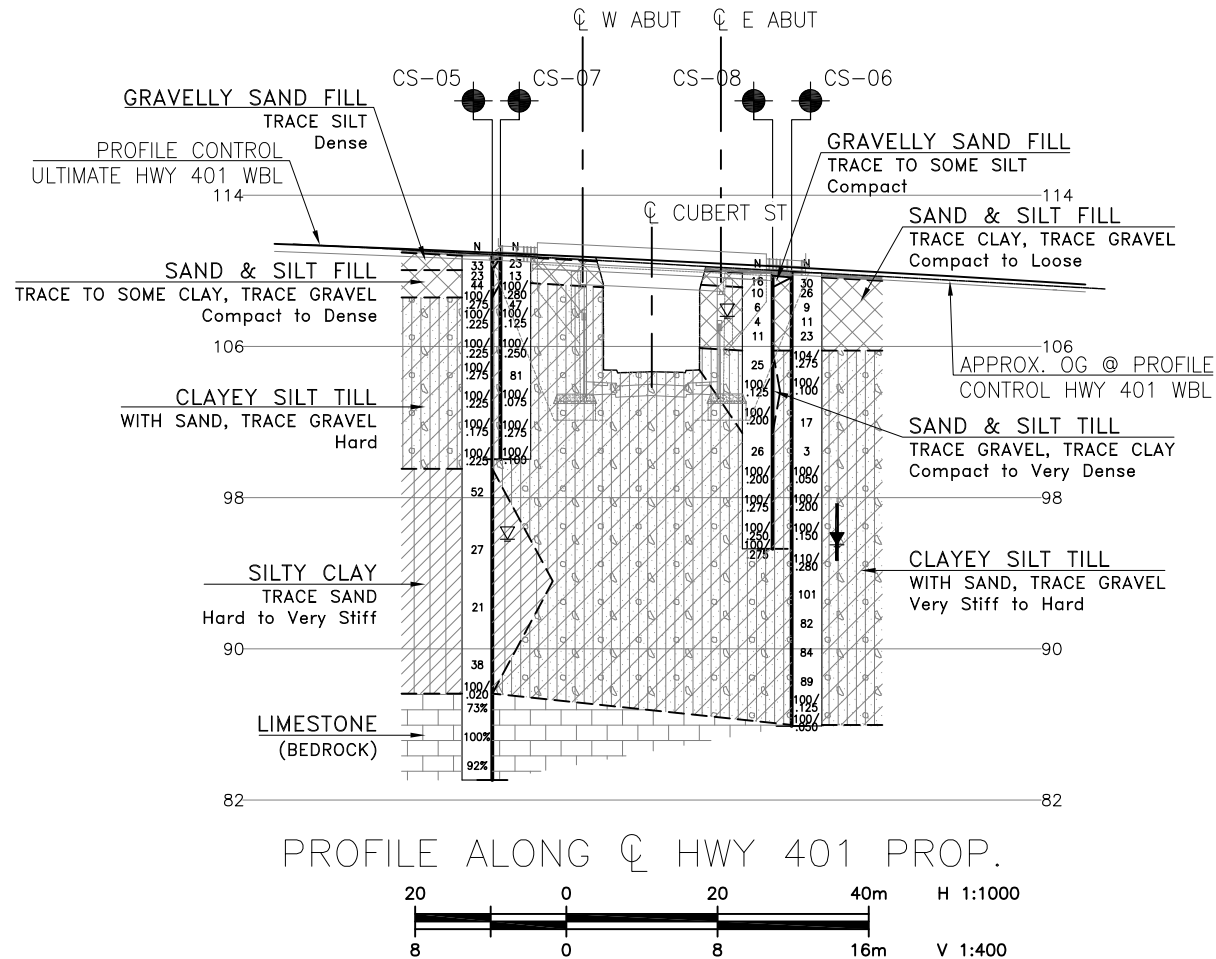
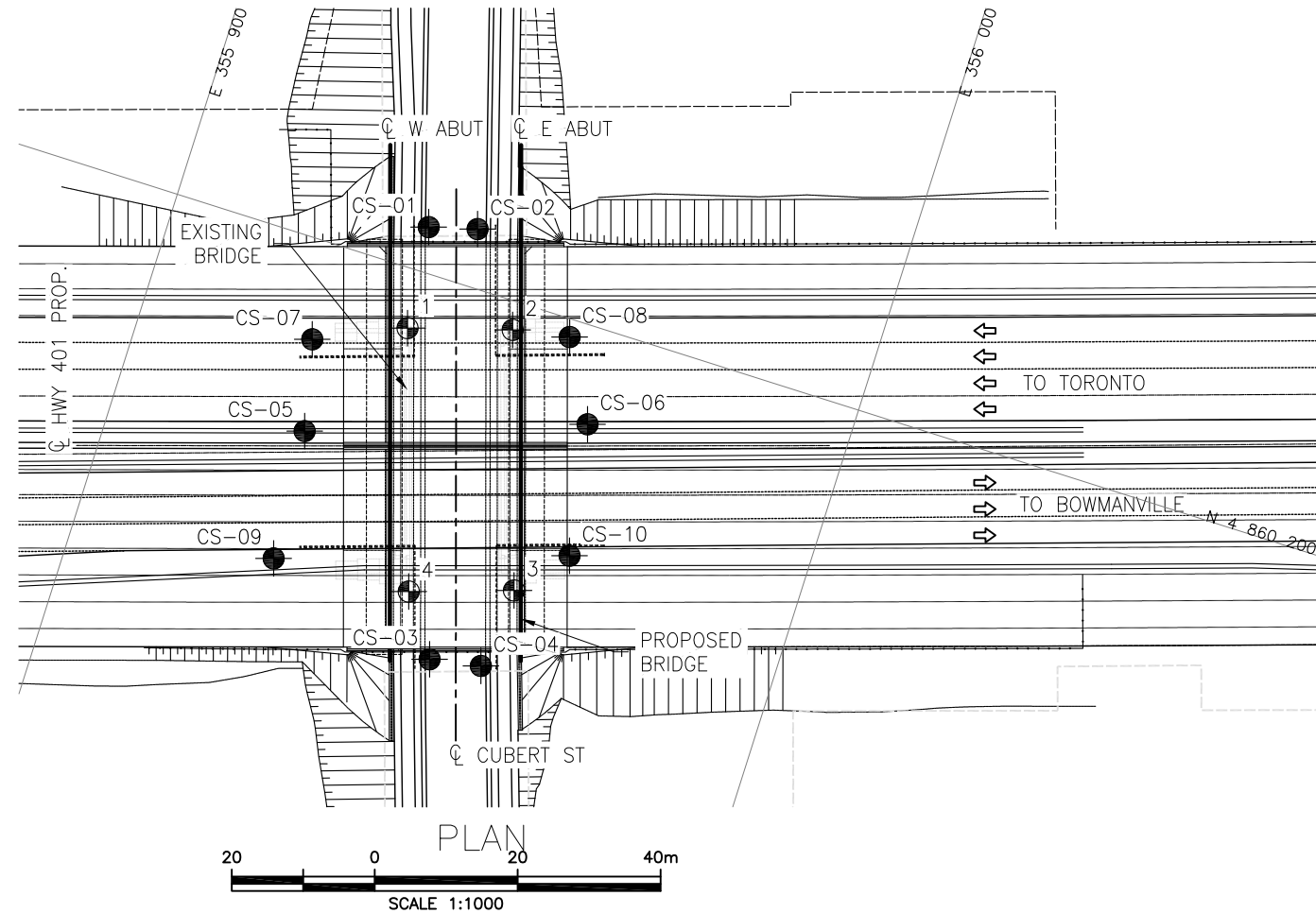
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The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.

APPENDIX A

Drawings 1 and 2

Borehole Locations and Soil Strata



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



CONT No 2025-2001
GWP No 2555-17-00

HIGHWAY 401
CUBERT STREET
OVERPASS REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

egis



KEYPLAN

LEGEND

	Borehole
	Borehole (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level Upon Completion of Drilling
	Water Level in Monitoring Well/Piezometer
	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

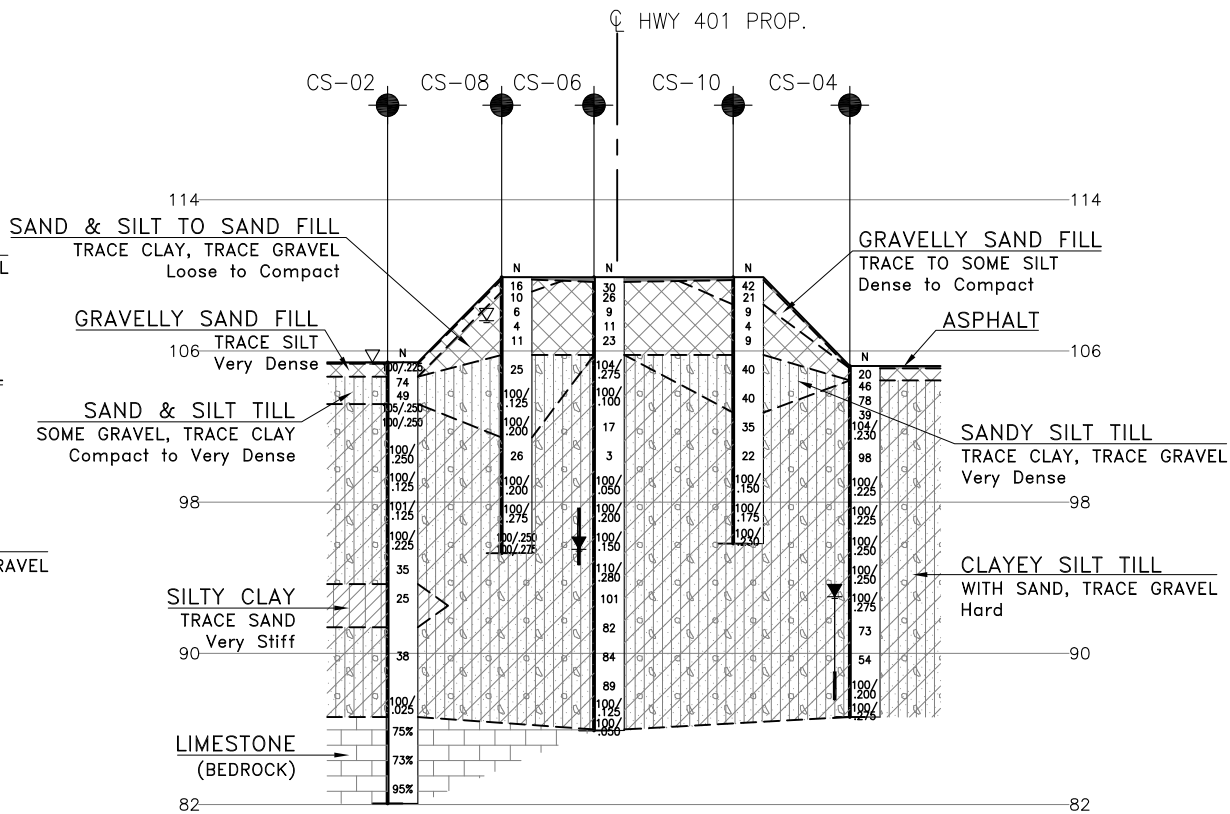
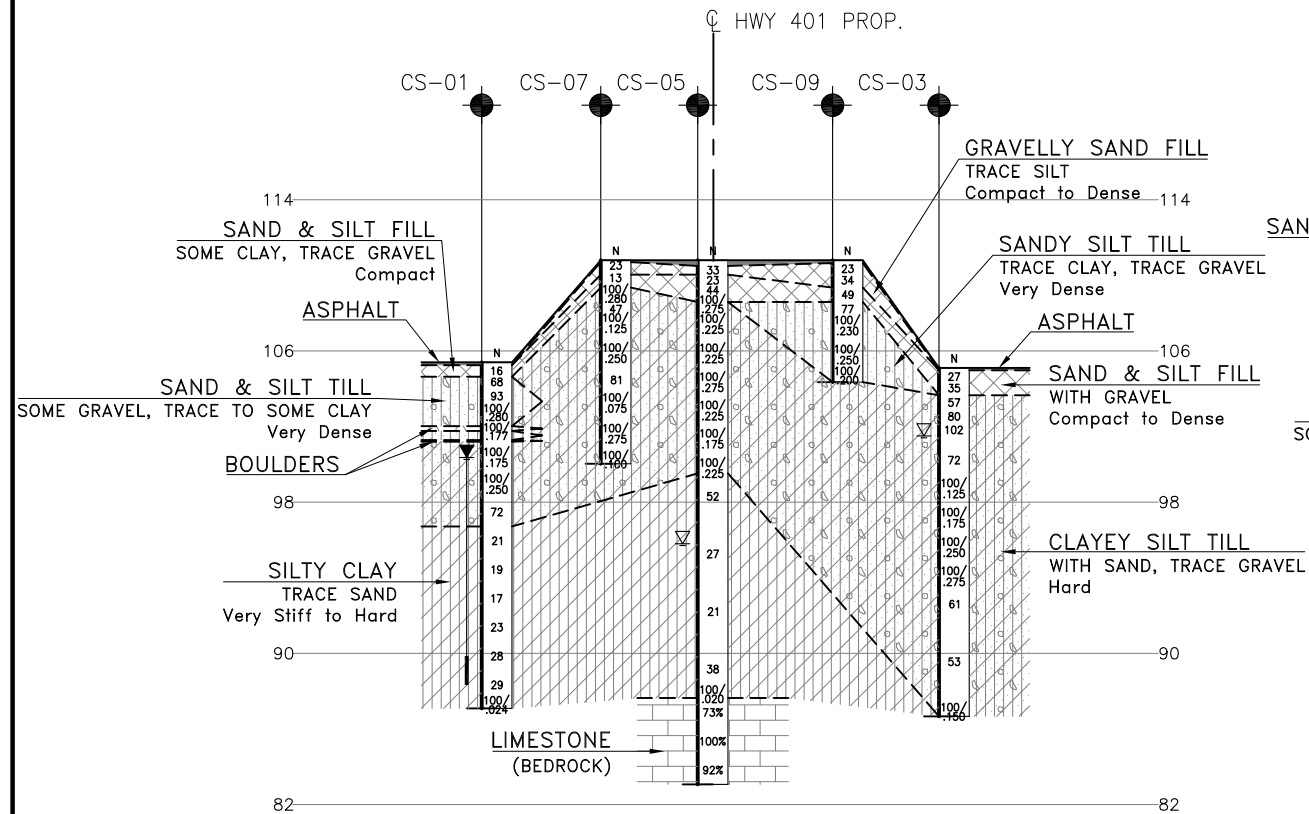
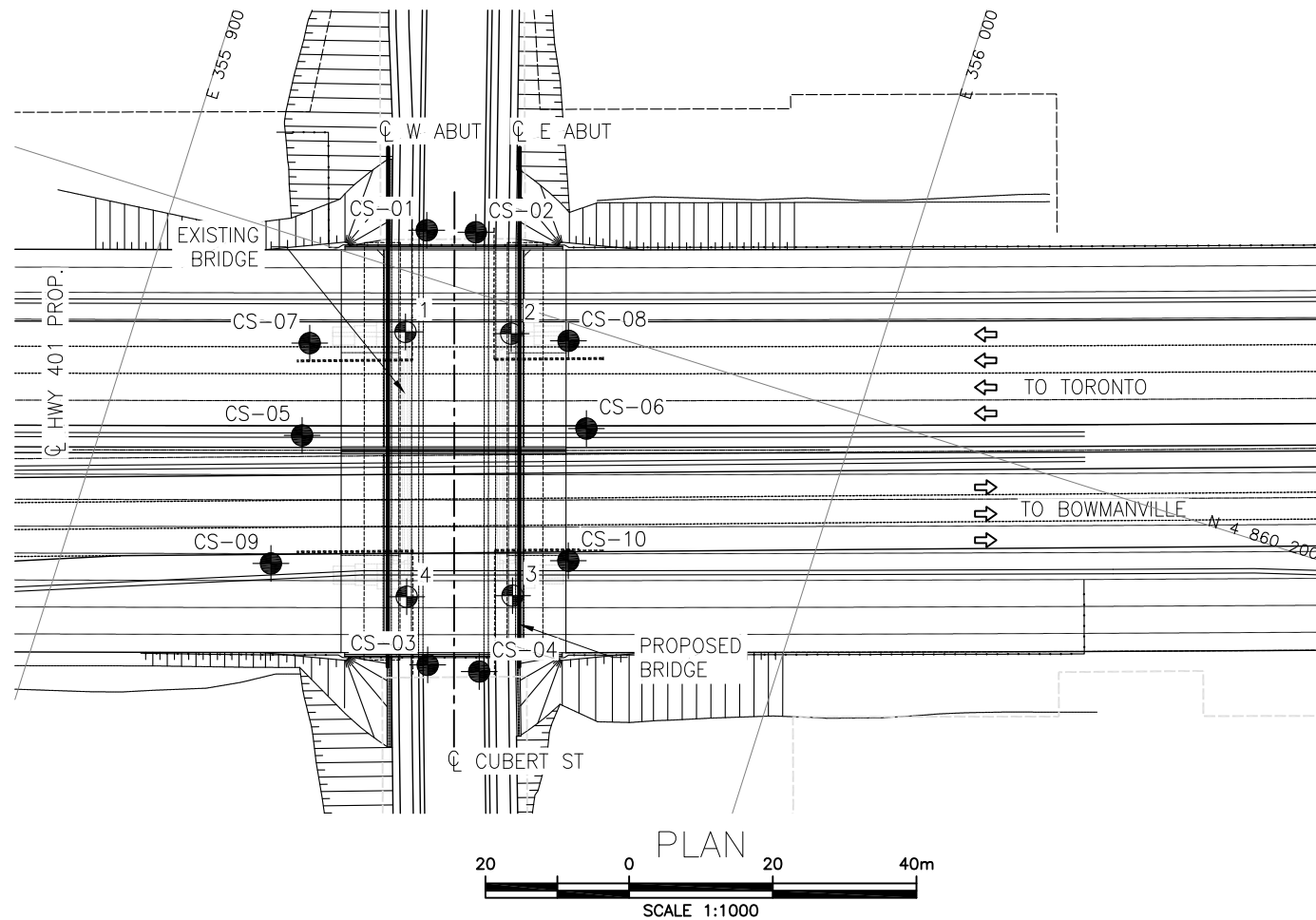
NO	ELEVATION	NORTHING	EASTING
1	105.1	4 860 191.9	355 936.4
2	105.2	4 860 196.1	355 950.5
3	105.1	4 860 161.4	355 961.7
4	105.1	4 860 156.8	355 947.7
CS-01	105.4	4 860 206.3	355 934.9
CS-02	105.4	4 860 208.1	355 941.5
CS-03	105.1	4 860 148.6	355 953.3
CS-04	105.2	4 860 149.9	355 960.4
CS-05	110.8	4 860 173.8	355 927.0
CS-06	109.9	4 860 186.7	355 964.5
CS-07	110.8	4 860 186.3	355 924.1
CS-08	109.9	4 860 197.5	355 958.4
CS-09	110.8	4 860 155.5	355 928.3
CS-10	109.9	4 860 168.4	355 967.6

-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. 30M15-347

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	RdC	CHK SKP	CODE
DRAWN	AN	CHK RdC	SITE
LOAD	DATE	DEC 2024	
STRUCT	DWG	1	



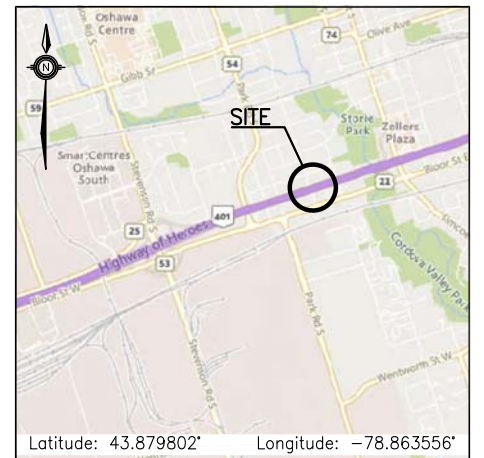
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



CONT No 2025-2001
GWP No 2555-17-00

HIGHWAY 401
CUBERT STREET
OVERPASS REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

egis



KEYPLAN

LEGEND

●	Borehole
⊕	Borehole (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level Upon Completion of Drilling
⬇	Water Level in Monitoring Well/Piezometer
⬆	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
1	105.1	4 860 191.9	355 936.4
2	105.2	4 860 196.1	355 950.5
3	105.1	4 860 161.4	355 961.7
4	105.1	4 860 156.8	355 947.7
CS-01	105.4	4 860 206.3	355 934.9
CS-02	105.4	4 860 208.1	355 941.5
CS-03	105.1	4 860 148.6	355 953.3
CS-04	105.2	4 860 149.9	355 960.4
CS-05	110.8	4 860 173.8	355 927.0
CS-06	109.9	4 860 186.7	355 964.5
CS-07	110.8	4 860 186.3	355 924.1
CS-08	109.9	4 860 197.5	355 958.4
CS-09	110.8	4 860 155.5	355 928.3
CS-10	109.9	4 860 168.4	355 967.6

