



DRAFT REPORT

FOUNDATION INVESTIGATION AND DESIGN REPORT

**Temporary Cofferdam at Structural Culvert (MTO Site No. 39E-313/C), Highway
634, Township of Adanac, Ontario**

Agreement No. 5015-E-0007

Assignment No. 4

WO. 2016-11040

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Northeastern Region Geotechnical Section

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Temporary Cofferdam at Structural Culvert (MTO Site No. 39E-313/C)
Highway 634, Township of Adanac, Ontario

Project Number:

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1 FOUNDATION INVESTIGATION REPORT

1.1 Introduction

This report presents the results of a geotechnical investigation completed by **exp** Services Inc. for temporary cofferdam design to facilitate lining of an existing Structural Culvert (MTO Site No. 39E-313/C) on Highway 634, approximately 37.8 km north of the Highway 11 junction, in Adanac Township, District of Cochrane. The work was undertaken under Agreement # 5015-E-0007, Assignment No. 4. The terms of reference (TOR) were as presented in MTO letter dated October 3, 2016.

The purpose of the investigation is to determine the existing soil conditions in the vicinity of the existing culvert system in order to construct temporary cofferdams for the purpose of dewatering during the rehabilitation of the culvert. The site specific geotechnical investigation consisted of a field investigation including visual inspections, drilling, soil sampling, and laboratory testing.

Factual results of the investigation and laboratory testing are included in this report. The report has been prepared specifically and solely for the projects described in the report.

1.2 Site Description and Geological Setting

1.2.1 Site Description

The Structural Culvert is located along Hwy 634, at the approximate Station of 30+292.8 (based on the GA drawing provided by the MTO). Hwy 634 is a two lane, north/south roadway with approximately 1 m wide granular shoulders and a wooden guardrail system at the culvert location. The highway crosses above the Structural Culvert with approximately 2.2 m of embankment fill above the culvert crown, and 2.5H:1V sideslopes. The existing Structural Culvert consists of a 3.0 m diameter SPCSP having a total length of approximately 27 m (based on the drawing provided by the MTO). Photographs of the site are included in Appendix A of this report. The culvert location and cross sectional profiles are shown on Drawings 1 and 2 in Appendix B.

During the site reconnaissance on November 10, 2016, the general site conditions were assessed. The existing Creek flows from west to east. Vegetation at the site consists primarily of large pine trees and wild bushes. The inlet of the culvert is generally surrounded by low lying grasses, small shrubs and trees. Embankment protection consisting of old CSP culverts is present immediately adjacent to the culvert inlet. At the outlet, low lying grasses and small shrubs are present immediately adjacent to the culvert.

In general, the slopes of highway embankment are covered with grass and light vegetation. Bedrock outcrops were not observed at the site. The surface of Hwy 634 at the culvert location was in fair shape with a number of localized cracks on the asphalt. No major transverse cracks were observed.

All relevant photographs can be found in Appendix A.

1.2.2 Geological Setting

According the Ministry of Northern Development and Mines, Maps 2555 (Quaternary Geology of Ontario, East-Central Sheet, 1991) and 2543 (Bedrock Geology of Ontario, East-Central Sheet, 1991), the site is located on the border of glaciolacustrine deposits and organic deposits underlain by Metasedimentary bedrock. The glaciolacustrine deposit consists of silt and clay, with minor sand, basin and quiet water deposits. The organic deposit, to the west, consists of peat, muck and marl. The Metasedimentary Rock Group comprises of wacke, siltstone, arkose, argillite, slate, mudstone, marble, chert, iron formation, minor metavolcanic rocks, conglomerate, arenite paragneiss, and migmatites.

1.3 Investigation Procedures

1.3.1 Site Investigation and Field Testing

The field investigation was performed November 10 and 17, 2016. The field program consisted of drilling four (4) sampled boreholes. Boreholes SC3 and SC4 were completed with a track mounted CME-55 drill. Boreholes SC1 and SC2, however, could not be accessed with the drill rig. As such, portable tripod mounted drilling equipment was utilized for these boreholes. These boreholes were located as close as possible to the proposed cofferdam locations shown on figure 1, provided with the TOR. The location details of all four boreholes are summarized on Table 1.1 as follows:

Table 1.1. The summary of borehole investigation information

Borehole No.	Coordination (MTM Zone 12)	Local Ground Surface Elevation (m)	Depth (m)
BH-SC1	5490767.99N, 267872.21E	95.8	8.8
BH-SC2	5490759.02N, 267872.46E	95.3	8.2
BH-SC3	5490760.98N, 267910.09E	95.9	9.8
BH-SC4	5490748.77N, 267907.12E	97.2	9.8

All drilling equipment utilized is owned and operated by Landcore Drilling out of Sudbury, Ontario.

The drilled boreholes were advanced to depths of approximately 8.2 to 9.8 m below ground surface. Drawings 1 and 2 in Appendix B show the locations of all four boreholes and cross-sections of stratigraphy along the existing culvert alignment and the proposed cofferdam location.

The borehole locations (referenced to the MTM NAD83 coordinate system, Zone 12) and their ground surface elevations were surveyed by **exp** personnel following drilling using hand-held GPS equipment. The local, non-geodetic borehole elevations and water elevations were surveyed using a Temporary Benchmark (TBM) established on the top of an existing screw within the existing guardrail. The local non geodetic elevation of TBM (100.3 m) was assumed based on the CAD drawing provided by MTO.

The borehole elevations and locations should be considered accurate only to the degree implied by the methods used.

During the drilling of the boreholes, soil samples were obtained directly from the augers or using a 51 mm outside diameter (O.D.) split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures (ASTM D 1586), at intervals ranging from 0.75 m to 1.5 m in depth as shown on the attached borehole logs (Appendix C). The original field (uncorrected) SPT "N" values were recorded on the borehole logs as recommended in the Canadian Foundation Engineering Manual (Section 4.5.2) and used to provide an assessment of in-situ consistency or compactness condition of the soils. A dynamic cone was advanced to refusal from the portable equipment refusal depth at boreholes SC1 and SC2, to provide an assessment of the in-situ consistency or compactness condition of the soils below the equipment refusal depth. Since the conventional hammer of 63.5 kg was used for sampling done by a portable tripod, the corresponding blow counts were not factored.

Following completion of boreholes, groundwater level measurements were carried out from the boreholes. The drilled boreholes were decommissioned by bentonite/cement mixtures in accordance with the Ministry of the Environment Regulation 903, as amended by Regulation 128/03 (the well regulation under the *Ontario Water Resources Act*).

The fieldwork was supervised by members of **exp's** engineering staff who directed the drilling and sampling operation, logged borehole data in accordance with MTO Soils Classification System for Foundation Investigation Report, and retrieved soil samples for subsequent laboratory testing and identification.

All of the recovered soil samples were placed in labelled moisture-proof bags, and returned to **exp's** Sudbury laboratory for additional visual, textual and olfactory examination. .

1.3.2 Laboratory Testing

All samples returned to the laboratory were subjected to visual examination and classification. The laboratory testing program included the determination of natural moisture content on all samples and particle size distribution for approximately 25% of the collected soil samples. Atterberg limits test were carried out for cohesive soils. All of the laboratory tests were carried out according to MTO and/or ASTM Standards as appropriate.

The laboratory test results are provided on the attached borehole log sheets in Appendix C. The results of the grain size analyses and plasticity chart are presented graphically in Appendix D.

1.3.3 Previous Investigation

No foundation reports are available in the MTO GEOCREST library for this site.

1.4 Subsurface Conditions

The detailed subsurface conditions encountered in the boreholes advanced during this investigation are presented on the borehole log sheets in Appendix C. Laboratory test results are provided in

Appendix D. The “Explanation of Terms Used in Report” preceding the borehole logs in Appendix C forms an integral part of and should be read in conjunction with this report.

A borehole location plan and cross section subsurface profiles are provided in Appendix B. It should be noted that the stratigraphic boundaries indicated on the borehole log and cross section stratigraphic profiles are inferred from semi-continuous sampling, observations of drilling progress and results of Standard Penetration Tests. These boundaries typically represent transitions from one soil type to another and should not be regarded as exact planes of geological change. Furthermore, subsurface conditions may vary between and beyond the borehole locations.

The subsurface conditions along the proposed temporary cofferdam locations varies as inlet and outlet side. In general, a layer organic sandy silt was underlain by clayey silt till at the inlet side, and a layer of silty clay till/ clayey silt till was underlain by silty sand to silt followed by clayey silt till at the outlet side. Bedrock was not encountered at the locations of drilling. A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

1.4.1 Subsurface Condition at Inlet Location

1.4.1.1 Topsoil

A layer of topsoil was encountered at the surface of borehole SC1 and thickness was approximately 100 mm. Topsoil thicknesses may further vary beyond the borehole locations.

1.4.1.2 Organic Sandy Silt

Organic sandy silt was encountered below the topsoil in borehole SC1. It was extended to depth of about 1.5 m below ground surface with elevation about 94.3 m. The explored thickness of this layer was about 1.4 m.

The organic sandy silt contained some rootlets and some clay. The soil was brown in colour and wet. Two SPT tests were performed within the soil, each resulting in “N” values of 1 blow per 300 mm, classifying the soil as very loose in compactness condition.

Laboratory testing performed on selected samples consisted of two (2) moisture content tests and one (1) particle size analysis. An Atterberg Limits test was attempted but could not be completed due to the silt content of the sample. The test results are as follows:

Moisture Content:

- 47.7% to 79.7%

Grain Size Distribution:

- 0% gravel
- 27% sand
- 61% silt, and

- 12% clay

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution test are also provided on Figure 1 in Appendix D.

1.4.1.3 Clayey Silt Till

A layer of clayey silt till was encountered below organic sandy silt and at surface of boreholes SC1 and SC2, respectively. The clayey silt till layer extended to depths ranging between 8.2 m and 8.8 m below ground surface with elevations ranging between 87.0 m to 87.1 m. The explored thickness of this layer was between 7.3 m and 8.2 m. Sampling of these boreholes were terminated at depth of about 7.0 m below ground surface on the portable equipment refusal, possibly encountered boulder. The layer below the portable equipment refusal was inferred to clayey silt till by advancing the dynamic cone. Boreholes SC1 and SC2 were terminated within this layer

The native clayey silt till contained silt and clay, trace to some sand, trace gravel and was brown to grey in color, and moist to wet. The SPT “N” values within the clayey silt till ranged from 5 to 49 blows per 300 mm, classifying the soil as firm to hard but generally very stiff to hard in consistency. The dynamic cone penetration values within this layer ranged from 35 to 94 blows per 300 mm, classifying the soil as hard in consistency.

Laboratory testing performed on a selected samples consisted of twelve (12) moisture content tests, three (3) particle size analyses, and three (3) Atterberg Limits tests. The test results are as follows:

Moisture Content:

- 12.7% to 18.7%

Grain Size Distribution:

- 0% to 1% gravel
- 6% to 9% sand
- 68% to 70% silt; and
- 22% to 25% clay

Atterberg Limits:

- Liquid Limit: 22% to 25%
- Plastic Limit: 15% to 16%
- Plasticity Index: 7% to 9%

The results of the moisture content, grain size distribution and Atterberg limit tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution test are also provided on Figures 2 in Appendix D. The results of the Atterberg Limits tests are provided on Figure 5 in Appendix D.

1.4.2 Subsurface Condition at Outlet Location

1.4.2.1 Topsoil

A layer of topsoil was encountered at the surface of boreholes SC3 and SC4 and ranged in thickness from approximately 100 to 150 mm. Topsoil thicknesses may further vary beyond the borehole locations.

1.4.2.2 Silty Clay Till

A layer of silty clay till was encountered below the topsoil in borehole SC3. It was extended to depth of about 0.8 m below ground surface with elevation about 95.1 m. The explored thickness of this layer was about 0.7 m.

