FOUNDATION INVESTIGATION AND DESIGN REPORT
CULVERTS

for

HIGHWAY 69 FOUR-LANING
FROM 5.3 KM SOUTH OF HIGHWAY 529 (NORTH JUNCTION)
NORTHERLY TO 2.2 KM NORTH OF HIGHWAY 529, 7.5 KM
G.W.P. 5112-07-00
MAGNETAWAN FIRST NATION / WALLBRIDGE TOWNSHIP, ONTARIO

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PML Ref.: 09TF044-CV
Index No.: 394FIR and 395FDR
GEOCRES No.: 41H-147
April 29, 2015

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Record of Borehole Sheets: C3-1, C3-2, 101-1, 101-2 and 101-3

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Culvert C-8 at sta.16+531.9, SBL
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Figure 105-GS-2: Results of Grain Size Distribution Analysis
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Culvert C-17at 16+991.7, SBL
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Record of Borehole Sheets: C17-1 and 105-8
Record of Pavement Borehole Sheet: PV-1

Drawing C16/C17-1: Borehole Locations and Soil Strata

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Drawing C28/C29-1: Borehole Locations and Soil Strata

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Culvert C-46 at Sta. 19+887.0, SBL
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Culvert C-47 at Sta. 19+893.4, NBL
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DrawingC46/C47-1: Borehole Locations and Soil Strata

Culvert C-48 at Sta. 20+226.0, SBL
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Drawing C48/C49-1: Borehole Locations and Soil Strata

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Record of Borehole Sheets: C51-1, C51-2, C51-3 and 116-22

Culvert C-52 at Sta. 20+935.5, SBL
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Drawing C51/C52-1: Borehole Locations and Soil Strata

Culvert C-53 at Sta. 21+816.4, SBL
Record of Borehole Sheets: C53-1 and C53-2

Culvert C-54 at Sta. 21+827.4, NBL
Figure C54-PC-1: Plasticity Chart
Figure C54-GS-1: Results of Grain Size Distribution Analysis
Record of Borehole Sheets: C54-1, C54-2 and C54-3

Drawing C53/C54-1: Borehole Locations and Soil Strata

Culvert C-65 at Sta. 22+675.0, NBL
Record of Borehole Sheets: C65-1 and C65-2

Culvert C-66 at Sta. 22+675.0, SBL
Figure C66-PC-1: Plasticity Chart
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Drawing C65/C66-1: Borehole Locations and Soil Strata

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Drawing C70-1: Borehole Locations and Soil Strata

Appendix A – Site Photographs

FOUNDATION INVESTIGATION REPORT
CULVERTS
for
Highway 69 Four-Laning
From 5.3 km South of Highway 529 (North Junction) Northerly
to 2.2 km North of Highway 529 (North Junction), 7.5 km
G.W.P. 5112-07-00
Magnetawan First Nation / Wallbridge Township, Ontario

1. INTRODUCTION

Realignment and four-laning of an approximately 7.5 km long section of Highway 69 that extends from 5.3 km south of Highway 529 (north junction) to 2.2 km north of Highway 529 (north junction), some 90 km south of Sudbury, is planned. This report was prepared for AECOM Canada Ltd. (AECOM) on behalf of the Ministry of Transportation of Ontario (MTO).

The study corridor of the project extends from Station 16+020 to 23+636 in the Magnetawan First Nation and the Township of Wallbridge, Highway 69 centreline. A total of 32 culverts were identified in the Request for Proposal (RFP) for foundation investigation within the project limit.

Figures, records of borehole and cone penetration tests as well as foundation drawings are provided in Appendices as listed in the Table of Contents.

Culvert ID	Location (Highway 69 Centerline)	Type and Size
C-2	Sta. 16+076.0 (SBL)	Concrete Box 3.0m×1.2m×4.0m
C-3	Sta. 16+086.2 (NBL)	Concrete Box 3.0m×1.2m×31.0m
C-8	Sta. 16+531.9 (SBL)	Concrete Box 3.0m×2.3m×18.0m
C-9	Sta. 16+556.7 (NBL)	Concrete Box 3.0m×2.3m×28.0m
C-16	Sta. 16+979.3 (NBL)	Concrete Box 1.2m×2.3m×33.0m
C-17	Sta. 16+991.7 (SBL)	Concrete Box 1.2m×2.3m×25.0m
C-18	Sta. 17+108.3 (SBL)	Concrete Box 3.0m×2.3m×27.0m
C-19	Sta. 17+127.1 (NBL)	Concrete Box 3.0m×2.3m×30.0m
C-20	Sta. 17+542.7 (NBL)	Concrete Box 3.0m×2.3m×17.0m
C-21	Sta. 17+542.7 (SBL)	Concrete Box 3.0m×2.3m×17.0m
C-22	Sta. 17+822.8 (NBL)	Concrete Box 1.2m×1.2m×35.0m
C-23	Sta. 17+864.5 (NBL)	Concrete Box 3.0m×2.3m×17.0m

Culvert ID	Location (Highway 69 Centerline)	Type and Size
C-24	Sta. 17+864.5 (SBL)	Concrete Box 3.0m×2.3m×17.0m
C-25	Sta. 18+235.3 (NBL)	Concrete Box 3.0m×2.3m×18.0m
C-26	Sta. 18+249.5 (SBL)	Concrete Box 3.0m×2.3m×18.0m
C-28	Sta. 18+585.0 (NBL)	Concrete Box 5.0m×5.3m×17.0m
C-29	Sta. 18+585.0 (SBL)	Concrete Box 5.0m×5.3m×17.0m
C-30	Sta. 18+612.9 (Median)	Concrete Box 2.4m×1.8m×87.0m
C-41	Sta. 19+385.3 (Median)	Concrete Box 2.4m×1.2m×85.0m
C-42	Sta. 19+410.0 (NBL)	Concrete Box 5.0m×5.3m×17.0m
C-43	Sta. 19+410.0 (SBL)	Concrete Box 5.0m×5.3m×17.0m
C-46	Sta. 19+887.0 (SBL)	Concrete Box 3.0m×2.3m×20.0m
C-47	Sta. 19+893.4 (NBL)	Concrete Box 3.0m×2.3m×17.0m
C-48	Sta. 20+226.0 (SBL)	Concrete Box 3.0m×2.3m×25.0m
C-49	Sta. 20+245.1 (NBL)	Concrete Box 3.0m×2.3m×33.0m
C-51	Sta. 20+935.5 (NBL)	Concrete Box 3.0m×2.3m×20.0m
C-52	Sta. 20+935.5 (SBL)	Concrete Box 3.0m×2.3m×17.0m
C-53	Sta. 21+816.4 (SBL)	Concrete Box 3.0m×2.3m×18.0m
C-54	Sta. 21+827.4 (NBL)	Concrete Box 3.0m×2.3m×18.0m
C-65	Sta. 22+675.0 (NBL)	Concrete Box 3.0m×2.3m×17.0m
C-66	Sta. 22+675.0 (SBL)	Concrete Box 3.0m×2.3m×17.0m
C-70	Sta. 20+940.0(N-E/W Ramp)	Concrete Box 3.0m×2.3m×13.0m

All elevations in this report are expressed in metres and refer to the geodetic datum.

2. SITE DESCRIPTION AND GEOLOGY

The approximately 7.5 km long section of Highway 69 to be realigned and four-laned is situated about 90 km south of Sudbury in a wooded region with open swampy areas. Land use includes limited farming and forestry exploration.

The Magnetawan First Nation reserve extends from the southern project boundary to the Magnetawan River, some 5.6 km. The residences of the Magnetawan First Nation community are mainly situated on the west side of the intersection of Highway 69 and Highway 529.

The study area is located in the physiographic region known as the Georgian Bay Fringe that includes a bedrock plain comprising exposed bedrock knobs, subordinate glacial till moraine and a peat / muck organic terrain over bedrock.

The mineral soil cover is typically less than 1 m and may vary greatly over short distances and locally extend to depths exceeding 30 m in swampy areas. The soils were deposited by glacial Lake Algonquin and later partly by Lake Nipissing. The soil cover also originated from beach and near shore deposits, deltas, subaquatic fans, quiet water deposits of silt and clay which were formed by sedimentation in and adjacent to Lake Algonquin and its successors.

Metasedimentary rocks of the Huronian Supergroup and gneisses of the Grenville Province underlie the alignment. The area has undergone considerable folding, intrusive activity, regional metamorphism and faulting. The bedrock outcrops at many locations throughout the project section.

3. INVESTIGATION PROCEDURES

The field work for the foundation investigation within the limits of 32 culverts for the project involved a total of 61 test holes comprising 60 boreholes and 1 dynamic cone penetration tests carried out during the period of March 06, 2013 to March 05, 2014. In addition, 3 dynamic cone penetration tests performed near the boreholes. A total of 25 boreholes and 1 dynamic cone penetration test previously conducted for the swamp investigations were also used to supplement the subsurface information.

The field work for the current investigation is detailed in the following table:

Culvert No.	NUMBER OF		FIELD WORK DATES
	BOREHOLES	CONES	
C-2	1	–	October 29, 2013
C-3	2	–	March 06 and 07, 2013
C-8	2	–	October 02 and 03, 2013
C-9	2	–	March 08, 2013
C-16	1	–	March 09, 2013
C-17	1	–	November 04, 2013
C-18	2	–	October 29 and 30, 2013
C-19	2	–	March 10 and October 29, 2013
C-20	3	–	March 08 and 09, 2013
C-21	2	–	September 27, 30 and October 01, 2013
C-22	1	–	October 25, 2013
C-23	2	–	October 28, 2013; February 20, 2014
C-24	2	–	October 09, 2013; February 19, 2014
C-25	2	–	September 24 and October 28, 2013
C-26	2	–	September 25, 26 and October 28, 2013
C-28	2	–	October 09, 2013;February 28, March 02 and 03, 2014
C-29	2	–	February 25 and March 04, 2014
C-30	2	–	March 10 and 12, 2013; February 24, 2014
C-41	1	–	March 04 and 05, 2014

Culvert No.	NUMBER OF		FIELD WORK DATES
	BOREHOLES	CONES	
C-42	1	–	October 10, 2013
C-43	1	–	October 09, 2013
C-46	2	–	October 23 and 24, 2013
C-47	3	–	March 14 and 15, 2013
C-48	2	–	February 25 and 26, 2014
C-49	2	–	February 24 to 27, 2014
C-51	3	–	July 31, October 17 and 18, 2013
C-52	2	–	July 31, October 21 and 22, 2013
C-53	2	–	August 19, 2013; February 14, 2014
C-54	3	–	February 14 and 15, 2014
C-65	2	1	February 13, 2014
C-66	2	–	February 11 to 13, 2014
C-70	2	–	October 22 and 23, 2013; February 17 and 18, 2014

The test locations and drawings for each culvert are identified by a prefix identical to the culvert. Numbered sequentially from left to right, the test locations at each culvert are shown on the corresponding Drawings. The Records of the test holes are appended.

The test hole locations were established in PML using the reference lines of the highway alignment laid out in the field by exp Services Inc. The geodetic elevations at the test hole locations were provided by exp Services Inc.

The test holes were advanced using a combination of methods including a track-mounted D-53 drill rig, a tripod and manual probing/sampling. The equipment was supplied and operated by specialist drilling contractors working under the full-time supervision of members of our engineering staff.

Representative samples of the soils were recovered at frequent depth intervals using a conventional split spoon sampler during drilling. Standard penetration tests were conducted simultaneously with the sampling operation to assess the strength characteristics of the substrata. In situ vane shear testing (using the MTO 'N' vane according to the procedure described in the Northern Region Pavement Design Practices and Guidelines dated May 1997) and penetrometer tests were also performed to further assess the shear strength of the cohesive soils encountered. The results of the field tests and observations are reported on the Record of Borehole sheets.

The groundwater conditions at the borehole locations were assessed during drilling by visual examination of the soil, the sampler and drill rods as the samples were retrieved and, when appropriate, by measurement of the water level in the open borehole.

Upon completion of drilling, the boreholes were backfilled with a bentonite/cement mixture in accordance with the MTO guidelines and Ontario Regulation 903 for borehole abandonment procedures.

Soils were identified in the field in accordance with the MTO Soil Classification procedures. The soil samples were returned to our laboratory for detailed visual examination, classification and routine moisture content determination. Atterberg limits tests (21) and grain size distribution analyses (28) were performed on selected soil samples. Organic content was determined on one sample. The laboratory test results are appended.

4. SUMMARISED SUBSURFACE CONDITIONS

Reference is made to the appended Record of Borehole and Record of Penetration Test sheets for details of the subsurface conditions including soil classifications, inferred stratigraphy, boundary elevations, standard penetration and dynamic cone test data, field vane and penetrometer shear strength values and groundwater observations. The results of laboratory natural moisture content determination are also shown on the Record of Borehole sheets.

The boundaries between soil strata have been established at the borehole locations only. Between and beyond the boreholes, the boundaries are assumed and may vary. The findings are described below.

4.1 Culvert C-2 at Sta. 16+076.0 (SBL)

Borehole C2-1 drilled near the proposed culvert extension located as shown on Drawing C2/C3-1.

The subsurface stratigraphy revealed in borehole C2-1 drilled at the site comprised surficial topsoil mantling bedrock. The bedrock surface was inferred by refusal at 0.5 m (elevation 194.1).

The strata encountered in this borehole are summarised below.

4.1.1 Topsoil

Surficial topsoil was present in borehole C2-1. The silty topsoil was 500 mm thick and penetrated at elevation 194.1.

4.1.2 Bedrock

Bedrock was inferred by refusal at 0.5 m (elevation 194.1) in borehole C2-1.

4.1.3 Groundwater

In borehole C2-1, water was detected at the ground surface (elevation 194.6) during drilling.

It is noted that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.2 Culvert C-3 at Sta. 16+086.2 (NBL)

Two new boreholes, numbered C3-1 and C3-2, were drilled at the location of culvert C-3. Borehole C3-1 was put down near the centre and borehole C3-2 near the right (east) end of the proposed culvert. Boreholes 101-1 to 101-3 previously drilled for the swamp investigations were also used to supplement the subsurface information. The borehole locations are shown on Drawing C2/C3-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised surficial topsoil and peat overlying a cohesive deposit of sandy clayey silt and/or bedrock. The bedrock surface was inferred by refusal at 0.1 to 2.0 m (elevation 192.2 to 194.7). Open water was present under 300 mm of snow at elevation 193.9 in boreholes C3-1 and C3-2 during and upon completion of drilling.

The soil strata encountered are summarised below.

4.2.1 Topsoil / Peat

Surficial topsoil was present in boreholes 101-1 and 101-3.The silty topsoil was 100 mm thick and mantled probable bedrock at elevation 194.6 and 194.7 in boreholes 101-1 and 101-3 respectively.

Peat was present surficially in borehole 101-2 and covered with 600 mm of snow, ice and water at elevation 193.6 in boreholes C3-1 and C3-2.The peat was fine fibrous to amorphous and had a thickness of 300 to 600 mm. The peat was penetrated at 0.3 to 1.2 m (elevation 193.0 to 194.2).

4.2.2 Clayey Silt

Underlying the peat, a 800 and 900 mm thick sandy clayey silt layer was contacted in boreholes C3-1 and C3-2 at respective depths of 1.2 and 0.9 m (elevation 193.0 and 193.3) and penetrated at 2.0 and 1.8 m (elevation 192.2 and 192.4). This deposit was stiff in consistency and 25 to 27% in moisture content.

4.2.3 Bedrock

Bedrock was inferred by refusal at 0.1 to 2.0 m (elevation 192.2 to 194.7) in all the boreholes.