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GEOCRES No. 30M15-347

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	RdC	CHK SKP	CODE
DRAWN	AN	CHK RdC	SITE
LOAD	DATE	DEC 2024	
STRUCT	DWG	2	



H 1:1000

V 1:400

APPENDIX B

Records 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

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


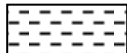



 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (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	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Very thinly bedded	20 to 60mm				
Laminated	6 to 20mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Thinly Laminated	Less than 6mm				

<u>TERMS</u>						
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty Can be peeled by a pocket knife, crumbles under firm blows of geological pick. Indented by thumbnail	
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Very Weak	1.0 to 5.0	150 to 750		
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.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150		
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 CS-01

1 OF 2

METRIC

WP# 2555-17-00 LOCATION Cubert Street Bridge: MTM83-10; N 4 860 206.3 E 355 934.9 ORIGINATED BY SG
DIST HWY 401 BOREHOLE TYPE Hollow Stem Augers/PW Casing/Tri-Coring/HQ Coring COMPILED BY AN
DATUM Geodetic DATE 2022.11.23 - 2022.11.23 LATITUDE 43.880058 LONGITUDE -78.863674 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						
105.4	GROUND SURFACE							20	40	60	80	100		
0.0	ASPHALT: (150mm)							20	40	60	80	100		
0.2	SAND and SILT, trace gravel, some clay		1	SS	16		105							5 43 40 12
104.6	Compact Brown Wet (FILL)		2	SS	68									
0.8	SAND and SILT, some gravel, trace to some clay						104							
	Very Dense Grey Moist (TILL)		3	SS	93									11 39 40 10
			4	SS	100/ 280		103							
			5	SS	100/ 177		102							
102.0	BOULDER: (granitic 200mm)													
3.4	SAND and SILT, some gravel, trace to some clay		6	NQ			101							
101.8	BOULDER: (granitic 100mm)													
3.6	Clayey SILT, with sand, trace gravel		7	SS	100/ 175		100							
101.3	Hard Grey Moist to Wet (TILL)		8	SS	100/ 250		99							0 46 35 19
101.2			9	SS	72		98							
4.2							97							
96.7	Silty CLAY		10	SS	21		96							0 0 38 62
8.7	Very Stiff Grey Wet													

Continued Next Page

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

RECORD OF BOREHOLE No CS-01

2 OF 2

METRIC

WP# 2555-17-00 LOCATION Cubert Street Bridge: MTM83-10; N 4 860 206.3 E 355 934.9 ORIGINATED BY SG
DIST HWY 401 BOREHOLE TYPE Hollow Stem Augers/PW Casing/Tri-Coring/HQ Coring COMPILED BY AN
DATUM Geodetic DATE 2022.11.23 - 2022.11.23 LATITUDE 43.880058 LONGITUDE -78.863674 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 (%)			
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				GR	SA	SI	CL
	Continued From Previous Page							20	40	60	80	100								
	Silty CLAY , trace sand Very Stiff Grey Wet																			
			11	SS	19															
			12	SS	17															
			13	SS	23															
			14	SS	28															
								15	SS	29										
87.1			16	SS	100/.024															
18.3	END OF BOREHOLE AT 18.3m UPON REFUSAL ON POSSIBLE BEDROCK. Monitoring Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 1.5m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2023.04.17 3.1 102.3 2023.05.18 5.0 100.4																			

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RECORD OF BOREHOLE No CS-02

1 OF 3

METRIC

WP# 2555-17-00 LOCATION Cubert Street Bridge: MTM83-10; N 4 860 208.1 E 355 941.5 ORIGINATED BY SG
DIST HWY 401 BOREHOLE TYPE Hollow Stem Augers/PW and HW Casing/Tri-Coring COMPILED BY AN
DATUM Geodetic DATE 2022.12.01 - 2022.12.02 LATITUDE 43.880074 LONGITUDE -78.863592 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			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%) W _p W W _L				
105.4	GROUND SURFACE															
0.0 0.1	ASPHALT: (75mm)		1	SS	100/ .225											
104.6	Gravelly SAND, trace silt Very Dense Brown Wet (FILL)		2	SS	74											
0.8	SAND and SILT, some gravel, trace clay Very Dense to Dense Grey Moist (TILL)		3	SS	49											
103.2	Clayey SILT, with sand, trace gravel Hard Grey Moist (TILL)		4	SS	105/ 250										4 35 44 17	
2.2			5	SS	100/ 250											
			6	SS	100/ 250											
			7	SS	100/ .125											
			8	SS	101/ .125											
			9	SS	100/ .225										0 44 36 20	

Continued Next Page

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

RECORD OF BOREHOLE No CS-02

2 OF 3

METRIC

WP# 2555-17-00 LOCATION Cubert Street Bridge: MTM83-10; N 4 860 208.1 E 355 941.5 ORIGINATED BY SG
DIST HWY 401 BOREHOLE TYPE Hollow Stem Augers/PW and HW Casing/Tri-Coring COMPILED BY AN
DATUM Geodetic DATE 2022.12.01 - 2022.12.02 LATITUDE 43.880074 LONGITUDE -78.863592 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			SHEAR STRENGTH kPa						
	Continued From Previous Page							20 40 60 80 100						
	Clayey SILT , with sand, trace gravel Hard Grey Moist (TILL)		10	SS	35		95							
93.7							94							
11.7	Silty CLAY , trace sand Very Stiff Grey Wet		11	SS	25		93							0 1 36 63
							92							
91.4							91							
14.0	Clayey SILT , with sand, trace gravel Hard Grey Moist (TILL)		12	SS	38		90							
							89							
							88							
			13	SS	100/		87							
86.6	Rock coring started at 18.8m				.025									
18.8	LIMESTONE highly to moderately weathered, grey, with frequent shale interbeds, laminated, horizontally bedded Horizontal fractures at 18.8, 18.9, 19.0, 19.1, 19.2, 19.3, 19.4, 19.5, 19.6, 19.7, 19.8, 19.9, 20.0, 20.1 and 20.2m		1	RUN			86						FI >10 6 7	RUN #1 TCR=100% SCR=80% RQD=75% UCS=55.0MPa (Average PLT)

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

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(%) STRAIN AT FAILURE

METRIC

[illegible]

RECORD OF BOREHOLE No CS-03

1 OF 2

METRIC

WP# 2555-17-00 LOCATION Cubert Street Bridge: MTM83-10; N 4 860 148.6 E 355 953.3 ORIGINATED BY SG
DIST HWY 401 BOREHOLE TYPE Hollow Stem Augers/PW Casing/Tri-Coring COMPILED BY AN
DATUM Geodetic DATE 2022.12.05 - 2022.12.05 LATITUDE 43.879538 LONGITUDE -78.863451 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			SHEAR STRENGTH kPa					
105.1	GROUND SURFACE							20 40 60 80 100					
0.0	ASPHALT: (125mm)						105	20 40 60 80 100					
0.1	SAND, trace to some silt, some gravel Compact to Dense Brown Wet (FILL)		1	SS	27			20 40 60 80 100					
			2	SS	35		104	20 40 60 80 100					
103.7								20 40 60 80 100					
1.4	ClayeySILT, with sand, trace gravel Hard Grey Moist (TILL)		3	SS	57		103	20 40 60 80 100					
			4	SS	80			20 40 60 80 100					
			5	SS	102		102	20 40 60 80 100					
								20 40 60 80 100					
			6	SS	72		101	20 40 60 80 100					
								20 40 60 80 100					
			7	SS	100/ .125		100	20 40 60 80 100					
								20 40 60 80 100					
			8	SS	100/ .175		99	20 40 60 80 100					
								20 40 60 80 100					
							98	20 40 60 80 100					
								20 40 60 80 100					
							97	20 40 60 80 100					
								20 40 60 80 100					
			9	SS	100/ .250		96	20 40 60 80 100					
								20 40 60 80 100					

Continued Next Page

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

RECORD OF BOREHOLE No CS-03

2 OF 2

METRIC

WP# 2555-17-00 LOCATION Cubert Street Bridge: MTM83-10; N 4 860 148.6 E 355 953.3 ORIGINATED BY SG
DIST HWY 401 BOREHOLE TYPE Hollow Stem Augers/PW Casing/Tri-Coring COMPILED BY AN
DATUM Geodetic DATE 2022.12.05 - 2022.12.05 LATITUDE 43.879538 LONGITUDE -78.863451 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 (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL	
								20 40 60 80 100	W _P W W _L											
	Continued From Previous Page							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
	Clayey SILT , with sand, trace gravel Hard Grey Moist (TILL)		10	SS	100/ .275		95							○						
							94													
			11	SS	61		93							○						
							92													
							91													
			12	SS	53		90							4-1		0	47	35	18	
							89													
							88													
							87							○						
86.7 18.4	END OF BOREHOLE AT 18.4m ON SPLIT SPOON REFUSAL ON POSSIBLE BEDROCK. WATER ADDED TO BOREHOLE DURING DRILLING AND WATER LEVEL MEASURED AT 3.6m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.3m, THEN CONCRETE TO 0.2m, THEN ASPHALT TO GROUND SURFACE		13	SS	100/ .150															

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RECORD OF BOREHOLE No CS-04

1 OF 2

METRIC

WP# 2555-17-00 LOCATION Cubert Street Bridge: MTM83-10; N 4 860 149.9 E 355 960.4 ORIGINATED BY SG
DIST HWY 401 BOREHOLE TYPE Hollow Stem Augers/PW Casing/Tri-Coring COMPILED BY AN
DATUM Geodetic DATE 2022.11.25 - 2022.11.28 LATITUDE 43.879549 LONGITUDE -78.863362 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER	CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa								
105.2	GROUND SURFACE																
0.0	ASPHALT: (125mm)																
0.1	SAND, trace to some gravel, trace silt Compact Brown Moist (FILL)		1	SS	20												
104.4			2	SS	46												
0.8	Clayey SILT, with sand, trace gravel Hard Grey Moist to wet (TILL)		3	SS	78												
			4	SS	39												
			5	SS	104/ .230												
			6	SS	98												
			7	SS	100/ .225												
			8	SS	100/ .225												
			9	SS	100/ 250												

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CS-04

2 OF 2

METRIC

WP# 2555-17-00 LOCATION Cubert Street Bridge: MTM83-10; N 4 860 149.9 E 355 960.4 ORIGINATED BY SG
DIST HWY 401 BOREHOLE TYPE Hollow Stem Augers/PW Casing/Tri-Coring COMPILED BY AN
DATUM Geodetic DATE 2022.11.25 - 2022.11.28 LATITUDE 43.879549 LONGITUDE -78.863362 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
	Continued From Previous Page															
	Clayey SILT , with sand, trace gravel Hard Grey Moist to wet (TILL)		10	SS	100/ 250		95									0 44 38 18
							94									
			11	SS	100/ 275		93									
							92									
			12	SS	73		91									
							90									3 42 37 18
			13	SS	54		89									
							88									
			14	SS	100/ 200		87									
86.6																
18.6	END OF BOREHOLE AT 18.6m. Monitoring Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 1.5m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2023.05.18 12.2 93.0		15	SS	100/ 275											

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RECORD OF BOREHOLE No CS-05

1 OF 3

METRIC

WP# 2555-17-00 LOCATION Cubert Street Bridge: MTM83-10; N 4 860 173.8 E 355 927.0 ORIGINATED BY SG
DIST HWY 401 BOREHOLE TYPE Hollow Stem Augers/PW Casing/Tri-Coring COMPILED BY AN
DATUM Geodetic DATE 2022.10.24 - 2022.10.27 LATITUDE 43.879766 LONGITUDE -78.863776 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												
110.8	GROUND SURFACE							20	40	60	80	100								
0.0	ASPHALT: (305mm)																			
110.5																				
0.3	Gravelly SAND, trace silt Dense		1	SS	33		110													
110.0	Brown Moist (FILL)		2	SS	23															
0.8	SAND and SILT, trace gravel, trace to some clay Compact to Dense Brown Moist (FILL)		3	SS	44		109													
108.6																				
2.2	ClayeySILT, with sand, trace gravel Hard Grey Moist to Wet (TILL)		4	SS	100/ .275		108													
			5	SS	100/ .225															
							107													
			6	SS	100/ .225		106													
							105													
			7	SS	100/ .275		104													
			8	SS	100/ .225		103													
							102													
			9	SS	100/ .175															
							101													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CS-05

2 OF 3

METRIC

WP# 2555-17-00 LOCATION Cubert Street Bridge: MTM83-10; N 4 860 173.8 E 355 927.0 ORIGINATED BY SG
 DIST HWY 401 BOREHOLE TYPE Hollow Stem Augers/PW Casing/Tri-Coring COMPILED BY AN
 DATUM Geodetic DATE 2022.10.24 - 2022.10.27 LATITUDE 43.879766 LONGITUDE -78.863776 CHECKED BY RPR

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	WATER CONTENT (%)					
	Continued From Previous Page													
99.5	Clayey SILT , with sand, trace gravel Hard Grey Moist to Wet (TILL)		10	SS	100/ .225		100							
11.3	Silty CLAY , trace sand Hard to Very Stiff Grey Moist		11	SS	52		99							
			12	SS	27		98							
			13	SS	21		92							

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CS-05

3 OF 3

METRIC

WP# 2555-17-00 LOCATION Cubert Street Bridge: MTM83-10; N 4 860 173.8 E 355 927.0 ORIGINATED BY SG
DIST HWY 401 BOREHOLE TYPE Hollow Stem Augers/PW Casing/Tri-Coring COMPILED BY AN
DATUM Geodetic DATE 2022.10.24 - 2022.10.27 LATITUDE 43.879766 LONGITUDE -78.863776 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			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	
							20	40	60	80	100	w _p	w	w _L	
												WATER CONTENT (%)			
												20	40	60	
87.6	Silty CLAY , trace sand Hard Grey Moist						90								
23.2	LIMESTONE highly to moderately weathered, black to grey, with frequent shale interbeds, laminated, horizontally bedded Horizontal fractures at 23.2, 23.3, 23.7, 23.8, 24.1, 24.2, 24.3, 24.4, 24.5 and 24.6m Horizontal fractures at 24.8, 24.9, 25.0, 25.1, 25.2, 25.4, 25.5, 25.6, 25.7, 25.8, 25.9 and 26.0m Moderately to fresh Horizontal fractures at 26.3, 26.5, 26.6, 26.8, 26.9, 27.0 and 27.2m		14	SS	38		89					○			
			15	SS	100/ .020		88					○			
			1	RUN			87								
			2	RUN			86								
			3	RUN			85								
							84								
83.1															
27.7	END OF BOREHOLE AT 27.7m. WATER ADDED TO BOREHOLE FOR DRILLING AND WATER LEVEL AT 15.0m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.3m, THEN CONCRETE TO 0.2m, THEN ASPHALT TO GROUND SURFACE.														

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CS-06

1 OF 3

METRIC

WP# 2555-17-00 LOCATION Cubert Street Bridge: MTM83-10; N 4 860 186.7 E 355 964.5 ORIGINATED BY SG
DIST HWY 401 BOREHOLE TYPE Hollow Stem Augers/PW Casing/Tri-Coring COMPILED BY AN
DATUM Geodetic DATE 2022.10.21 - 2022.10.24 LATITUDE 43.879879 LONGITUDE -78.863308 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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa				WATER CONTENT (%)				
109.9	GROUND SURFACE								20 40 60 80 100								
0.0	ASPHALT: (250mm)								20 40 60 80 100								
0.2	SAND and SILT, trace clay, trace gravel Compact Brown Moist (FILL)		1	SS	30												
			2	SS	26												
108.5																	
1.4	Loose		3	SS	9												
107.7																	
2.2			4	SS	11												
			5	SS	23												
105.8																	
4.1	ClayeySILT, with sand, trace gravel Hard to Very Stiff Grey Moist (TILL)		6	SS	104/.275												
			7	SS	100/.100												
			8	SS	17												
101.2																	
8.7	Soft between 8.7m and 10.1m		9	SS	3												

Continued Next Page

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

RECORD OF BOREHOLE No CS-06

2 OF 3

METRIC

WP# 2555-17-00 LOCATION Cubert Street Bridge: MTM83-10; N 4 860 186.7 E 355 964.5 ORIGINATED BY SG
DIST HWY 401 BOREHOLE TYPE Hollow Stem Augers/PW Casing/Tri-Coring COMPILED BY AN
DATUM Geodetic DATE 2022.10.21 - 2022.10.24 LATITUDE 43.879879 LONGITUDE -78.863308 CHECKED BY RPR

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													
	Clayey SILT , with sand, trace gravel Hard Grey Moist (TILL)		10	SS	100/ .050		99							
			11	SS	100/ .200		98							
			12	SS	100/ .150		96							
			13	SS	110/ .280		94							
			14	SS	101		93							
			15	SS	82		91							
							90							

Continued Next Page

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

RECORD OF BOREHOLE No CS-06

3 OF 3

METRIC

WP# 2555-17-00 LOCATION Cubert Street Bridge: MTM83-10; N 4 860 186.7 E 355 964.5 ORIGINATED BY SG
DIST HWY 401 BOREHOLE TYPE Hollow Stem Augers/PW Casing/Tri-Coring COMPILED BY AN
DATUM Geodetic DATE 2022.10.21 - 2022.10.24 LATITUDE 43.879879 LONGITUDE -78.863308 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			SHEAR STRENGTH kPa							WATER CONTENT (%)
								20 40 60 80 100							
	Continued From Previous Page														
	Clayey SILT , with sand, trace gravel Hard Grey Moist (TILL)		16	SS	84		89								
	Weathered shale fragments below 22.9m		17	SS	89		88								
86.0															
85.9															
24.0	LIMESTONE highly weathered, black to grey		18	SS	100/ .125		87								
	END OF BOREHOLE AT 24.0m. Monitoring Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.														
	WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2022.10.25 14.4 95.5														
	MONITORING WELL DECOMMISSIONED ON 2022-10-25, AFTER TAKING WATER LEVEL MEASUREMENT.														