The silty clay till contained silt, clay and trace to some sand. The soil was brown in color and moist to wet. Laboratory testing performed on a selected samples consisted of one (1) moisture content test. The test result is as follows:

Moisture Content:

- 29.9%

The results of the moisture content is provided on the record of borehole sheets in Appendix C.

1.4.2.3 Silty Sand

A silty sand layer was encountered below silty clay till and clayey silt till of boreholes SC3 and SC4, respectively. This layer further extended below silt layer in borehole SC3. The silty sand layer extended to depths ranging between 1.5 m to 6.1 m below ground surface with elevations ranging between 94.4 m to 91.1 m. The lower silty sand layer encountered in borehole SC3 was extended to depth of about 4.6 m below ground surface with elevation about 91.3 m. The explored thickness of this layer was between 0.7 m to 2.3 m.

The silty sand contained some gravel and trace to some clay. The silty sand was brown to grey in colour and wet. The SPT "N" values within the silty sand ranged from 5 to 31 blows per 300 mm, classifying the soil as loose to dense in compactness condition.

Laboratory testing performed on a selected samples consisted of four (4) moisture content tests. The test results are as follows:

Moisture Content:

- 11.8% to 34.0%

The results of the moisture content tests are provided on the record of borehole sheets in Appendix C.

1.4.2.4 Silt

A layer of silt was encountered between the silty sand layer in borehole SC3. This layer extended to depth of about 2.3 m below ground surface with elevation about 93.6 m. The explored thickness of this layer was about 0.7 m.

The silt was grey in colour, wet, and contained some clay and trace sand. One SPT performed within the silt resulted in an “N” value of 8 blows per 300 mm, classifying the silt as loose in compactness condition.

Laboratory testing performed on a sample of the silt consisted of one (1) moisture content test, one (1) particle size analysis, and one (1) Atterberg Limits test. The test results are as follows:

Moisture Content:

- 16.7%

Grain Size Distribution:

- 0% gravel
- 9% sand
- 76% silt; and
- 15% clay

Atterberg Limits:

- Liquid Limit: 19.0%
- Plastic Limit: 16%
- Plasticity Index: 3%

The results of the moisture content, grain size distribution and Atterberg limit tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution and Atterberg limit tests are also provided on Figure 3 and 6, respectively in Appendix D.

1.4.2.5 Clayey Silt Till

A layer of clayey silt till was encountered below silty sand topsoil of boreholes SC3 and SC4, respectively. This layer further extended below silty sand layer in borehole SC4. The clayey silt till layer extended to depths ranging between 4.6 m to 9.8 m with elevations ranging between 86.1 m to 92.6 m. The lower clayey silt till layer encountered in borehole SC4 was extended to depth of about 9.8 m with elevation 87.4 m. The explored thickness of this layer was between 3.7 m to 5.2 m. Boreholes SC3 and SC4 were terminated within this layer.

The native clayey silt till contained silt and clay, trace to some sand, trace gravel and was brown to grey in color, and moist to wet. The SPT “N” values within the clayey silt till ranged from 3 to 42 blows per 300 mm, classifying the soil as soft to hard but generally very stiff to hard in consistency.

Laboratory testing performed on a selected samples consisted of twelve (12) moisture content tests, three (3) particle size analyses, and three (3) Atterberg Limits tests. The test results are as follows:

Moisture Content:

- 12.3% to 21.6%

Grain Size Distribution:

- 0% to 1% gravel
- 8% to 9% sand
- 62% to 72% silt; and
- 20% to 29% clay

Atterberg Limits:

- Liquid Limit: 22% to 26%
- Plastic Limit: 15% to 16%
- Plasticity Index: 6% to 10%

The results of the moisture content, grain size distribution and Atterberg limit tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution test and Atterberg limit test are also provided on Figures 2 and 5 in Appendix D.

1.5 Groundwater Conditions

The Information regarding groundwater levels at the site was obtained by measuring the water levels in the open boreholes after completion. At boreholes SC3 and SC4, groundwater was observed at approximately 3.7 m and 6.1 m depth, respectively (Elev. 92.2 m and 91.1 m). The portable equipment at boreholes SC1 and SC2 were not left open for any significant length of time, and as such, groundwater levels were not able to stabilize within the fine grained soils encountered. As such, no groundwater was observed within boreholes SC1 and SC2.

At the time of the investigation, the water level at the existing creek was approximately at Elev. 95.4 m. Seasonal variations in the water table should be expected, with higher levels occurring during wetter periods of the year and lower levels during drier periods.

2 ENGINEERING DISCUSSION & RECOMMENDATIONS

2.1 General

This section of the report provides engineering recommendations on the foundation aspects of design of the temporary cofferdam to facilitate lining of an existing Structural Culvert (MTO Site No. 39E-313/C) on Highway 634, approximately 37.8 km north of the Highway 11 junction, in Adanac Township, District of Cochrane, Ontario, the Ministry of Transportation (MTO) Northeastern Region. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the current investigation at the site and presented in **Part I-Foundation Investigation Report**. The interpretation and recommendations provided are intended solely to permit designers design a temporary cofferdam. Comments on construction are only provided to highlight issues that could affect the design. Contractors bidding on the works should make their own assessments of the factual data and how it might affect construction means and methods, scheduling and the like.

This report provides geotechnical parameters that may be required for the design of the temporary cofferdam in accordance with the latest edition of the *Canadian Highway Bridge Design Code (CHBDC)* (CAN/CSA-S6-14), the *Guideline for Professional Engineers Providing Geotechnical Engineering Service* (1992), the *Canadian Foundation Engineering Manual (CFEM)* (2006), the *provisions in the TOR* and good practice.

2.2 Expected Ground Conditions

It is understood that the existing structural culvert will be lined. In order to facilitate lining, a temporary cofferdam will be required to dewater the site. The proposed locations of the temporary cofferdam were indicated in the GA drawings provided with TOR.

The following ground conditions along the proposed cofferdams are evident from the subsurface investigation at this site:

- a) Hwy 634 is a two lane, north/south roadway with approximately 1 m wide granular shoulders and a wooden guardrail system at the culvert location. The highway crosses above the Structural Culvert with approximately 2.2 m of embankment fill above the culvert, and 2.5H:1V sideslopes. The current elevation of the crest of the roadway is about 100.2 m.
- b) At the inlet side, underlying organic sandy silt (SC1, 1.4 m thick) or at surface firm to hard clayey silt till (5.5 m to 7.0 m thick) was encountered. The portable drilling equipment refusal was encountered at the depth of 7.0 m in both boreholes SC1 and SC2, possibly encountered boulder. The dynamic cone was advanced further from the portable equipment refusal and the layer inferred as clayey silt till (1.2 m to 1.8 m thick). Boreholes SC1 and SC2 were terminated within this layer due to DCPT refusal at a depth of 8.8 m and 8.2 m below ground surface, respectively.
- c) At the outlet side, native silty clay till (SC3, 0.7 m thick)/ clayey silt till (SC4, 4.4 m thick) was underlain by silty sand to silt (1.5 m to 3.8 m thick) followed by clayey silt till (3.7 m to 5.2 m). Boreholes SC3 and SC4 were terminated within this layer.

- d) The water level in the creek was approximately at Elevation 95.4 m. However, seasonal variations in the water table should be expected, with higher levels occurring during wetter periods of the year (such as spring thaw and late fall) and lower level during drier periods.

2.3 Temporary Cofferdam

Temporary cofferdams will be required at both upstream and downstream ends to envelop the construction site and keep it free of water during lining of existing structural culvert. The proposed locations of the temporary cofferdam were indicated in Figure 1 provided with TOR. Two types of cofferdams, i) sheet pile wall and ii) rockfill dam, could be considered.

Based on the geotechnical conditions, suitably designed steel sheet pile walls can be used as cofferdams at this site. Sheet piles perpendicular to the highway at least 3 m into the embankment slopes should be considered to prevent water getting in through the sides. If a cantilever system is used, an embedded depth of sheet piles can be approximately 2.0 to 2.5 times of its exposed height. The proposed sheet pile wall should be at least one meter above the HWL. The required minimum section modulus and embedment pile length should be designed based on the recommended design parameters. Cobbles and boulders were noted to be contained within the glacial till, therefore care has to be taken during installation of sheet piles. A Non-Standard Special Provision (NSSP) should be included in the Contract to alert the contractor the cobbles and boulders may present within the glacial till in the selection of the appropriate equipment and procedures for piling. An example of NSSP is included in Appendix E.

Alternatively, a rockfill cofferdam can be used. This cofferdam will have to be constructed to the same topographic constraints as the sheet pile cofferdam, i.e. at each end of the existing culvert and, if necessary, adjacent to it due to the river diversion. The size of material suitable for use depends on the erosion potential, stream flow velocity, etc. The rockfill cofferdam should be designed with a more impervious water barrier at the outside face to create a more watertight enclosure. Schemes involving 2-inch minus crusher run with finer facing material upstream have been successfully used in similar settings. Any required permitting must be determined.

As mentioned, which cofferdam system is best suited depends on many technical and economic factors. The advantages and disadvantages of both cofferdam systems are summarized in Table 2.1. Given the soil conditions, topography of the surrounding terrain and available space, the use of a suitably designed steel sheet pile system of sufficiently robust cross-section is recommended for the inlet and outlet of structural culvert. However, the presence of cobbles and boulders has to be considered. The design of these cofferdams, which are temporary retaining structures is the responsibility of the Contractor. The cofferdam must be designed to withstand the anticipated design loads and to be watertight as practically possible. The Contractor is also responsible for cofferdam's materials, construction, monitoring and removal.

Table 2.1 Comparison of cofferdam systems

Option	Rank	Advantages	Disadvantages	Relative Cost	Risk/Consequence
Steel sheet piles	1	<ul style="list-style-type: none"> Provides more watertight base Structural elements and seals easier to positively construct Increased safety with appropriate design Easily removed Less seepage Reusable 	<ul style="list-style-type: none"> More costly More likely time consuming for installation May present issues for seepage and/or piping Larger machines required May require bracing May face difficulty driving through the glacial till because of presence of cobbles and boulders May require strengthening toe of sheet pile 	MEDIUM TO HIGH	<ul style="list-style-type: none"> Possible piping problem May take longer to install Difficulties in driving sheet piles due to presence of cobbles and boulders Environmental permits
Rockfill	2	<ul style="list-style-type: none"> Less costly Relatively less time consuming for installation Native material can be usable Not affected by presence of cobbles and boulders 	<ul style="list-style-type: none"> Require more space for installation Less safe Subjected to wave erosion Less watertight Prone to land shifts, slides and collapse More likely time consuming to remove 	LOW TO MEDIUM	<ul style="list-style-type: none"> Less stable and safe. May generate 'mud waves' May take longer to remove May require to install clay cutoff More dewatering Environmental permits

As can be seen in the table, the steel sheet piling is ranked as more practical for this project, noting the possible presence of cobbles and boulders in the till. Design and construction specification for the chosen temporary cofferdam system should be prepared in accordance with OPSS 539 by the

Contractor. Pilling should be in accordance with OPSS 903. Cantilevered walls should be designed for the earth pressures shown in Section 2.4 and earth pressure diagram shown in CFEM Figure 26.3. Besides design and construction of the temporary cofferdam system, the Contractor is also responsible for its materials, maintenance, monitoring and removal. The temporary cofferdam shall be fully removed, unless it is specified in the Contract Documents that the cofferdam system may be partially left in place. The method and sequence of removal shall be so that there shall be no damage to the new work, existing work, and facility being protected.

2.3.1 Dewatering

It is understood that number of bypass pumps, across the highway, are proposed to be used for dewatering behind the cofferdams at the construction side.

Dewatering requirements behind the cofferdams to keep the construction site dry will be impacted by water levels in the creek at the time of construction activities. Dewatering shall be carried out in accordance with OPSS 517 and OPSS 518. It is responsibility of the Contractor to propose a suitable dewatering system based on the time of construction, water levels and creek flow conditions for prior approval of the MTO. The method used should not undermine the existing culvert, highway embankment or adjacent side slopes. In this connection the provision of toe protection at side slopes during drawdown may be required to minimize sloughing and undercutting during dewatering.