4.2.4 Groundwater

Open water was present under 300 mm of snow at elevation 193.9 in boreholes C3-1 and C3-2. No water was detected in the remaining boreholes during or upon completion of drilling.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.3 Culvert C-8 at Sta. 16+531.9 (SBL)

Boreholes C8-1 and C8-2 were drilled at the location of this culvert. Borehole C8-1 was put down at the left (west) end and borehole C8-2 near the right (east) end of the proposed culvert. The borehole locations are shown on Drawing C8/C9-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised surficial fill mantling granitic gneiss bedrock. Cobbles and boulders were encountered in the boreholes. The bedrock surface was contacted at 1.3 and 4.1 m (elevation 191.9 and 189.5). No water was observed in the boreholes in the process of augering.

The strata encountered are summarised below.

4.3.1 Fill

A 1.3 and 4.1 m thick surficial fill was present in boreholes C8-1 and C8-2 and penetrated at respective elevation 191.9 and 189.5. It is composed of surficial topsoil, sand, gravel, cobbles and boulders.

4.3.2 Bedrock

Bedrock was contacted at 1.3 and 4.1 m (elevation 191.9 and 189.5) in boreholes C8-1 and C8-2. It was proven upon contact by coring 3.1 and 3.3 m into the rock to 7.2 and 4.6 m depths (elevations 186.4 and 188.6) in boreholes C8-2 and C8-1, respectively.

The bedrock comprised granitic gneiss. The measured core recovery varied between 82 and 100%. The RQD determined from the rock cores was in a range of 79 to 100%, thus indicating a good to excellent quality rock.

4.3.3 Groundwater

No groundwater was established in boreholes C8-1 and C8-2 charged with drilling water for rock coring.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.4 Culvert C-9 at Sta. 16+556.7 (NBL)

Two new boreholes, numbered C9-1 and C9-2, were drilled at the location of culvert. Borehole C9-1 was put down near left (west) end and borehole C9-2 near the right (east) end of the proposed culvert. Boreholes 102-2 and 102-4 previously drilled for the swamp investigation and located near the left and centre of the culvert were also used to supplement the subsurface information. The borehole locations are shown on Drawing C8/C9-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised surficial topsoil overlying a cohesive deposit of clay or bedrock. The bedrock surface was inferred by refusal at 0.1 to 3.1 m (elevation 190.6 to 194.9). Open water was present under 300 and 600 mm of snow/ice at elevation 193.4 and 193.8 in boreholes C9-1 and C9-2 respectively.

The strata encountered in the boreholes are summarised below.

4.4.1 Topsoil

Topsoil was present surficially in boreholes 102-2 and 102-4 and under the 400 mm of snow, ice and water at elevation 193.3 in borehole C9-1. The silty topsoil had a thickness of 100 mm in boreholes 102-2 and C9-1 and was penetrated at respective depths of 0.1 and 0.5 (elevation 194.9 and 193.2). The 200 mm thick topsoil in borehole 102-4 was penetrated at 0.2 m (elevation 194.1).

4.4.2 Clay

Underlying the topsoil, a 2.6 m thick cohesive clay deposit was contacted at 0.5 m (elevation 193.2) in borehole C9-1 and penetrated at 3.1 m (elevation 190.6). This deposit was firm becoming soft in consistency. The results of in situ vane testing carried out in the clay yielded an undisturbed shear strength value of 15 kPa (soil sensitivity of 8). Penetrometer tests on 3 samples of the clay samples indicated shear strength values of 25 to 50 kPa.

The results of Atterberg limits testing and grain size distribution analysis performed on a cohesive sample are presented in respective Figures C9-PC-1 and C9-GS-1. The liquid and plastic limits of the clay were 61 and 23 respectively, thus giving the plasticity index of 38 indicating a high plasticity cohesive soil. Moisture contents of 50 to 67% were measured.

4.4.3 Bedrock

Bedrock was inferred by refusal at 0.1 to 3.1 m (elevation 190.6 to 194.9) in all the boreholes.

4.4.4 Groundwater

Open water was present under 300 and 600 mm of snow/ice at elevation 193.4 and 193.8 in boreholes C9-1 and C9-2 respectively. No groundwater was observed in borehole 102-4 during or upon completion of drilling.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.5 Culvert C-16 at Sta. 16+979.3 (NBL)

Borehole C16-1 was advanced at the right (east) end of this culvert. Boreholes 105-7 and 105-8 previously drilled for the swamp investigation and located near the centre and left (west) end of the culvert were also used to supplement the subsurface information. The borehole locations are shown on Drawing C16/C17-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised surficial peat overlying a cohesive deposit of clayey silt, silty clay and clay extending to bedrock. The bedrock surface was inferred by refusal at 0.2 to 3.2 m (elevation 192.8 to 196.1). Upon completion of drilling groundwater was at 0.0 and 0.3 m (elevation 195.9 and 195.8) in boreholes C16-1 and 105-7 respectively.

The strata encountered in the boreholes are summarised below.

4.5.1 Peat

Surficial peat was present at surface in all the boreholes. The fine fibrous / amorphous peat was 0.2 to 1.1 m thick and penetrated at elevation 195.0 to 196.1.

4.5.2 Clayey Silt to Clay

Under the peat, a 500 mm thick clayey silt layer was identified at 1.1 m (elevation 195.0) in borehole 105-7 and penetrated at 1.6 m (elevation 194.5). The clayey silt was firm in consistency.

Directly beneath the peat at 0.5 m (elevation 195.4) in borehole C16-1 was a cohesive silty clay deposit. It had a thickness of 2.6 m and extended to probable bedrock contacted at 3.1 m (elevation 192.8). The deposit was soft to firm in consistency and 59 to 60% in moisture content. The results of in situ vane testing carried out in the deposit yielded an undisturbed shear strength value of 36 kPa (soil sensitivity of 5). Penetrometer tests on samples of the silty clay indicated a shear strength value of 25 kPa.

Overlain by the clayey silt at 1.6 m (elevation 194.5) in borehole 105-7 was a deposit of clay. The clay was 1.6 m thick and penetrated at 3.2 m (elevation 192.9). This deposit was firm in consistency.

The results of Atterberg limits testing and grain size distribution analysis performed on a sample of the clay are presented in respective Figures 105-PC-2 and 105-GS-2. The liquid and plastic limits of the clay were 53 and 23 respectively, thus giving the plasticity index of 30. Moisture contents of 23 to 45% were measured.

4.5.3 Bedrock

Bedrock was inferred by refusal at 0.2 to 3.2 m (elevation 192.8 to 196.1) in all the boreholes.

4.5.4 Groundwater

In the process of augering and upon completion of drilling, groundwater was at the ground surface and 0.3 m (elevation 195.9 and 195.8) in boreholes C16-1 and 105-7 respectively. No groundwater was observed in borehole 105-8 during and upon completion of drilling.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.6 Culvert C-17 at Sta. 16+991.7 (SBL)

Borehole C17-1 was advanced at the left (west) end of this culvert. Borehole 105-8 located near the right (west) end of the culvert previously drilled for the swamp investigation was also used to supplement the subsurface information. The borehole locations are shown on Drawing C16/C17-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised surficial topsoil / peat overlying cohesionless sand or bedrock. The bedrock surface was inferred by refusal at 0.2 and 1.3 m (elevation 196.1 and 195.4).

The strata encountered in boreholes are summarised below.

4.6.1 Topsoil / Peat

Surficial topsoil was present in borehole C17-1. The silty topsoil was 100 mm thick and penetrated at elevation 196.6.

A 200 mm thick fine fibrous peat was present at surface in borehole 105-8 and mantled the probable bedrock at elevation 196.1.

4.6.2 Sand

Overlain by the topsoil, a 1.2 m thick cohesionless sand layer was encountered at 0.1 m (elevation 196.6) in borehole C17-1 and penetrated at 1.3 m (elevation 195.4). This stratum was very loose in relative density (SPT-‘N’ values of weight of hammer and 1).

The results of grain size distribution analysis performed on a sample of the sand are presented in Figure C17-GS-1.

4.6.3 Bedrock

Bedrock was inferred by refusal in boreholes C17-1 and 105-8 at respective depths of 1.3 and 0.2 m (elevation 195.4 and 196.1).

4.6.4 Groundwater

In the process of augering, water was detected at 0.2 m (elevation 196.5) in borehole C17-1. Groundwater was not established in the borehole upon completion of drilling. No groundwater was observed in borehole 105-8 during and upon completion of drilling.

It is worth noting that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.7 Culvert C-18 at Sta. 17+108.3 (SBL)

Boreholes C18-1 and C18-2 were drilled for this culvert. The boreholes were advanced at both ends of the culvert. The borehole locations are shown on Drawing C18/C19-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised surficial topsoil underlain by cohesionless sand / silty sand containing boulders and mantling granitic gneiss bedrock. The bedrock surface was contacted or inferred by refusal at 0.6 and 1.2 m (elevation 196.9 and 196.0).

The soil strata encountered are summarised below.

4.7.1 Topsoil

Surficial topsoil was present in both boreholes. The silty topsoil was 200 and 400 mm thick in borehole C18-1 and C18-2 and penetrated at elevation 197.0 and 197.1.

4.7.2 Sand

Cohesionless sand was encountered below the topsoil at 0.2 m (elevation 197.0) in borehole C18-1. This stratum was very loose in relative density and contained boulders. The sand had a thickness of 1.0 m and was penetrated at 1.2 m (elevation 196.0).

The results of grain size distribution analysis performed on a sample of the sand are presented in Figure C18-GS-1.

4.7.3 Silty Sand

Overlain by the topsoil, a 200 mm layer of silty sand was contacted at 0.4 m (elevation 197.1) in borehole C18-2 and mantled probable bedrock at 0.6 m (elevation 196.9). This unit was very loose in relative density (SPT-‘N’ value of 1).

4.7.4 Bedrock

Bedrock was inferred by refusal at 0.6 m (elevation 196.9) in borehole C18-2 and contacted at 1.2 m (elevation 196.0) in borehole C18-1. Bedrock was proven upon contact by coring 2.7 m into the rock to 3.9 m (elevation 193.3) in borehole C18-1.

The bedrock comprised granitic gneiss. The measured core recovery was 100%. The RQD determined from the rock core was 100%, thus indicating an excellent quality rock.

4.7.5 Groundwater

In the process of augering, water was detected at 0.2 and 0.6 m (elevation 197.0 and 196.9) in boreholes C18-1 and C18-2 respectively. No groundwater was established in either borehole upon completion of drilling.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.8 Culvert C-19 at Sta. 17+127.1 (NBL)

Boreholes C19-1 and C19-2 were drilled for this culvert. The boreholes were advanced at both ends of the proposed culvert. The borehole locations are shown on Drawing C18/C19-1.

The subsurface stratigraphy revealed in the boreholes comprised surficial topsoil / peat overlying silty sand or silty clay mantling probable bedrock. The bedrock surface was inferred by refusal at 0.4 and 0.9 m (elevation 197.0 and 196.1). Groundwater was at 0.0 and 0.2 m (elevation 197.0 and 197.2) upon completion of drilling.

The soil strata encountered are summarised below.

4.8.1 Topsoil / Peat

Surficial topsoil was present in borehole C19-2. The silty topsoil was 200 mm thick and penetrated at elevation 197.2.

Peat was present surficially in borehole C19-1. The amorphous peat was 600 mm in thickness and penetrated at elevation 196.4.

4.8.2 Silty Sand

Directly beneath the peat at 0.6 m (elevation 196.4) in borehole C19-1 was cohesionless silty sand. This unit had a thickness of 300 mm and was penetrated at 0.9 m (elevation 196.1).

4.8.3 Silty Clay

Underlying the topsoil at 0.2 m (elevation 197.2) in borehole C19-2 was a cohesive silty clay deposit. Firm in consistency, this deposit was 200 mm thick and mantled probable bedrock at 0.4 m (elevation 197.0).

4.8.4 Bedrock

Bedrock was inferred by refusal in boreholes C19-1 and C19-2 at respective depths of 0.9 and 0.4 m (elevation 196.1 and 197.0).

4.8.5 Groundwater

In the process of augering, water was present at the ground surface in borehole C19-1. Upon completion of drilling, groundwater was at 0.0 and 0.2 m (elevation 197.0 and 197.2) in boreholes C19-1 and C19-2 respectively.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.9 Culvert C-20 at Sta. 17+542.7 (NBL)

Boreholes C20-1, C20-2 and C20-3 were drilled at the location of this culvert. The boreholes were advanced at both ends and near the centre of the culvert. The borehole locations are shown on Drawing C20/C21-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised surficial peat and/or organic sand underlain by silty clay and silty/sandy soils extending to bedrock. The bedrock surface was inferred by refusal at 3.0 to 4.0 m (elevation 193.3 to 194.7). Open water was present under 200 to 300 mm of snow and ice in all the boreholes.

The strata encountered in boreholes are summarised below.

4.9.1 Peat

Peat was present under 300 mm of snow / ice and water at elevation 197.0 in borehole C20-2. The amorphous peat was 300 mm thick and penetrated at 0.6 m (elevation 196.7).

4.9.2 Organic Sand

Overlain by 300 to 900 mm of snow, ice and water and/or the peat was organic sand at 0.6 to 0.9 m (elevation 196.4 to 196.9) in all the boreholes. The organic sand was 0.9 to 2.1 m in thickness and penetrated at 1.8 to 2.7 m (elevation 194.6 to 195.5). Loose to compact in relative density, this stratum had an organic content of 0.6% and moisture content of 32 to 42%.

The results of grain size distribution analysis performed on a sample of the organic sand are presented in Figure C20-GS-1.

4.9.3 Silty Clay

Underlying the organic sand or silty sand at 1.8 to 3.2 m (elevation 194.1 to 195.5) in boreholes C20-1 to C20-3 was a cohesive silty clay deposit. This deposit had a thickness of 0.2 to 1.2 m and was penetrated at 3.0 to 3.4 m (elevation 193.9 to 194.7). The silty clay was firm to very stiff in consistency. Penetrometer tests on cohesive samples indicated shear strength values of 25 to 100 kPa.

The results of Atterberg limits testing and grain size distribution analysis performed on a sample of the deposit are presented in respective Figures C20-PC-1 and C20-GS-2. The liquid and plastic limits of the silty clay were 37 and 18 respectively, thus giving the plasticity index of 19 indicating a medium plasticity cohesive soil. The moisture content varying between 22 to 29%.

4.9.4 Silty Sand / Sand

A 500 mm thick silty sand layer was identified below the organic sand at 2.7 m (elevation 194.6) in borehole C20-2 and penetrated at 3.2 m (elevation 194.1). This layer was compact in relative density.

Cohesionless sand was encountered below the silty clay at 3.0 m (elevation 194.3) in borehole C20-3. The sand had a thickness of 1.0 m and mantled probable bedrock at 4.0 m (elevation 193.3). This unit was loose in relative density (SPT-'N' value of 5) and 25% in moisture content.

The results of grain size distribution analysis performed on a sample of the sand are presented in Figures C20-GS-3.

4.9.5 Bedrock

Bedrock was inferred by refusal at 3.0 to 4.0 m (elevation 193.3 to 194.7) in boreholes C20-1 to C20-3.

4.9.6 Groundwater

Open water was present under 200 to 300 mm of snow and ice (elevation 197.0 to 197.5) in all the boreholes.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.10 Culvert C-21 at Sta. 17+542.7 (SBL)

Boreholes C21-1 and C21-2 were drilled at this culvert. The boreholes were advanced at both ends of the culvert. The borehole locations are shown on Drawing C20/C21-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised surficial peat overlying silty/sandy soils and clayey silt / silty clay extending to bedrock. The bedrock surface was contacted at 3.3 and 4.3 m (elevation 194.4 and 193.9).

The strata encountered in boreholes are summarised below.

4.10.1 Peat

Surficial peat was present in both boreholes. The peat was 200 to 300 mm thick and penetrated at elevation 197.9 and 197.5 in boreholes C21-1 and C21-2 respectively. The peat was fine to coarse fibrous and had a moisture content of 89% in one determination.

4.10.2 Sand

Directly beneath the peat, a 1.1 and 1.2 m thick cohesionless sand was contacted at 0.3 and 0.2 m (elevation 197.9 and 197.5) in boreholes C21-1 and C21-2 respectively and penetrated at 1.4 m (elevation 196.8 and 196.3). This stratum was very loose to compact in relative density (SPT-‘N’ values of weight of hammer to 12) and 26 to 27% in moisture content.