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RECORD OF BOREHOLE No CS-07

1 OF 2

METRIC

WP# 2555-17-00 LOCATION Cubert Street Bridge: MTM83-10; N 4 860 186.3 E 355 924.1 ORIGINATED BY SG
DIST HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2022.10.20 - 2022.10.20 LATITUDE 43.879879 LONGITUDE -78.863810 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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						PLASTIC LIMIT W _P NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L						
110.8	GROUND SURFACE							20	40	60	80	100								
0.0	ASPHALT: (100mm)																			
0.1	SAND, some gravel, trace silt Compact Brown Moist (FILL)		1	SS	23															
110.0																				
0.8	Silty SAND, trace gravel, trace clay Compact Brown Moist (FILL)		2	SS	13															
109.4																				
1.4	Clayey SILT, with sand Hard Brown becoming grey at 3.0m depth Moist to Wet (TILL)		3	SS	100/ .280															
			4	SS	47															
			5	SS	100/ .125															
			6	SS	100/ .250															
			7	SS	81															
			8	SS	100/ .075															

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CS-07

2 OF 2

METRIC

WP# 2555-17-00 LOCATION Cubert Street Bridge: MTM83-10; N 4 860 186.3 E 355 924.1 ORIGINATED BY SG
DIST HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2022.10.20 - 2022.10.20 LATITUDE 43.879879 LONGITUDE -78.863810 CHECKED BY RPR

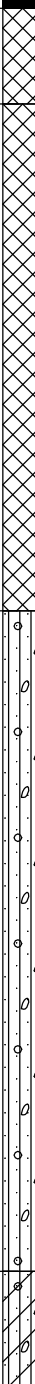



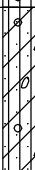

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE											
						20	40	60	80	100	20	40	60				
	Continued From Previous Page																
100.0	Clayey SILT, with sand, trace gravel Hard Grey Wet (TILL)		10	SS	100/						o						
10.8	END OF BOREHOLE AT 10.8m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.3m, THEN CONCRETE TO 0.2m, THEN ASPHALT TO GROUND SURFACE.				.100												

RECORD OF BOREHOLE No CS-08

1 OF 2

METRIC

WP# 2555-17-00 LOCATION Cubert Street Bridge: MTM83-10; N 4 860 197.5 E 355 958.4 ORIGINATED BY SG
DIST HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2022.10.19 - 2022.10.20 LATITUDE 43.879978 LONGITUDE -78.863383 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	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)								
109.9	GROUND SURFACE							20	40	60	80	100		W _P	W	W _L				
0.0	ASPHALT: (130mm)							20	40	60	80	100								
0.1	Gravelly SAND, trace to some silt and clay		1	SS	16		109							○				34 50 16 (SI+CL)		
109.1	Compact Brown Moist (FILL)		2	SS	10										○					
0.8	SAND and SILT trace gravel, trace clay															○				
	Compact to Loose Brown Moist (FILL)		3	SS	6											○				
	Occasional rootlets and organics between 1.4m and 3.0m		4	SS	4											○				11 45 39 5
		5	SS	11											○					
105.8									106											
4.1	SAND and SILT, trace gravel, trace clay		6	SS	25				105							○				9 42 41 8
	Compact to Very Dense Grey Moist (TILL)																			
			7	SS	100/ .125										○					
			8	SS	100/ .200															
101.4							102													
8.5	Clayey SILT, with sand, trace gravel		9	SS	26		101							○				6 36 47 11		
	Very Stiff Grey Wet (TILL)																			
							100													

Continued Next Page

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

RECORD OF BOREHOLE No CS-08

2 OF 2

METRIC

WP# 2555-17-00 LOCATION Cubert Street Bridge: MTM83-10; N 4 860 197.5 E 355 958.4 ORIGINATED BY SG
DIST HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2022.10.19 - 2022.10.20 LATITUDE 43.879978 LONGITUDE -78.863383 CHECKED BY RPR

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									WATER CONTENT (%)			
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
	Continued From Previous Page							20	40	60	80	100								
95.3 <																				

RECORD OF BOREHOLE No CS-09

1 OF 1

METRIC

WP# 2555-17-00 LOCATION Cubert Street Bridge: MTM83-10; N 4 860 155.5 E 355 928.3 ORIGINATED BY SG
DIST HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2022.11.07 - 2022.11.07 LATITUDE 43.879601 LONGITUDE -78.863762 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											
110.8	GROUND SURFACE							20	40	60	80	100							
0.0	ASPHALT: (150mm)																		
0.2	Gravelly SAND , trace to some silt Compact to Dense Brown Moist (FILL)		1	SS	23		110												
			2	SS	34														
109.4																			
1.4	Sandy SILT , trace to some clay, trace gravel Dense Brown Moist (FILL)		3	SS	49		109												
108.6																			
2.2	Sandy SILT , trace clay, trace gravel Very Dense Brown Moist (TILL)		4	SS	77		108												
			5	SS	100/ 230														
							107												
			6	SS	100/ 250		106												
							105												
	Grey		7	SS	100/ 200														
104.4																			
6.4	END OF BOREHOLE AT 6.4m. BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE TO 0.3m, THEN CONCRETE TO 0.2m, THEN ASPHALT TO GROUND SURFACE.																		

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RECORD OF BOREHOLE No CS-10

1 OF 2

METRIC

WP# 2555-17-00 LOCATION Cubert Street Bridge: MTM83-10; N 4 860 168.4 E 355 967.6 ORIGINATED BY SG
DIST HWY 401 BOREHOLE TYPE COMPILED BY AN
DATUM Geodetic DATE 2022.11.06 - 2022.11.06 LATITUDE 43.879715 LONGITUDE -78.863271 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	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)					
109.9	GROUND SURFACE							20	40	60	80	100					GR SA SI CL
0.0	ASPHALT: (150mm)							20	40	60	80	100					
0.2	Gravelly SAND, some silt, trace clay Dense to Compact Brown Moist (FILL)		1	SS	42		109										30 53 15 2
108.5			2	SS	21												
1.4	SAND and SILT, trace clay, trace gravel Loose Brown Wet (FILL)		3	SS	9		108										
			4	SS	4		107										
			5	SS	9												8 47 40 5
105.8							106										
4.1	SAND and SILT, trace clay, trace gravel Dense Brown Moist (TILL)		6	SS	40		105										
							104										
	Grey		7	SS	40		103										
102.7																	
7.2	Clayey SILT, with sand, trace gravel Hard to Very Stiff Grey Moist (TILL)		8	SS	35		102										4 37 45 14
							101										
			9	SS	22												8 37 42 13
							100										

Continued Next Page


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

RECORD OF BOREHOLE No CS-10

2 OF 2

METRIC

WP# 2555-17-00 LOCATION Cubert Street Bridge: MTM83-10; N 4 860 168.4 E 355 967.6 ORIGINATED BY SG
DIST HWY 401 BOREHOLE TYPE COMPILED BY AN
DATUM Geodetic DATE 2022.11.06 - 2022.11.06 LATITUDE 43.879715 LONGITUDE -78.863271 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			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								
	Clayey SILT , with sand, trace gravel Hard Grey Moist (TILL)		10	SS	100/ .150		99						○			
			11	SS	100/ .175		98						○			
			12	SS	100/ .230		97									
95.8							96						○			
14.1	END OF BOREHOLE AT 14.1m. BOREHOLE OPEN AND DRY UPON COMPLETION. BACKFILLED WITH BENTONITE HOLEPLUG TO 0.2m THEN CONCRETE TO 0.2m THEN ASPHALT TO GROUND SURFACE.															