2.3.2 Piping

Since the sheet piles will be embedded partially into pervious materials (silt and sand) piping might occur when an unbalanced hydrostatic head causes large upward seepage pressures in the soil at the bottom of the inside cofferdam. Piping should be controlled by lowering the water table outside the cofferdam or driving the sheeting to sufficient depth to mitigate against piping.

2.4 Lateral Pressure

Temporary cofferdam system, which is temporary retaining structure, should properly designed so that the lateral movement of any portion of the protection system will not exceed the established criterion for the structural performance level. In this case, Performance Level 2 would be required (OPSS 539). The shoring system should be designed by a Professional Engineer, experienced in this type of work and employed by the contractor.

The expression for calculating lateral earth pressure is given by:

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

where

P = earth pressure intensity at depth h, kPa

K = earth pressure coefficient

γ = unit weight of retained soil/ water, kN/m³

q = surcharge near wall, kPa

h = depth to point of interest, m

For design purposes, the following parameters given in Table 2.2 can be assumed after installation of retaining system.

Table 2.2 Soil parameters and lateral earth pressure coefficient information required for temporary cofferdam design

Unit	Elevation (m)	Materials	Unit Weight γ (kN/m ³)	Unfactored Internal Angle of Friction (ϕ')	GWL/ Creek Water Elevation (m)	Coefficient of Lateral Earth Pressure		
						K_a	K_p	K_o
Inlet	95.4 – 94.0	Very loose organic sandy silt/ firm to very stiff clayey silt till	19	27	95.4	0.38	2.66	0.55
	94.0 – 87.0	Very stiff to hard clayey silt till	21	32		0.31	3.25	0.47
Outlet	97.0 – 95.1	Silty clay till/ soft to stiff clayey silt till	20	30		0.33	3.0	0.5
	95.1 to 93.6	Loose silty sand to silt	19	28		0.36	2.8	0.53
	93.6 – 91.1	Compact silty sand	20	30		0.33	3.0	0.5
	91.1 – 86.1	Very stiff to hard clayey silt till	21	32		0.31	3.25	0.47

K_a = active earth pressure coefficient

K_o = coefficient of earth pressure at rest

K_p = passive earth pressure coefficient

3 CLOSURE

The recommendations made in this report are in accordance with our present understanding of the project and are provided solely for the team responsible for the design of the works described herein.

We recommend that we be retained to review our recommendations as the design nears completion to ensure that the final design is in agreement with the assumptions on which our recommendations are based and that our recommendations have been interpreted as intended. If not accorded this review, exp will assume no responsibility for the interpretation and use of the recommendations in this report.

A subsurface investigation is a limited sampling of a site; the subsurface conditions have been established only at the test hole locations. Should conditions at the site be encountered which differ from those reported at the test locations, we require that we be notified immediately in order to assess this additional information and our recommendations, as appropriate. It may then be necessary to perform additional investigation and analysis.

Contractors bidding on or undertaking any proposed work at this site should, relative to the subsurface conditions, decide on their own investigations, if deemed necessary, as well as their own interpretations of the factual results provided herein, so they may draw their own conclusions as to how the subsurface conditions may affect them.

This Foundation Investigation and Design Report has been prepared by Nimesh Tamrakar, M.Eng, EIT., Ian MacMillan, P.Eng. and Silvana Micic, Ph.D., P.Eng. It was reviewed by TaeChul Kim, M.E.Sc., P.Eng. and by Stan E. Gonsalves, M.Eng., P.Eng., Designated MTO Foundation Contact. The field investigation was supervised by Shane Tobias.

exp Services Inc.

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Principal Engineer
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4 LIMITATIONS AND USE OF REPORT

BASIS OF REPORT

This report ("Report") is based on site conditions known or inferred by the geotechnical investigation undertaken as of the date of the Report. Should changes occur which potentially impact the geotechnical condition of the site, or if construction is implemented more than one year following the date of the Report, the recommendations of exp may require re-evaluation.

The Report is provided solely for the guidance of design engineers and on the assumption that the design will be in accordance with applicable codes and standards. Any changes in the design features which potentially impact the geotechnical analyses or issues concerning the geotechnical aspects of applicable codes and standards will necessitate a review of the design by exp. Additional field work and reporting may also be required.

Where applicable, recommended field services are the minimum necessary to ascertain that construction is being carried out in general conformity with building code guidelines, generally accepted practices and exp's recommendations. Any reduction in the level of services recommended will result in exp providing qualified opinions regarding the adequacy of the work. exp can assist design professionals or contractors retained by the Client to review applicable plans, drawings, and specifications as they relate to the Report or to conduct field reviews during construction.

Contractors contemplating work on the site are responsible for conducting an independent investigation and interpretation of the borehole results contained in the Report. The number of boreholes necessary to determine the localized underground conditions as they impact construction costs, techniques, sequencing, equipment and scheduling may be greater than those carried out for the purpose of the Report.

Classification and identification of soils, rocks, geological units, contaminant materials, building envelopment assessments, and engineering estimates are based on investigations performed in accordance with the standard of care set out below and require the exercise of judgment. As a result, even comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations or building envelope descriptions involve an inherent risk that some conditions will not be detected. All documents or records summarizing investigations are based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated. Some conditions are subject to change over time. The Report presents the conditions at the sampled points at the time of sampling. Where special concerns exist, or the Client has special considerations or requirements, these should be disclosed to exp to allow for additional or special investigations to be undertaken not otherwise within the scope of investigation conducted for the purpose of the Report.

RELIANCE ON INFORMATION PROVIDED

The evaluation and conclusions contained in the Report are based on conditions in evidence at the time of site inspections and information provided to exp by the Client and others. The Report has been prepared for the specific site, development, building, design or building assessment objectives and purpose as communicated by the Client. exp has relied in good faith upon such representations, information and instructions and accepts no responsibility for any deficiency, misstatement or

inaccuracy contained in the Report as a result of any misstatements, omissions, misrepresentation or fraudulent acts of persons providing information. Unless specifically stated otherwise, the applicability and reliability of the findings, recommendations, suggestions or opinions expressed in the Report are only valid to the extent that there has been no material alteration to or variation from any of the information provided to exp.

STANDARD OF CARE

The Report has been prepared in a manner consistent with the degree of care and skill exercised by engineering consultants currently practicing under similar circumstances and locale. No other warranty, expressed or implied, is made. Unless specifically stated otherwise, the Report does not contain environmental consulting advice.

COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment form part of the Report. This material includes, but is not limited to, the terms of reference given to exp by its client ("Client"), communications between exp and the Client, other reports, proposals or documents prepared by exp for the Client in connection with the site described in the Report. In order to properly understand the suggestions, recommendations and opinions expressed in the Report, reference must be made to the Report in its entirety. exp is not responsible for use by any party of portions of the Report.

USE OF REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. No other party may use or rely upon the Report in whole or in part without the written consent of exp. Any use of the Report, or any portion of the Report, by a third party are the sole responsibility of such third party. exp is not responsible for damages suffered by any third party resulting from unauthorised use of the Report.

REPORT FORMAT

Where exp has submitted both electronic file and a hard copy of the Report, or any document forming part of the Report, only the signed and sealed hard copy shall be the original documents for record and working purposes. In the event of a dispute or discrepancy, the hard copy shall govern. Electronic files transmitted by exp have utilize specific software and hardware systems. exp makes no representation about the compatibility of these files with the Client's current or future software and hardware systems. Regardless of format, the documents described herein are exp's instruments of professional service and shall not be altered without the written consent of exp.

Appendix A – Site Photographs



Photo 1. Inlet side of Structural Culvert System (facing west) on November 10, 2016



Photo 2. Outlet side of Structural Culvert (facing east) on November 10, 2016



Photo 3. Inlet side of Structural Culvert (facing south) on November 10, 2016



Photo 4. Outlet side of Structural Culvert (facing south-west) on November 10, 2016

Appendix B – Drawings

DRAFT

METRIC

DIMENSIONS ARE IN METERS AND/OR
MILLIMETERS UNLESS OTHERWISE SHOWN.
STATIONS ARE IN KILOMETERS +METERS

Agreement No. 5015-E-0007
Assignment No. 4

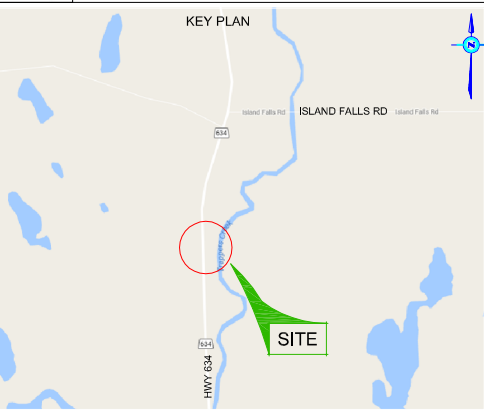


TEMPORARY COFFERDAM AT STRUCTURAL
CULVERT/ HWY 634
BOREHOLE LOCATION PLAN AND SOIL STRATA

SHEET



exp Services Inc.



LEGEND

- Location of Drilled Boreholes
- Standard Penetration Test (Blows/0.3 m)
- Water Level Upon Completion of Drilling
- Temporary Bench Mark (EL. 100.3m)

SOIL STRATA SYMBOLS

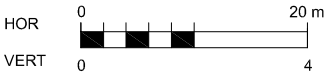
- TOPSOIL
- CLAYEY SILT TILL/
SILTY CLAY TILL
- SILT
- SILTY SAND
- ORGANIC SANDY SILT

BH No.	APPROX. ELEV.	MTM CO-ORDINATES	
		NORTH	EAST
SC 1	95.83	5490767.993	267872.214
SC 2	95.31	5490759.016	267872.459
SC 3	95.88	5490760.985	267910.096
SC 4	97.18	5490748.772	267907.119
TBM	100.3	5490754.572	267884.659

NOTE

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents

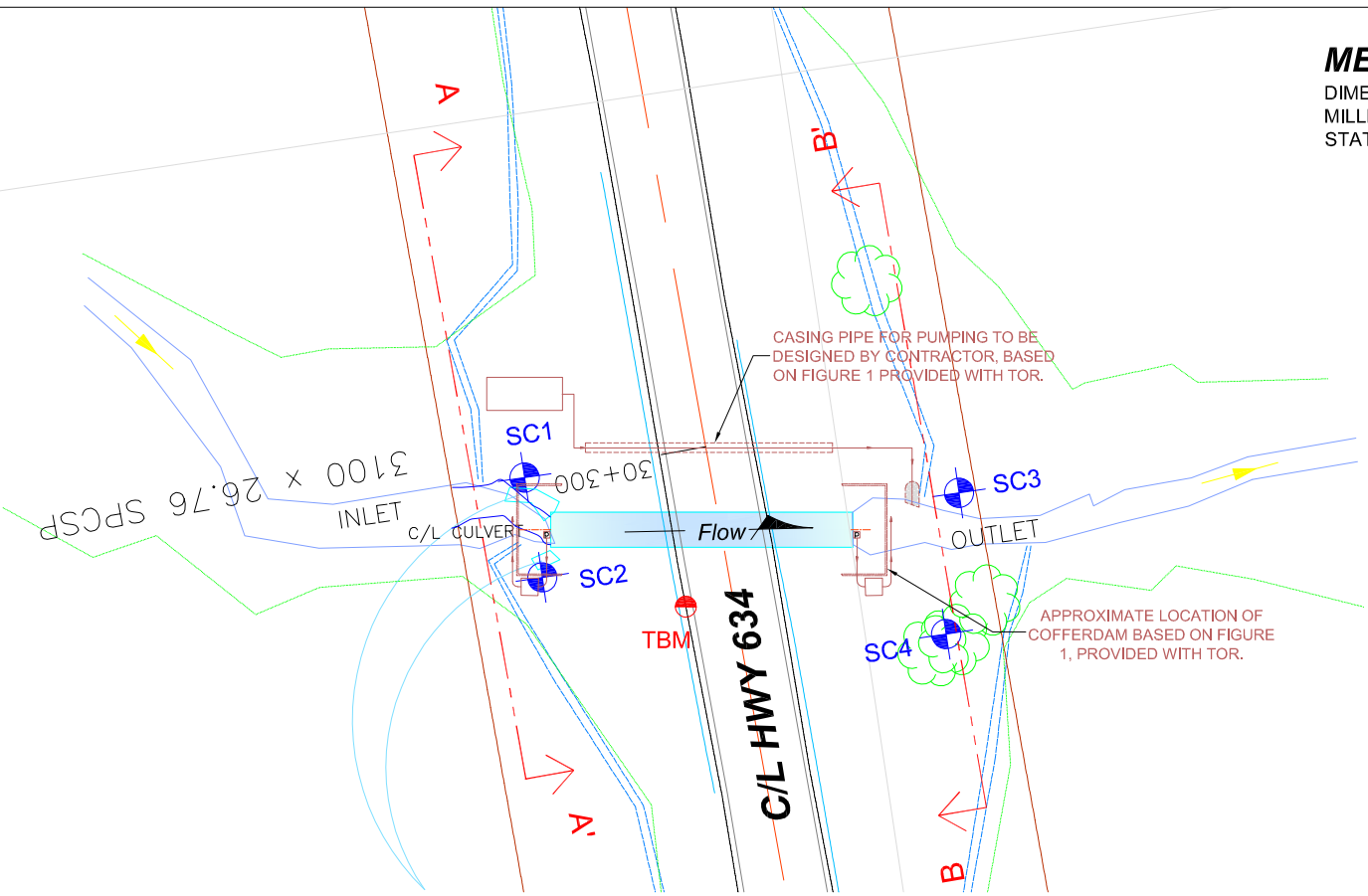
The complete foundation investigation and design report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in the report and related documents are specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen. Cond.