A lower sand layer was also revealed below silty clay and silt units at 3.0 m (elevation 195.2) in borehole C21-1 and 2.1 m (elevation 195.6) in boreholes C21-2. The sand had a thickness of 1.3 m in borehole C21-1 and 1.2 m in borehole C21-2 and extended to bedrock contacted at respective depths of 4.3 and 3.3 m (elevation 193.9 and 194.4). This layer was loose to dense in relative density and about 20% in moisture content. It is noteworthy that the sand layer contained cobbles and boulders.

The results of grain size distribution analysis performed on a sample of the sand are presented in Figure C21-GS-1.

4.10.3 Sandy Silt / Silt

Overlain by the sand, a 800 mm thick sandy silt layer was contacted at 1.4 m (elevation 196.8) in borehole C21-1 and penetrated at 2.2 m (elevation 196.0). This unit was loose in relative density with a moisture content of about 25%.

Underlying a layer of clayey silt, a 300 mm thick non-plastic silt was contacted at 1.8 m (elevation 195.9) in borehole C21-2 and penetrated at 2.1 m (elevation 195.6). The silt was compact in relative density and its moisture content was about 21%.

4.10.4 Clayey Silt / Silty Clay

A 400 mm thick clayey silt layer was identified at 1.4 m (elevation 196.3) in borehole C21-2 and penetrated at 1.8 m (elevation 195.9). The clayey silt was firm in consistency.

A 800 mm thick cohesive silty clay deposit was encountered below the sandy silt at 2.2 m (elevation 196.0) in borehole C21-1 and penetrated at 3.0 m (elevation 195.2). This deposit was stiff to very stiff in consistency. A penetrometer test on the silty clay sample indicated a shear strength value of 112 kPa.

The results of Atterberg limits testing and grain size distribution analysis performed on the sample of the deposit are presented in respective Figures C21-PC-1 and C21-GS-2. The liquid and plastic limits of the silty clay were 48 and 21 respectively, thus giving the plasticity index of 27 indicating a medium plasticity cohesive soil. Moisture content of 29% was measured.

4.10.5 Bedrock

Bedrock was contacted in boreholes C21-1 and C21-2 at respective depths of 4.3 and 3.3 m (elevation 193.9 and 194.4). It was proven upon contact by coring 3.1 and 3.2 m into the rock to 7.4 and 6.5 m (elevation 190.8 and 191.2) in boreholes C21-1 and C21-2, respectively.

The bedrock comprised granitic gneiss. The measured core recovery varied between 83 and 100%. The RQD determined from the rock cores was in a range of 68 to 100%, thus indicating a fair to excellent quality rock, with the exception of a 200 mm rock core sample revealed at 4.1 m (elevation 193.6).

4.10.6 Groundwater

In the process of augering, groundwater was present at the surface (elevation 197.7) in borehole C21-2 and detected at 0.8 m (elevation 197.4) in borehole C21-1. No groundwater was established in either borehole upon completion of drilling.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.11 Culvert C-22 at Sta. 17+822.8 (NBL)

Borehole C22-1 was advanced at left (west) end of this culvert. Boreholes 107-19 and 107-20 previously drilled for the swamp investigation and located near the right (east) end and centre of the proposed culvert were also used to supplement the subsurface information. The borehole locations are shown on Drawing C22-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised surficial fill or peat overlying sand/sandy silt and a cohesive deposit of silty clay underlain by gravelly sand extending to bedrock. The bedrock surface was inferred by refusal at 1.0 to 11.5 m (elevation 186.5 to 196.6). Water was at 0.0 to 0.8 m (elevation 197.2 to 197.6).

The strata encountered in boreholes are summarised below.

4.11.1 Fill

Surficial fill was present in borehole C22-1. Composed of topsoil, silty sand and silty clay layers, the fill had a thickness of 0.8 m and was penetrated at elevation 197.2.

Generally, unless records were kept during the placement of the fill and are available for review, the condition of the fill placement should be considered variable and uncontrolled.

4.11.2 Peat

Peat was encountered below the fill at 0.8 m (elevation 197.2) in borehole C22-1 and under 800 mm of snow, ice and water at elevation 196.8 in borehole 107-20. The peat was 0.7 and 1.4 m thick and penetrated at respective depths of 1.5 and 2.2 m (elevation 196.5 and 195.4) in boreholes C22-1 and 107-20. The fine fibrous to amorphous peat had a moisture content of 87 to 122%.

4.11.3 Sand / Sandy Silt

Directly beneath the fill or peat at 1.5 m (elevation 196.5) in borehole C22-1 and at 2.2 m (elevation 195.4) in borehole 107-20 was sand/sandy silt. Very loose in relative density (SPT-‘N’ values of 0 to 2), this unit had a thickness of 1.5 m in the former borehole and 1.1 m in the latter and was penetrated at respective depths of 3.0 to 3.3 m (elevation 195.0 and 194.3).

The results of grain size distribution analysis performed on a sample of the sand are presented in Figure C22-GS-1.

4.11.4 Silty Clay

Overlain by the sand/sandy silt at 3.0 and 3.3 m (elevation 195.0 and 194.3) in boreholes C22-1 and 107-20 was a cohesive deposit of silty clay. The deposit had a thickness of 8.5 m in borehole C22-1 and 5.4 m in borehole 107-20 and was penetrated at respective depths of 11.5 and 8.7 m (elevation 186.5 and 188.9). The silty clay was soft to firm in consistency and 35 to 99% in moisture content.

The results of in situ vane testing carried out in the silty clay yielded undisturbed shear strength values of 14 to 56 kPa (soil sensitivity of 2 to 7).

The results of Atterberg limits testing and grain size distribution analysis conducted on a cohesive sample are presented in respective Figures 107-PC-1 and 107-GS-2. The liquid and plastic limits of the clay were 42 and 19 respectively, thus giving the plasticity index of 23 indicating a medium plasticity cohesive soil.

4.11.5 Gravelly Sand

A 900 mm thick gravelly sand was contacted below the silty clay at 8.7 m (elevation 188.9) in borehole 107-20 and mantled probable bedrock at 9.6 m (elevation 188.0). This stratum was very dense (SPT-‘N’ value of 53), with a moisture content of about 9%.

The results of grain size distribution analysis performed on a sample of the gravelly sand are presented in Figure 107-GS-4.

4.11.6 Bedrock

The bedrock surface was inferred by refusal under snow/ice, water or the native soils of silty clay and gravelly sand at 1.0 to 11.5 m (elevation 186.5 to 196.6) in all the borehole.

4.11.7 Groundwater

In the process of augering, water was detected at the ground surface (elevation 197.6) in boreholes 107-19 and 107-20 and at 0.8 m (elevation 197.2) in borehole C22-1. Upon completion of drilling, water was at the ground surface (elevation 197.6) in boreholes 107-19 and 107-20.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.12 Culvert C-23 at Sta. 17+864.5 (NBL)

Boreholes C23-1 and C23-2 were advanced at both ends of this culvert. Borehole 107-27 previously drilled for the swamp investigation and located near the centre of the culvert was also used to supplement the subsurface information. The borehole locations are shown on Drawing C23/C24-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised topsoil / peat or silty sand over a cohesive deposit of silty clay or bedrock. The bedrock surface was contacted at 0.7 to 2.6 m (elevation 195.2 to 197.0). Water was at 0.0 to 0.4 m (elevation 197.4 to 197.8).

The strata encountered in the boreholes are summarised below.

4.12.1 Topsoil / Peat

Topsoil was present under 200 mm of water at elevation 197.5 in borehole C23-1. The sandy topsoil was 500 mm thick and mantled probable bedrock at 0.7 m (elevation 197.0).

Peat was present under 500 mm of ice and water at elevation 197.3 in borehole C23-2. The amorphous peat was 1.3 m in thickness and 43% in moisture content. The peat was penetrated at 1.8 m (elevation 196.0).

4.12.2 Silty Sand

A silty sand layer was present under 700 mm of snow, ice and water at elevation 197.0 in borehole 107-27. The silty sand was 200 mm thick and penetrated at 0.9 m (elevation 196.8). This layer was very dense and had a moisture content of 28%.

4.12.3 Silty Clay

Underlying the peat, a 800 mm thick cohesive silty clay deposit was encountered at 1.8 m (elevation 196.0) in borehole C23-2 and penetrated at 2.6 m (elevation 195.2). This deposit was soft to firm in consistency.

4.12.4 Bedrock

Bedrock was inferred by refusal at 0.7 to 2.6 m (elevation 195.2 to 197.0) in all the boreholes.

4.12.5 Groundwater

In the process of augering, water was detected at ground surface (elevation 197.7) in boreholes C23-1 and 107-27 and at 0.4 m (elevation 197.4) in borehole C23-2. Upon completion of drilling, water was at the ground surface (elevation 197.7 and 197.8) in all the boreholes.

It is worth noting that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.13 Culvert C-24 at Sta. 17+864.5 (SBL)

Boreholes C24-1 and C24-2 were advanced at both ends of this culvert. The borehole locations are shown on Drawing C23/C24-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised surficial fill or peat overlying sandy silt, silty clay and silty sand extending to bedrock. The bedrock surface was contacted/inferred at 1.6 and 8.1 m (elevation 196.0 and 189.8). Water was at the ground surface (elevation 197.9) in borehole C24-1.

The strata encountered in the boreholes are summarised below.

4.13.1 Fill

Surficial fill was present in borehole C24-2. Composed of peat, sandy silt, cobbles and boulders, the fill had a total thickness of 1.6 m and was penetrated at elevation 196.0.

Generally, unless records were kept during the placement of the fill and are available for review, the condition of the fill placement should be considered variable and uncontrolled.

4.13.2 Peat

Peat was encountered under 200 mm of ice and water at elevation 197.7 in borehole C24-1. The peat was 1.5 m thick and penetrated at 1.7 m (elevation 196.2). The amorphous peat had a moisture content varying widely between 61 and 404%.

4.13.3 Sandy Silt

Overlain by the peat, a 700 mm thick cohesionless silty sand was contacted at 1.7 m (elevation 196.2) in borehole C24-1 and penetrated at 2.4 m (elevation 195.5). Containing organics, this unit was very loose in relative density (SPT-‘N’ value of 1) and 93% in moisture content.

4.13.4 Silty Clay

A 5.4 m thick cohesive silty clay deposit was encountered below the sandy silt at 2.4 m (elevation 195.5) in borehole C24-1 and penetrated at 7.8 m (elevation 190.1). This deposit was very soft to soft in consistency. The results of in situ vane testing carried out in the silty clay yielded undisturbed shear strength values varying between 8 and 24 kPa (soil sensitivity of 2 to 4). Penetrometer tests on cohesive samples indicated shear strength values in range of 12.5 to 25 kPa.

The results of Atterberg limits testing and grain size distribution analysis conducted on a sample of the deposit are presented in respective Figures C24-PC-1 and C24-GS-1. The liquid and plastic limits of the silty clay were 46 and 22 respectively, thus giving the plasticity index of 24. Moisture contents of 44 to 64% were measured.

4.13.5 Silty Sand

Below the silty clay, a 300 mm thick cohesionless silty sand was contacted at 7.8 m (elevation 190.1) in borehole C24-1 and penetrated at 8.1 m (elevation 189.8). This stratum was compact to very dense in relative density. It is noteworthy that the silty sand contains cobbles and boulders.

4.13.6 Bedrock

Bedrock was inferred by refusal at 8.1 m (elevation 189.8) in borehole C24-1 and contacted at 1.6 m (elevation 196.0) in borehole C24-2. The bedrock was proven upon contact by coring 3.0 m into the rock to 4.6 m (elevations 193.0) in borehole C24-2.

The bedrock comprised granitic gneiss. The measured core recovery was 96 to 100%. The RQD determined from the rock cores was in a range of 96 to 100%, thus indicating an excellent quality rock.

4.13.7 Groundwater

In the process of augering, water was present under 100 mm of ice at elevation 197.8 in borehole C24-1. Water was at ground surface (elevation 197.9) in borehole C24-1 upon completion of drilling. No groundwater was established in borehole C24-2 charged with drilling water for rock coring.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.14 Culvert C-25 at Sta. 18+235.3 (NBL)

Boreholes C25-1 and C25-2 were advanced at both end of this culvert. Boreholes 108-3 and 108-7 previously drilled for the swamp investigation and located near the centre of the culvert were also used to supplement the subsurface information. The borehole locations are shown on Drawing C25/C26-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised surficial topsoil overlying silty sand and clay or bedrock. The bedrock surface was inferred/contacted at 0.2 to 2.1 m (elevation 193.1 to 196.8).

The strata encountered in the boreholes are summarised below.

4.14.1 Topsoil

Surficial topsoil was present in all the boreholes. The silty topsoil had a thickness of 200 to 400 mm and was penetrated at elevation 194.8 to 196.8.

4.14.2 Silty Sand

Directly beneath the topsoil, a 300 mm thick silty sand layer was contacted at 0.4 m (elevation 194.8) in borehole C25-2 and penetrated at 0.7 m (elevation 194.5). This layer was very loose in relative density.

4.14.3 Clay

Underlying the silty sand, a 1.4 m thick cohesive clay was encountered at 0.7 m (elevation 194.5) in borehole C25-2 and penetrated at 2.1 m (elevation 193.1). This deposit was firm to stiff in consistency.

The results of in situ vane testing carried out in the clay yielded an undisturbed shear strength value of 24 kPa (soil sensitivity of 6). A penetrometer test on a cohesive sample indicated a shear strength value of 100 kPa.

The results of Atterberg limits testing and grain size distribution analysis performed on the clay sample are presented in respective Figures C25-PC-1 and C25-GS-1. The liquid and plastic limits of the clay were 51 and 30 respectively, thus giving the plasticity index of 21 indicating a high plasticity cohesive soil.

4.14.4 Bedrock

The bedrock surface was inferred by refusal at 0.2 to 0.3 m (elevation 194.8 to 196.8) in boreholes C25-1, 108-3 and 108-7.

Granitic gneiss bedrock was contacted at 2.1 m (elevation 193.1) in borehole C25-2. The bedrock was proven upon contact by coring 3.9 m into the rock to 6.0 m (elevations 189.2).

The measured core recovery varied between 92 and 100%. The RQD determined from the rock cores was in a range of 92 to 100%, thus indicating an excellent quality rock.

4.14.5 Groundwater

In the process of augering, water was detected at the ground surface (elevation 195.2) in borehole C25-2. No groundwater was observed in any of the boreholes during or upon completion of drilling.

It is worth noted that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.15 Culvert C-26 at Sta. 18+249.5 (SBL)

Boreholes C26-1 and C26-2 were drilled at this culvert. The boreholes were advanced at both ends of the culvert. The borehole locations are shown on Drawing C25/C26-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised surficial topsoil overlying sand / silty sand and clayey silt mantling bedrock. The bedrock surface was contacted at 1.3 and 1.7 m (elevation 194.7 and 194.0).

The strata encountered in the boreholes are summarised below.

4.15.1 Topsoil

Surficial topsoil was presented in both boreholes. Having a moisture content of 29%, the silty topsoil was 0.3 and 1.0 m thick and penetrated at elevation 195.4 and 195.0 in boreholes C26-1 and C26-2 respectively.

4.15.2 Sand / Silty Sand

Directly beneath the topsoil, a 300 mm thick cohesionless sand / silty sand was contacted at 0.3 and 1.0 m (elevation 195.4 and 195.0) in boreholes C26-1 and C26-2 respectively and penetrated at 0.6 and 1.3 m (elevation 195.1 and 194.7). This stratum was loose to compact in relative density.

A 200 mm thick layer of silty sand was also identified at 1.5 m (elevation 194.2) in borehole C26-1 and mantled bedrock at 1.7 m (elevation 194.0). This layer was loose to compact in relative density.