APPENDIX C

Geotechnical and Analytical Laboratory Test Results

Point Load Test Results

Rock Core Photographs

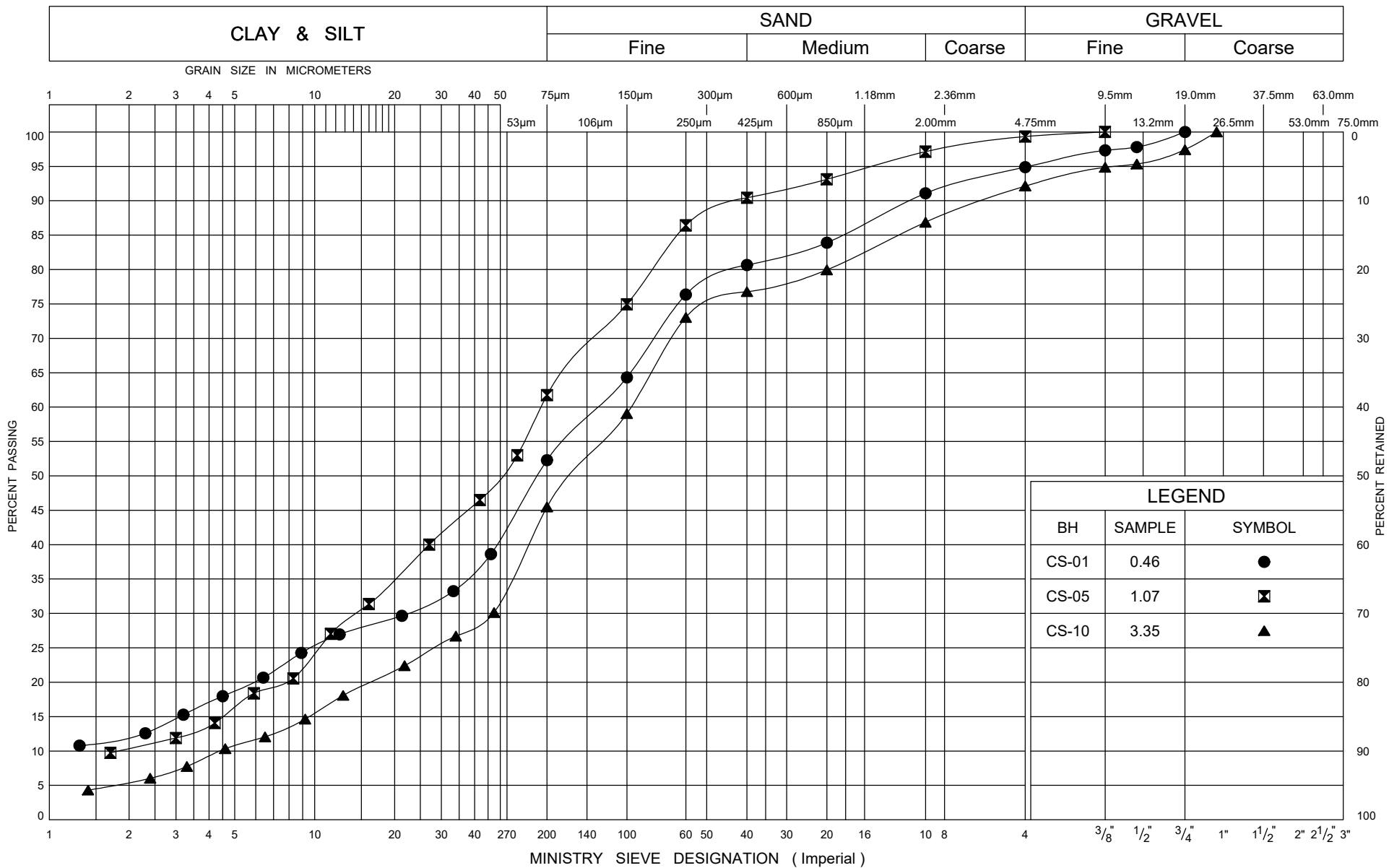
Soil Corrosivity Test Results



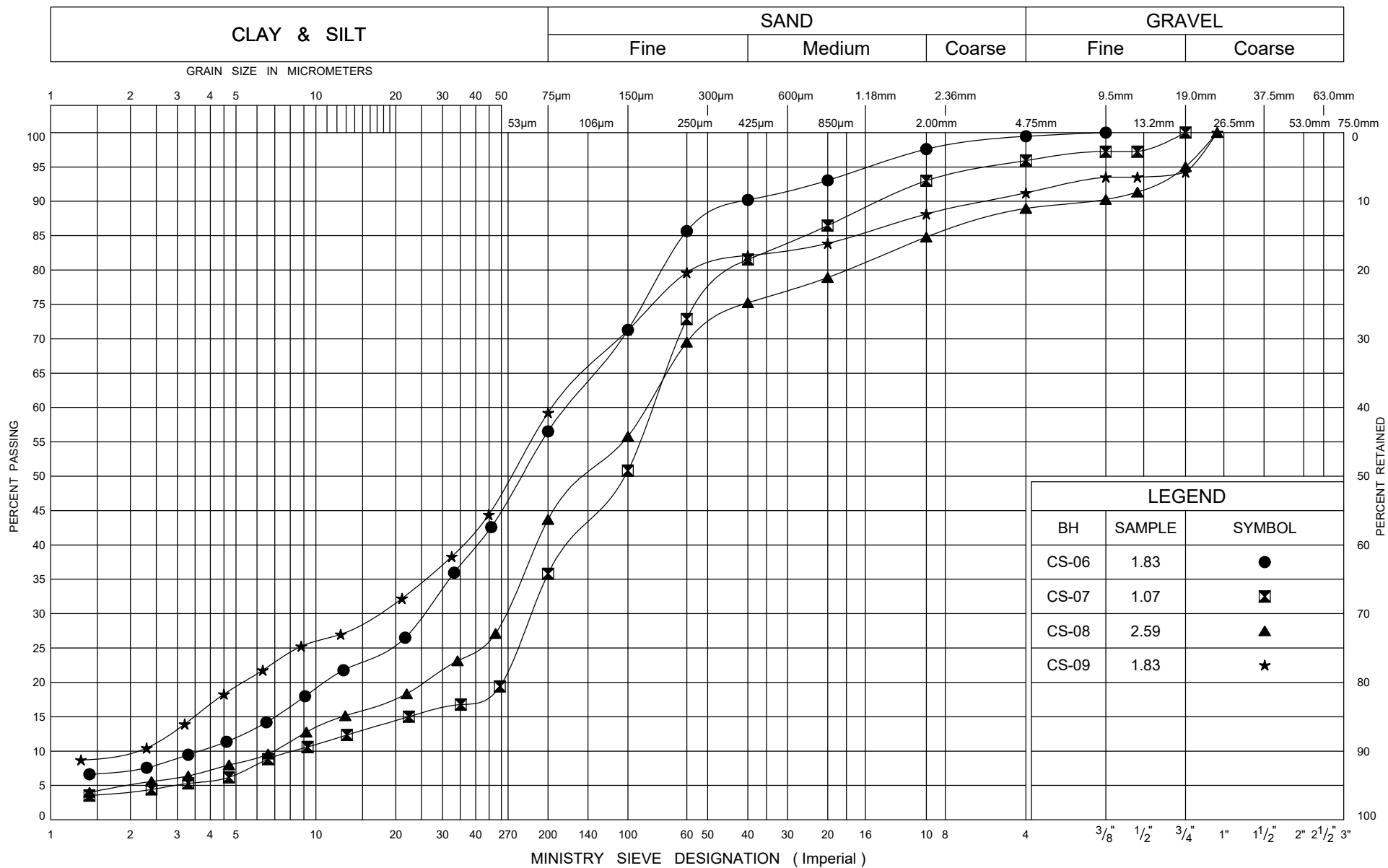
FIG No C1

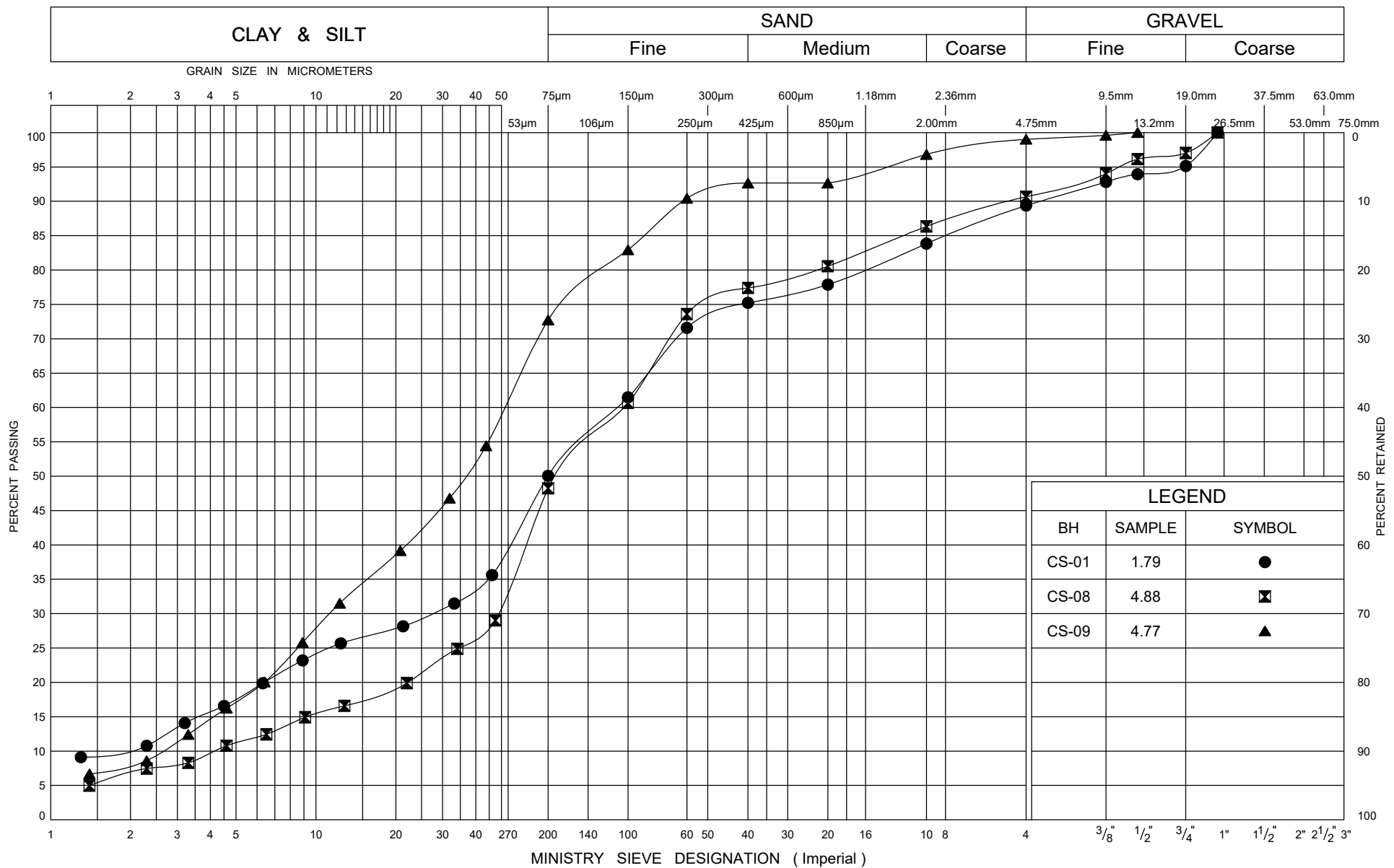
WP# 2555-17-00

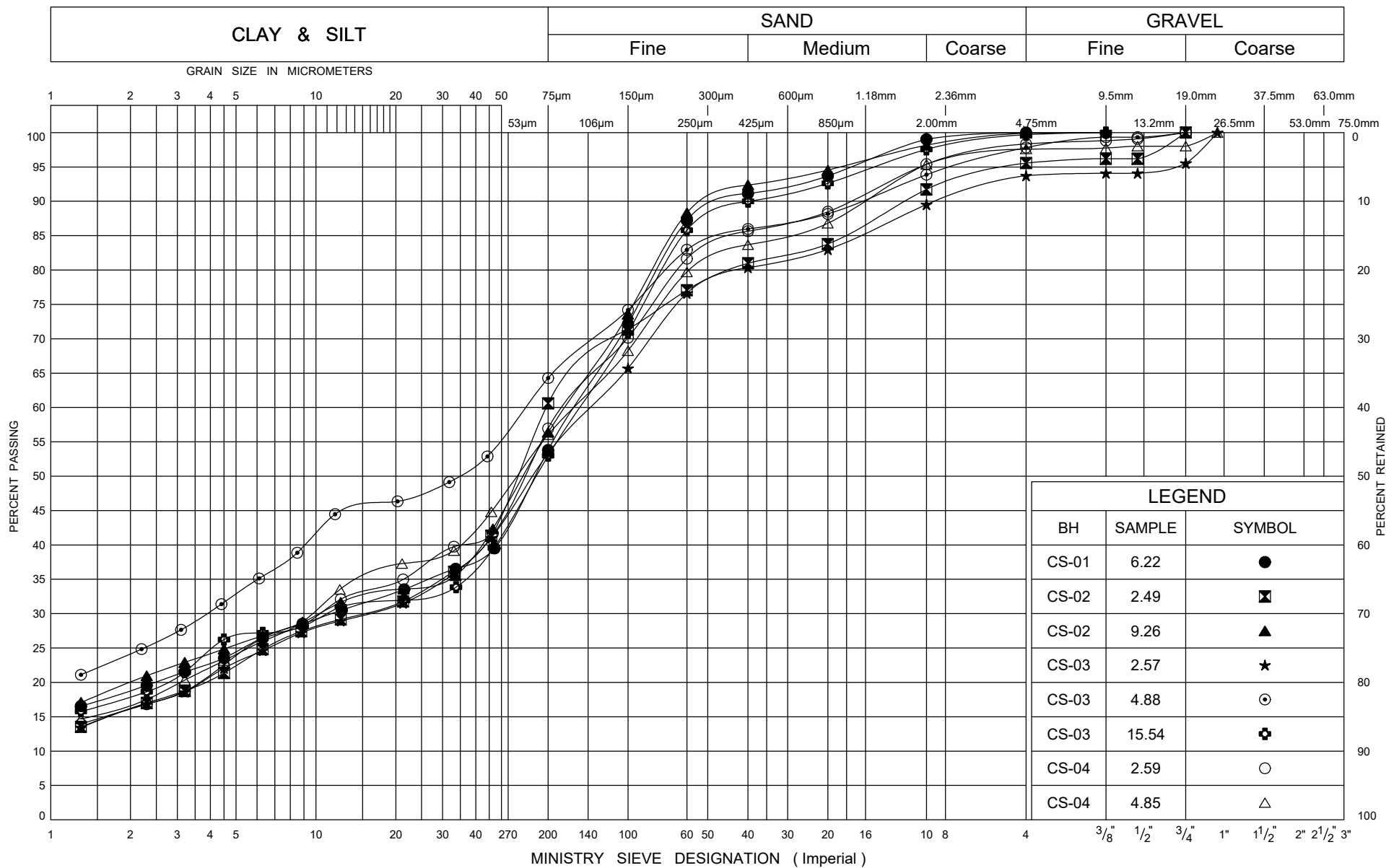
Cubert Street Bridge

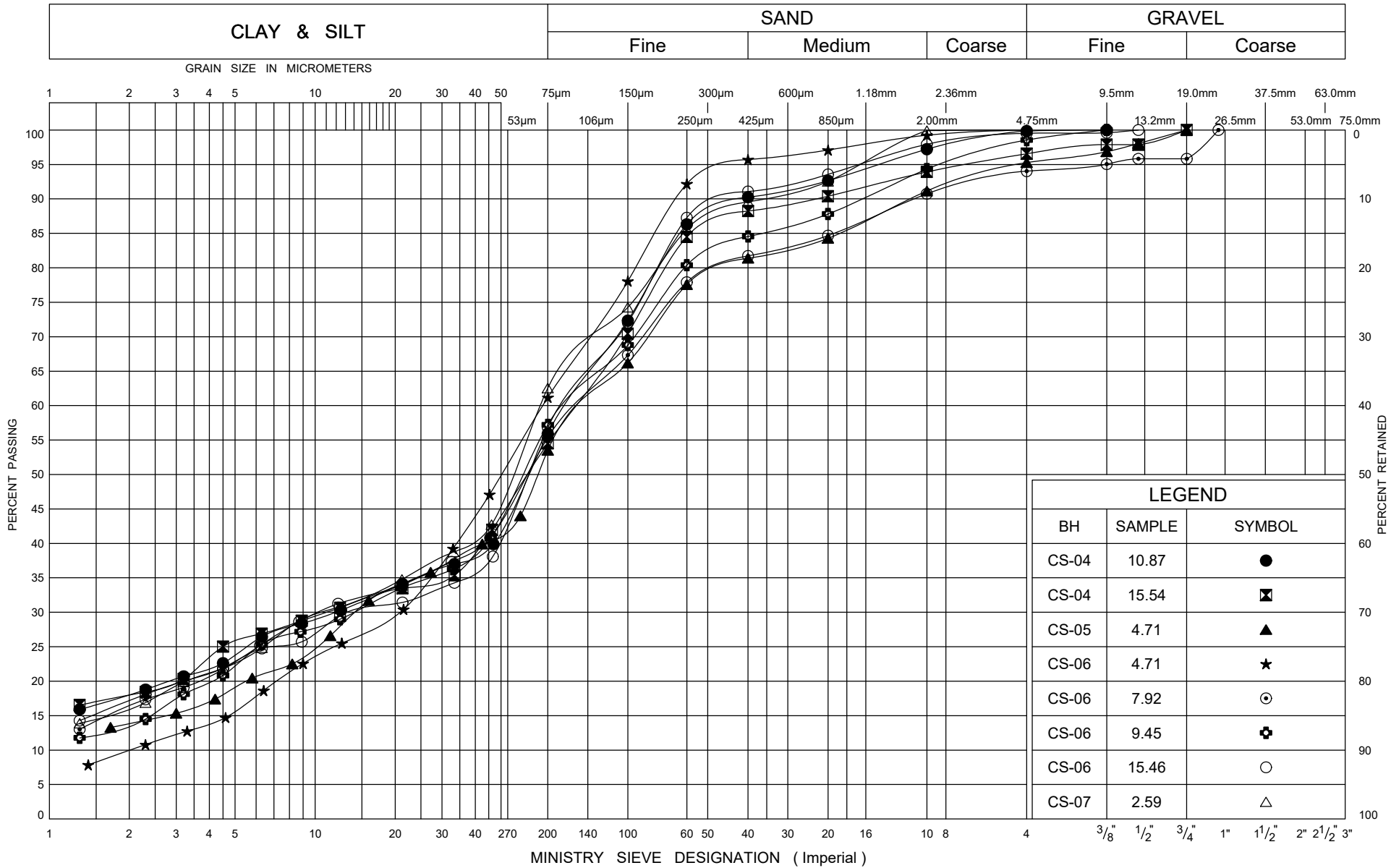


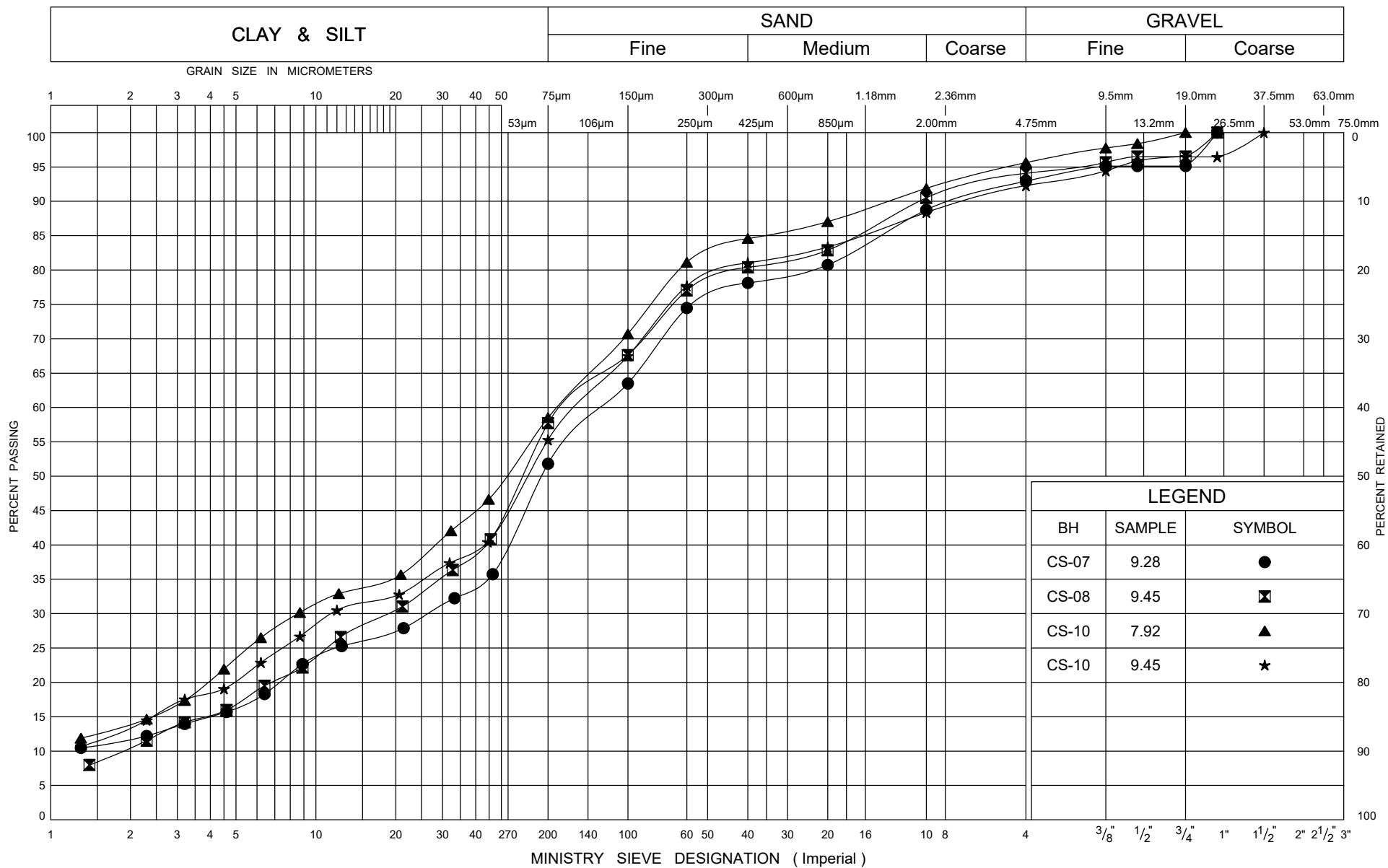
LEGEND		
BH	SAMPLE	SYMBOL
CS-01	0.46	●
CS-05	1.07	⊠
CS-10	3.35	▲