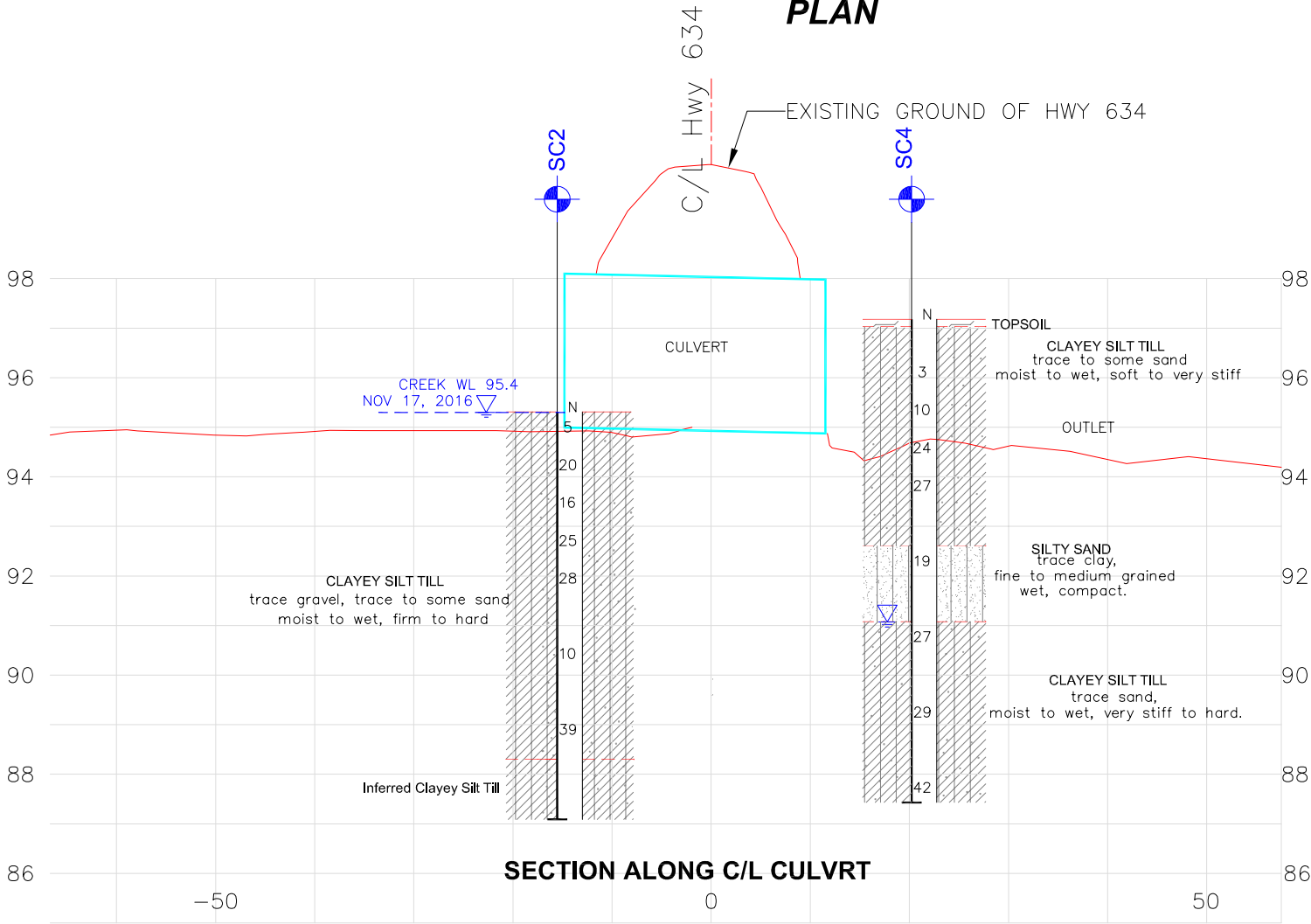
12/12/2016	SM	SUBMISSION FOR MTO REVIEW	
DATE	BY	DESCRIPTION	
		GEOCRES NO.	
		PROJECT NO. ADM-00233185-D0	
SUBM'D SM	CHECKED SM	DATE	12/12/2016
DRAWN SH	CHECKED SG	APPROVED SG	DWG. 1

008 06 N

DISTRICT COCHRANE
TWP ADANAC
(UNSUBDIVIDED)

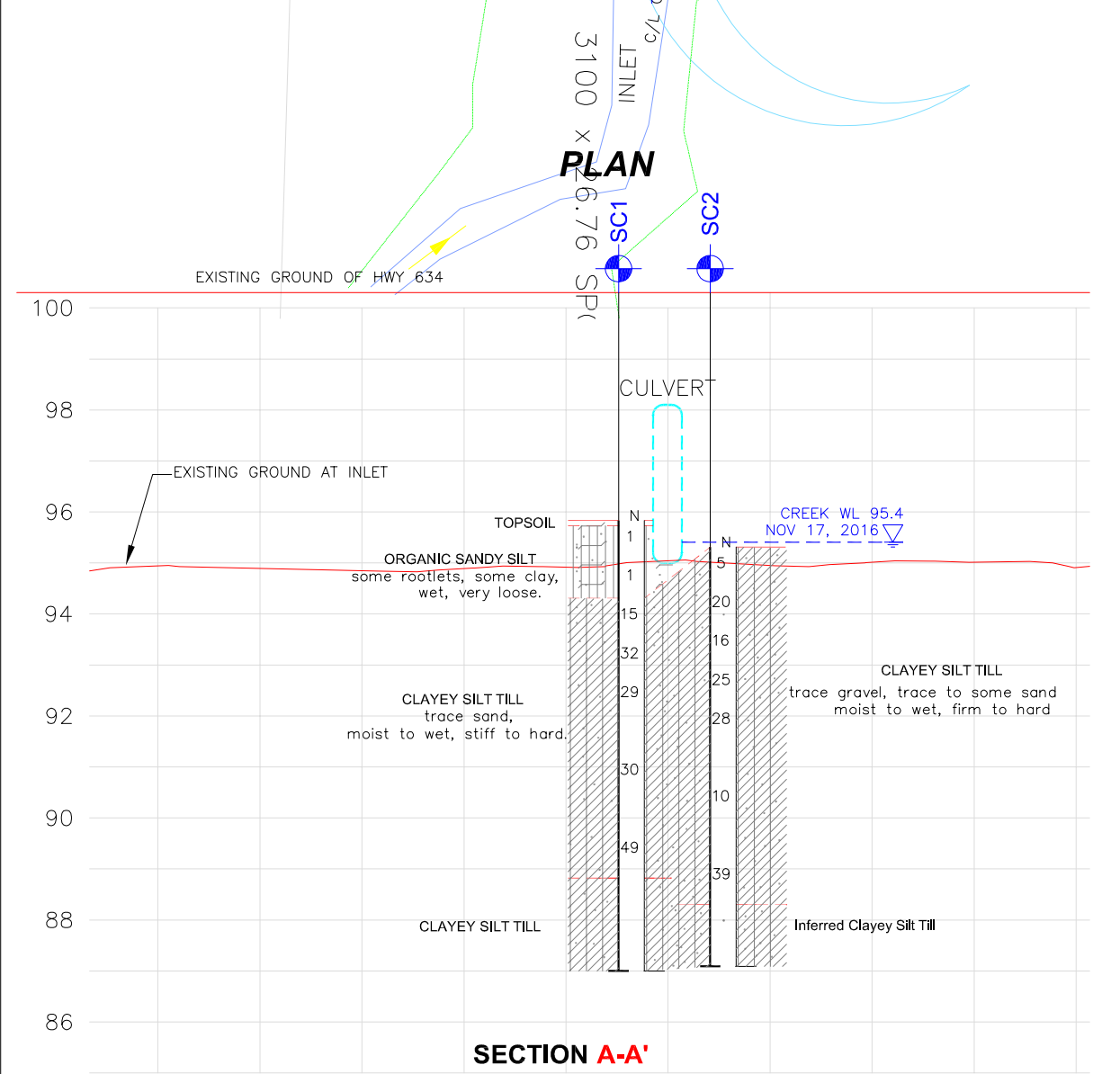
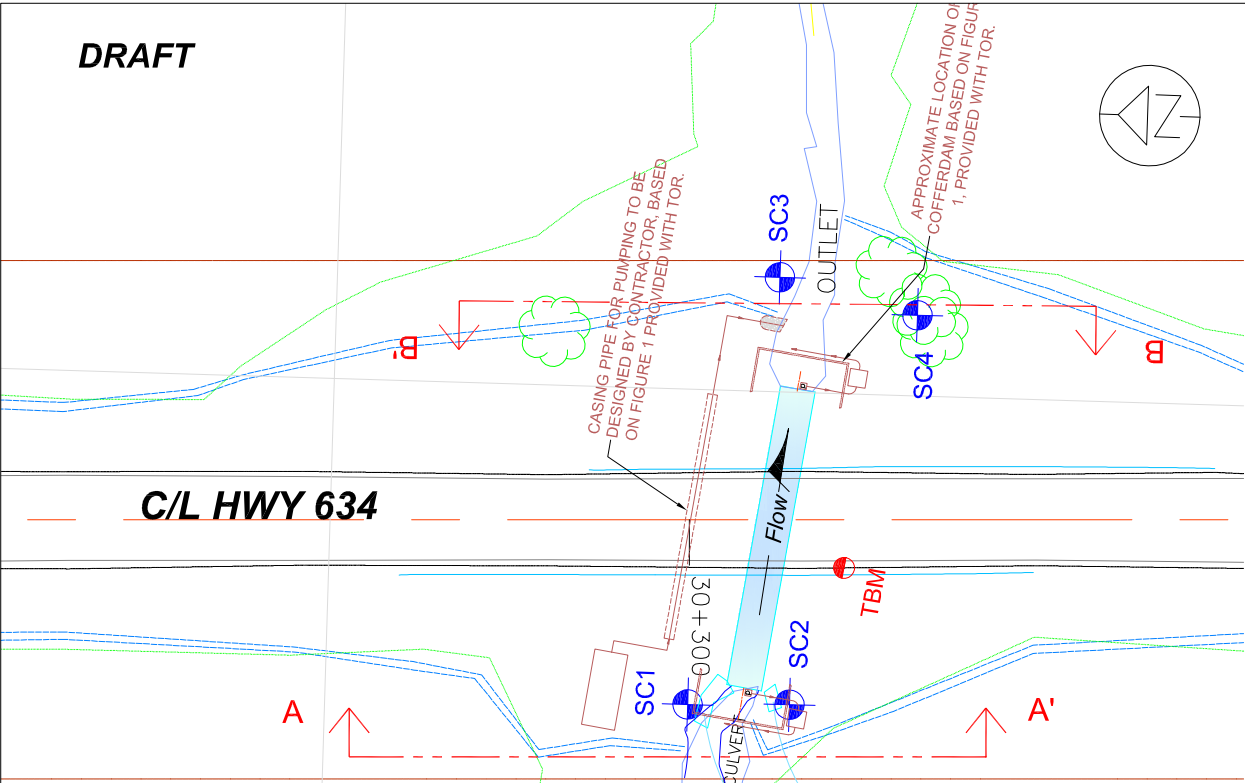