4.15.3 Clayey Silt

Underlying the sand, a 900 mm thick cohesive clayey silt deposit was encountered at 0.6 m (elevation 195.1) in borehole C26-1 and penetrated at 1.5 m (elevation 194.2). This deposit was stiff in consistency and about 44% in moisture content. A penetrometer test on the clayey silt sample indicated a shear strength value of 62 kPa.

4.15.4 Bedrock

Bedrock was contacted at 1.7 m (elevation 194.0) in borehole C26-1 and 1.3 m (elevation 194.7) in borehole C26-2. It was proven upon contact by coring 3.6 m into the rock to 4.9 and 5.3 m (elevation 191.1 and 190.4) in boreholes C26-2 and C26-1 respectively.

The bedrock comprised granitic gneiss. The measured core recovery varied between 64 and 100%. The RQD determined from the rock cores was in a range of 52 to 100%, thus indicating a fair to excellent quality rock.

4.15.5 Groundwater

In the process of augering, water was detected at 1.5 m (elevation 194.2) in borehole C26-1. No groundwater was established in either borehole charged with drilling water for rock coring.

It is worth noting that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.16 Culvert C-28 at Sta. 18+585.0 (NBL)

Boreholes C28-1 and C28-2 were advanced at the left (west) end and the right (east) end of this culvert. Borehole 109-1 previously drilled for the swamp investigation and located near the centre of the culvert was also used to supplement the subsurface information. The borehole locations are shown on Drawing C28/C29-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised surficial peat overlying silty sand and silty clay extending to bedrock. The bedrock surface was contacted/inferred at 0.0 to 15.1 m (elevation 173.9 to 193.2). Open water was under 200 mm of ice at elevation 188.8 in borehole C28-1.

The strata encountered in the boreholes are summarised below.

4.16.1 Peat

Covered with 900 mm of ice and water, peat was present at elevation 188.1 in borehole C28-1. The peat was 300 mm thick and penetrated at 1.2 m (elevation 187.8).

4.16.2 Silty Sand

A 200 mm thick silty sand layer was identified below the peat at 1.2 m (elevation 187.8) in borehole C28-1 and penetrated at 1.4 m (elevation 187.6). This unit was loose in relative density (SPT-'N' value of 5).

4.16.3 Silty Clay

Overlain by the silty sand at 1.4 m (elevation 187.6) in borehole C28-1 was a cohesive deposit of silty clay. This deposit was at least 11.8 m thick and likely extended to probable bedrock encountered at 15.1 m (elevation 173.9). The silty clay was stiff to soft in consistency. The results of in situ vane testing carried out in the silty clay yielded undisturbed shear strength values of 24 to 44 kPa (soil sensitivity of 2 to 4). Penetrometer tests on cohesive samples indicated shear strength values in a range of 13 to 75 kPa.

The results of Atterberg limits testing and grain size distribution analyses conducted on 2 samples of the deposit are presented in respective Figures C28-PC-1 and C28-GS-1. The liquid and plastic limits of the silty clay were 38 to 42 and 19 to 21 respectively, thus giving the plasticity index of 19 and 21. Moisture contents of 17 to 62% were measured.

4.16.4 Bedrock

Bedrock was contacted at surface (elevation 193.1 and 193.2) in boreholes 109-1 and C28-2 and inferred by refusal at 15.1 m (elevation 173.9) in borehole C28-1. The bedrock was proven upon contact by coring 3.5 m into the rock to 3.5 m (elevations 189.7) in borehole C28-2.

The bedrock comprised granitic gneiss. The measured core recovery varied between 62 and 100%. The RQD determined from the rock cores was in a range of 67 to 100%, thus indicating a fair to excellent quality rock, with the exception of a 0.3 m core sample at 1.7 m (elevation 191.5) below the bedrock surface where the rock quality was poor (RQD of 31%).

4.16.5 Groundwater

Open water was present under 200 mm of ice at elevation 188.8 in borehole C28-1. No groundwater was established in the other two boreholes, during or upon completion of drilling.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.17 Culvert C-29 at Sta. 18+585.0 (SBL)

Boreholes C29-1 and C29-2 were advanced at this culvert. Borehole C29-1 was put down near the left (west) end and borehole C29-2 at the right (east) end of the culvert. The borehole locations are shown on Drawing C28/C29-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised surficial rockfill or peat overlying a cohesive deposit of clayey silt, silty clay and clay extending to bedrock. The bedrock surface was inferred at 9.1 m (elevation 182.4).

The strata encountered in the boreholes are summarised below.

4.17.1 Fill

Rockfill was present at the surface (elevation 189.7) in borehole C29-2.

4.17.2 Peat

Peat was present under 300 mm of ice at elevation 191.2 in borehole C29-1. The amorphous peat was 100 mm thick and penetrated at 0.4 m (elevation 191.1).

4.17.3 Clayey Silt to Clay

Overlain by the peat at 0.4 m (elevation 191.1) in borehole C29-1 was a cohesive deposit of clayey silt, silty clay and clay. This deposit had a total thickness of 8.7 m and was penetrated at 9.1 m (elevation 182.4). The cohesive deposit was firm to stiff in consistency. The results of in situ vane testing carried out in the silty clay yielded undisturbed shear strength values of 32 to 64 kPa (soil sensitivity of 3 to 10). Penetrometer tests on cohesive samples indicated shear strength values in a range of 13 to 50 kPa.

The results of Atterberg limits testing and grain size distribution analyses conducted on 2 cohesive samples are presented in respective Figures C29-PC-1, C29-PC-2 and C29-GS-1, C29-GS-2. The liquid and plastic limits of the silty clay were 48 and 22 respectively, thus giving the plasticity index of 26. The clay had a liquid limit of 54, plastic limit of 24, its plasticity index being 30. Moisture contents of 28 to 66% were measured.

4.17.4 Bedrock

Bedrock was inferred by refusal at 9.1 m (elevation 182.4) in boreholes C29-1.

4.17.5 Groundwater

Upon completion of drilling, water was present at the ground surface (elevation 191.5) in borehole C29-1. No groundwater was established in borehole C29-2 during or upon completion of drilling.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.18 Culvert C-30 at Sta. 18+612.9 (Median)

Boreholes C30-1 and C30-2 were advanced at the left (west) end and the right (east) end of this culvert. Borehole 109-8 previously drilled for the swamp investigation and located near the centre of the culvert was also used to supplement the subsurface information. The borehole locations are shown on Drawing C30-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised surficial peat overlying a cohesive deposit of clayey silt, silty clay and clay extending to bedrock. The bedrock surface was inferred by refusal at 4.4 and 6.1 m (elevation 184.9 and 182.3) in two boreholes but was not encountered at 9.8 m (elevation 178.7) in the third borehole. Open water was at 0.0 to 0.5 m (elevation 188.0 to 189.0).

The soil strata encountered in the boreholes are summarised below.

4.18.1 Peat

Peat was present under 200 to 900 mm of ice and water at elevation 187.6 to 188.7 in all the boreholes. The peat was fine fibrous to amorphous and had a moisture content of 141% in one determination. The peat was 0.2 to 1.3 m thick and penetrated at 0.4 to 2.2 m (elevation 186.3 to 188.0).

4.18.2 Clayey Silt / Silty Clay / Clay

Overlain by the peat at 0.4 to 2.2 m (elevation 186.3 to 188.0) in all the boreholes was a cohesive deposit of clayey silt, silty clay and clay. The deposit had a thickness of 5.7 m in borehole C30-1 and 2.8 m in borehole 109-8 and was penetrated at respective depths of 6.1 and 4.4 m (elevation 182.3 and 184.9). Borehole C30-2 was terminated in the clay at 9.8 m (elevation 178.7). The cohesive deposit was soft to stiff in consistency. An unconfined compressive test on a sample of the clay gave a shear strength of 17 kPa with a strain of failure of 3.2%. The results of in situ vane testing carried out in the deposit yielded undisturbed shear strength values varying between 10 and 80 kPa (soil sensitivity of 2 to 7). Penetrometer tests on cohesive samples indicated shear strength values in a range of 12 to 100 kPa.

The results of Atterberg limits testing and grain size distribution analyses conducted on 3 cohesive samples are presented in respective Figures C30-PC-1, C30-PC-2 and C30-GS-1, C30-GS-2. The liquid and plastic limits of the clayey silt were 25 and 16 respectively, thus giving the plasticity index of 9. The liquid and plastic limits of the clay ranged from 55 to 61 and from 22 to 24 respectively, with the plasticity index of 33 to 37. Moisture contents of 24 to 86% were measured.

4.18.3 Bedrock

Bedrock was inferred by refusal at 4.4 and 6.1 m (elevation 184.9 and 182.3) in boreholes 109-8 and C30-1 respectively. No bedrock was encountered in borehole C30-2 terminated at 9.8 m (elevation 178.7).

4.18.4 Groundwater

In the process of augering, water was encountered at 0.3 to 0.6 m (elevation 187.8 to 189.0) in all the boreholes. Upon completion of drilling, water was at the ground surface (elevation 188.4) in borehole C30-1 and under 300 to 500 mm of ice at elevation 188.0 to 189.0 in other two boreholes.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.19 Culvert C-41 at Sta. 19+385.3 (Median)

Borehole C41-1 was advanced at the left (west) end of this culvert. Boreholes 112-6 and 112-7 previously drilled for the swamp investigation and located near the right (east) and centre of the culvert were also used to supplement the subsurface information. In addition, two dynamic cone penetration tests (DCPTs) were conducted adjacent to the boreholes C41-1 and 112-7. The borehole locations are shown on Drawing C41-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised surficial peat overlying organic silty sand / organic silt underlain by a cohesive deposit of clayey silt / silty clay / clay and cohesionless sandy soils extending to bedrock. The bedrock surface was inferred at 3.8 to 11.1 m (elevation 177.7 to 189.2). Groundwater was at 0.3 and 0.6 m (elevation 188.5 and 188.1) in two boreholes.

The strata encountered in the boreholes are summarised below.

4.19.1 Peat

Peat was present surficially in borehole C41-1 and under 200 to 600 mm of snow and ice at elevation 188.1 to 188.6 in the other two boreholes. The fine to coarse fibrous peat was 100 to 600 mm thick and penetrated at 0.1 to 1.2 m (elevation 187.5 to 192.9). The moisture content of the peat was in a range of 33 to 41%.

4.19.2 Organic Silty Sand / Organic Silt

Directly beneath the peat at 0.1 and 0.5 m (elevation 192.9 and 188.3) in boreholes C41-1 and 112-6 was organic silty sand or organic silt. This unit was 200 and 900 mm thick and penetrated at 0.3 and 1.4 m (elevation 192.7 and 187.4) in boreholes C41-1 and 112-6 respectively. The organic silty sand/organic silt was very loose to loose in relative density (SPT-'N' values of 3 and 5) and had a moisture content of 37 to 48%.

4.19.3 Clayey Silt / Silty Clay / Clay

Overlain by the organic silty sand, organic silt or peat at 0.3 to 1.4 m (elevation 187.4 to 192.7) in all the boreholes was a cohesive deposit of clayey silt, silty clay and clay. The deposit had a total thickness of 2.4 to 9.5 m and was penetrated at 2.7 to 10.9 m (elevation 177.9 to 190.3). The cohesive deposit was very soft to stiff in consistency. An unconfined compressive test on a sample of the clayey silt gave a shear strength of about 11 kPa (strain at failure of 2%). The results of in situ vane testing carried out in the deposit yielded undisturbed shear strength values varying between 12 and 40 kPa (soil sensitivity of 3 to 10). Penetrometer tests on samples of the silty clay indicated shear strength values in a range of 50 to 100 kPa.

The results of Atterberg limits testing and grain size distribution analyses conducted on 3 cohesive samples are presented in respective Figures C41-PC-1, 112-PC-1, 112-PC-3 and C41-GS-1, 112-GS-2 and 112-GS-4. The liquid and plastic limits of the clayey silt were 29 and 18 respectively, thus giving the plasticity index of 11. The silty clay unit had a liquid limit of 41, plastic limit of 20, its plasticity index being 21. The liquid and plastic limits of the clay were 58 and 23 respectively, with the plasticity index of 35. Moisture contents of 28 to 84% were measured.

4.19.4 Sand / Sand and Gravel

Underlying the silty clay/clay at 2.7 and 10.9 m (elevation 190.3 and 177.9) in boreholes C41-1 and 112-6 was cohesionless sand / sand and gravel. This stratum had a thickness of 1.1 m in borehole C41-1 and 0.2 m in borehole 112-6 and was penetrated at respective depths of 3.8 and 11.1 m (elevation 189.2 and 177.7). The sand / sand and gravel was compact in relative density (SPT-'N' values of 13 and 24.)

4.19.5 Bedrock

Bedrock was inferred by refusal at 3.8 to 11.1 m (elevation 177.7 to 189.2) in all the boreholes.

4.19.6 Groundwater

In the process of augering, water was detected at 0.3 and 0.6 m (elevation 188.5 and 188.1) in boreholes 112-6 and 112-7 respectively. Upon completion of drilling, groundwater was measured in borehole 112-6 to be at 0.3 m (elevation 188.5). No groundwater was established in borehole C41-1 during or upon completion of drilling.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.20 Culvert C-42 at Sta. 19+410.0 (NBL)

Borehole C42-1 was advanced at the right (east) end of this culvert. Boreholes 112-10, 112-11 and 112-13 previously drilled for the swamp investigation and located near the centre, left (west) end and right (east) end of the culvert were also used to supplement the subsurface information. The borehole locations are shown on Drawing C42/C43-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised exposed bedrock or topsoil over silty clay extending to bedrock. The bedrock surface was contacted/inferred at 0.0 to 2.1 m (elevation 189.0 to 193.7). Water was present at the surface (elevation 191.1) in one borehole.

The soil strata encountered in the boreholes are summarised below.

4.20.1 Topsoil

Topsoil was present surficially (elevation 191.6) in borehole 112-11 and under 300 mm of snow and ice at elevation 190.8 in borehole 112-13. The silty topsoil was 100 and 300 mm thick and penetrated at 0.1 and 0.6 m (elevation 191.5 and 190.5) in boreholes 112-11 and 112-13 respectively.

4.20.2 Silty Clay

A 1.5 m thick silty clay was contacted below the topsoil at 0.6 m (elevation 190.5) in borehole 112-13 and penetrated at 2.1 m (elevation 189.0). This deposit was stiff in consistency. A penetrometer test on a sample of the silty clay indicated a shear strength value of 175 kPa.

The results of Atterberg limits testing and grain size distribution analysis performed on a sample of the deposit are presented in Figures 112-PC-2 and 112-GS-3. The liquid and plastic limits of the silty clay were 38 and 20 respectively, thus giving the plasticity index of 18.

4.20.3 Bedrock

Bedrock was contacted or inferred by refusal at 0.0 to 2.1 m (elevation 189.0 to 193.7) in all the boreholes.

The bedrock was proven upon contact by coring 3.0 m into the rock to 3.0 m (elevation 189.2) in borehole C42-1. The bedrock comprised granitic gneiss. The measured core recovery varied between 83 and 100%. The RQD determined from the rock cores was in a range of 83 to 100%, thus indicating a good to excellent quality rock.

4.20.4 Groundwater

In the process of auguring, water was detected at 1.2 m (elevation 189.9) in borehole 112-13. Upon completion of drilling, groundwater was at the surface (elevation 191.1). No groundwater was established in the remaining boreholes during or upon completion of drilling.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns

4.21 Culvert C-43 at Sta. 19+410.0 (SBL)

Borehole C43-2 was advanced at the right (east) end of this culvert. Borehole C43-1 previously drilled for the pavement investigation and located near the left (west) end of the culvert was also used to supplement the subsurface information. The borehole locations are shown on Drawing C42/C43-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised exposed bedrock or asphalt over granular soils extending to rockfill. Bedrock was contacted at the surface (elevation 194.3) in borehole C43-2. It is noteworthy that rockfill was encountered at 0.8 m (elevation 197.4) in borehole C43-1.