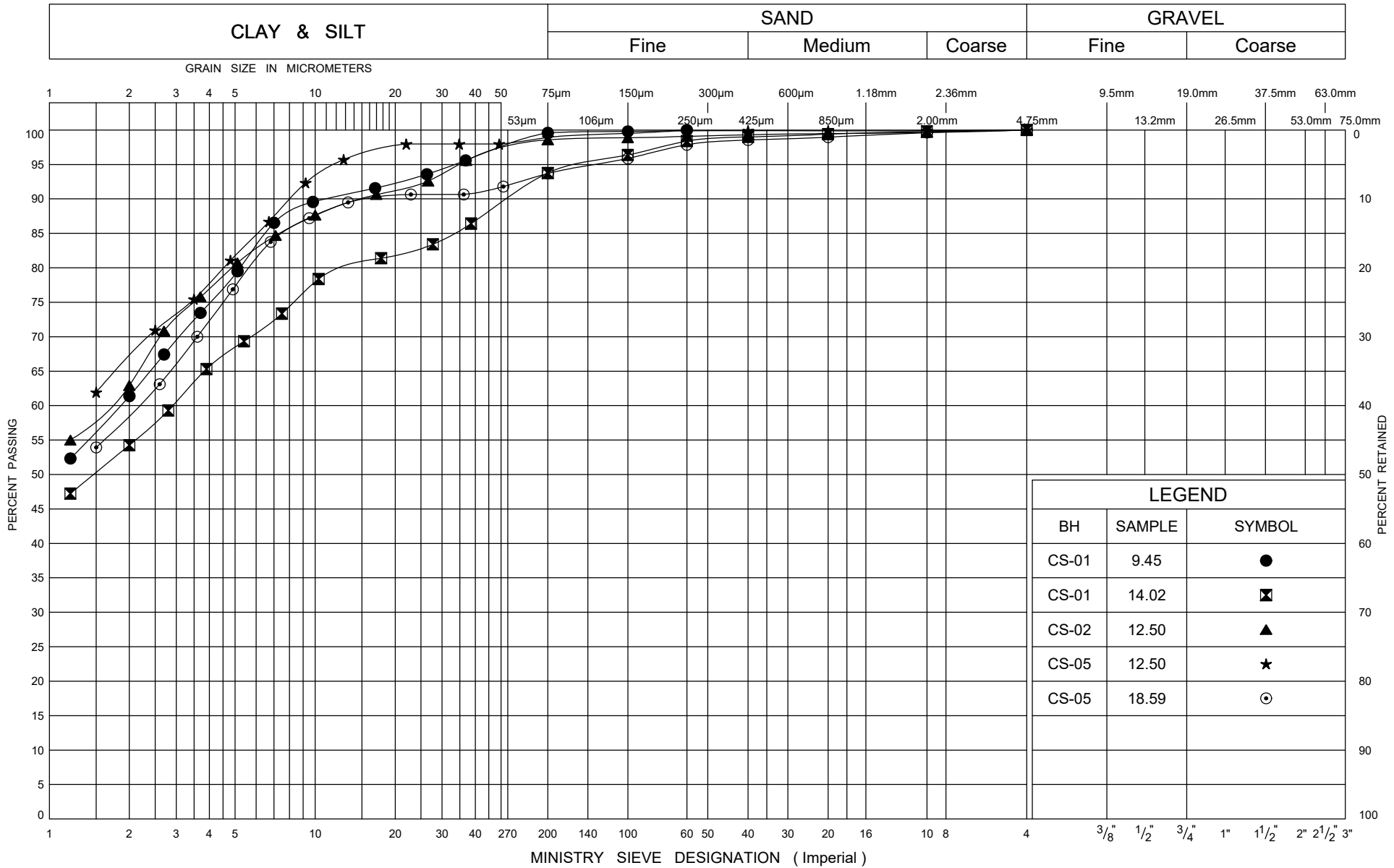


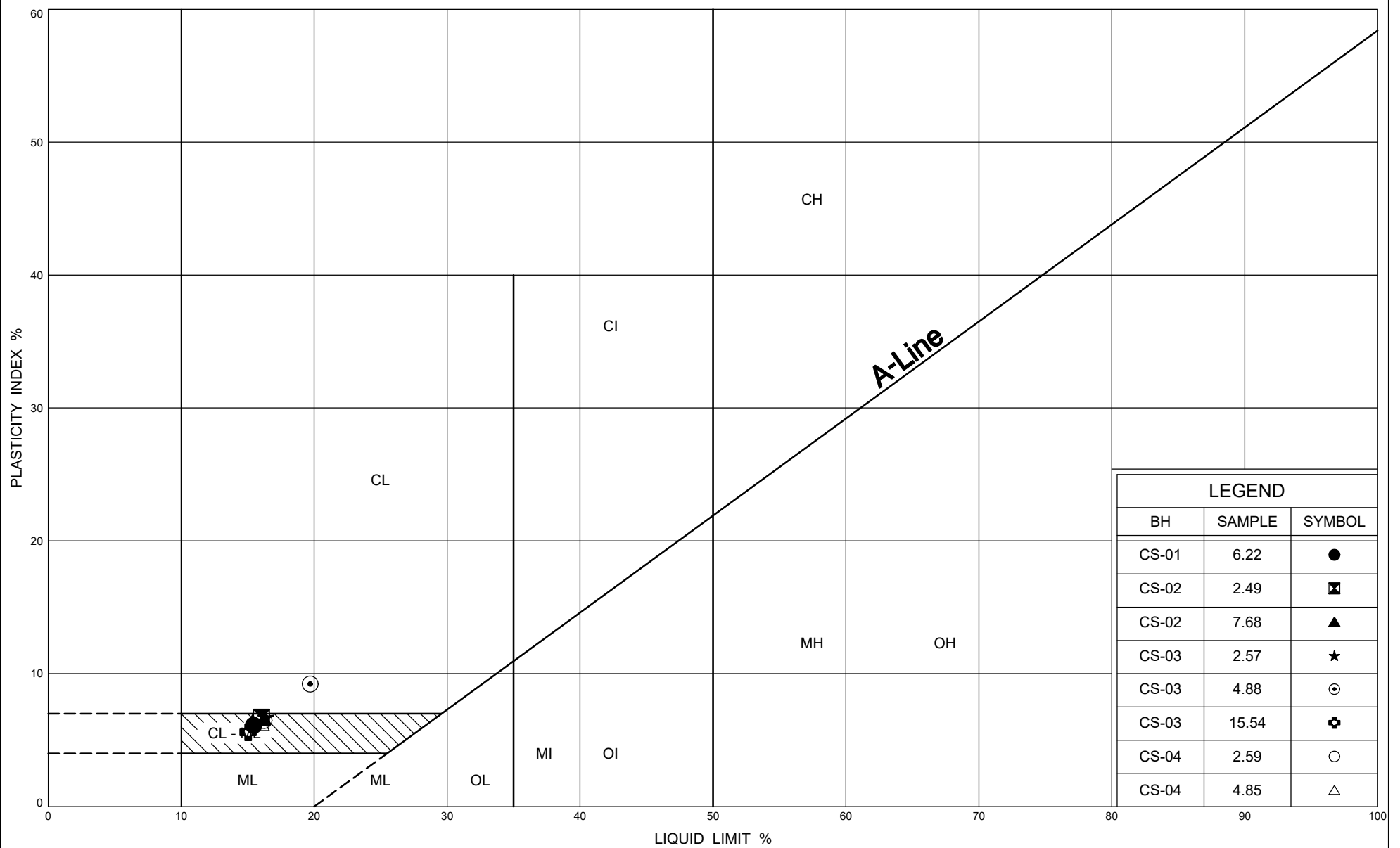












Ministry of
Transportation

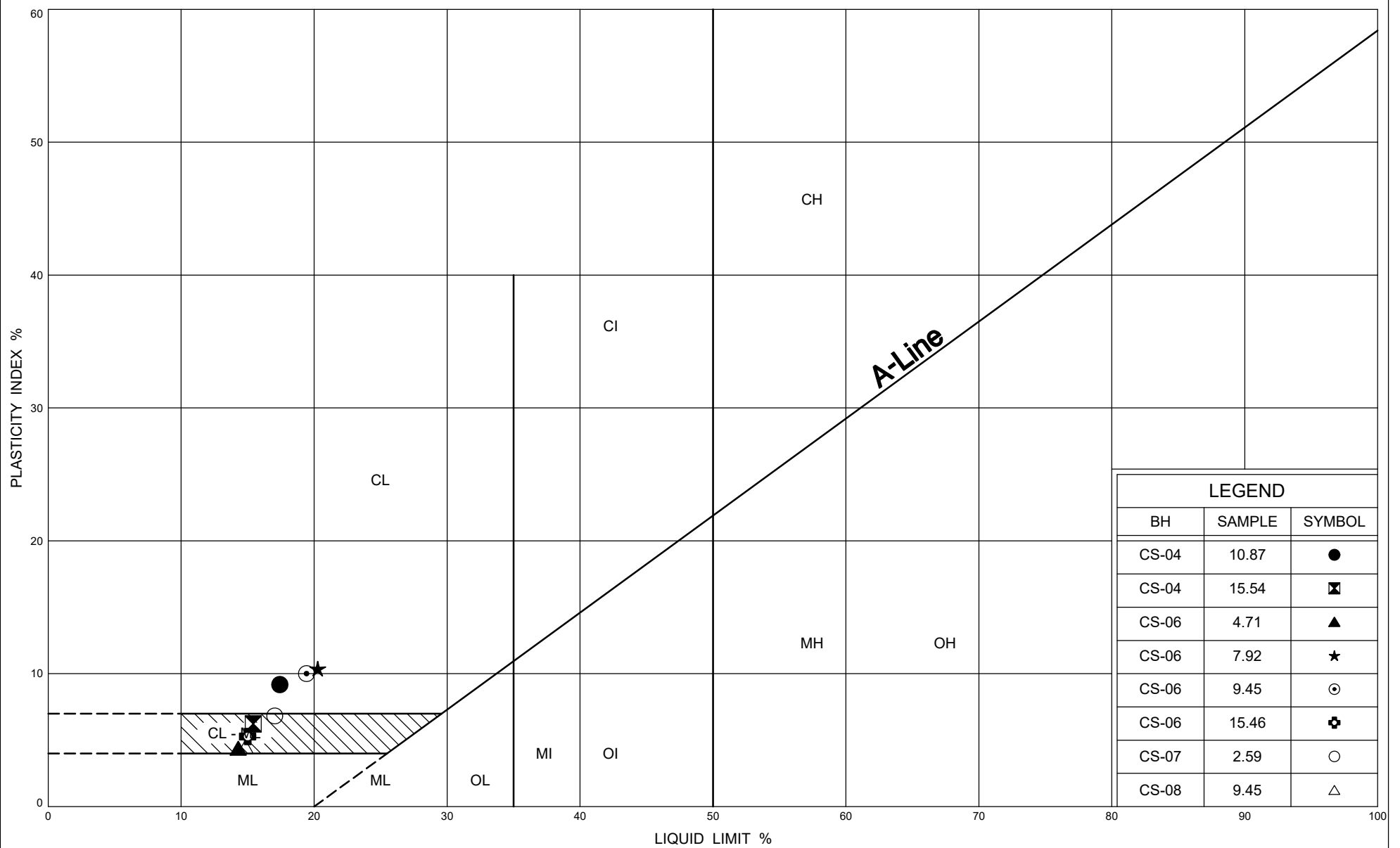
PLASTICITY CHART

Clayey SILT TILL

FIG No C9

WP# 2555-17-00

Cubert Street Bridge



Ministry of
Transportation

PLASTICITY CHART

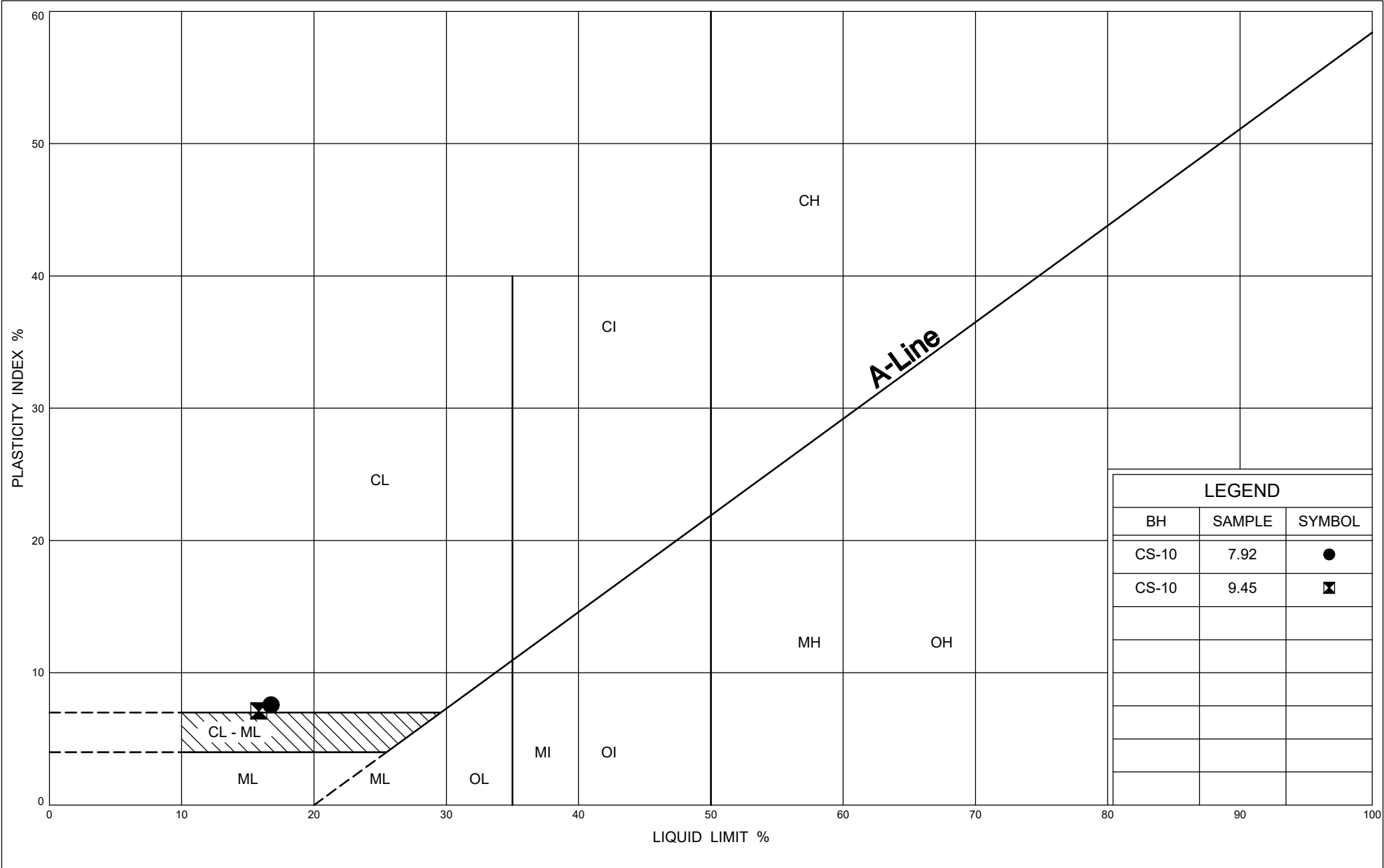
Clayey SILT TILL

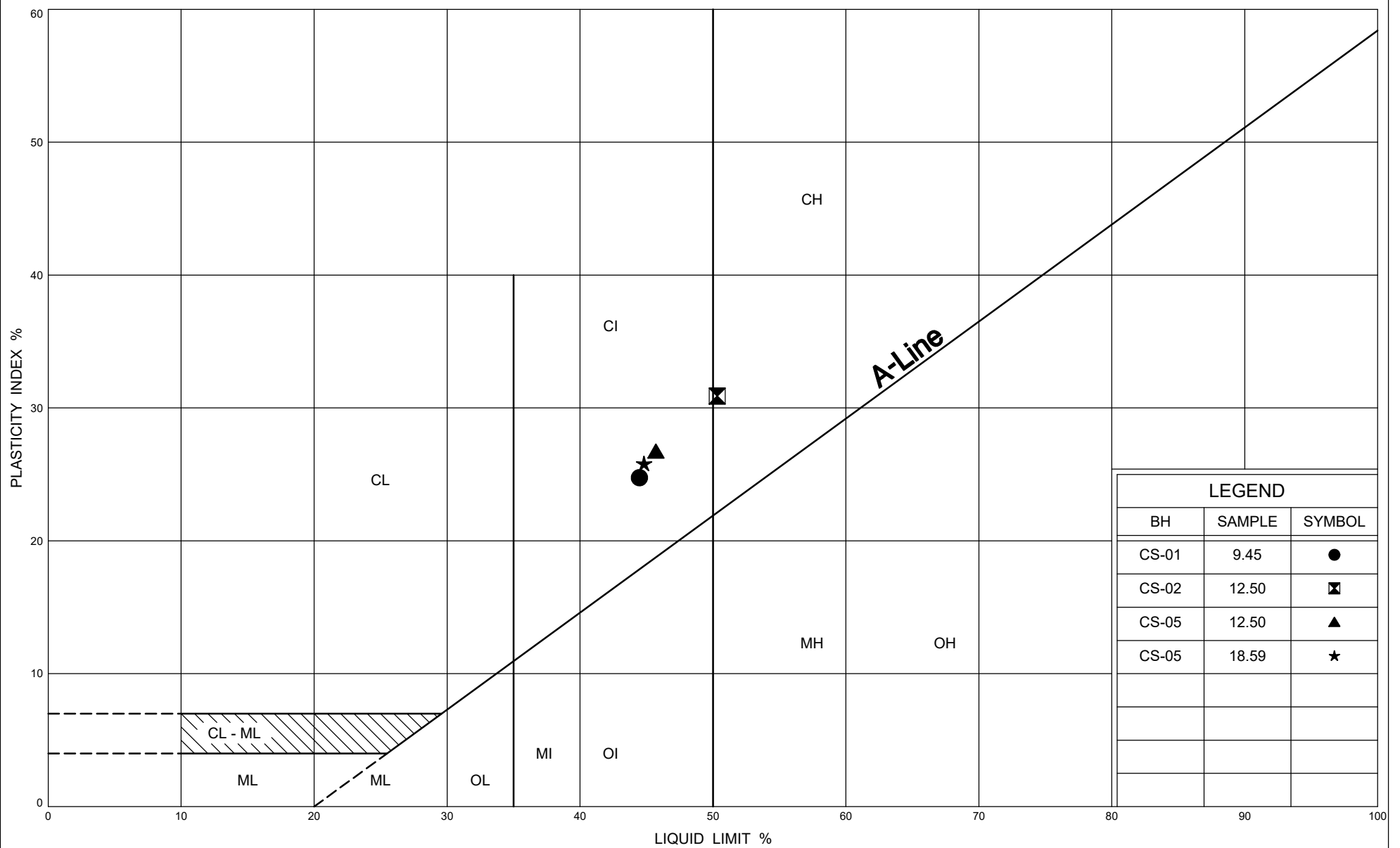
FIG No C10

WP# 2555-17-00

Cubert Street Bridge

ONTARIO MOT PLASTICITY CHART MTO-309/15.GPJ ONTARIO MOT.GDT 7/19/23







THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 30915

Date Drilled: 02-Dec-22

Project Name: Hwy 401 & Cubert St. Overpass

Date Tested: 17-May-23

Core Size: HQ BH No : CS-02

Tester: AK

Client:

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	19.9	D	6.7	60.7	75.6	1.9	45.1	Limestone	Medium Strong
2	1	20.1	D	8.9	60.7	68.2	2.5	60.0	Limestone	Strong
3	1	20.2	D	8.9	60.7	76.6	2.5	60.0	Limestone	Strong
4	2	20.3	D	12.9	60.7	68.7	3.6	86.9	Limestone	Strong
5	2	21.0	D	12.5	60.7	63.0	3.5	84.2	Limestone	Strong
6	2	21.3	D	8.4	60.7	62.0	2.4	56.6	Limestone	Strong
7	3	22.0	D	11.8	60.7	85.0	3.3	79.5	Limestone	Strong
8	3	22.2	D	8.2	60.7	86.7	2.3	55.3	Limestone	Strong
9	3	22.8	D	14.0	60.7	90.6	3.9	94.3	Limestone	Strong
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										
35										

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have $0.7 \times D$ on either side of test point.

* Correlation factor to obtain UCS values is 24.

PHOTOGRAPHS OF ROCK CORES - BOREHOLE CS-02

RUNS 1 to 3

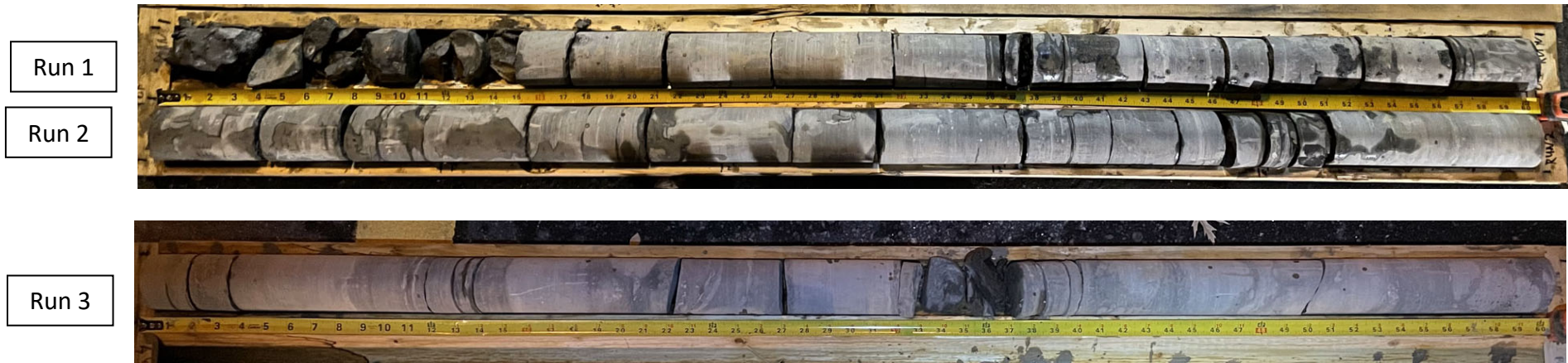


Date Drilled: December 2, 2022

Run #	Depth (ft)	Depth (m)
1	(61'7" – 66'7")	(18.8 – 20.3)
2	(66'7" – 71'7")	(20.3 – 21.8)
3	(71'7" – 76'7")	(21.8 – 23.3)

PHOTOGRAPHS OF ROCK CORES - BOREHOLE CS-05

RUNS 1 to 3



TOP

BOTTOM

Date Drilled: October 27, 2022

Run #	Depth (ft)	Depth (m)
1	(76' – 81')	(23.2 – 24.7)
2	(81' – 86')	(24.7 – 26.2)
3	(86" – 91")	(26.2 – 27.7)



FINAL REPORT

CA40202-JUN23 R1

30915

Prepared for

Thurber Engineering Ltd.

First Page

CLIENT DETAILS

Client Thurber Engineering Ltd.

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

Contact Rod de Castro

Telephone

Facsimile

Email rdecastro@thurber.ca

Project 30915

Order Number

Samples Soil (8)

LABORATORY DETAILS

Project Specialist Maarit Wolfe, Hon.B.Sc

Laboratory SGS Canada Inc.

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

Telephone 705-652-2000

Facsimile 705-652-6365

Email Maarit.Wolfe@sgs.com

SGS Reference CA40202-JUN23

Received 06/20/2023

Approved 06/29/2023

Report Number CA40202-JUN23 R1

Date Reported 06/29/2023

COMMENTS

Temperature of Sample upon Receipt: 12 degrees C

Cooling Agent Present: Yes

Custody Seal Present: Yes

Chain of Custody Number: n/a

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

SIGNATORIES

Maarit Wolfe, Hon.B.Sc

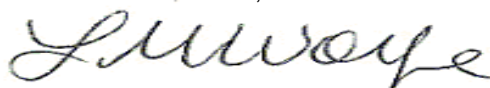




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Legend..... 7

Annexes..... 8



FINAL REPORT

CA40202-JUN23 R1

Client: Thurber Engineering Ltd.

Project: 30915

Project Manager: Rod de Castro

Samplers: Abdul Basit

MATRIX: SOIL

Sample Number	5	6	7	8	9	10	11	12
Sample Name	PRS-01 SS5	PRS-02 SS5	PRS-03 SS5	PRS-04 SS4	CS-01 SS5	CS-02 SS5	CS-03 SS3	CS-04 SS4
Sample Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sample Date	16/11/2022	17/11/2022	14/11/2022	22/11/2022	23/11/2022	12/01/2023	12/12/2022	25/11/2022

Parameter	Units	RL		Result	Result	Result	Result	Result	Result	Result
-----------	-------	----	--	--------	--------	--------	--------	--------	--------	--------

Corrosivity Index

Corrosivity Index	none	1		6	6	6	18	8	4	6	6
Soil Redox Potential	mV	no		254	210	241	204	269	314	314	291
Sulphide (Na2CO3)	%	0.04		0.06	0.05	0.06	0.06	0.11	0.06	0.07	0.05
pH	pH Units	0.05		8.63	8.52	8.39	8.61	8.69	8.44	8.57	8.54
Resistivity (calculated)	ohms.cm	-9999		5590	7300	2480	972	2650	5050	3150	5460

General Chemistry

Conductivity	uS/cm	2		179	137	403	1030	378	198	317	183
--------------	-------	---	--	-----	-----	-----	------	-----	-----	-----	-----

Metals and Inorganics

Moisture Content	%	0.1		0.9	4.2	3.6	5.7	0.7	1.6	0.6	0.4
Sulphate	µg/g	0.4		100	120	160	160	350	250	200	210

Other (ORP)

Chloride	µg/g	0.4		47	40	2400	3400	18	18	47	14
----------	------	-----	--	----	----	------	------	----	----	----	----



FINAL REPORT

CA40202-JUN23 R1

QC SUMMARY

Anions by IC
Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-IENVIIC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0625-JUN23	µg/g	0.4	<0.4	4	35	95	80	120	100	75	125
Sulphate	DIO0625-JUN23	µg/g	0.4	<0.4	15	35	96	80	120	99	75	125

Carbon/Sulphur
Method: ASTM E1915-07A | Internal ref.: ME-CA-IENVIARD-LAK-AN-020

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide (Na2CO3)	ECS0057-JUN23	%	0.04	< 0.04	ND	20	109	80	120			
Sulphide (Na2CO3)	ECS0066-JUN23	%	0.04	< 0.04	ND	20	115	80	120			



FINAL REPORT

CA40202-JUN23 R1

QC SUMMARY

Conductivity

Method: SM 2510 | Internal ref.: ME-CA-IENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0556-JUN23	uS/cm	2	< 2	0	20	98	90	110	NA		

pH

Method: SM 4500 | Internal ref.: ME-CA-IENVIEWL-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0556-JUN23	pH Units	0.05	NA	0		100			NA		



FINAL REPORT

CA40202-JUN23 R1

QC SUMMARY

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

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

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

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

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

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

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

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

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

LEGEND

FOOTNOTES

NSS Insufficient sample for analysis.

RL Reporting Limit.

↑ Reporting limit raised.

↓ Reporting limit lowered.

NA The sample was not analysed for this analyte

ND Non Detect

Results relate only to the sample tested.

Data reported represent the sample as submitted to SGS. Solid samples expressed on a dry weight basis.

"Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

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

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated.

SGS Canada Inc. statement of conformity decision rule does not consider uncertainty when analytical results are compared to a specified standard or regulation.

This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at http://www.sgs.com/terms_and_conditions.htm.

The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents. Reproduction of this analytical report in full or in part is prohibited.

This report supersedes all previous versions.

-- End of Analytical Report --

Laboratory Information Section - Lab use only

Received By: K. McKinnon
Received Date (mm/dd/yy): 06-20-23
Received Time: 14:40Received By (signature): [Signature]
Custody Seal Present: ☒
Custody Seal Intact: ☒Cooling Agent Present: ☒
Temperature Upon Receipt (°C): 18.3LAB LIMS #: CA40202-2023

REPORT INFORMATION		INVOICE INFORMATION		PROJECT INFORMATION	
Company: <u>Thurber Engineering Ltd.</u>		<input checked="" type="checkbox"/> (same as Report Information)		Quotation #: _____ P.O. #: _____	
Contact: <u>Rod de Castro</u>		Company: _____		Project #: <u>30915</u> Site Location/ID: _____	
Address: <u>103-2010 Winston Park Drive</u>		Contact: _____		TURNAROUND TIME (TAT) REQUIRED	
<u>Oakville, Ontario</u>		Address: _____		Regular TAT (5-7days) <input checked="" type="checkbox"/> Regular TAT (Additional Charges May Apply): <input type="checkbox"/> 1 Day <input type="checkbox"/> 2 Days <input type="checkbox"/> 3 Days <input type="checkbox"/> 4 Days	
Phone: <u>905 829 8666 x 5244</u>		Phone: _____		RUSH TAT (Additional Charges May Apply): <input type="checkbox"/> 1 Day <input type="checkbox"/> 2 Days <input type="checkbox"/> 3 Days <input type="checkbox"/> 4 Days	
Email: <u>rdecastro@thurber.ca</u>		Email: _____		PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION	
Email: _____		Email: _____		Specify Due Date: _____ Rush Confirmation ID: _____	
REGULATIONS					
Regulation 153/04:		Other Regulations:		ANALYSIS REQUESTED	
Soil Texture: <input type="checkbox"/> R/P/I <input type="checkbox"/> J/C/C <input type="checkbox"/> A/O <input type="checkbox"/> Coarse <input type="checkbox"/> Medium <input type="checkbox"/> Fine		<input type="checkbox"/> Reg 347/658 (3 Day min TAT) <input type="checkbox"/> PWQO <input type="checkbox"/> CCME <input type="checkbox"/> MISA <input type="checkbox"/> Other: _____		<input type="checkbox"/> Metals & Inorganics <input type="checkbox"/> PAH <input type="checkbox"/> ABN <input type="checkbox"/> SVOC(ail) <input type="checkbox"/> PCB Total <input type="checkbox"/> Aroclor <input type="checkbox"/> PBC F1-F4 <input type="checkbox"/> VOC <input type="checkbox"/> BTEX <input type="checkbox"/> BTEX/F1 <input type="checkbox"/> F2-F4 <input type="checkbox"/> VOC <input type="checkbox"/> BTEX <input type="checkbox"/> BTEX <input type="checkbox"/> THM <input type="checkbox"/> Pesticides OC <input type="checkbox"/> OP <input type="checkbox"/> TCLP M&I <input type="checkbox"/> VOC <input type="checkbox"/> PCB <input type="checkbox"/> B(a)P <input type="checkbox"/> ABN <input type="checkbox"/> Ignit. <input type="checkbox"/> Water Pkg Gen. <input type="checkbox"/> Ext. <input type="checkbox"/> Use: <input type="checkbox"/> Sewer <input type="checkbox"/> Corrosivity/Resistivity	
RECORD OF SITE CONDITION (RSC) <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO		Sewer By-Law: <input type="checkbox"/> Sanitary <input type="checkbox"/> Storm <input type="checkbox"/> Municipality: _____		COMMENTS:	
SAMPLE IDENTIFICATION		DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX
1 PRS-01 SS5	11/16/22	AM	1	SOIL	
2 PRS-02 SS5	11/17/22	AM	1	SOIL	
3 PRS-03 SS5	11/14/22	AM	1	SOIL	
4 PRS-04 SS4	11/22/22	AM	1	SOIL	
5 CS-01 SS5	11/23/22	AM	1	SOIL	
6 CS-02 SS5	11/23/22	AM	1	SOIL	
7 CS-03 SS3	12/5/22	AM	1	SOIL	
8 CS-04 SS4	11/25/22	AM	1	SOIL	
9					
10					
11					
12					
Observations/Comments/Special Instructions					

Sampled By (NAME): Abdul BasitSignature: ABDate: 06/19/23

(mm/dd/yy)

Pink Copy - Client

Relinquished by (NAME): Czarlene PontejosSignature: C-PDate: 06/20/23

(mm/dd/yy)

Yellow & White Copy - SGS

APPENDIX D

Records of Boreholes – Previous Investigation

FD- (Rev. Jan. 73)

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

PENETRATION RESISTANCE

'N' = STANDARD PENETRATION RESISTANCE : - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS :-

<u>CONSISTENCY</u>	<u>c LB./SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
VERY SOFT	0 - 250	VERY LOOSE	0 - 4
SOFT	250 - 500	LOOSE	4 - 10
FIRM	500 - 1000	COMPACT	10 - 30
STIFF	1000 - 2000	DENSE	30 - 50
VERY STIFF	2000 - 4000	VERY DENSE	> 50
HARD	> 4000		

TERMS TO BE USED IN DESCRIBING SOILS:-

TRACE < 10% , SOME 10-25% , WITH 25-40% , > 40% SILTY, SANDY, GRAVELLY, CLAYEY ETC.