PLAN

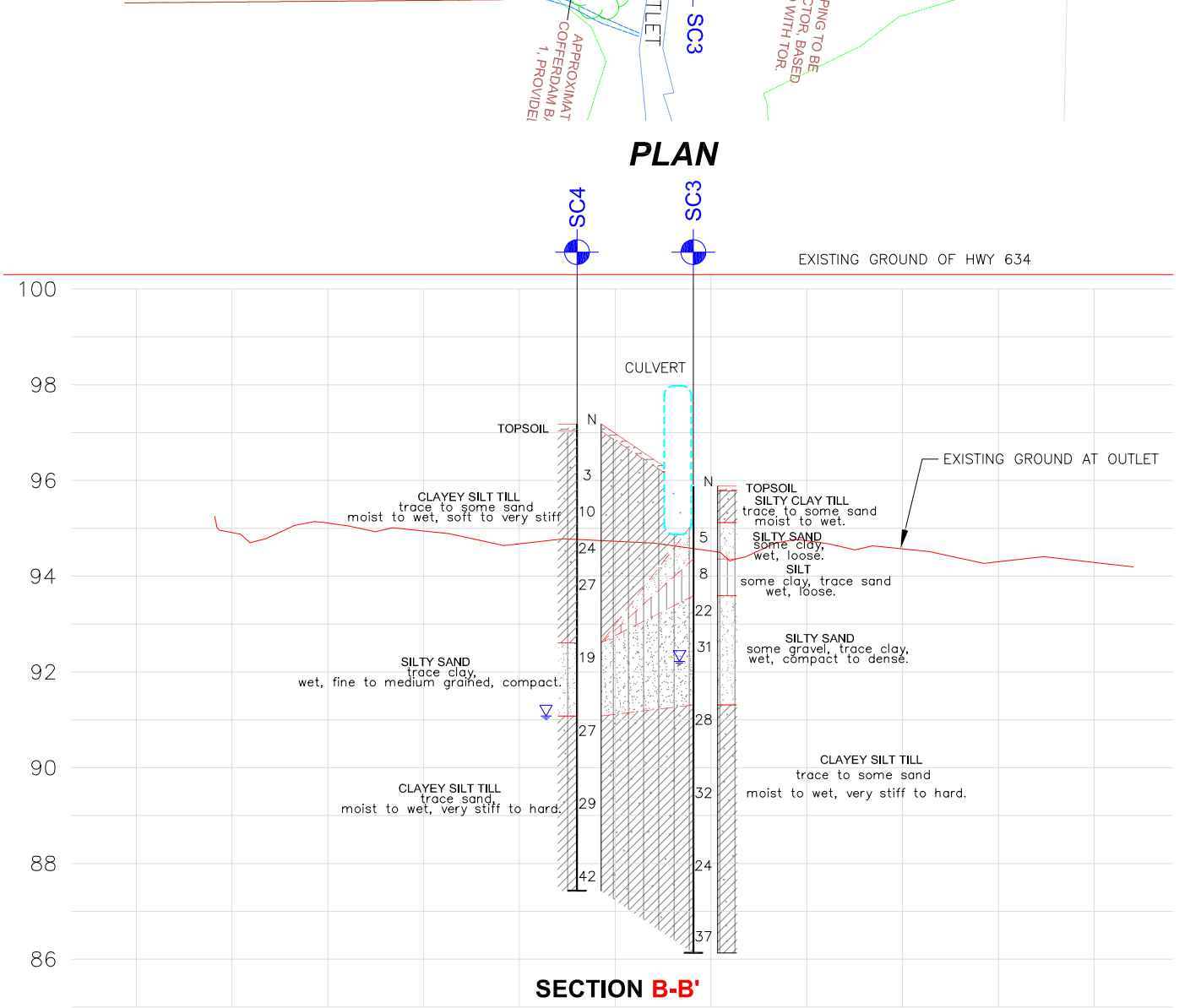
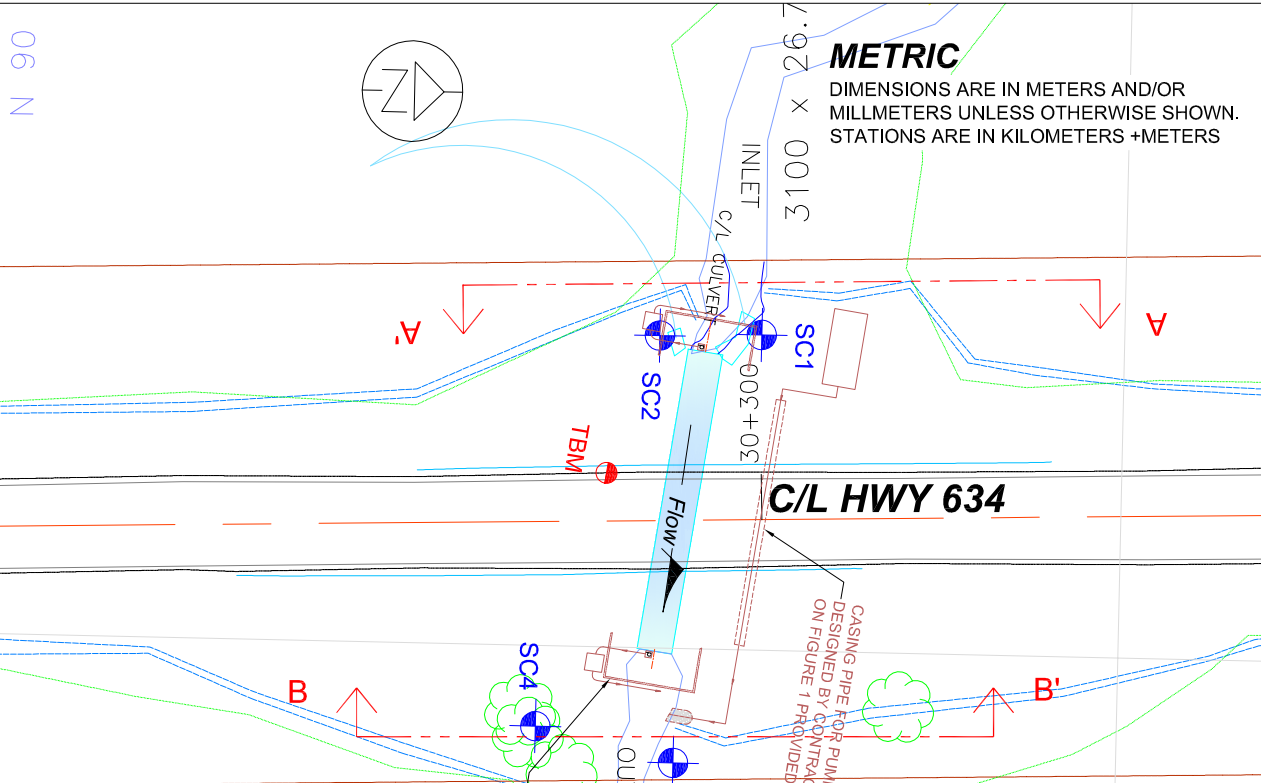


SECTION ALONG C/L CULVRT

DRAFT



N 90



Agreement No. 5015-E-0007
Assignment No. 4

TEMPORARY COFFERDAM AT STRUCTURAL
CULVERT/ HWY 634
BOREHOLE LOCATION PLAN AND SOIL STRATA

exp. exp Services Inc.

KEY PLAN

LEGEND

- Location of Drilled Boreholes
- N Standard Penetration Test (Blows/0.3 m)
- Water Level Upon Completion of Drilling
- Bench Mark (EL. 100.3m)

SOIL STRATA SYMBOLS

TOPSOIL	CLAYEY SILT TILL/ SILTY CLAY TILL
SILT	SILTY SAND
ORGANIC SANDY SILT	

BH No.	APPROX. ELEV.	MTM CO-ORDINATES	
		NORTH	EAST
SC 1	95.83	5490767.993	267872.214
SC 2	95.31	5490759.016	267872.459
SC 3	95.88	5490760.985	267910.096
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TBM	100.3	5490754.572	267884.659

NOTE

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The complete foundation investigation and design report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in the report and related documents are specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen. Cond.

HOR 0 20 m

VERT 0 4

12/12/2016	SM	SUBMISSION FOR MTO REVIEW	
DATE	BY	DESCRIPTION	
		GEOCRES NO.	
		PROJECT NO. ADM-00233185-D0	
SUBM'D SM	CHECKED SM	DATE	12/12/2016
DRAWN SH	CHECKED SG	APPROVED SG	DWG. 2

Appendix C – Borehole Logs

Explanation of Terms Used on Borehole Records

SOIL DESCRIPTION

Terminology describing common soil genesis:

Topsoil: mixture of soil and humus capable of supporting good vegetative growth.

Peat: fibrous fragments of visible and invisible decayed organic matter.

Fill: where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc.; none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advise of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional geotechnical site investigation.

Till: the term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (60 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

Terminology describing soil structure:

Desiccated: having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.

Stratified: alternating layers of varying material or color with the layers greater than 6 mm thick.

Laminated: alternating layers of varying material or color with the layers less than 6 mm thick.

Fissured: material breaks along plane of fracture.

Varved: composed of regular alternating layers of silt and clay.

Slickensided: fracture planes appear polished or glossy, sometimes striated.

Blocky: cohesive soil that can be broken down into small angular lumps which resist further breakdown.

Lensed: inclusion of small pockets of different soil, such as small lenses of sand scattered through a mass of clay; not thickness.

Seam: a thin, confined layer of soil having different particle size, texture, or color from materials above and below.

Homogeneous: same color and appearance throughout.

Well Graded: having wide range in grain sized and substantial amounts of all predominantly on grain size.

Uniformly Graded: predominantly on grain size.

All soil sample descriptions included in this report follow generally the ASTM D2487-11 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) with some modification to reflect current MTO practices. The system divides soils into three major categories: (1) coarse grained, (2) fine-grained, and (3) highly organic. The soil is then subdivided based on either gradation or plasticity characteristics. The system provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification. The classification excludes particles larger than 76 mm. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually in accordance with ASTM D2488-09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems. Others may use different classification systems; one such system is the ISSMFE Soil Classification.