The strata encountered in the boreholes are summarised below.

4.21.1 Asphalt

Surficial asphalt present in borehole C43-1, had a thickness of about 290 mm and was penetrated at elevation 197.4.

4.21.2 Sand and Gravel / Sand

Pavement structure made up of about 200 mm thick sand and gravel overlying 290 mm of sand was encountered at 0.3 m (elevation 197.9) in borehole C43-1 and extended to rockfill at 0.8 m (elevation 197.4)

4.21.3 Rockfill

Rockfill was encountered at 0.8 m (elevation 197.4) in borehole C43-1.

4.21.4 Bedrock

Bedrock was contacted at the surface (elevation 194.3) in borehole C43-2. It was proven by coring 3.6 m into the rock (elevations 190.7) in borehole C43-2.

The bedrock comprised granitic gneiss. The measured core recovery varied between 86 and 100%. The RQD determined from the rock cores was in a range of 65 to 100%, thus indicating a fair to excellent quality rock.

4.21.5 Groundwater

No groundwater was established in any of the borehole during or upon completion of drilling.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.22 Culvert C-46 at Sta. 19+887.0 (SBL)

Boreholes C46-1 and C46-2 were advanced at the left (west) end and the right (east) end of this culvert. Boreholes 114-5 and 114-9 previously drilled for the swamp investigation and located near the centre of the culvert were also used to supplement the subsurface information. The borehole locations are shown on Drawing C46/C47-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised surficial boulders over bedrock contacted at elevation 193.6 to 195.3.

The strata encountered in the boreholes are summarised below.

4.22.1 Boulders

Layer of boulders was present surficially in borehole C46-2. This layer was 500 mm thick and penetrated at 0.5 m (elevation 193.9).

4.22.2 Bedrock

Bedrock was exposed at elevation 193.6 to 195.3 in boreholes C46-1, 114-5, 114-9 and contacted below the boulders at 0.5 m (elevation 193.9) in borehole C46-2. The bedrock was proven upon contact by coring 3.1 and 3.2 m into the rock to 3.1 and 3.7 m (elevation 191.3 and 190.7) in boreholes C46-1 and C46-2 respectively.

The bedrock comprised granitic gneiss. The measured core recovery was 100%. The RQD determined from the rock cores was in a range of 88 to 100%, thus indicating a good to excellent quality rock, with the exception of upper 0.6 m thick zone in borehole C46-2 where the rock quality was poor (RQD of 30%).

4.22.3 Groundwater

No groundwater was established in any of the borehole during or upon completion of drilling.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.23 Culvert C-47 at Sta. 19+893.4 (NBL)

A total of three boreholes, numbered C47-1, C47-2 and C47-3, were advanced for this culvert. Boreholes C47-1 and C47-3 were put down near the left (west) end and right (east) end respectively and borehole C47-2 near the centre of the culvert. The borehole locations are shown on Drawing C46/C47-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised silty sand and/or bedrock covered with ice and water. The bedrock surface was inferred by refusal at 2.3 to 4.6 m (elevation 190.2 to 193.2). Open water was present under 300 to 500 mm of ice at elevation 193.8 to 195.0.

The strata encountered in the boreholes are summarised below.

4.23.1 Silty Sand

Overlain by 4.3 m of ice and water at elevation 190.5 in borehole C47-2 was silty sand. Loose in relative density, this unit was 300 mm thick and mantled probable bedrock at 4.6 m (elevation 190.2).

4.23.2 Bedrock

Bedrock was inferred by refusal at 2.3 to 4.6 m (elevation 190.2 to 193.2) in all the boreholes.

4.23.3 Groundwater

Open water was present under 300 to 500 mm of ice at elevation 193.8 to 195.0 in boreholes C47-1 to C47-3.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.24 Culvert C-48 at Sta. 20+226.0 (SBL)

Boreholes C48-1 and C48-2 were advanced at the location of this culvert. Borehole C48-1 was put down at the left (west) end and borehole C48-2 at the right (east) end of the proposed culvert. Borehole 115-10 previously drilled for the swamp investigation and located near the centre of the culvert was also used to supplement the subsurface information. The borehole locations are shown on Drawing C48/C49-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised surficial peat or organic silty sand / silty sand with organics overlying a cohesive deposit of silty clay / clay underlain by sand extending to bedrock. The bedrock surface was inferred by refusal at 0.6 to 3.2 m (elevation 191.7 to 194.2). Open water was present under 300 mm of ice at elevation 195.0 in borehole 115-10.

The strata encountered in the boreholes are summarised below.

4.24.1 Peat

Surficial peat was present in boreholes C48-1 and C48-2. The peat was 100 to 200 mm thick and penetrated at elevation 194.6 and 194.8 in boreholes C48-1 and C48-2 respectively.

4.24.2 Organic Silty Sand / Silty Sand with Organics

Organic silty sand or silty sand with organics was identified below the peat or covered with ice and water at 0.1 to 0.6 m (elevation 194.6 to 194.8). Very loose to loose in relative density (SPT-‘N’ values of weight of hammer to 3), this unit was 300 to 800 mm in thickness and penetrated at 0.6 to 0.9 m (elevation 194.0 to 194.4).

4.24.3 Silty Clay / Clay

Overlain by the organic silty sand / silty sand with organics at 0.9 m (elevation 194.4 and 194.0) in boreholes 115-10 and C48-2 was a cohesive deposit of silty clay or clay. This deposit was 0.8 and 2.3 m thick and penetrated at 1.7 and 3.2 m (elevation 193.6 and 191.7) in boreholes 115-10 and C48-2 respectively. The deposit was firm to very stiff in consistency. The results of in situ vane testing carried out in the clay yielded undisturbed shear strength values of 28 and 44 kPa (soil sensitivity of 4 and 6). Penetrometer tests on cohesive samples indicated a shear strength of 50 to 125 kPa.

The results of Atterberg limits testing and grain size distribution analysis conducted on a clay sample are presented in respective Figures C48-PC-1 and C48-GS-1. The liquid and plastic limits of the clayey were 53 and 24 respectively, thus giving the plasticity index of 29. Moisture contents of 30 to 54% were measured.

4.24.4 Sand

A 300 mm thick cohesionless sand layer was revealed below the silty clay at 1.7 m (elevation 193.6) in borehole 115-10 and penetrated at 2.0 m (elevation 193.3). This layer was loose to compact in relative density.

4.24.5 Bedrock

Bedrock was inferred by refusal at 0.6 to 3.2 m (elevation 191.7 to 194.2) in all the boreholes.

4.24.6 Groundwater

Open water was present under 300 mm of ice at elevation 195.0 in borehole 115-10. No groundwater was established in boreholes C48-1 and C48-2 during or upon completion of drilling.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.25 Culvert C-49 at Sta. 20+245.1 (NBL)

Boreholes C49-1 and C49-2 were advanced at the location of this culvert. Borehole C49-1 was put down at the left (west) end and borehole C49-2 at the right (east) end of the proposed culvert. Borehole 115-16 previously drilled for the swamp investigation and located near the centre of the culvert was also used to supplement the subsurface information. The borehole locations are shown on Drawing C48/C49-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised peat overlying silty sand / organic clayey silt overlying a cohesive deposit of clayey silt, silty clay and clay underlain by sand extending to bedrock. The bedrock surface was inferred by refusal at 5.1 to 8.8 m (elevation 185.9 to 189.5). Open water was present under 300 mm of ice at elevation 194.4 in borehole 115-16.

The strata encountered in the boreholes are summarised below.

4.25.1 Peat

Peat was present surficially in borehole C49-2 and under 0.5 to 1.0 m of snow / ice and water at elevation 194.2 and 193.7 in boreholes C49-1 and 115-16. The amorphous peat was 100 to 400 mm in thickness and penetrated at 0.2 to 1.4 m (elevation 193.3 to 194.4) in boreholes C49-1, C49-2 and 115-16.

4.25.2 Organic Clayey Silt

An 800 mm thick organic clayey silt was directly beneath the peat at 1.4 m (elevation 193.3) in borehole 115-16 and penetrated at 2.2 m (elevation 192.5). This unit was firm in consistency.

4.25.3 Silty Sand

A silty sand layer was identified below the peat at 0.6 m (elevation 194.1) in borehole C49-1 and 0.2 m (elevation 194.4) in borehole C49-2. Loose in relative density, this layer had a thickness of 600 mm in the former borehole and 100 mm in the latter and was penetrated at 1.2 and 0.3 m (elevation 193.5 and 194.3).

4.25.4 Clayey Silt / Silty Clay / Clay

Overlain by the silty sand or organic clayey silt at 0.3 to 2.2 m (elevation 192.5 to 194.3) in all the boreholes was a cohesive deposit of clayey silt, silty clay and clay. This deposit was 4.2 to 6.3 m thick and penetrated at 5.1 to 8.5 m (elevation 186.2 to 189.5). The cohesive deposit was soft to very stiff in consistency. The results of in situ vane testing carried out in the deposit yielded undisturbed shear strength values varying between 16 and 76 kPa (soil sensitivity of 3 to 26). Penetrometer tests on cohesive samples indicated shear strength values in a range of 12 to 162 kPa.

The results of Atterberg limits testing and grain size distribution analyses conducted on 4 cohesive samples are presented in respective Figures C49-PC-1, C49-PC-2, 115-PC-1,115-PC-3 and C49-GS-1, C49-GS-2, 115-GS-1, 115-GS-3. The liquid and plastic limits of the clayey silt were 30 to 31 and 19 respectively, thus giving the plasticity index of 11 and 12. The silty clay unit had a liquid limit of 35, plastic limit of 19, its plasticity index being 16. The liquid and plastic limits of the clay were 52 and 24 respectively, with the plasticity index of 28. Moisture contents of 24 to 85% were measured.

4.25.5 Sand

A 300 mm thick cohesionless sand layer was revealed below the clay at 8.5 m (elevation 186.2) in borehole 115-16. This layer was compact in relative density and penetrated at 8.8 m (elevation 185.9).

4.25.6 Bedrock

Bedrock was inferred by refusal at 5.1 to 8.8 m (elevation 185.9 to 189.5) in all the boreholes.

4.25.7 Groundwater

Open water was present under 300 mm of ice at elevation 194.4 in borehole 115-16. No groundwater was established in boreholes C49-1 and C49-2 during or upon completion of drilling.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.26 Culvert C-51 at Sta. 20+935.5 (NBL)

A total of three boreholes, C51-1, C51-2 and C51-3, were advanced at this culvert. Boreholes C51-1 and C51-3 were put down at the left (west) and right (east) end of the culvert and borehole C51-3 near the centre of the culvert. In addition, a dynamic cone penetration test (DCPT) was conducted adjacent to the borehole 116-22 at the right end of the culvert. The borehole locations are shown on Drawing C51/C52-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised surficial peat overlying sand / silty sand underlain by a cohesive deposit of silty clay / clayey silt mantling bedrock. The bedrock surface was contacted/inferred at 1.2 and 2.2 m (elevation 190.1 to 192.0).Groundwater was at the ground surface (elevation 193.1) in borehole C51-2 upon completion of drilling.

The strata encountered in the boreholes are summarised below.

4.26.1 Peat

Surficial peat was present in boreholes C51-1 to C51-3. The fine fibrous to amorphous peat was 200 to 300 mm thick and penetrated at elevation 192.6 to 192.9. The moisture content of one peat sample was about 33%.

4.26.2 Sand / Silty Sand

Directly beneath the peat at 0.2 to 0.3 m (elevation 192.6 to 192.9) in borehole C51-1 to C51-3 was cohesionless sand / silty sand. Very loose in relative density, this unit had a thickness of 400 to 500 mm and was penetrated at 0.6 to 0.8 m (elevation 192.1 to 192.5).

4.26.3 Silty Clay / Clayey Silt

Overlain by the sand / silty sand at 0.6 to 0.8 m (elevation 192.1 to 192.5) in all the boreholes was a cohesive deposit of silty clay / clayey silt. This deposit was 0.4 to 1.3 m thick and penetrated at 1.2 to 2.1 m (elevation 190.8 to 192.0). The silty clay / clayey silt was firm to very stiff in consistency. The results of in situ vane testing carried out in the silty clay yielded an undisturbed shear strength value of 28 kPa (soil sensitivity of 2). Penetrometer tests on cohesive samples indicated shear strength values in a range of 100 to 112 kPa.

The results of Atterberg limits testing and grain size distribution analyses performed on 2 samples of the deposit are presented in Figures C51-PC-1, C51-GS-1 and C51-GS-2. The liquid and plastic limits of the silty clay were 46 and 21 respectively, thus giving the plasticity index of 25 indicating a medium plasticity cohesive soil. Moisture contents of 28 to 30% were measured.

4.26.4 Bedrock

Bedrock was contacted or inferred by refusal at 1.2 and 2.2 m (elevation 190.1 to 192.0) in all the boreholes. Probable bedrock was inferred by dynamic cone refusal in borehole 116-22 at 2.2 m (elevation 190.1).The bedrock was also proven by coring 3.5 m into the rock to 5.6 m (elevations 187.3) in borehole C51-3.

The bedrock comprised granitic gneiss. The measured core recovery varied between 96 and 100%. The RQD determined from the rock cores was in a range of 75 to 100%, thus indicating a good to excellent quality rock.

4.26.5 Groundwater

Groundwater was measured in borehole C51-2 to be at 0.2 and 0.0 m (elevation 192.9 and 193.1) during and upon completion of drilling respectively. No groundwater was established in the other two boreholes.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.27 Culvert C-52 at Sta. 20+935.5 (SBL)

Boreholes C52-1 and C52-2 were advanced at this culvert. Borehole C52-1 was put down near the left (west) end and borehole C52-2 at the right (east) end of the culvert. The borehole locations are shown on Drawing C51/C52-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised surficial topsoil overlying silty sand mantling bedrock. The bedrock surface was contacted / inferred at 0.4 m (elevation 193.2 and 193.3).

The strata encountered in the boreholes are summarised below.

4.27.1 Topsoil

Surficial topsoil was present in both boreholes. The silty topsoil was 100 mm thick and penetrated at elevation 193.5 and 193.6 in boreholes C52-1 and C52-2 respectively.

4.27.2 Silty Sand

The silty sand was identified below the topsoil at 0.1 m (elevation 193.5 and 193.6) in boreholes C52-1 and C52-2. This unit had a thickness of 300 mm and was penetrated at 0.4 m (elevation 193.2 and 193.3).

4.27.3 Bedrock

Bedrock was contacted or inferred by refusal at 0.4 m (elevation 193.2 and 193.3) in boreholes C52-1 and C52-2. The bedrock was proven by coring 3.3 m into the rock to 3.7 m (elevations 189.9) in borehole C52-1.

The bedrock comprised granitic gneiss. The measured core recovery was 100%. The RQD determined from the rock cores was in a range of 60 to 100%, thus indicating a fair to excellent quality rock.

4.27.4 Groundwater

No groundwater was established in any of the borehole during or upon completion of drilling. Borehole C52-1 was charged with water during the drilling.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.28 Culvert C-53 at Sta. 21+816.4 (SBL)

Two boreholes were drilled at the location of culvert C-53. Borehole C53-1 was put down near the left (west) end and borehole C53-2 near the right (east) end of the culvert. The borehole locations are shown on Drawing C53/C54-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised surficial topsoil or peat mantling granitic gneiss bedrock. The bedrock surface was contacted / inferred at 0.1 and 0.6 m (elevation 193.9 and 194.0). Open water was present under 100 mm of ice at elevation 194.5 in borehole C53-2.

The soil strata encountered in the boreholes are summarised below.

4.28.1 Topsoil / Peat

Surficial topsoil was present in borehole C53-1. The silty topsoil was 100 mm thick and penetrated at elevation 193.9.

Covered with 200 mm of ice and water, peat was present at elevation 194.4 in borehole C53-2. The fine fibrous peat had a thickness of 400 mm and was penetrated at 0.6 m (elevation 194.0).