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.T.	SLOTTED TUBE SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE

P.H. SAMPLE ADVANCED HYDRAULICALLY

P.M. SAMPLE ADVANCED MANUALLY

SOIL TESTS

U	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
UU	UNCONSOLIDATED UNDRAINED TRIAXIAL	F.V.	FIELD VANE
CIU	CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL	C	CONSOLIDATION
CID	" " DRAINED "	S	SENSITIVITY
CAU	" ANISOTROPIC UNDRAINED "		
CAD	" " DRAINED "		

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

SOIL PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s	UNIT WEIGHT OF SOLID PARTICLES
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
S_v	DEGREE OF SATURATION
w_L	LIQUID LIMIT
w_p	PLASTIC LIMIT
I_p	PLASTICITY INDEX
w_s	SHRINKAGE LIMIT
I_L	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
I_c	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
e_{max}	VOID RATIO IN LOOSEST STATE
e_{min}	VOID RATIO IN DENSEST STATE
I_D	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY D_r IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
m_v	COEFFICIENT OF VOLUME CHANGE = $\frac{-\Delta e}{(1+e)\Delta\sigma}$
C_v	COEFFICIENT OF CONSOLIDATION
C_c	COMPRESSION INDEX = $\frac{\Delta e}{\Delta \log_{10} \sigma}$
T_v	TIME FACTOR = $\frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
τ_f	SHEAR STRENGTH
c'	EFFECTIVE COHESION
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
μ	COEFFICIENT OF FRICTION
S_t	SENSITIVITY

GENERAL

π	= 3.1416
e	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

STRESS AND STRAIN

u	PORE PRESSURE
σ	NORMAL STRESS
$\bar{\sigma}$	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ϵ	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO (μ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_0	COEFFICIENT OF EARTH PRESSURE AT REST

FOUNDATIONS

B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
k_s	MODULUS OF SUBGRADE REACTION

SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β	ANGLE OF SLOPE TO HORIZONTAL

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 1

JOB 73-11010

LOCATION Co-ords. 15,944,784 N & 1,167,715 E

ORIGINATED BY V.K.

W.P. 44-71-07

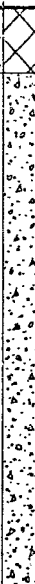
BORING DATE April 17, 1973.

COMPILED BY V.K.

DATUM Geodetic

BOREHOLE TYPE Auger and Cone Test

CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT			LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		20 40 60 80 100			w_p — w — w_L					
							SHEAR STRENGTH P.S.F.			WATER CONTENT %					
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE			15 30 45					
344.7	Ground level.														
0.0	Clayey silt with some sand and gravel.		1	SS	9	340								WL 339.7	
339.7	(Fill material)Stiff		2	SS	140	10"									
5.0	Heterogeneous mixture of clayey silt to silty clay, sand and gravel.		3	SS	156	11"									9-37-35-19
			4	SS	179	11"									4-37-40-19
			5	SS	133	11"									
			6	SS	71										
			7	SS	37										0-3-24-73
			8	SS	43										
	(Glacial till)	9	SS	58											
	Hard														
300.2			10	SS	37	300								2-28-42-28	
44.5	End of Borehole														

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 2

JOB 73-11010

LOCATION Co-ords. 15,944,798N & 1,167,761E

ORIGINATED BY V.K.

W.P. 44-71-07

BORING DATE April 18, 1973

COMPILED BY V.K.

DATUM Geodetic

BOREHOLE TYPE Auger and Cone Test

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE			LIQUID LIMIT — w_L			BULK DENSITY	REMARKS		
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		BLOWS / FOOT			PLASTIC LIMIT — w_p						
							20	40	60	80	100	WATER CONTENT — w				
												w_p			w	w_L
SHEAR STRENGTH P.S.F.							+ FIELD VANE			WATER CONTENT %						
○ UNCONFINED							× LAB VANE									
							10			20			30			
345.0	Ground level															
0.0	Clayey silt with some sand and gravel and traces of organics															
338.5	(Fill material) Firm		1	SS	7	340								WL 3385		
6.5			2	SS	97									1-21-69-9		
	Heterogeneous mixture of clayey silt, sand and gravel		3	SS	175	11"								3-39-41-17		
			4	SS	162	10"										
	(Glacial till)		5	SS	121	9"	330							1-32-48-19		
			6	SS	100	3"										
	Hard		7	SS	100	3"	320									
310.8			8	SS	100	2"	310									
34.2	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 3

JOB 73-11010

LOCATION Co-ords. 15,944,684N & 1,167,798E

ORIGINATED BY V.K.

W.P. 44-71-07

BORING DATE April 19, 1973

COMPILED BY V.K.

DATUM Geodetic

BOREHOLE TYPE Auger and Core Test

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — w_L			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		BLOWS / FOOT					PLASTIC LIMIT — w_p				
							20	40	60	80	100	WATER CONTENT — w				
SHEAR STRENGTH P.S.F.							w_p — w — w_L			WATER CONTENT %						
○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE										10 20 30						
344.7	Ground level															
0.0	Clayey silt with some sand and gravel and traces of organics (Fill material) Stiff		1	SS	9	340									WL 339.7	
339.7			2	SS	160/9"										14-34-34-18	
5.0			3	SS	74/7"	0"										
	Heterogeneous mixture of clayey silt, sand and gravel		4	SS	145/7"	1"										
			5	SS	173											
	(Glacial till)		6	SS	377/0"											
			7	SS	100/7"											
			8	SS	81/6"	320									4-38-40-18	
	Hard															
			9	SS	100/7"	310										
308.2																
36.5	End of Borehole															
						300										

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 1

JOB 73-11010

LOCATION Co-ords. 15,944,784 N & 1,167,715 E

ORIGINATED BY V.K.

W.P. 44-71-07

BORING DATE April 17, 1973.

COMPILED BY V.K.

DATUM Geodetic

BOREHOLE TYPE Auger and Cone Test

CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE			LIQUID LIMIT w_L			BULK DENSITY γ	REMARKS		
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		BLOWS / FOOT			PLASTIC LIMIT w_p						
							20	40	60	80	100	WATER CONTENT w				
												w_p			w	w_L
SHEAR STRENGTH P.S.F.						UNCONFINED + FIELD VANE			QUICK TRIAXIAL x LAB VANE			WATER CONTENT %				
344.7	Ground level.															
0.0	Clayey silt with some sand and gravel.															
339.7	(Fill material)Stiff		1	SS	9	340									WL 339.7	
5.0			2	SS	140	10"										
	Heterogeneous mixture of clayey silt to silty clay, sand and gravel.		3	SS	156	11"									9-37-35-19	
			4	SS	179	11"									4-37-40-19	
			5	SS	133	11"										
	(Glacial till)		6	SS	71										0-3-24-73	
			7	SS	37											
	Hard		8	SS	43	320										
			9	SS	58	310										
300.2			10	SS	37	300									2-28-42-28	
44.5	End of Borehole															

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 2

JOB 73-11010

LOCATION Co-ords. 15,944,798N & 1,167,761E

ORIGINATED BY V.K.

W.P. 44-71-07

BORING DATE April 18, 1973

COMPILED BY V.K.

DATUM Geodetic

BOREHOLE TYPE Auger and Cone Test

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE				LIQUID LIMIT — w_L			BULK DENSITY	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		BLOWS / FOOT				PLASTIC LIMIT — w_p					
							20	40	60	80	100	WATER CONTENT — w				
												w_p	w			w_L
SHEAR STRENGTH P.S.F.							WATER CONTENT %			γ	P.C.F.					
○ UNCONFINED + FIELD VANE																
● QUICK TRIAXIAL × LAB VANE																
345.0	Ground level										10	20	30		GR. SA. SI. CL.	
0.0	Clayey silt with some sand and gravel and traces of organics														WL 3385	
338.5	(Fill material) Firm		1	SS	7	340									1-21-69-9	
6.5			2	SS	97											
	Heterogeneous mixture of clayey silt, sand and gravel		3	SS	175	11"									3-39-41-17	
			4	SS	162	10"										
			5	SS	121	9"	330									
	(Glacial till)		6	SS	100	3"									1-32-48-19	
	Hard		7	SS	100	3"	320									
310.8			8	SS	100	2"	310									
34.2	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 3

JOB 73-11010

LOCATION Co-ords. 15,944,684N & 1,167,798E

ORIGINATED BY V.K.

W.P. 44-71-07

BORING DATE April 19, 1973

COMPILED BY V.K.

DATUM Geodetic

BOREHOLE TYPE Auger and Core Test

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT				LIQUID LIMIT — W _L PLASTIC LIMIT — W _P WATER CONTENT — W			BULK DENSITY γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		20	40	60	80	100	W _P	W	W _L	
344.7	Ground level														
0.0	Clayey silt with some sand and gravel and traces of organics		1	SS	9	340									WL 339.7
339.7	(fill material) Stiff		2	SS	160/9"										14-34-34-18
5.0	Heterogeneous mixture of clayey silt, sand and gravel		3	SS	74/7"	330									
	(Glacial till)		4	SS	145/7"										
			5	SS	173										
			6	SS	377/0"										
			7	SS	100/7"	320									4-38-40-18
	Hard		8	SS	81/6"										
			9	SS	100/7"	310									
308.2															
36.5	End of Borehole														
						300									

DESIGN SERVICES BRANCH

RECORD OF BOREHOLE NO 4

FOUNDATIONS OFFICE

JOB 73-11010

LOCATION Co-ords. 15,944,669N & 1,167,752E

ORIGINATED BY V.K.

W.P. 44-71-07

BORING DATE April 24, 1973

COMPILED BY V.K.

DATUM Geodetic

BOREHOLE TYPE Auger and Cone Test

CHECKED BY *AK*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT				LIQUID LIMIT — W _L PLASTIC LIMIT — W _P WATER CONTENT — W			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		20	40	60	80	100	W _P	W	W _L	
344.7	Ground level														
0.0	clayey silt with some sand and gravel														
341.2	(Fill material) Stiff		1	SS	58	340									WL 341.2
3.5	Heterogeneous mixture of clayey silt, sand and gravel		2	SS	169	11"									6-38-38-18
			3	SS	100	6"									
			4	SS	174	10"									
			5	SS	163	10"									12-33-35-20
	(Glacial till)		6	SS	100	6"									
	Hard		7	SS	165	11"									4-40-37-10
310.2			8	SS	100	5"									
34.5	End of Borehole														

DESIGN SERVICES BRANCH

RECORD OF BOREHOLE NO 4

FOUNDATIONS OFFICE

JOB 73-11010

LOCATION Co-ords. 15,944,669N & 1,167,752E

ORIGINATED BY V.K.

W.P. 44-71-07

BORING DATE April 24, 1973

COMPILED BY V.K.

DATUM Geodetic

BOREHOLE TYPE Auger and Cone Test

CHECKED BY *AK*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT				LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		20	40	60	80	100	w_p	w	w_L	
344.7	Ground level														
0.0	clayey silt with some sand and gravel														
341.2	(Fill material) Stiff		1	SS	58	340									WL 341.2
3.5	Heterogeneous mixture of clayey silt, sand and gravel		2	SS	169	11"									6-38-38-18
			3	SS	100	6"									
			4	SS	174	10"									
			5	SS	163	10"									12-33-35-20
	(Glacial till)		6	SS	100	6"									
	Hard		7	SS	165	11"									4-40-37-10
310.2			8	SS	100	5"									
34.5	End of Borehole														

APPENDIX E

Selected Site Photographs



Photo 1- North Side of Highway 401 and Cubert St. Overpass
Date: July 2023



Photo 2- Highway 401 and Cubert St. Overpass
West abutment, north side (looking west)
Date: July 2023



Photo 3- South Side of Highway 401 and Cubert St. Overpass
Date: July 2023



Photo 4- South Side of Highway 401 and Cubert St. Overpass
Date: July 2023



Photo 5- South Side of Highway 401 and Cubert St. Overpass
East abutment, south side (looking east)
Date: July 2023



Photo 6- South Side of Highway 401 and Cubert St. Overpass
West abutment, south side (looking west)
Date: July 2023



Photo 1- North Side of Highway 401 and Cubert St. Overpass
Date: July 2023



Photo 2- Highway 401 and Cubert St. Overpass
West abutment, north side (looking west)
Date: July 2023



Photo 3- South Side of Highway 401 and Cubert St. Overpass
Date: July 2023



Photo 4- South Side of Highway 401 and Cubert St. Overpass
Date: July 2023



**Photo 5- South Side of Highway 401 and Cubert St. Overpass
East abutment, south side (looking east)
Date: July 2023**



Photo 6- South Side of Highway 401 and Cubert St. Overpass
West abutment, south side (looking west)
Date: July 2023

APPENDIX F

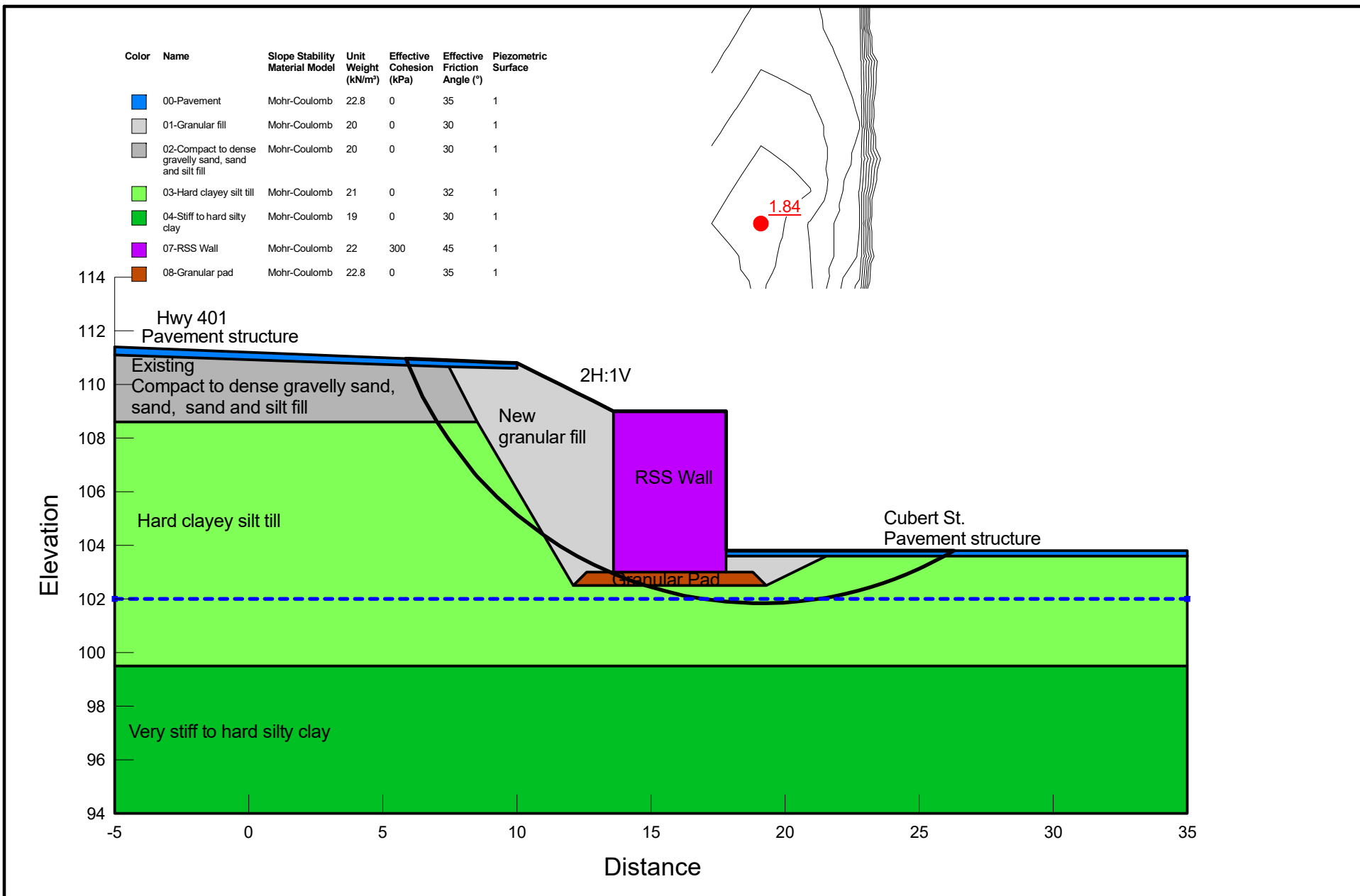
Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT

Foundation Element	Spread Footings	Caissons	Driven Piles
	<p>Advantages:</p> <ul style="list-style-type: none"> i. Generally less costly construction than deep foundation elements. ii. Ease of construction. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Relatively large excavations required. ii. Dewatering may be required, depending on depth of excavation and groundwater level at time of construction. iii. May increase requirements for roadway protection. iv. At some locations along the footing alignments, the founding surface should be re-established using mass concrete. 	<p>Advantages:</p> <ul style="list-style-type: none"> i. High geotechnical resistances available for units founded on bedrock. ii. Construction could continue in freezing weather. iii. Higher axial resistance than H-pile. iv. Higher lateral resistance is available due to larger diameter. v. Less number of caissons is required for each foundation element than if steel piles were used. vi. Likely requires smaller work zone than other alternatives during construction. vii. Minimal disruption to traffic particularly at the pier since pile caps are not required. <p>Disadvantages:</p> <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 to minimize sidewall sloughing and water seepage. iii. Potential basal instability if water-bearing soils are exposed at the base. iv. Potential difficulty in cleaning and inspecting bases. v. Not suitable for integral abutments. 	<p>Advantages:</p> <ul style="list-style-type: none"> i. Comparatively short abutment stem possible. ii. Permits integral abutment design. iii. Ease of construction. iv. Minimal excavation and dewatering required. v. Construction could continue in freezing weather. vi. Readily installed. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Higher unit cost compared to footings. ii. Very dense soils at shallow depth may limit length of pile. iii. Cobbles and boulders may be encountered in glacially derived soils that could impede pile penetration to required depths. iv. Will require roadway protection for pile cap construction at abutments. v. Relatively lower lateral resistance is available given the pile dimension. vi. Larger number of piles will likely be required to resist foundation loads.
ABUTMENTS	RECOMMENDED	<p style="text-align: center;">FEASIBLE</p> <p style="text-align: center;">(if non-integral abutments are considered in the bridge design)</p>	NOT RECOMMENDED