ISSMFE SOIL CLASSIFICATION											
CLAY	SILT			SAND			GRAVEL			COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE		
<div><div>0.002</div><div>0.006</div><div>0.02</div><div>0.06</div><div>0.2</div><div>0.6</div><div>2.0</div><div>6.0</div><div>20</div><div>60</div><div>200</div></div>											
EQUIVALENT GRAIN DIAMETER IN MILLIMETRES											
CLAY (PLASTIC) TO				FINE		MEDIUM		CRS.	FINE	COARSE	
SILT (NONPLASTIC)				SAND				GRAVEL			
UNIFIED SOIL CLASSIFICATION											

Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter, construction debris) is based upon the proportion of these materials present and as described below in accordance with Note 16 in ASTM D2488-09a:

Table a: Percent or Proportion of Soil, Pp

	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	$5 \leq Pp \leq 10\%$
Little	$15 \leq Pp \leq 25\%$
Some	$30 \leq Pp \leq 45\%$
Mostly	$50 \leq Pp \leq 100\%$

The standard terminology to describe cohesionless soils includes the compactness as determined by the Standard Penetration Test 'N' value:

Table b: Apparent Density of Cohesionless Soil

	'N' Value (blows/0.3 m)
Very Loose	$N < 5$
Loose	$5 \leq N < 10$
Compact	$10 \leq N < 30$
Dense	$30 \leq N < 50$
Very Dense	$50 \leq N$

The standard terminology to describe cohesive soils includes consistency, which is based on undrained shear strength as measured by insitu vane tests, penetrometer tests, unconfined compression tests or similar field and laboratory analysis, Standard Penetration Test 'N' values can also be used to provide an approximate indication of the consistency and shear strength of fine grained, cohesive soils:

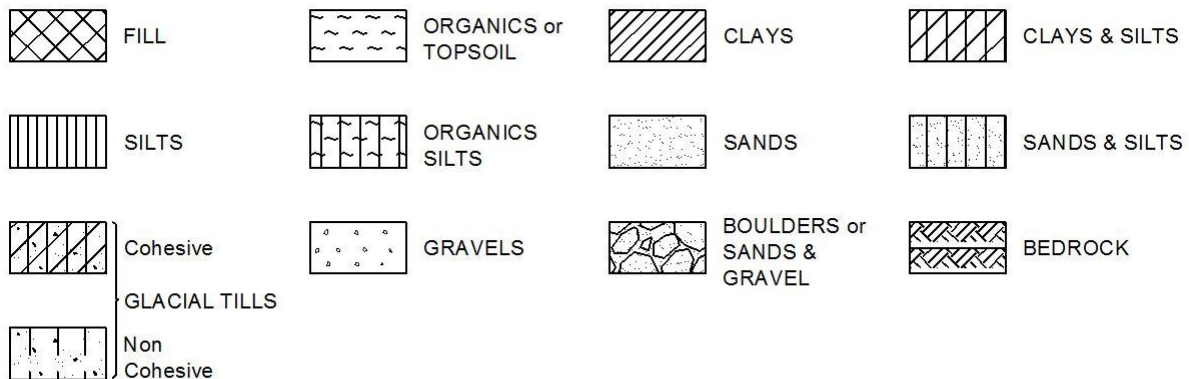
Table c: Consistency of Cohesive Soil

Consistency	Vane Shear Measurement (kPa)	'N' Value
Very Soft	<12.5	<2
Soft	12.5-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very Stiff	100-200	15-30
Hard	>200	>30

Note: 'N' Value - The Standard Penetration Test records the number of blows of a 140 pound (64kg) hammer falling 30 inches (760mm), required to drive a 2 inch (50.8mm) O.D. split spoon sampler 1 foot (305mm). For split spoon samples where full penetration is not achieved, the number of blows is reported over the sampler penetration in meters (e.g. 50/0.15).

STRATA PLOT

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols:



WATER LEVEL MEASUREMENT



Open Borehole or Test Pit



Monitoring Well, Piezometer or Standpipe

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS	Split spoon sample (obtained from the Standard Penetration Test)
WS	Wash sample
BS	Bulk sample
TW	Thin wall sample or Shelby tube
PS	Piston sample
AS	Auger sample
VT	Vane test
GS	Grab sample
HQ, NQ, etc.	Rock core samples obtained with the use of standard size diamond drilling bits

STRESS AND STRAIN

u_w	kPa	Pore water pressure
r_u	1	Pore pressure ratio
σ	kPa	Total normal stress
σ'	kPa	Effective normal stress
τ	kPa	Shear stress
$\sigma_1, \sigma_2, \sigma_3$	kPa	Principal stresses
ε	%	Linear strain
$\varepsilon_1, \varepsilon_2, \varepsilon_3$	%	Principal strains
E	kPa	Modulus of linear deformation
G	kPa	Modulus of shear deformation
μ	1	Coefficient of friction

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	Coefficient of volume change
c_c	1	Compression index
c_s	1	Swelling index
c_r	1	Recompression index
c_v	m^2/s	Coefficient of consolidation
H	m	Drainage path
T_v	1	Time factor
U	%	Degree of consolidation
σ'_{v0}	kPa	Effective overburden pressure
σ'_p	kPa	Preconsolidation pressure
τ_f	kPa	Shear strength
c'	kPa	Effective cohesion intercept
ϕ'	$^\circ$	Effective angle of internal friction
c_u	kPa	Apparent cohesion intercept
ϕ_u	$^\circ$	Apparent angle of internal friction
τ_R	kPa	Residual shear strength
τ_r	kPa	Remoulded shear strength
S_t	1	Sensitivity = c_u/τ_r

PHYSICAL PROPERTIES OF SOIL

P_s	kg/m^3	Density of solid particles
γ_s	kN/m^3	Unit weight of solid particles
ρ_w	kg/m^3	Density of water
γ_w	kN/m^3	Unit weight of water
ρ	kg/m^3	Density of soil
γ	kN/m^3	Unit weight of soil
ρ_d	kg/m^3	Density of dry soil
γ_d	kN/m^3	Unit weight of dry soil
ρ_{sat}	kg/m^3	Density of saturated soil
γ_{sat}	kN/m^3	Unit weight of saturated soil
ρ'	kg/m^3	Density of submerged soil
γ'	kN/m^3	Unit weight of submerged soil
e	1, %	Void ratio
n	1, %	Porosity
w	1, %	Water content
S_r	%	Degree of saturation
W_L	%	Liquid limit
W_P	%	Plastic limit
W_s	%	Shrinkage limit
I_p	%	Plasticity index = $(W_L - W_P)$
I_L	%	Liquidity index = $(W - W_P)/I_p$
I_C	%	Consistency index = $(W_L - W)/I_p$
e_{max}	1, %	Void ratio in loosest state
e_{min}	1, %	Void ratio in densest state
I_D	1	Density index = $(e_{max} - e)/(e_{max} - e_{min})$
D	mm	Grain diameter
D_n	mm	N percent - diameter
C_u	1	Uniformity coefficient
h	m	Hydraulic head or potential
q	m^3/s	Rate of discharge
v	m/s	Discharge velocity
i	1	Hydraulic gradient
k	m/s	Hydraulic conductivity
j	kN/m^3	Seepage force

RECORD OF BOREHOLE No SC1

1 OF 1

METRIC

W.P. 2016-11040 LOCATION Structural Culvert (Site No. 39E-313/C), MTM-12, 5490767.99N, 267872.21E ORIGINATED BY ST
DIST Cochrane HWY 634 BOREHOLE TYPE Portable Tripod Drill and Cone Test COMPILED BY ST
DATUM Local (non-geodetic) DATE 2016.11.17 - 2016.11.17 LATITUDE 49.55355 LONGITUDE -81.5104 CHECKED BY IM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)	
								○ UNCONFINED + FIELD VANE								
						● QUICK TRIAXIAL × LAB VANE										
95.8	Ground Surface															
95.8 0.1	TOPSOIL (~ 100 mm thick) ORGANIC SANDY SILT, some rootlets, some clay, dark brown, wet, very loose.		1	SS	1										0 27 61 12	
			2	SS	1		95									
94.3	CLAYEY SILT TILL, trace sand, grey, moist to wet, stiff to hard.		3	SS	15		94				○					
1.5			4	SS	32						○					
			5	SS	29		93					41			0 8 70 22	
			6	SS	30		92									
					91					○						
					90					○						
			7	SS	49											
88.8	Portable Equipment Refusal @ ~ 7.0 m depth below ground surface DCPT Commenced Inferred Clayey Silt Till					89										
7.0							88									
87.0	END OF BOREHOLE DCPT refusal @ ~ 8.8 m					87										
8.8	NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Groundwater level was not measured in open hole due to borehole was not left open for any significant length of time. 3. At the time of investigation water level in the creek was at approximate Elevation 95.4 m.															

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

RECORD OF BOREHOLE No SC2

1 OF 1

METRIC

W.P. 2016-11040 LOCATION Structural Culvert (Site No. 39E-313/C), MTM-12, 5490759.0N, 267872.46E ORIGINATED BY ST
DIST Cochrane HWY 634 BOREHOLE TYPE Portable Tripod Drill and Cone Test COMPILED BY ST
DATUM Local (non-geodetic) DATE 2016.11.17 - 2016.11.17 LATITUDE 49.55348 LONGITUDE -81.5104 CHECKED BY IM

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
95.3	Ground Surface															
0.0	CLAYEY SILT TILL, trace gravel, trace to some sand, brown to grey, moist to wet, firm to hard		1	SS	5											
	moist, very stiff below ~ 0.8 m depth.		2	SS	20									1 9 68 22		
	trace sand below ~ 1.5 m depth.		3	SS	16											
			4	SS	25											
			5	SS	28											
			6	SS	10											
	no gravel, trace sand, moist, hard below ~ 6.1 m depth.		7	SS	39									0 6 69 25		
88.3	Portable Equipment Refusal @ ~ 7.0 m depth below ground surface DCPT Commenced															
7.0	Inferred Clayey Silt Till															
87.1	END OF BOREHOLE DCPT refusal @ ~ 8.2 m															
8.2	NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Groundwater level was not measured in open hole due to borehole was not left open for any significant length of time. 3. At the time of investigation water level in the creek was at approximate Elevation 95.4 m.															

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

METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE						
95.9	Ground Surface														
96.0	TOPSOIL (~ 100 mm thick)														
96.0	SILTY CLAY TILL, trace to some sand, brown, moist to wet.		1	AUGER											
95.1	SILTY SAND, some clay, brown, wet, loose.		2	SS	5										
94.4	SILT, some clay, trace sand, grey, wet, loose.		3	SS	8										
93.6	SILTY SAND, some gravel, trace clay, grey, wet, compact to dense.		4	SS	22										
93.6			5	SS	31										
91.3	CLAYEY SILT TILL, trace to some sand, grey, moist to wet, very stiff to hard.		6	SS	28										
91.3			7	SS	32										
86.1			8	SS	24										
9.8			9	SS	37										
9.8	END OF BOREHOLE Borehole terminated @ ~ 9.8 m depth														
NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Groundwater level was observed at a depth of 3.7 m upon completion of borehole. 3. At the time of investigation water level in the creek was at approximate Elevation 95.4 m.															