4.28.2 Bedrock

Bedrock was contacted or inferred by refusal at 0.1 and 0.6 m (elevation 193.9 and 194.0) in boreholes C53-1 and C53-2 respectively. The bedrock was proven by coring 3.5 m to 3.6 m (elevation 190.4) in borehole C53-1.

The bedrock comprised granitic gneiss. The measured core recovery varied between 97 and 100%. The RQD determined from the rock cores was in a range of 73 to 98%, thus indicating a fair to excellent quality rock.

4.28.3 Groundwater

Open water was present under 100 mm of ice in borehole C53-2 at elevation 194.5. No groundwater was established in borehole C53-1 charged with drilling water for rock coring.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.29 Culvert C-54 at Sta. 21+827.4 (NBL)

Boreholes C54-1, C54-2 and C54-3 were drilled at the location of this culvert. Borehole C54-1 was put down near the left (west) end and boreholes C54-2 and C54-3 near the right (east) end of the culvert. The borehole locations are shown on Drawing C53/C54-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised surficial peat over organic sand or sand with organics overlying a cohesive deposit of clayey silt underlain by sand extending to bedrock. The bedrock surface was inferred by refusal at 1.1 and 1.9 m (elevation 192.6 and 192.7) in boreholes C54-1 and C54-3. Open water was present under 200 mm of ice at elevation 193.5 and 193.8 in boreholes C54-1 and C54-2.

The soil strata encountered in the boreholes are summarised below.

4.29.1 Peat

Peat was present under 400 to 500 mm of snow, ice and water at elevation 193.2 to 194.2 in all the boreholes. The fine fibrous peat was 300 to 400 mm thick and penetrated at 0.7 to 0.9 m (elevation 192.8 to 193.9).

4.29.2 Organic Sand / Sand with Organics

Directly beneath the peat at 0.9 m (elevation 192.8 and 193.1) in boreholes C54-1 and C54-2 and at 0.7 m (elevation 193.9) in borehole C54-3 was organic sand or sand with organics. This unit was 200 to 500 mm in thickness and penetrated at 1.1 and 1.2 m (elevation 192.6 and 193.4) in boreholes C54-1 and C54-3 respectively. Borehole C54-2 was terminated in the organic sand at 1.2 m (elevation 192.8). The sand identified in borehole C54-3 was dense (SPT-‘N’ value of 36).

4.29.3 Clayey Silt

Underlying the sand at 1.2 m (elevation 193.4) in borehole C54-3 was a cohesive clayey silt deposit. The clayey silt had a thickness of 600 mm and was penetrated at 1.8 m (elevation 192.8). This deposit was very stiff in consistency.

The results of Atterberg limits testing and grain size distribution analysis performed on a cohesive sample are presented in respective Figures C54-PC-1 and C54-GS-1. The liquid and plastic limits of the clayey silt were 34 and 18 respectively, thus giving the plasticity index of 16. A moisture content of 23% was measured.

4.29.4 Sand

A 100 mm thick layer of sand was revealed below the clayey silt at 1.8 m (elevation 192.8) in borehole C54-3. This layer was dense and penetrated at 1.9 m (elevation 192.7).

4.29.5 Bedrock

Bedrock was inferred by refusal at 1.1 and 1.9 m (elevation 192.6 and 192.7) in boreholes C54-1 and C54-3. No bedrock was encountered in borehole C54-2 terminated at 1.2 m (elevation 192.8).

4.29.6 Groundwater

Open water was present under 200 mm of ice at elevation 193.5 and 193.8 in boreholes C54-1 and C54-2. No groundwater was established in the borehole C54-3 during or upon completion of drilling.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.30 Culvert C-65 at Sta. 22+675.0 (NBL)

Test holes C65-1 and C65-2 were put down at the location of this culvert. Test hole C65-1 was advanced at the left (west) end and borehole C65-2 near the right (east) end of the culvert. The borehole locations are shown on Drawing C65/C66-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised surficial peat overlying silty sand extending to bedrock. The bedrock surface was inferred by refusal at 1.2 and 2.0 m (elevation 195.6 and 194.7)

The soil strata encountered in the boreholes are summarised below.

4.30.1 Peat

Surficial peat was present under 400 mm of snow and ice at elevation 196.4 in borehole C65-2. The fine fibrous peat was 500 mm thick and penetrated at 0.9 m (elevation 195.9).

4.30.2 Silty Sand

Overlain by the peat, a 300 mm layer of silty sand was contacted at 0.9 m (elevation195.9) in borehole C65-2 and mantled probable bedrock at 1.2 m (elevation 195.6). This unit was dense in relative density.

4.30.3 Bedrock

Bedrock was inferred by refusal at 2.0 m (elevation 194.7) in borehole C65-1 and at 1.2 m (elevation 195.6) in borehole C65-2.

4.30.4 Groundwater

Groundwater was measured in borehole C65-2 at 0.4 m (elevation 196.4) upon completion of drilling.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.31 Culvert C-66 at Sta. 22+675.0 (SBL)

Boreholes C66-1 and C66-2 were advanced at the location of this culvert. Borehole C66-1 was put down near the left (west) end and borehole C66-2 near the right (east) end of the proposed culvert. Borehole 121-12 previously drilled for the swamp investigation and located near the centre of the culvert was also used to supplement the subsurface information. The borehole locations are shown on Drawing C65/C66-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised peat overlying organic sand, a cohesive deposit of clayey silt and/or sand / silty sand extending to bedrock. The bedrock surface was inferred by refusal at 1.0 to 2.1 m (elevation 193.2 to 195.5). Water was present under 100 to 600 mm of snow / ice at elevation 194.7 to 196.3.

The strata encountered in the boreholes are summarised below.

4.31.1 Peat

Covered with 200 to 600 mm of snow, ice and water, peat was present at elevation 194.7 to 196.2 in all the boreholes. The peat was fine fibrous to amorphous and had a thickness of 200 to 300 mm with a moisture content of about 26% in one determination. The peat was penetrated at 0.5 to 0.8 m (elevation 194.5 to 196.0).

4.31.2 Organic Sand

A 300 mm thick organic sand layer was identified at 0.5 m (elevation 196.0) in borehole C66-2 and penetrated at 0.8 m (elevation 195.7). The organic sand was very loose in relative density (SPT-‘N’ value of 3).

4.31.3 Clayey Silt

Overlain by the peat or organic sand at 0.8 m (elevation 194.5 and 195.7) in boreholes C66-1 and C66-2 was a cohesive clayey silt deposit. This deposit had a thickness of 1.0 m in borehole C66-1 and 0.2 m in borehole C66-2 and was penetrated at respective depths of 1.8 and 1.0 m (elevation 193.5 and 195.5). The clayey silt was firm to hard in consistency.

The results of Atterberg limits testing and grain size distribution analysis performed on a cohesive sample are presented in respective Figures C66-PC-1 and C66-GS-1. The liquid and plastic limits of the clay were 30 and 18 respectively, thus giving the plasticity index of 12. A moisture content of 30% was measured.

4.31.4 Sand / Silty Sand

Underlying the peat or clayey silt, at 1.8 m (elevation 193.5) in borehole C66-1 and at 0.5 m (elevation 195.9) in borehole 121-12 was cohesionless sand / silty sand. Loose to very dense, this stratum was 300 to 700 mm in thickness and penetrated in boreholes C66-1 and 121-12 at respective depths of 2.1 and 1.2 m (elevation 193.2 and 195.2).

4.31.5 Bedrock

Bedrock was inferred by refusal at 1.0 to 2.1 m (elevation 193.2 to 195.5) in boreholes C66-1, C66-2 and 121-12.

4.31.6 Groundwater

Water was present under 100 to 600 mm of snow / ice at elevation 194.7 to 196.3 in all the boreholes. Groundwater was established at 0.8 m (elevation 195.7) in borehole C66-2, upon completion of drilling.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

4.32 Culvert C-70 at Sta. 20+940.0, N-E/W Ramp Chainage

Boreholes C70-1 and C70-2 were drilled at the location of this culvert. Borehole C70-1 was put down near the left (west) end and borehole C70-2 near the right (east) end of the culvert. Borehole NEW-16 previously drilled for the swamp investigation and located near the centre of the culvert was also used to supplement the subsurface information. The borehole locations are shown on Drawing C70-1.

The subsurface stratigraphy revealed in the boreholes drilled at the site comprised surficial topsoil or peat overlying organic silt / sand, a cohesive deposit of clayey silt / silty clay / clay and sandy soils extending to bedrock. The bedrock surface was inferred by refusal at 1.4 to 4.7 m (elevation 187.5 to 191.7).

The strata encountered in the boreholes are summarised below.

4.32.1 Topsoil / Peat

Surficial topsoil was present in borehole C70-2. The silty topsoil was 100 mm thick and penetrated at elevation 193.0.

Peat was present surficially in borehole NEW-16 and under 300 mm of ice at elevation 191.9 in borehole C70-1. The fine fibrous to amorphous peat had a thickness of 200 and 300 mm and was penetrated at 0.3 to 0.5 m (elevation 192.2 and 191.7) in boreholes NEW-16 and C70-1, respectively.

4.32.2 Organic Silt/Sand

Directly beneath the peat at 0.5 m (elevation 191.7) in borehole C70-1 and 0.3 m (elevation 192.2) in borehole NEW-16 was organic silt / organic sand. Loose to compact in relative density, this unit was 400 mm thick and penetrated at 0.9 m (elevation 191.3) in borehole C70-1 and at 0.7 m (elevation 191.8) in borehole NEW-16.

4.32.3 Clayey Silt to Clay

Overlain by the organic silt, organic sand or silty sand at 0.7 to 0.9 m (elevation 191.3 to 192.2) in all the boreholes was a cohesive deposit of clayey silt, silty clay and clay. This deposit was 0.5 to 3.4 m thick and penetrated at 1.4 m to 4.3 m (elevation 187.9 to 191.7). The cohesive deposit was soft to very stiff in consistency. The results of in situ vane testing carried out in the clayey silt / silty clay yielded undisturbed shear strength values varying between 12 and 92 kPa (soil sensitivity of 2 to 15). Penetrometer tests on cohesive samples indicated shear strength values in range of 38 to 175 kPa.

The results of Atterberg limits testing and grain size distribution analyses conducted on 3 cohesive samples are presented in respective Figures C70-PC-1, C70-PC-2, NEW-PC-2 and C70-GS-1, C70-GS-2, NEW-GS-2. The liquid and plastic limits of the clayey silt were 27 and 16 respectively, thus giving the plasticity index of 11. The silty clay unit had a liquid limit of 48, plastic limit of 22 and plasticity index of 26. The liquid and plastic limits of the clay were 55 and 21 respectively, with the plasticity index of 34. Moisture contents of 18 to 58% were measured.

4.32.4 Sandy Soils

Cohesionless soils (sand, silty sand, sand and gravel) were encounters below the topsoil or silty clay / clay at 0.1 to 4.3 m (elevation 187.9 to 193.0) in boreholes C70-1, C70-2 and NEW-16. The cohesionless soils were 0.4 to 1.5 m thick and penetrated at 0.9 to 4.7 m (elevation 187.5 to 192.2). These strata were very loose to very dense in relative density (SPT-'N' values of 2 to 50) and 26% in moisture content.

4.32.5 Bedrock

Bedrock was inferred by refusal at 1.4 to 4.7 m (elevation 187.5 to 191.7) in all the boreholes.

4.32.6 Groundwater

In the process of augering, water was detected at 0.8 m (elevation 192.3) in borehole C70-2. No groundwater was established in any of the boreholes upon completion of drilling.

It is noteworthy that the groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.

5 CLOSURE

Most of the field investigation for this study was carried out by Mr. F. Portela, Senior Technician, under the direction of Mr. G.O. Degil, PhD, P.Eng., Senior Foundation Engineer. The equipment was supplied by Landcore Drilling Inc. and Walker Drilling Ltd.

This report was prepared by Ms. Marzieh Kamranzadeh, MSc, Project Supervisor (EIT) and reviewed by Mr. B.R. Gray, MEng, P.Eng., MTO Designated Principal Contact. Mr. C.M.P. Nascimento, P.Eng., Project Manager, conducted an independent review of the report.

Yours very truly,

Peto MacCallum Ltd.

Marzieh Kamranzadeh, MSc
Project Supervisor (EIT), Geotechnical Services

REGISTERED PROFESSIONAL ENGINEER
C M P Nascimento
Apr. 29, 2015
PROVINCE OF ONTARIO

Carlos M.P. Nascimento, P.Eng.
Project Manager

REGISTERED PROFESSIONAL ENGINEER
B. R. GRAY
Apr 29/15
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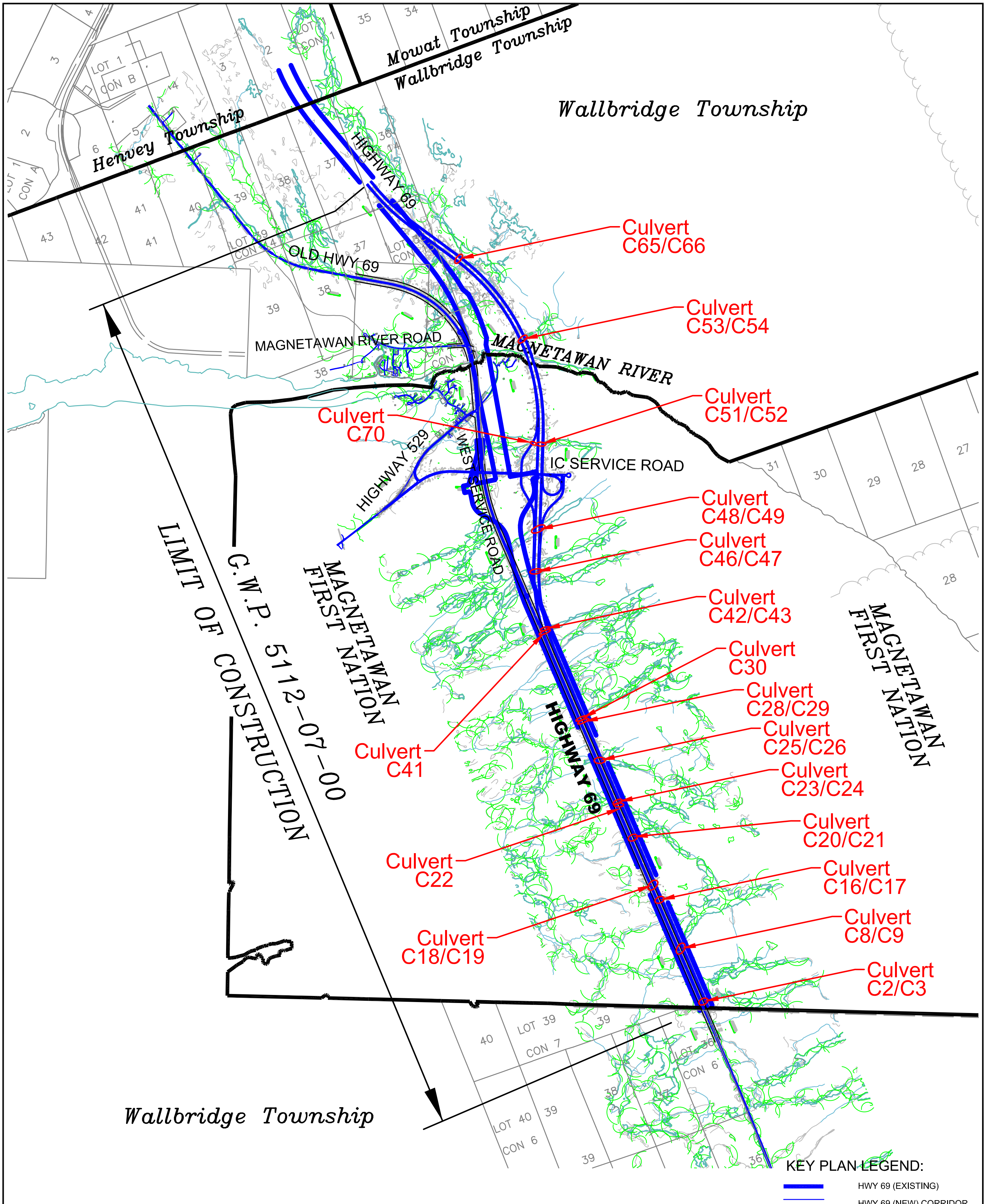
Brian R. Gray, MEng, P. Eng.
MTO Designated Principal Contact

MK/BRG/CN:mk-mi-jk



KEY PLAN
CULVERTS
HIGHWAY 69 FOUR-LANING FOR 21.5 km
From 4.5 km North of Highway 64 to
8.7 km North of Highway 637
District 52, Sudbury

METRIC

0.5 km 0 0.5 1.0 km
SCALE

Ontario
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PRINCIPAL CONSULTANT
AECOM

FIGURE
1

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS $\bar{N}$.