APPENDIX G

Selected Embankment Stability Output




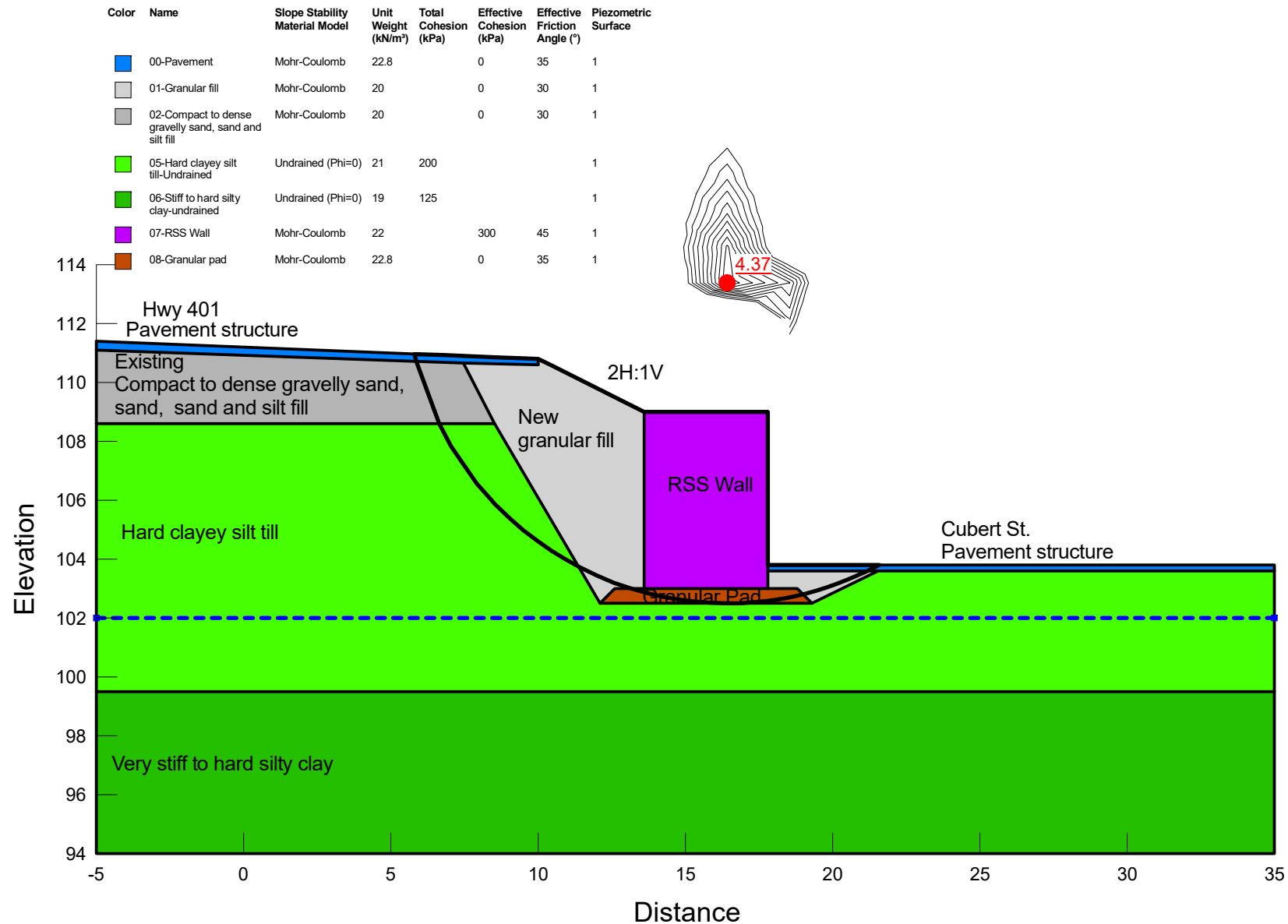
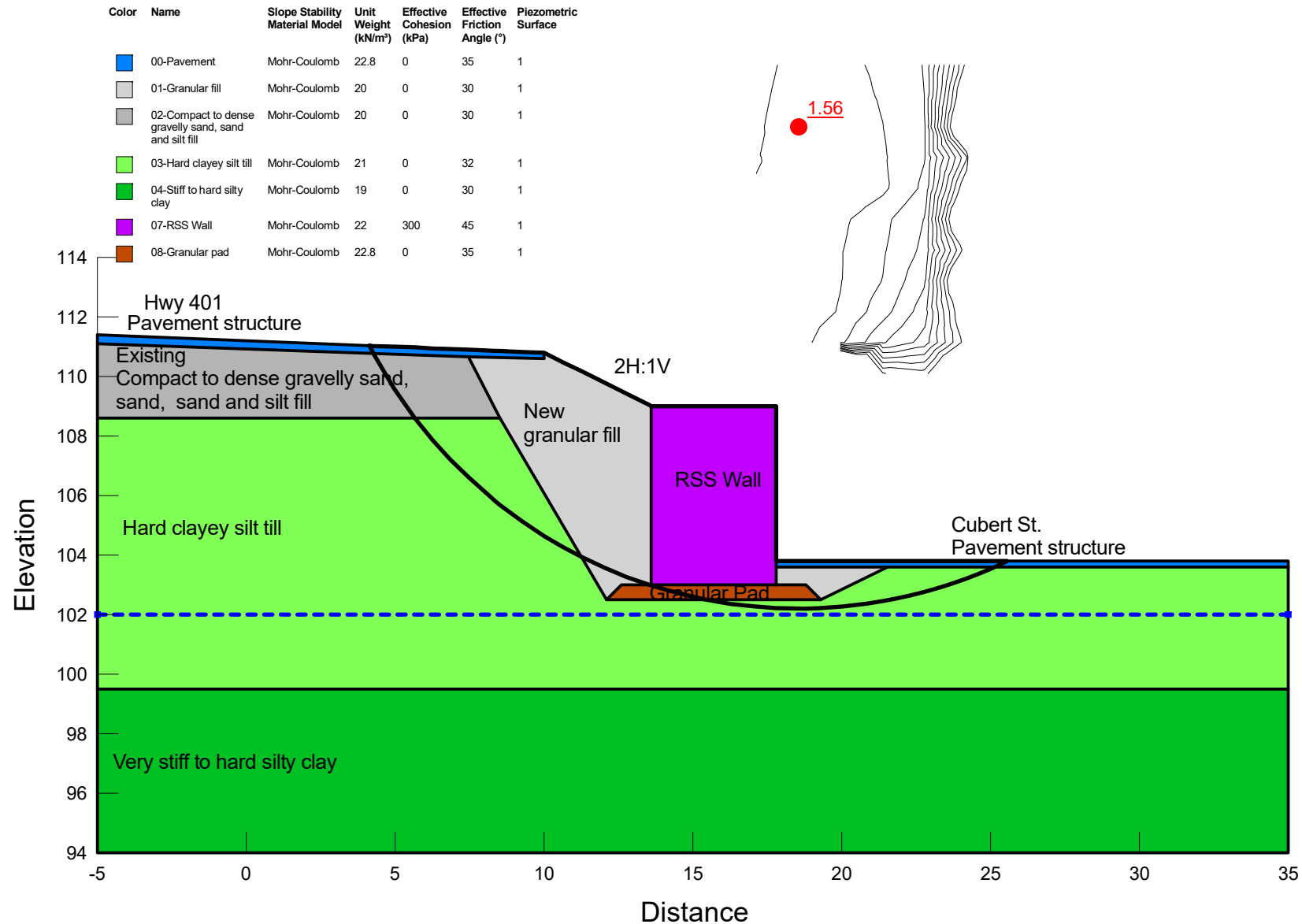
	Project			Additional Details		GWL- Elevation 102.0
	30915- Hwy 401 & Cubert St.- Bridge			Name: Hwy 401 & Cubert St. Bridge		
	Analysis			Comments: RSS Wall		
	Drained Analysis - RSS Wall			Method: Morgenstern-Price, Half-Sine		
	Seismic Coefficient		Last Run	Scale		
	H: 0g, V: 0g		2023-10-11,09:52:12 AM	1:200		Figure G1

Figure G1



Project		
30915- Hwy 401 & Cubert St.- Bridge		
Analysis		
Undrained Analysis - RSS Wall		
Seismic Coefficient	Last Run	Scale
H: 0g, V: 0g	2023-10-11,09:52:12 AM	1:200

Additional Details		GWL- Elevation 102.0
Name: Hwy 401 & Cubert St. Bridge		
Comments: RSS Wall		
Method: Morgenstern-Price, Half-Sine		Figure G2



Project		
30915- Hwy 401 & Cubert St.- Bridge		
Analysis		
Seismic Analysis - RSS Wall		
Seismic Coefficient	Last Run	Scale
H: 0.0845g, V: 0g	2023-10-11,09:52:12 AM	1:200

Additional Details

Name: Hwy 401 & Cubert St. Bridge

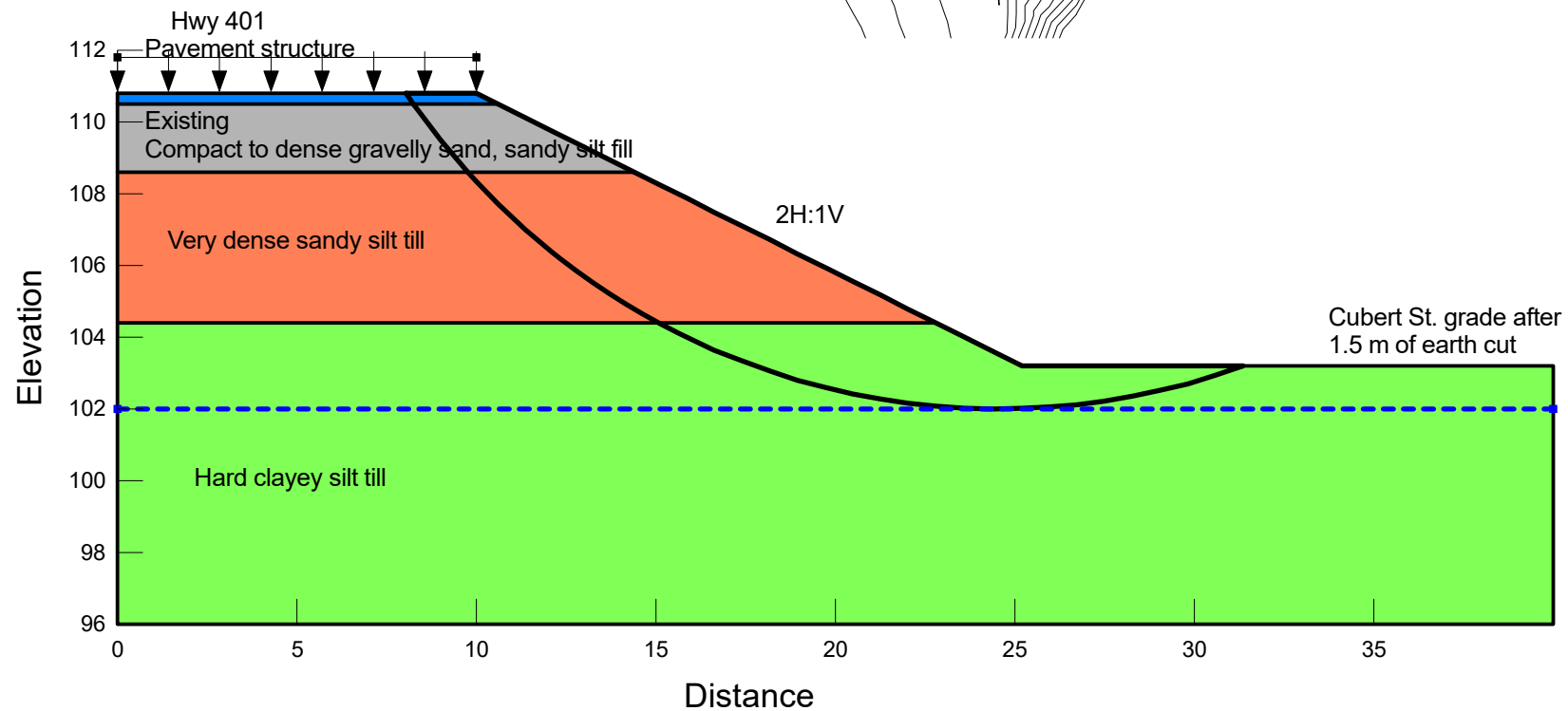
Comments: RSS Wall

Method: Morgenstern-Price, Half-Sine

GWL- Elevation 102.0

Figure G3

Color	Name	Slope Stability Material Model	Unit Weight (kN/m ³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Surface
Blue	00-Pavement	Mohr-Coulomb	22.8	0	35	1
Grey	02-Compact to dense gravelly sand, sandy silt fill	Mohr-Coulomb	20	0	30	1
Green	03-Hard clayey silt till	Mohr-Coulomb	21	0	32	1
Orange	Very dense sandy silt till	Mohr-Coulomb	21	0	31	1




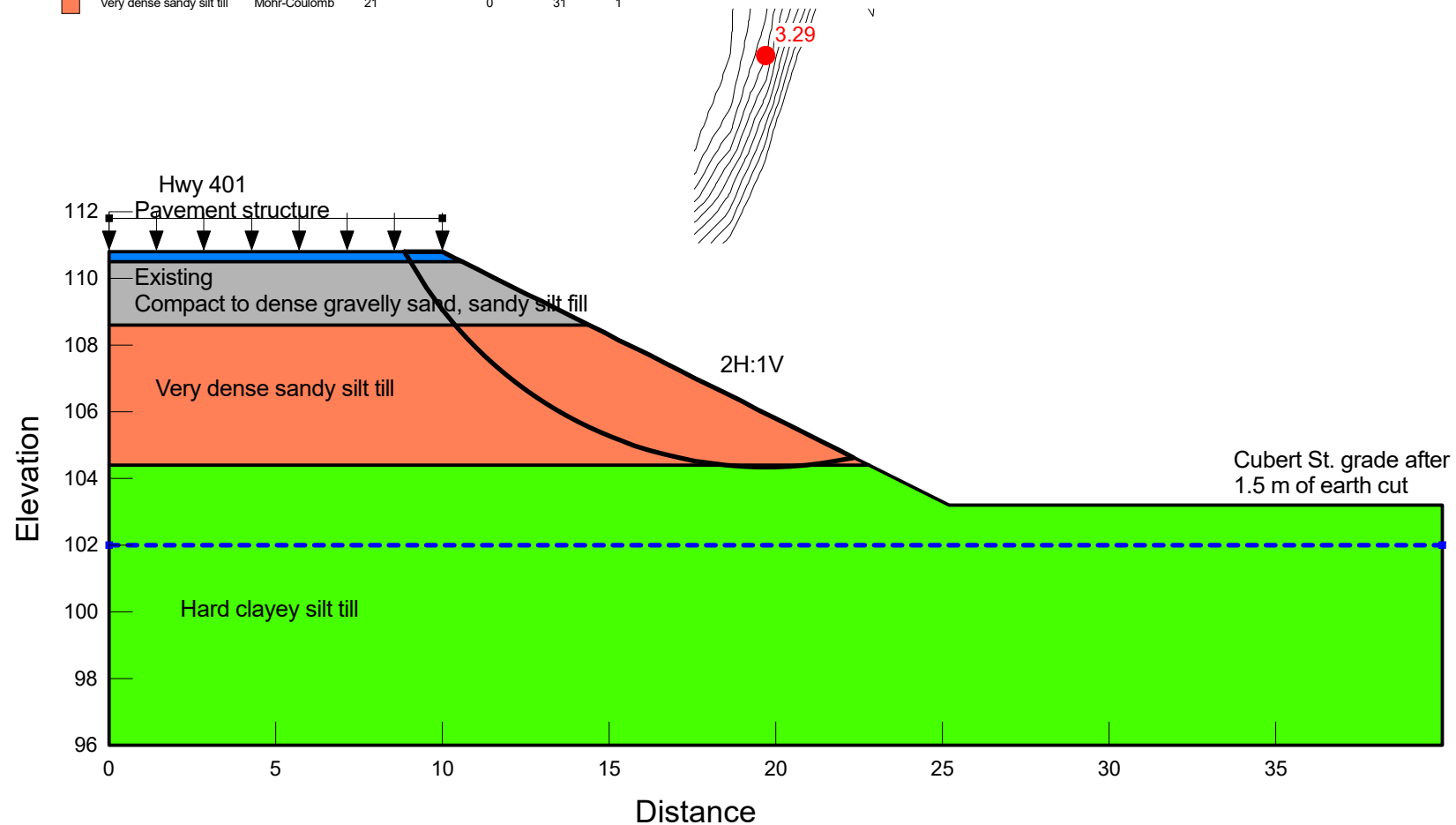

	Project			Additional Details	
	30915- Hwy 401 & Cubert St.- Bridge			Name: Hwy 401 & Cubert St. Bridge	
	Analysis			Method: Morgenstern-Price, Half-Sine	
	Drained Analysis - Highway 401 Widening - Earth Cut			GWL- Elevation 102.0	
Seismic Coefficient		Last Run		Scale	
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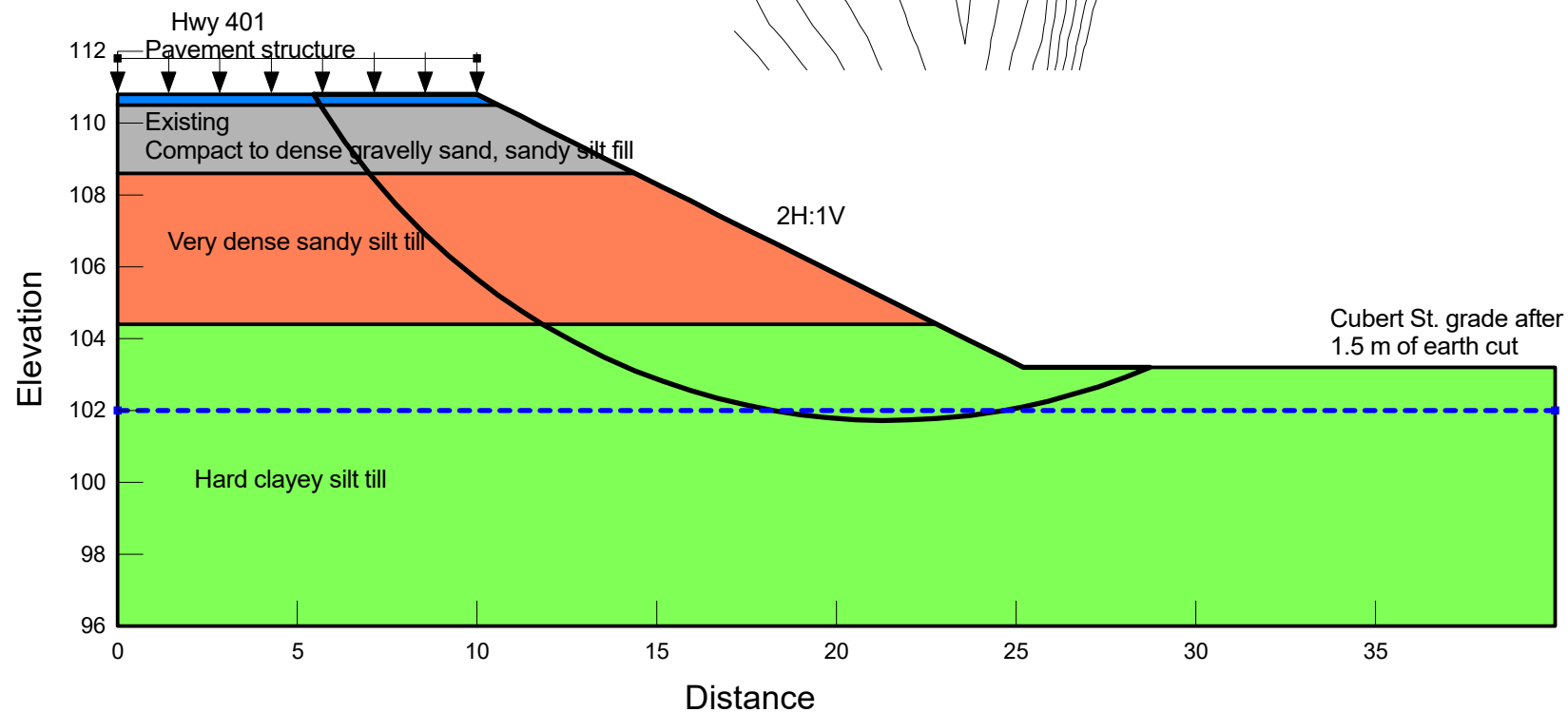
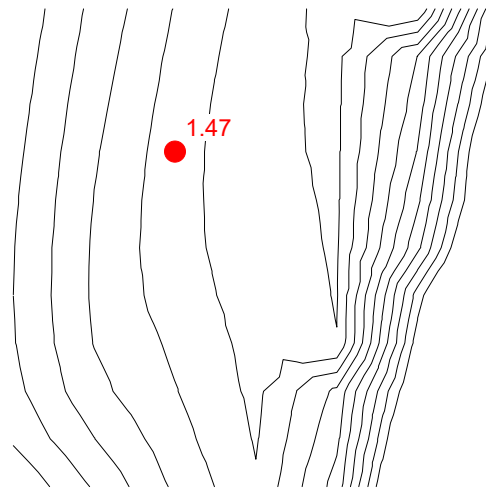
Figure G4


Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Total Cohesion (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Surface
■	00-Pavement	Mohr-Coulomb	22.8		0	35	1
■	02-Compact to dense gravelly sand, sandy silt fill	Mohr-Coulomb	20		0	30	1
■	05-Hard clayey silt till-Undrained	Undrained (Phi=0)	21	200			1
■	Very dense sandy silt till	Mohr-Coulomb	21		0	31	1



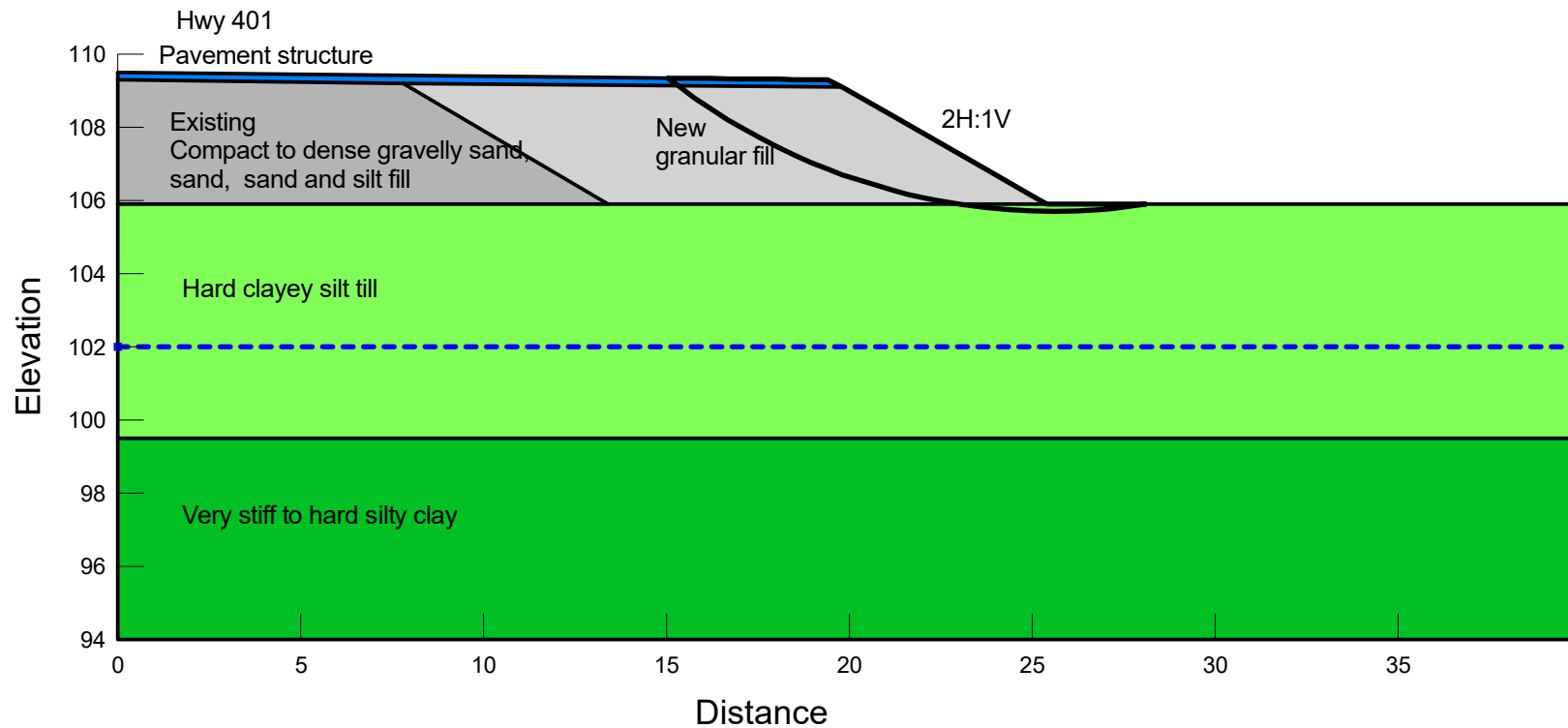
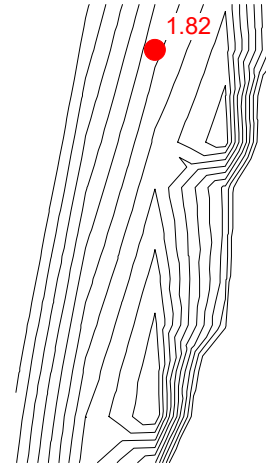
	Project			Additional Details			GWL- Elevation 102.0
	30915- Hwy 401 & Cubert St.- Bridge			Name: Hwy 401 & Cubert St. Bridge			
	Analysis			Northwest side			
	Undrained Analysis - Highway 401 Widening - Earth Cut			Method: Morgenstern-Price, Half-Sine			
	Seismic Coefficient	Last Run	Scale	Figure G5			
H: 0g, V: 0g	2024-12-10,02:14:37 PM	1:200					