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

RECORD OF BOREHOLE No SC4

1 OF 1

METRIC

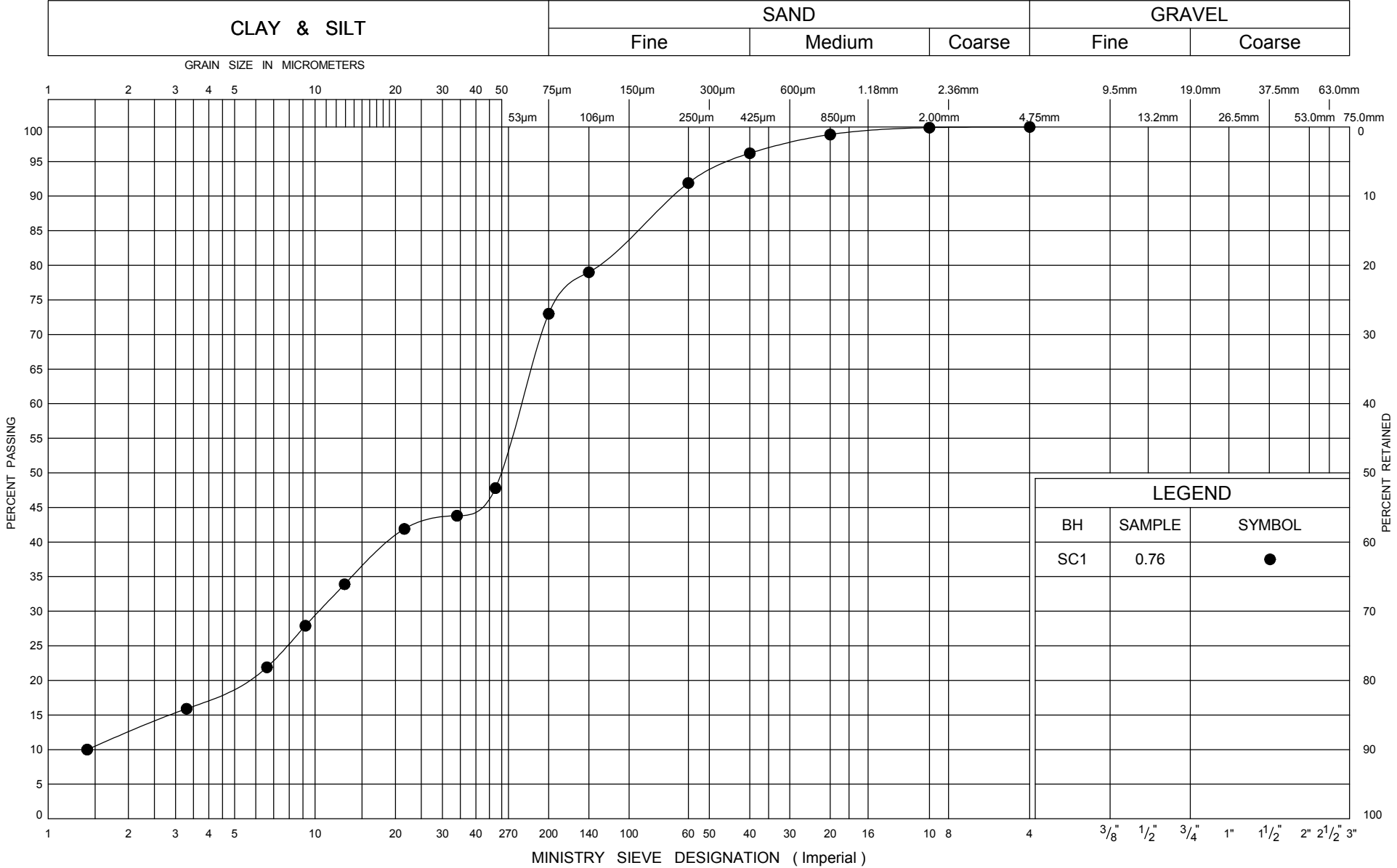
W.P. 2016-11040 LOCATION Structural Culvert (Site No. 39E-313/C), MTM-12, 5490748.77N, 267907.12E ORIGINATED BY ST
DIST Cochrane HWY 634 BOREHOLE TYPE CME 55/Hollow Stem Auger COMPILED BY ST
DATUM Local (non-geodetic) DATE 2016.11.10 - 2016.11.10 LATITUDE 49.55339 LONGITUDE -81.50992 CHECKED BY IM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
97.2	Ground Surface							20	40	60	80	100								
97.0	TOPSOIL (~ 150 mm thick)																			
0.2	CLAYEY SILT TILL, trace to some sand, brown to grey, moist to wet, soft to very stiff moist to wet, soft below ~ 0.8 m depth. trace to some gravel, stiff to very stiff below ~ 1.5 m depth. grey below ~ 3.1 m depth.		1	AUGER		▽	97													
			2	SS	3		96													
			3	SS	10		95													
			4	SS	24		94													
			5	SS	27		93													
			6				92													
92.6	SILTY SAND, trace clay, grey, wet, fine to medium grained, compact.		6	SS	19			91										1 8 68 23		
91.1	CLAYEY SILT TILL, trace sand, grey, moist to wet, very stiff to hard. hard below ~ 9.1 m depth.		7	SS	27			90												
8			SS	29	89															
9			SS	42	88															
87.4																				
9.8	END OF BOREHOLE Borehole terminated @ ~ 9.8 m depth NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Groundwater level was observed at a depth of 6.1 m upon completion of borehole. 3. At the time of investigation water level in the creek was at approximate Elevation 95.4 m.																0 9 62 29			

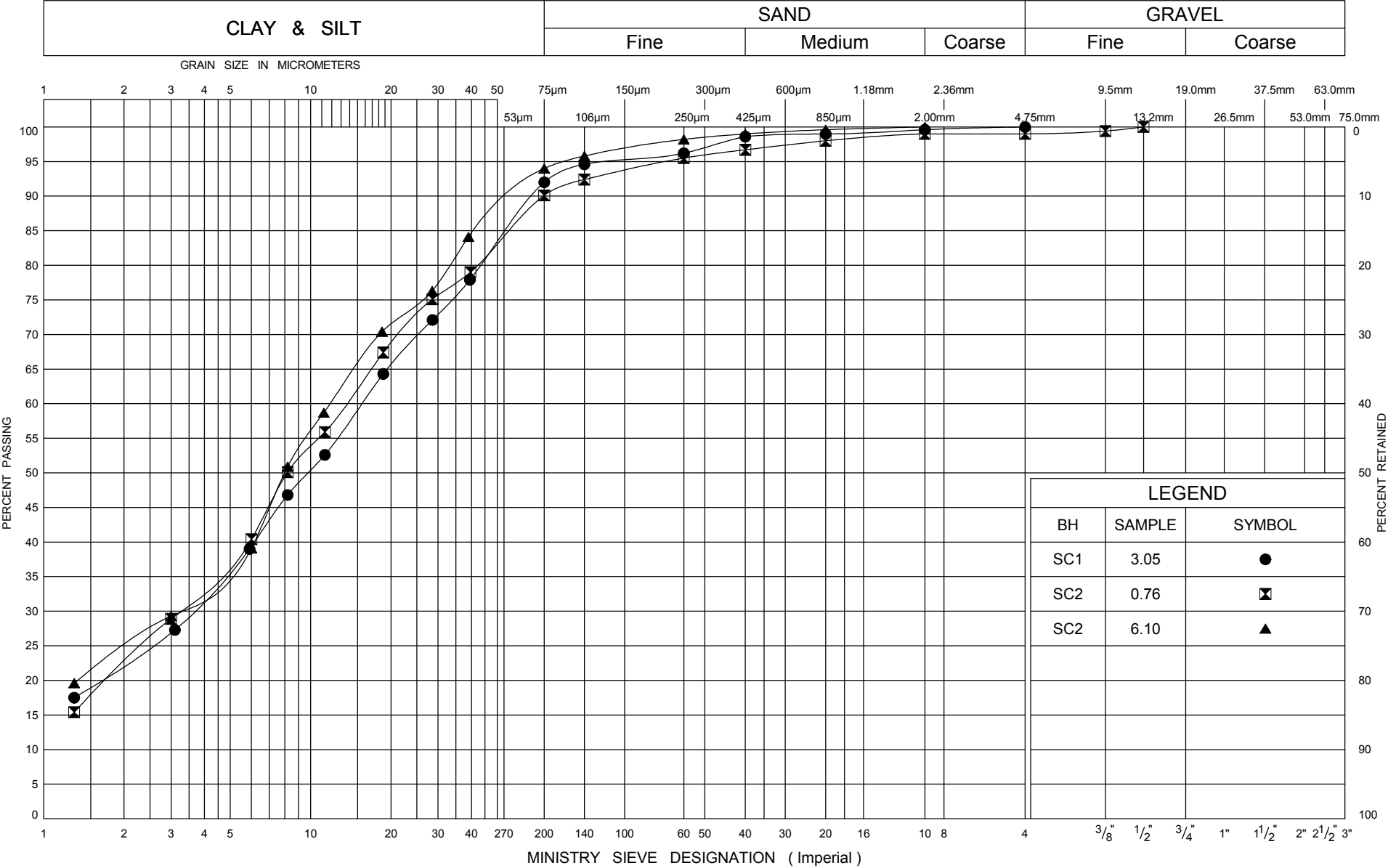
+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Appendix D – Laboratory Data