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

COMPOSITION: SECONDARY SOIL COMPONENTS ARE DESCRIBED ON THE BASIS OF PERCENTAGE BY MASS OF THE WHOLE SAMPLE AS FOLLOWS:

PERCENT BY MASS	0 – 10	10 – 20	20 – 30	30 – 40	> 40
	TRACE	*SOME*	*WITH*	*ADJECTIVE (SILTY)*	*AND (AND SILT)*

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	>200
	VERY SOFT	*SOFT*	*FIRM*	*STIFF*	*VERY STIFF*	*HARD*

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3 m)	0 - 5	5 - 10	10 - 30	30 - 50	>50
	VERY LOOSE	*LOOSE*	*COMPACT*	*DENSE*	*VERY DENSE*

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	>3m
JOINTING	*VERY CLOSE*	*CLOSE*	*MOD. CLOSE*	*WIDE*	*VERY WIDE*
BEDDING	*VERY THIN*	*THIN*	*MEDIUM*	*THICK*	*VERY THICK*

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE
F V	FIELD VANE		

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
$\epsilon_1, \epsilon_2, \epsilon_3$	%	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_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY $= \frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_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	1	LIQUIDITY INDEX $= \frac{w - w_P}{I_P}$
I_C	1	CONSISTENCY INDEX $= \frac{w_L - w}{I_P}$
DTPL		DRIER THAN PLASTIC LIMIT
APL		ABOUT PLASTIC LIMIT
WTPL		WETTER THAN PLASTIC LIMIT
e_{max}	1,%	VOID RATIO IN LOOSEST STATE
e_{min}	1,%	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
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

Culvert C-2 at Sta. 16+076.0, SBL

Record of Borehole Sheets: C2-1

Culvert C-3 at Sta. 16+086.2, NBL

Record of Borehole Sheets: C3-1, C3-2, 101-1, 101-2 and 101-3

Drawing C2/C3-1 – Borehole Locations and Soil Strata

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RECORD OF BOREHOLE No. C2-1

METRIC

G.W.P. 5112-07-00 LOCATION Hwy 69, Sta. 16+085, o/s 4.0m Lt. Coords: 5 065 763.7 N; 229 140.9 E ORIGINATED BY A.L.

DIST Parry Sound HWY 69 BOREHOLE TYPE Tripod COMPILED BY G.D.

DATUM Geodetic DATE October 29, 2013 CHECKED BY B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
194.6	Ground Surface										
0.0	Topsoil		1	SS	1						
194.1 / 0.5	End of borehole Refusal on probable bedrock										

* 2013 10 29

▽ Water level observed during drilling

ON MTO_VER3 NEW LOGO 09TF044.GPJ ON_MOT.GDT 7/9/2014 10:39:21 AM

$+^{7}$, $\times^{5}$: Numbers refer to Sensitivity

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

Ontario

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Foundation Design

RECORD OF BOREHOLE No. C3-1

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 16+090, o/s 19.0m Rt. Coords: 5 065 777.4 N; 229 160.0 E **ORIGINATED BY** A.L.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Continuous Flight Solid Stem Augers **COMPILED BY** G.D.

DATUM Geodetic **DATE** March 07, 2013 **CHECKED BY** B.R.G.

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.2	Top of Snow										
0.0	Snow and Ice/water					▽* ▼*	194				
193.6 / 0.6	Peat, amorphous Dark brown		1	SS	3						
193.0 / 1.2	Clayey silt, sandy rootlets Stiff Dark brown Moist to wet		2	SS	13		193				
			3	SS	50/13cm				○		
192.2 / 2.0	End of borehole Refusal on probable bedrock										

* 2013 03 07

▽ Water level observed during drilling

▼ Water level measured after drilling

$+^{7}$, $\times^{5}$: Numbers refer to Sensitivity

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

Ontario

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Foundation Design

RECORD OF BOREHOLE No. C3-2

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 16+097, o/s 34.0m Rt. Coords: 5 065 789.8 N; 229 171.1 E **ORIGINATED BY** A.L.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Continuous Flight Solid Stem Augers **COMPILED BY** G.D.

DATUM Geodetic **DATE** March 06, 2013 **CHECKED BY** B.R.G.

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.2	Top of Snow										
0.0	Snow and Ice/water					▽* ▼*	194				
193.6 0.6	Peat, amorphous Dark brown		1	SS	17						
193.3 0.9	Clayey silt, sandy rootlets Stiff Dark brown Moist to wet		2	SS	15		193		○ (approx. 25)		
192.4 1.8	End of borehole Refusal on probable bedrock										

* 2013 03 06

▽ Water level observed during drilling

▼ Water level measured after drilling

ON MTO_VER3 NEW LOGO 09TF044.GPJ ON_MOT.GDT 7/23/2014 2:18:30 PM

+7 , ×5 : Numbers refer to Sensitivity

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

Ontario

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Foundation Design

RECORD OF BOREHOLE No. 101-1

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 16+075, o/s 18.8m Rt. Coords: 5 065 763.5 N; 229 165.7 E **ORIGINATED BY** R.B.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Manual Probing **COMPILED BY** G.D.

DATUM Geodetic **DATE** October 06, 2011 **CHECKED BY** C.N.

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.7	Ground Surface										
0.0	Topsoil										
194.6 0.1	End of borehole Refusal on probable bedrock										

* Borehole dry

ON MTO_VER3 NEW LOGO 09TF044.GPJ ON_MOT.GDT 7/3/2014 3:31:48 PM

+7, ×5: Numbers refer to Sensitivity

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

Ontario

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RECORD OF BOREHOLE No. 101-2

METRIC

G.W.P. 5112-07-00	**LOCATION** Hwy 69, Sta. 16+087.5, o/s 4.0m Rt. Coords: 5 065 769.2 N; 229 147.3 E		**ORIGINATED BY** R.B.
DIST Parry Sound **HWY** 69	**BOREHOLE TYPE** Manual Probing		**COMPILED BY** G.D.
DATUM Geodetic	**DATE** October 06, 2011		**CHECKED BY** C.N.

ELEV / DEPTH	SOIL PROFILE - DESCRIPTION	STRAT PLOT	SAMPLES - NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT W_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.5	Ground Surface										
0.0	Peat, fine fibrous										
194.2 / 0.3	Dark brown/black Wet										
	End of borehole										
	Refusal on probable bedrock										
	* Borehole dry										

$+^7$, $\times^5$: Numbers refer to Sensitivity

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

Ontario

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Foundation Design

RECORD OF BOREHOLE No. 101-3

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 16+087.5, o/s 35.0m Rt. Coords: 5 065 781.5 N; 229 175.7 E **ORIGINATED BY** R.B.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Manual Probing **COMPILED BY** G.D.

DATUM Geodetic **DATE** October 06, 2011 **CHECKED BY** C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	*					
194.8	Ground Surface										
0.0	Topsoil										
194.7 / 0.1	End of borehole Refusal on probable bedrock * Borehole dry										

$+^7$, $\times^5$: Numbers refer to Sensitivity

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

HIGHWAY 69
CONT No 2011–
GWP No 5112–07–00

CULVERTS C–2 AND C–3

HIGHWAY 69 FOUR–LANING

BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

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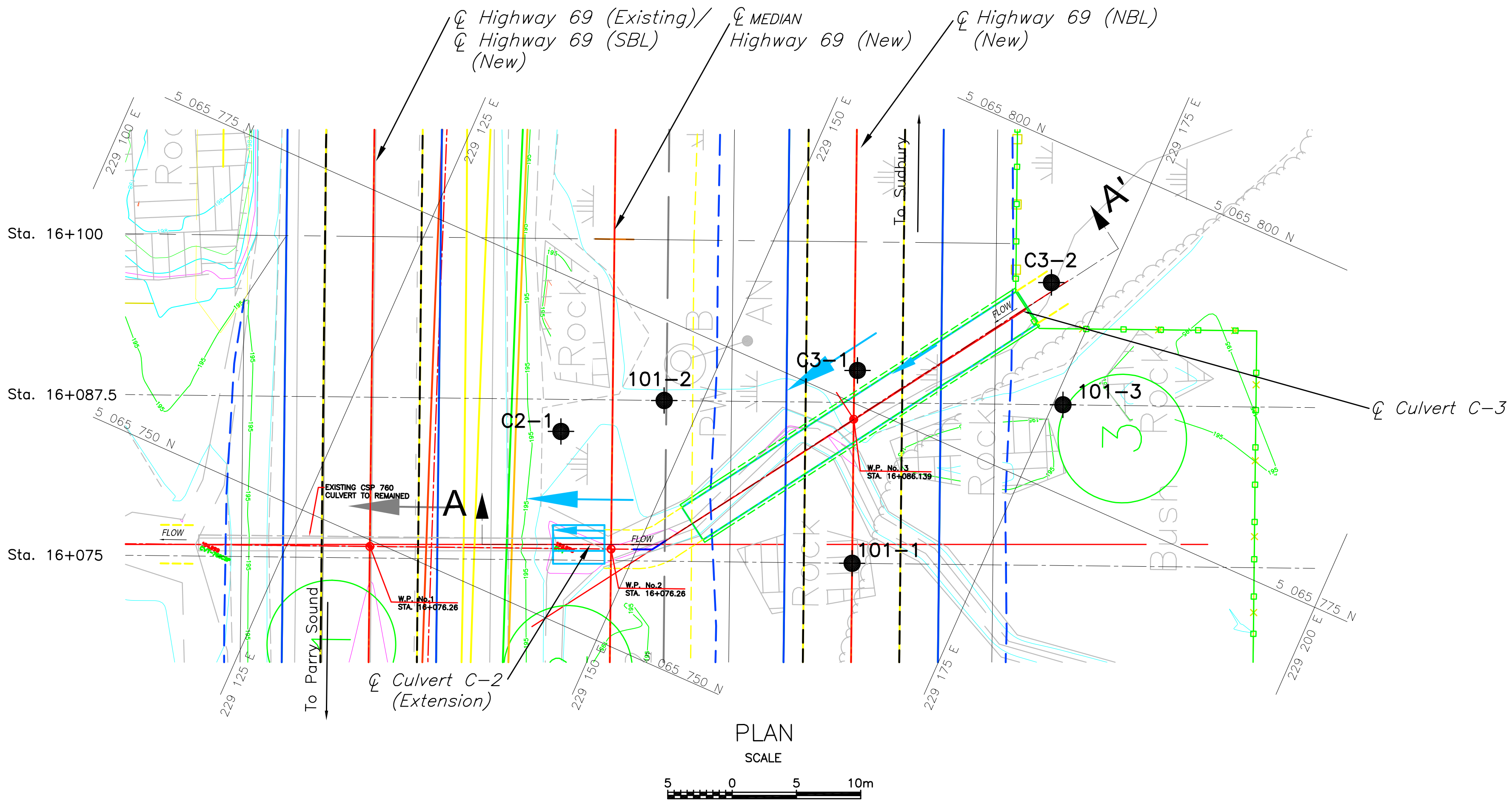
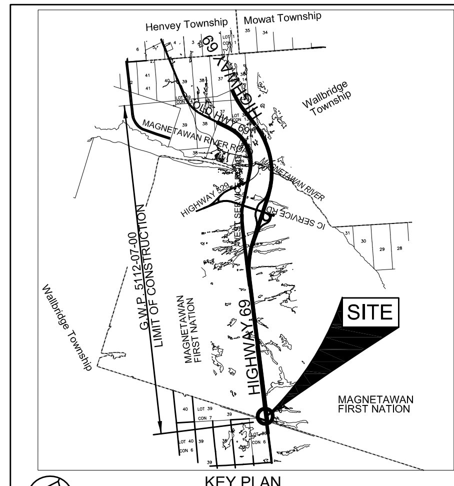
CONSULTING ENGINEERS



PLAN

SCALE

5 0 5 10m



KEY PLAN

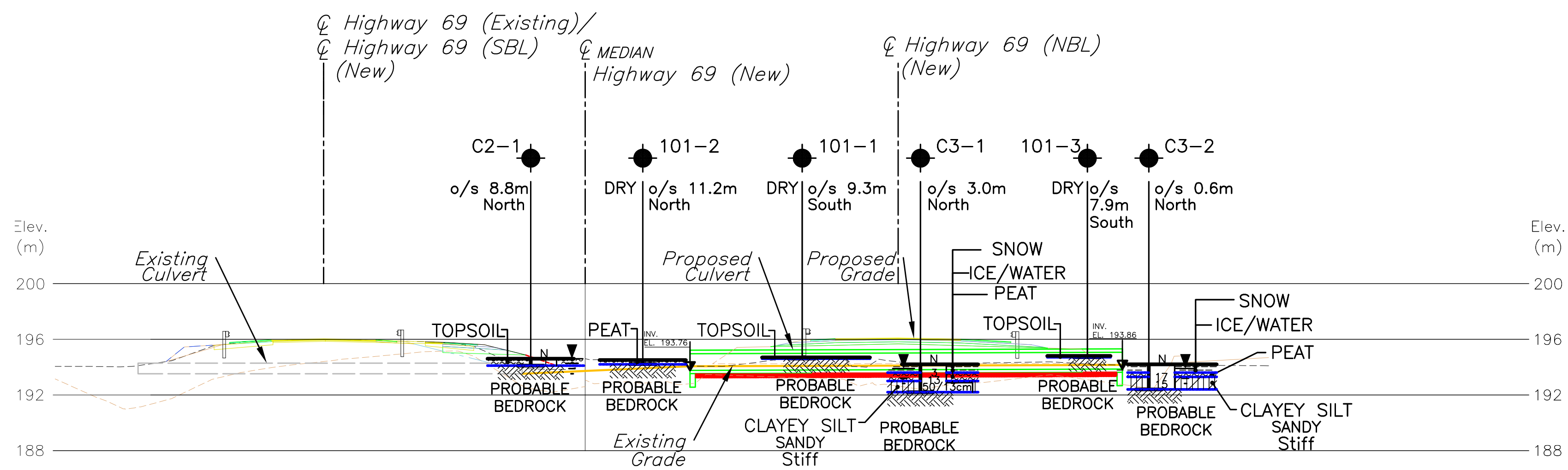
SCALE

1.0 0 1.0 2.0 km

LEGEND

Symbol	Description
●	Borehole
⊕	Dynamic Cone Penetration Test (Cone)
⊕	Borehole & Cone
N	Blows/0.3m (Std. Pen Test, 475 J/blow)
CONE	Blows/0.3m (60°Cone, 475 J/blow)
WH	Penetration due to weight of rods and hammer
▼	WL at time of investigation Oct. 2011, March 2013 and Oct. 2013
*	Water level not established
▽	Head
▽	ARTESIAN WATER Encountered
|	PIEZOMETER

BH No	ELEVATION	COORDINATES NORTHINGS	COORDINATES EASTINGS
C2–1	194.6	5 065 763.7	229 140.9
C3–1	194.2	5 065 777.4	229 160.0
C3–2	194.2	5 065 789.8	229 171.1
101–1	194.7	5 065 763.5	229 165.7
101–2	194.5	5 065 769.2	229 147.3
101–3	194.8	5 065 781.5	229 175.7



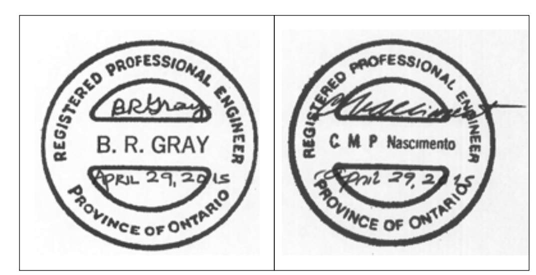
PROFILE A-A' ALONG CENTRELINES OF CULVERTS C-2 AT STA. 16+076.0 AND C-3 AT STA. 16+086.2

SCALE

5 0 5 10m

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.