Color	Name	Slope Stability Material Model	Unit Weight (kN/m ³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Surface
Blue	00-Pavement	Mohr-Coulomb	22.8	0	35	1
Grey	02-Compact to dense gravelly sand, sandy silt fill	Mohr-Coulomb	20	0	30	1
Green	03-Hard clayey silt till	Mohr-Coulomb	21	0	32	1
Orange	Very dense sandy silt till	Mohr-Coulomb	21	0	31	1



	Project			Additional Details	
	30915- Hwy 401 & Cubert St.- Bridge			Name: Hwy 401 & Cubert St. Bridge	GWL- Elevation 102.0
	Analysis			Method: Morgenstern-Price, Half-Sine	
	Seismic Coefficient	Last Run	Scale	Figure G6	
H: 0.0845g, V: 0g		2024-12-10, 11:05:51 AM	1:200		






Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Surface
■	00-Pavement	Mohr-Coulomb	22.8	0	35	1
■	01-Granular fill	Mohr-Coulomb	20	0	30	1
■	02-Compact to dense gravelly sand, sand and silt fill	Mohr-Coulomb	20	0	30	1
■	03-Hard clayey silt till	Mohr-Coulomb	21	0	32	1
■	04-Stiff to hard silty clay	Mohr-Coulomb	19	0	30	1

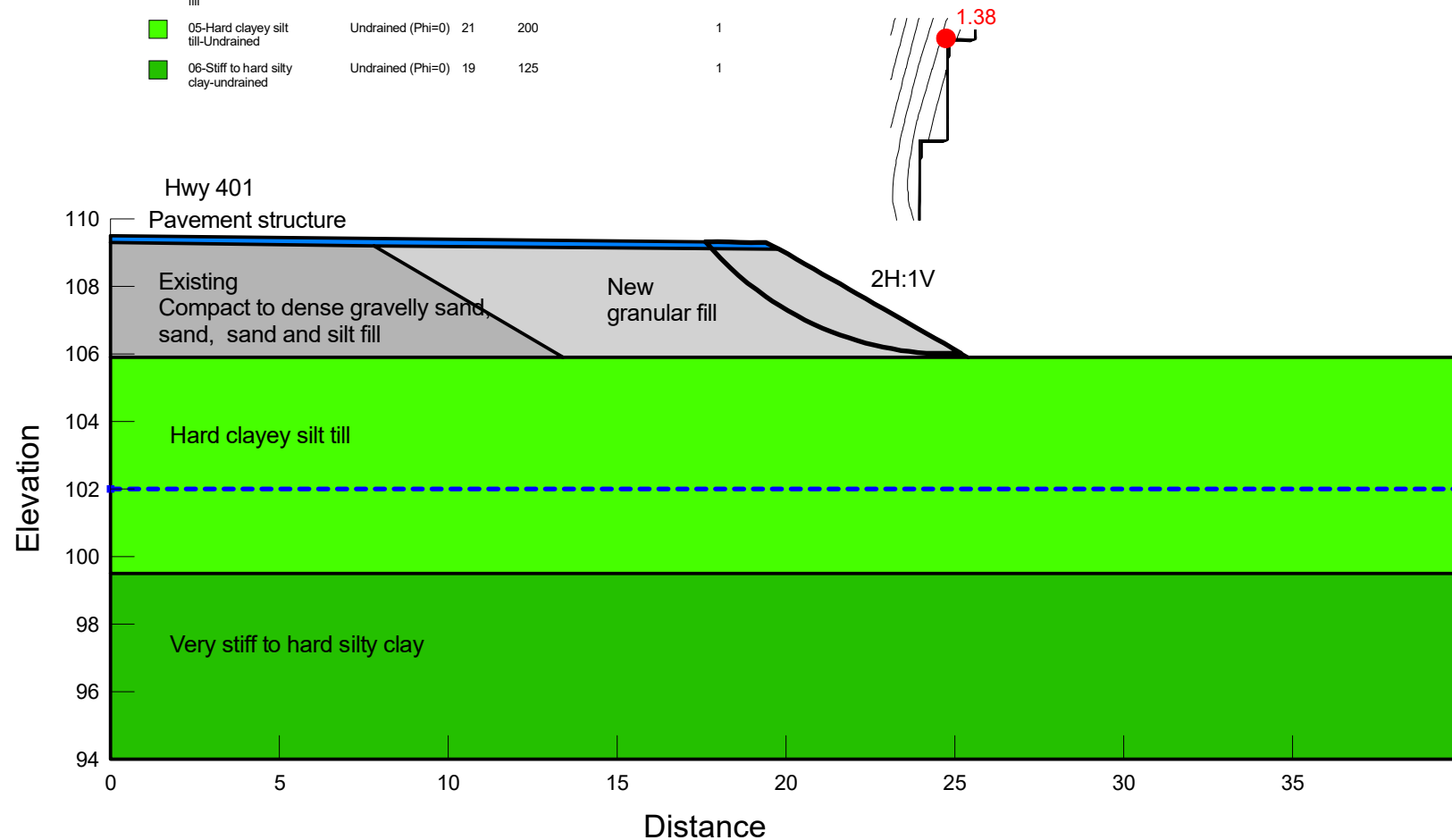


Project 30915- Hwy 401 & Cubert St.- Bridge		
Analysis Drained Analysis - Highway 401 Widening		
Seismic Coefficient H: 0g, V: 0g	Last Run 2024-05-09, 12:32:06 PM	Scale 1:200

Additional Details Name: Hwy 401 & Cubert St. Bridge	GWL- Elevation 102.0
Method: Morgenstern-Price, Half-Sine	

Figure G7

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Total Cohesion (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Surface
	00-Pavement	Mohr-Coulomb	22.8		0	35	1
	01-Granular fill	Mohr-Coulomb	20		0	30	1
	02-Compact to dense gravelly sand, sand and silt fill	Mohr-Coulomb	20		0	30	1
	05-Hard clayey silt till-Undrained	Undrained (Phi=0)	21	200			1
	06-Stiff to hard silty clay-undrained	Undrained (Phi=0)	19	125			1

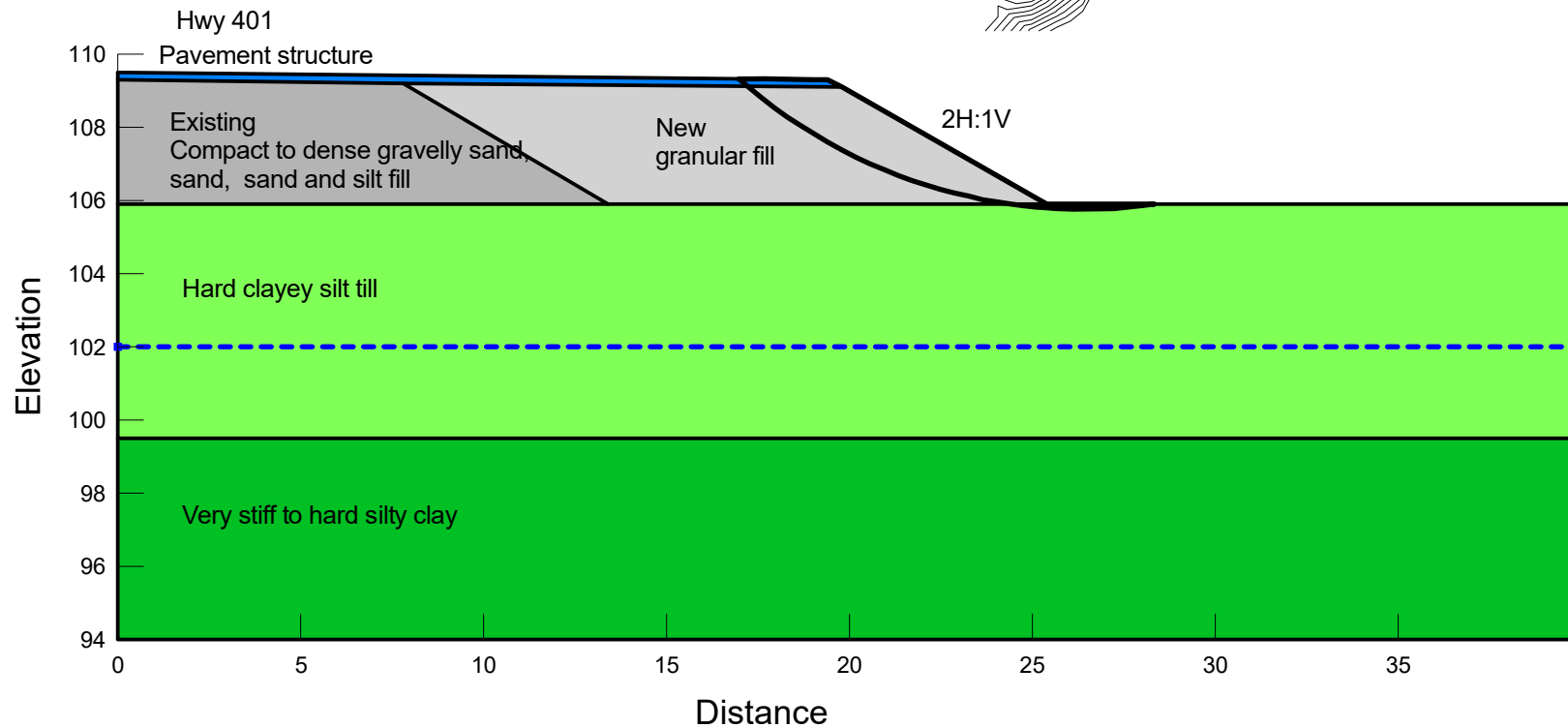
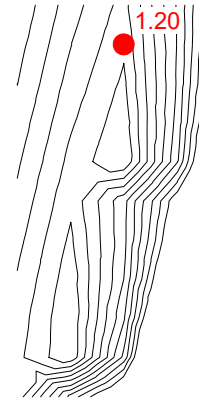


Project 30915- Hwy 401 & Cubert St.- Bridge		
Analysis Undrained Analysis - Highway 401 Widening		
Seismic Coefficient H: 0g, V: 0g	Last Run 2024-05-09,12:32:06 PM	Scale 1:200

Additional Details Name: Hwy 401 & Cubert St. Bridge	GWL- Elevation 102.0
Method: Morgenstern-Price, Half-Sine	

Figure G8






Color	Name	Slope Stability Material Model	Unit Weight (kN/m ³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Surface
■	00-Pavement	Mohr-Coulomb	22.8	0	35	1
■	01-Granular fill	Mohr-Coulomb	20	0	30	1
■	02-Compact to dense gravelly sand, sand and silt fill	Mohr-Coulomb	20	0	30	1
■	03-Hard clayey silt till	Mohr-Coulomb	21	0	32	1
■	04-Stiff to hard silty clay	Mohr-Coulomb	19	0	30	1

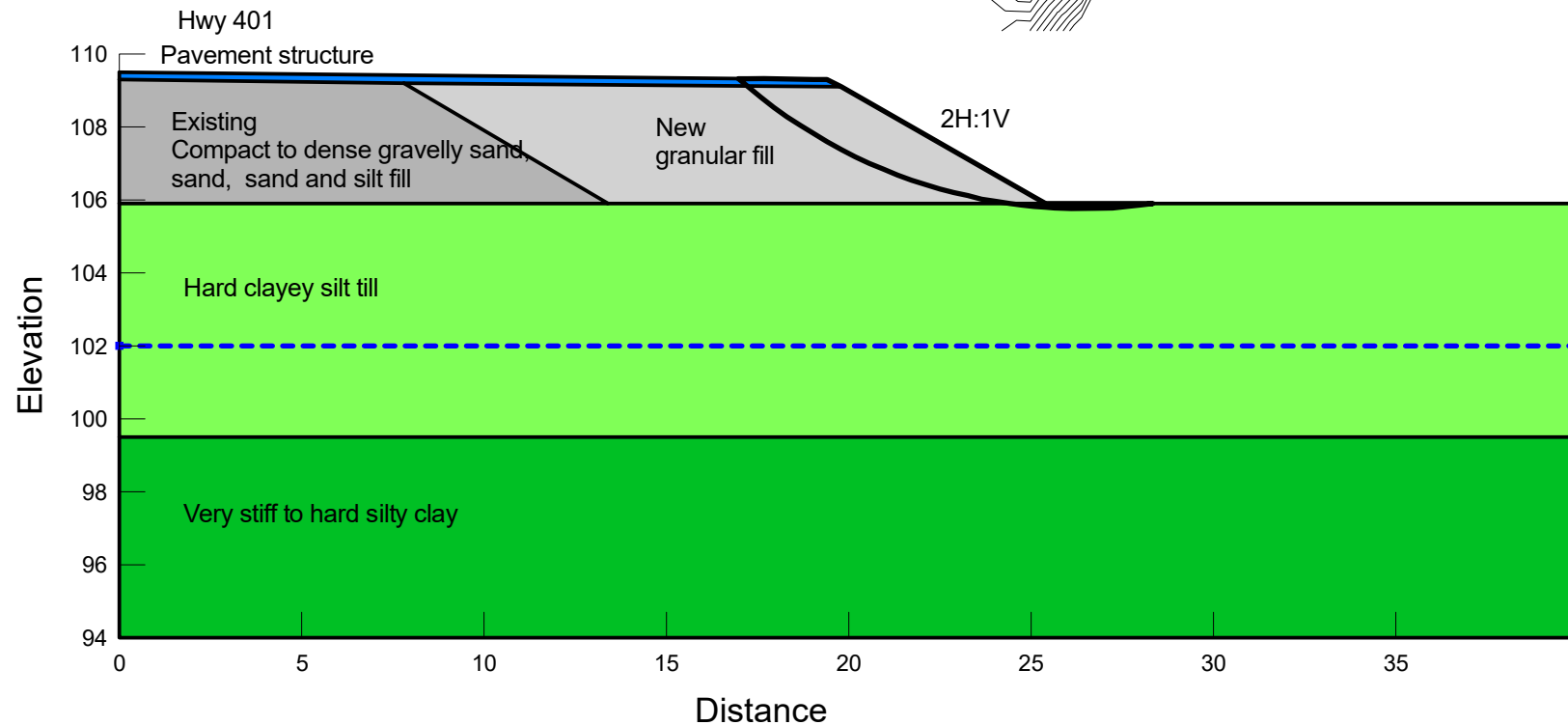
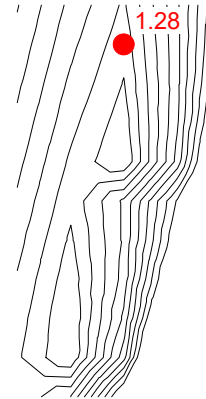



Project 30915- Hwy 401 & Cubert St.- Bridge		
Analysis Seismic Analysis - Highway 401 Widening		
Seismic Coefficient H: 0.0845g, V: 0g	Last Run 2024-05-09, 12:34:34 PM	Scale 1:200

Additional Details Name: Hwy 401 & Cubert St. Bridge	GWL- Elevation 102.0
Method: Morgenstern-Price, Half-Sine	

Figure G9

Color	Name	Slope Stability Material Model	Unit Weight (kN/m ³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Surface
	00-Pavement	Mohr-Coulomb	22.8	0	35	1
	01-Granular fill	Mohr-Coulomb	21	0	32	1
	02-Compact to dense gravelly sand, sand and silt fill	Mohr-Coulomb	20	0	30	1
	03-Hard clayey silt till	Mohr-Coulomb	21	0	32	1
	04-Stiff to hard silty clay	Mohr-Coulomb	19	0	30	1



	Project			Additional Details	
	30915- Hwy 401 & Cubert St.- Bridge			Name: Hwy 401 & Cubert St. Bridge	GWL- Elevation 102.0
	Analysis			Method: Morgenstern-Price, Half-Sine	
	Seismic Coefficient	Last Run	Scale	Figure G10	
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APPENDIX H

OPS Used in the Report and Suggested Wordings for NSSP



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 517 Construction specification for dewatering
- SP 517F01 Amendment to OPSS 517
- OPSS PROV 539 Construction specification for temporary protection systems
- OPSS PROV 804 Construction specification for seed and cover
- OPSS PROV 902 Construction specification for excavating and backfilling – Structures
- NSSP FOUN0003 Amendment to OPSS.PROV 902
- OPSS PROV 903 Construction specification for deep foundations
- OPSS PROV 1010 Material specification for aggregates - base, subbase, select subgrade, and backfill material
- OPSD 3102.100 Wall Abutments, backfill drain
- OPSD 3101.150 Wall Abutment, backfill, minimum granular requirement

2. Suggested Text for NSSP on “Spread Footings”

Along the footing alignments, most probably on the east side, the exposed subgrade at footing level may contain soft to firm soils. Once identified by subgrade inspection, sub-excavation is required to remove these unsuitable materials from below the design founding level and expose the underlying very stiff to hard clayey silt till. The founding surface should be re-established using mass concrete.

The base of the footing excavation should be inspected by a Foundation Engineering Specialist to confirm that the footing subgrade is the native, undisturbed very stiff to hard clayey silt till conforming to the design requirements and has been adequately prepared to receive concrete.



3. Suggested Text for NSSP on “Installation of Caissons”

All caissons shall be installed in accordance with OPSS 903. Very dense/hard glacial tills were encountered at shallow depths at this site. Caisson installation through glacially derived soil deposits may encounter cobbles and/or boulders. The caisson installation equipment shall be capable of dislodging and removing any obstructions, cobbles and boulders within the fill and till deposits, and penetrating the very dense/hard layers. Caisson installation equipment with rock drilling / coring capabilities must be used to penetrate the typically strong limestone for seating the caissons

Construction of caissons will require the use of temporary steel liners to support the caisson sidewalls and to provide seepage cut-off where required. Any accumulated water will need to be pumped out from the hole prior to placing concrete. Concrete shall be placed with a minimum delay after each caisson is drilled, cleaned and inspected. If accumulated water in the caisson hole cannot be removed, tremie techniques shall be used to place concrete inside the caisson hole.

4. Suggested Text for NSSP on Groundwater Control

The foundation excavations are expected to near or just above the current groundwater level. Groundwater control measures such as perimeter ditches and pumping from filtered sumps will need to be employed to remove any accumulation of water from the excavation base prior to placing concrete. In addition to effective sump pumping, other measures of groundwater control including the use of interlocking sheetpiles and well points may be required where the excavations extend below the groundwater table in order to maintain a reasonably dry subgrade for construction. Filtered sumps must be designed properly so that construction drainage water containing eroded soil and fines do not flow onto the existing roadways. It is also important to minimize disturbance of the exposed sand, and sand and silt fill surfaces by limiting construction traffic.

5. 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 401 during excavation and foundation construction at the new abutments.
- Protection of the existing structure foundations, and utilities (if present at this site) during excavation.
- Protection of existing approach fills.