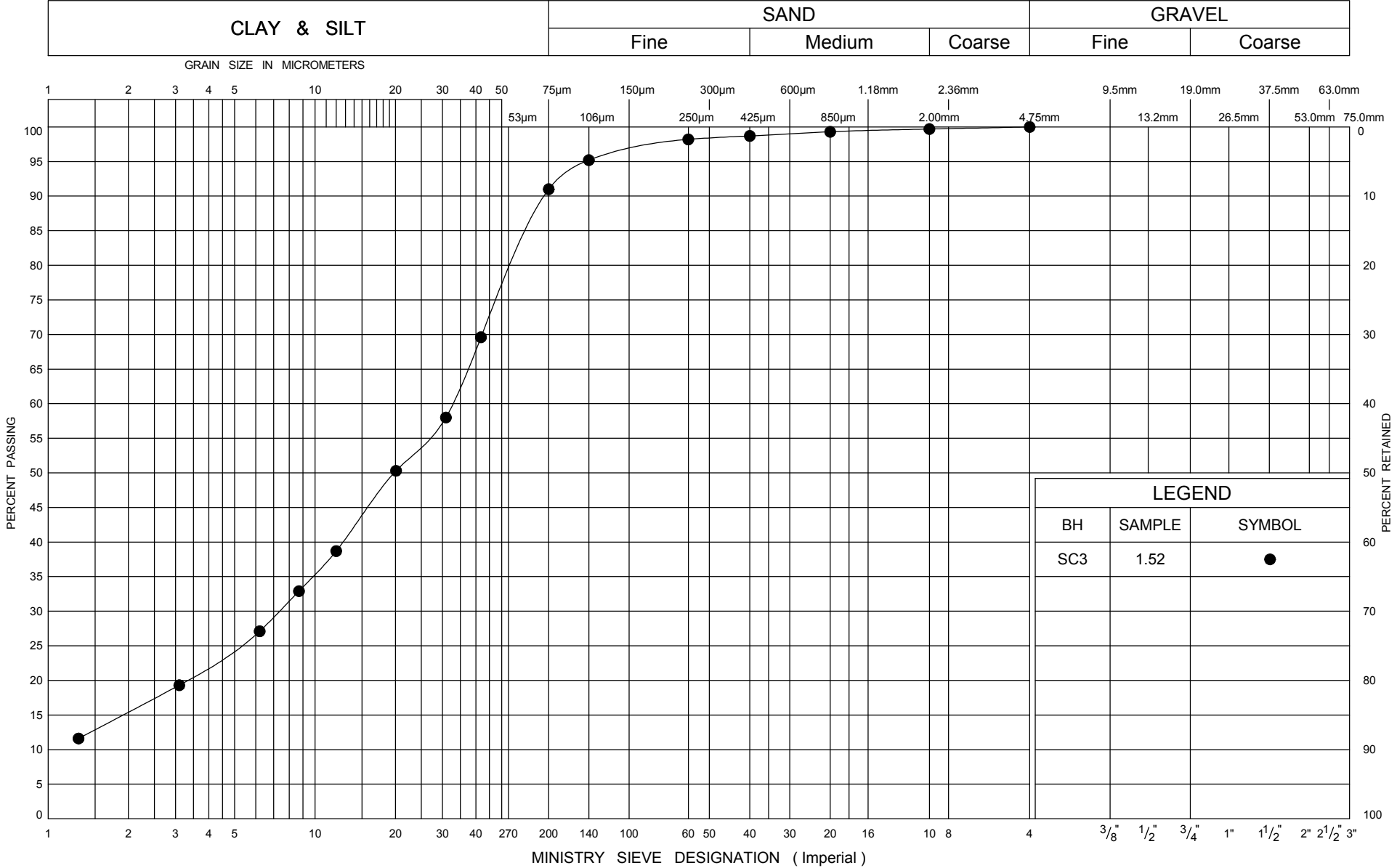
UNIFIED SOIL CLASSIFICATION SYSTEM



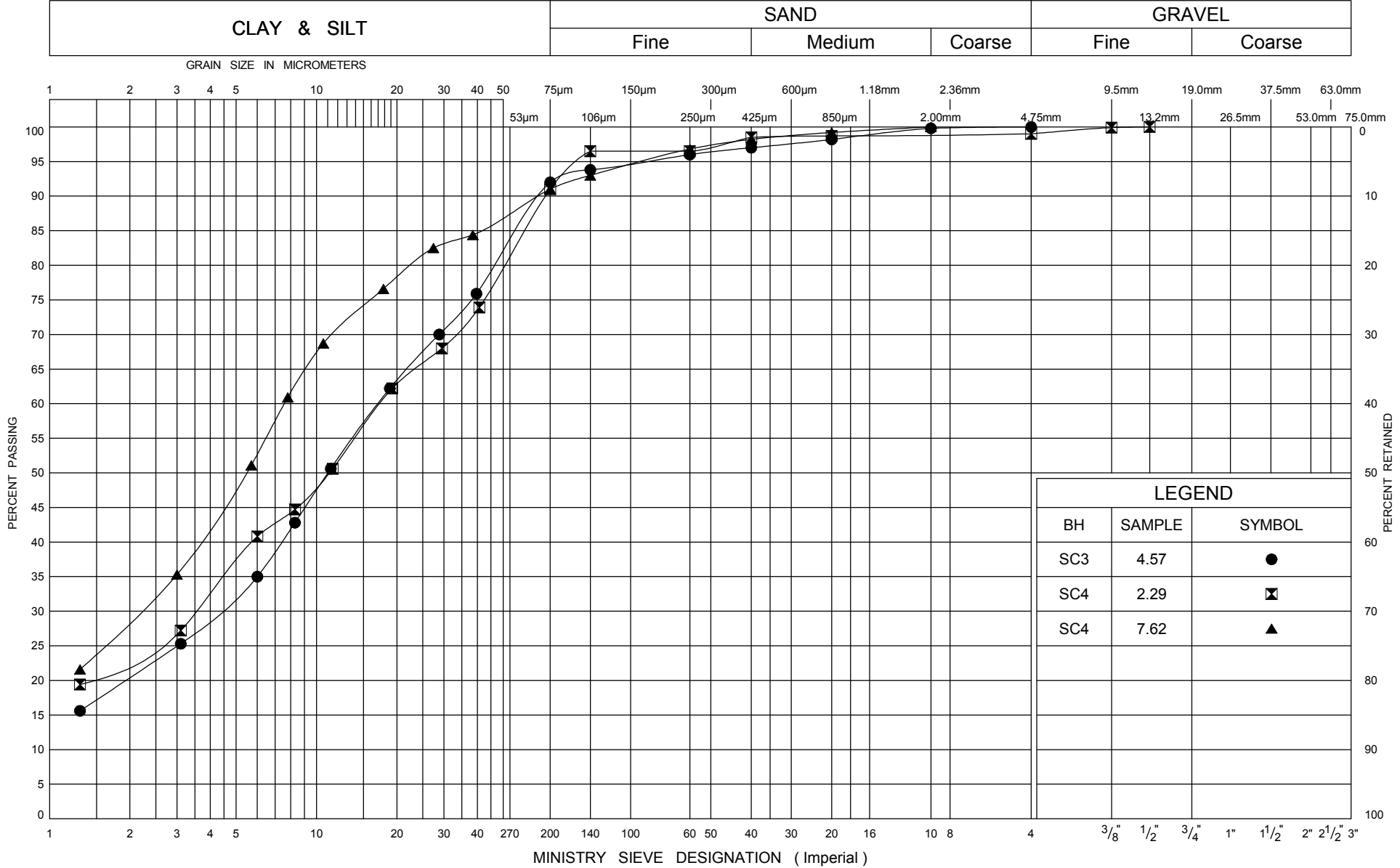
UNIFIED SOIL CLASSIFICATION SYSTEM

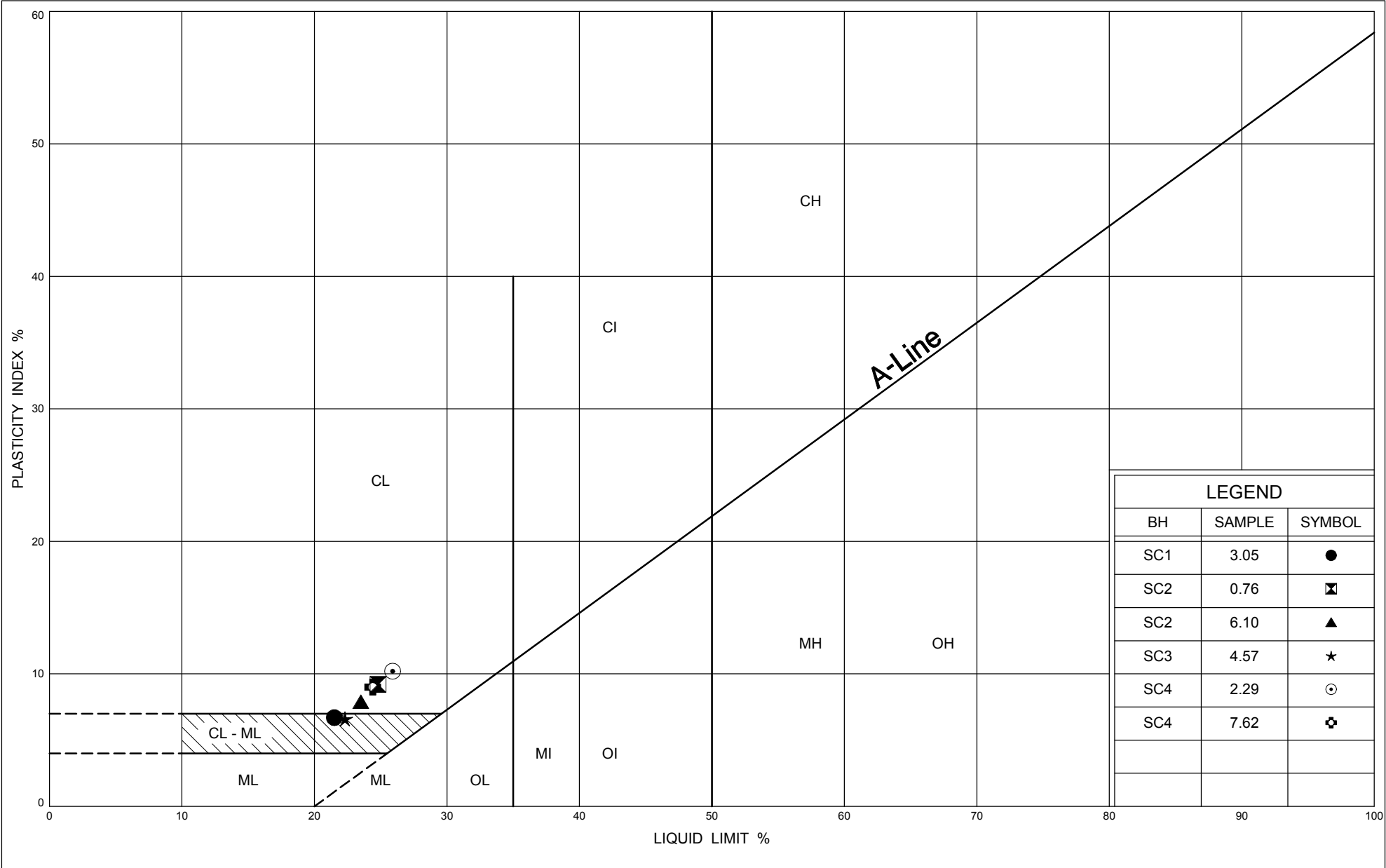


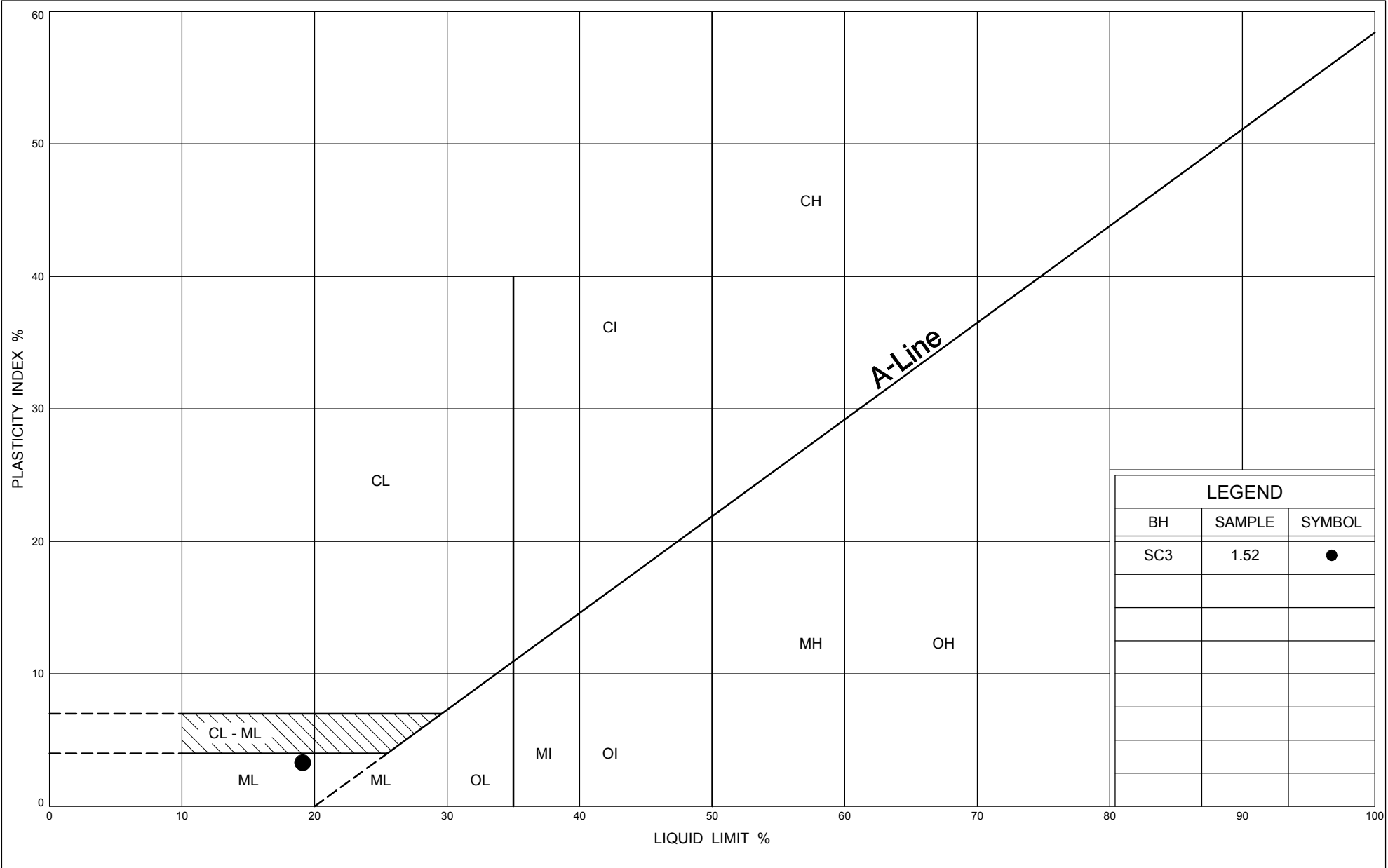
UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM







Appendix E – Non-Standard Special Provision (NSSP)

NSSP FOR COBBLES AND/ BOULDERs OBSTRUCTIONS

Scope of Work

The Contractor should be aware that cobbles and boulders noted to be contained within the glacial till. Boreholes at the inlet side encountered possible boulder at the portable equipment refusal depth of 7.0 m below ground surface. Consideration of the presence of these obstructions must be made in the selection of appropriate equipment and procedures for piling for temporary shoring through these materials.

Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.