Reference AECOM Drawings: 60143751-BOX CULVERT_no. 2 & 3 _Sta.16+0986.2_1_GA.dwg dated March 2015

– NOTE –
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS	DATE	BY	DESCRIPTION

Geocres No. 41H–147

HWY No 69			DIST 54
SUBM'D NA	CHECKED MK	DATE APR. 10, 2015	SITE C301
DRAWN NA	CHECKED GD	APPROVED BRG	DWG C2/C3–1

DRAWING NAME: 09TF044 Culverts 2 n 3.dwg
CREATED: APRIL 2015 MODIFIED:

Culvert C-8 at sta.16+531.9, SBL

Record of Borehole Sheets: C8-1 and C8-2

Culvert C-9 at Sta. 16+556.7, NBL

Figure C9-PC1: Plasticity Chart

Figure C9-GS-1: Results of Grain Size Distribution Analysis

Record of Borehole Sheets: C9-1, C9-2, 102-2 and 102-4

Drawing C8/C9-1 – Borehole Locations and Soil Strata

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Foundation Design

RECORD OF BOREHOLE No. C8-1

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 16+527, o/s 32.0m Lt. Coords: 5 066 158.6 N; 228 940.4 E **ORIGINATED BY** F.P.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Hilti **COMPILED BY** G.D.

DATUM Geodetic **DATE** October 03, 2013 **CHECKED BY** B.R.G.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.2	Ground Surface				*		
193.0 0.2	Topsoil					193	
	Sand and gravel cobbles (FILL)					192	
191.9 1.3	Granitic Gneiss bedrock	1	RC	REC 100%			RQD 79%
	Slightly weathered to moderately weathered	2	RC	REC 86%			RQD 86%
	High strength	3	RC	REC 100%		191	RQD 100%
	Good to excellent quality	4	RC	REC 93%			RQD 93%
		5	RC	REC 100%			RQD 100%
		6	RC	REC 100%		190	RQD 100%
		7	RC	REC 96%			RQD 96%
		8	RC	REC 100%			RQD 100%
		9	RC	REC 100%		189	RQD 100%
188.6 4.6		10	RC	REC 100%			RQD 100%
	End of borehole						
	* Borehole charged with drilling water						

Column headings also printed: SOIL PROFILE; SAMPLES; STRAT PLOT; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m^3

$+^7$, $\times^5$: Numbers refer to Sensitivity

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

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. C8-2

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 16+537, o/s 5.0m Lt. Coords: 5 066 178.5 N; 228 961.2 E **ORIGINATED BY** F.P.

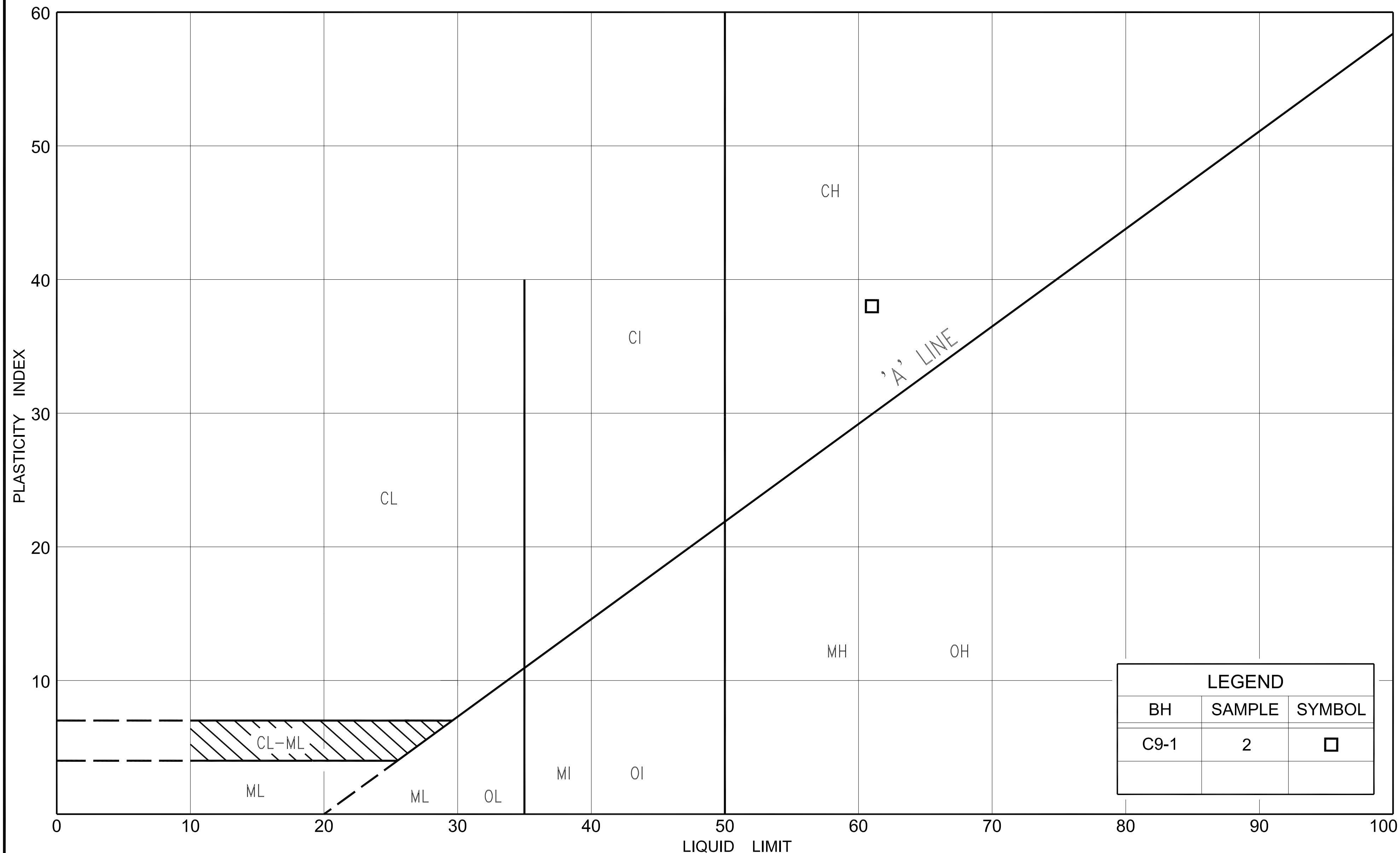
DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Hilti **COMPILED BY** G.D.

DATUM Geodetic **DATE** October 2 and 3, 2013 **CHECKED BY** B.R.G.

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	STRAT PLOT	SAMPLES – NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L – WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.6	Ground Surface										
193.4 / 0.2	Topsoil										
	Cobbles and boulders sand and gravel pockets (FILL)						193				
							192				
							191				
							190				
189.5 / 4.1	Granitic Gneiss bedrock Slightly weathered to moderately weathered High strength Good to excellent quality		1	RC	REC 100%						RQD 100%
							189				
			2	RC	REC 100%						RQD 100%
			3	RC	REC 100%						RQD 100%
							188				
			4	RC	REC 100%						RQD 100%
			5	RC	REC 82%						RQD 82%
							187				
			6	RC	REC 100%						RQD 100%
186.4			7	RC	REC 96%						RQD 96%
7.2	End of borehole										
	* Borehole charged with drilling water										

$+^7$, $\times^5$: Numbers refer to Sensitivity

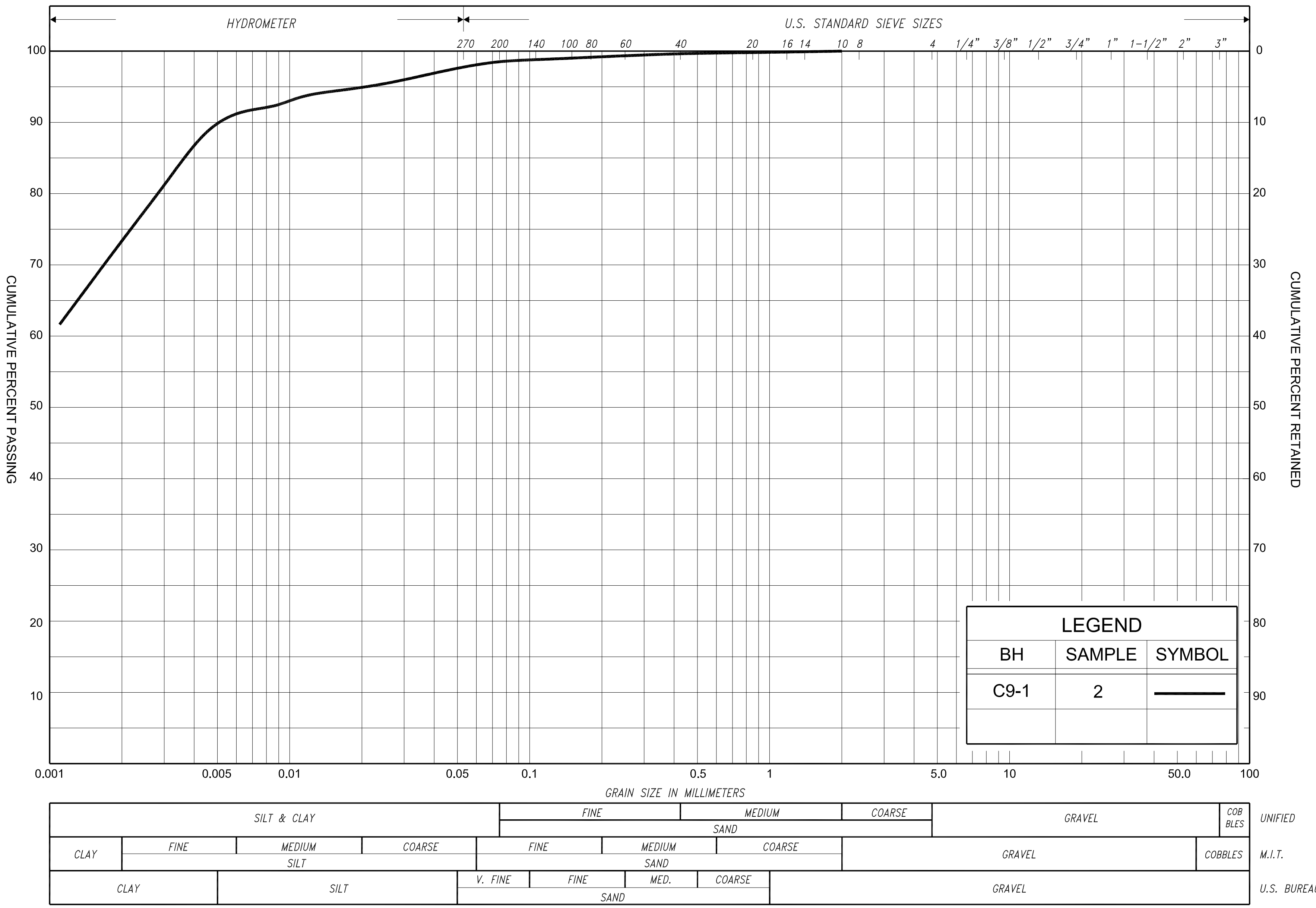
20 / 15 – ○ – 5 / 10 (%) STRAIN AT FAILURE



PLASTICITY CHART

CLAY, trace sand

FIG No.	C9-PC-1
HWY:	69
G.W.P. No.	5112-07-00



LEGEND

BH	SAMPLE	SYMBOL
C9-1	2	———

Ontario

GRAIN SIZE DISTRIBUTION

CLAY, trace sand

FIG No.	C9-GS-1
HWY:	69
G.W.P. No.	5112-07-00

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. C9-1

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 16+547, o/s 6.0m Rt. Coords: 5 066 192.0 N; 228 967.3 E **ORIGINATED BY** A.L.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** 'N' Casing + Wash Boring **COMPILED BY** G.D.

DATUM Geodetic **DATE** March 08, 2013 **CHECKED BY** B.R.G.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.7	Top of Snow/Ice						
0.0	Snow/Ice and water				▽* ▼*		
193.3 / 0.4	Topsoil						
193.2 / 0.5	Clay, trace sand; Firm to soft; Grey; Moist to wet	1	SS	4		193	
		2	SS	4			0 2 25 73
		3	SS	3		192	
			FV				
190.6 / 3.1	seams of silty sand	4	SS	50/8cm		191	
	End of borehole						
	Refusal on probable bedrock						
	Sample 4: Sampler bouncing						

* 2013 03 08

▽ Water level observed during drilling

▼ Water level measured after drilling

■ Penetrometer test

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m^3

Field vane: 8

$+^7$, $\times^5$: Numbers refer to Sensitivity; 20 / 15 ○ 5 / 10 (%) STRAIN AT FAILURE

Ontario

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RECORD OF BOREHOLE No. C9-2

METRIC

G.W.P. 5112-07-00 LOCATION Hwy 69, Sta. 16+562, o/s 29.0m Rt. Coords: 5 066 214.9 N; 228 982.5 E ORIGINATED BY A.L.

DIST Parry Sound HWY 69 BOREHOLE TYPE Manual Probing COMPILED BY G.D.

DATUM Geodetic DATE March 08, 2013 CHECKED BY B.R.G.

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.4	Top of Snow/Ice										
0.0	Snow/Ice and water					▽* ▼*	194				
193.2 / 1.2	End of borehole Refusal on probable bedrock										

* 2013 03 08

▽ Water level observed during drilling

▼ Water level measured after drilling

$+^{7}$, $\times^{5}$: Numbers refer to Sensitivity

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

Ontario

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RECORD OF BOREHOLE No. 102-2

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 16+537.5, o/s 5.0m Rt. Coords: 5 066 182.9 N; 228 970.2 E **ORIGINATED BY** R.B.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Manual Probing **COMPILED BY** G.D.

DATUM Geodetic **DATE** October 06, 2011 **CHECKED BY** C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
195.0	Ground Surface										
0.0	Topsoil										
194.9 0.1	End of borehole										
	Refusal on probable bedrock										
	* Borehole dry										

ON MTO_VER3 NEW LOGO 09TF044.GPJ ON_MOT.GDT 7/14/2014 3:20:54 PM

$+^{7}, \times^{5}$: Numbers refer to Sensitivity

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

Ontario

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CONSULTING ENGINEERS
Foundation Design

RECORD OF BOREHOLE No. 102-4

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 16+550, o/s 18.8m Rt. Coords: 5 066 199.8 N; 228 977.9 E **ORIGINATED BY** R.B.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Manual Probing **COMPILED BY** G.D.

DATUM Geodetic **DATE** October 06, 2011 **CHECKED BY** C.N.

SOIL PROFILE			SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE				
194.3	Ground Surface										
194.1 0.2	Topsoil										
	End of borehole Refusal on probable bedrock * Borehole dry										

$+^7$, $\times^5$: Numbers refer to Sensitivity

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

MINISTRY OF TRANSPORTATION, ONTARIO PR-D-707 88-05

HWY. 69
CONT No 2011–
GWP No 5112-07-00

SHEET

CULVERTS C-8 AND C-9

HIGHWAY 69 FOUR-LANING

BOREHOLE LOCATIONS AND SOIL STRATA

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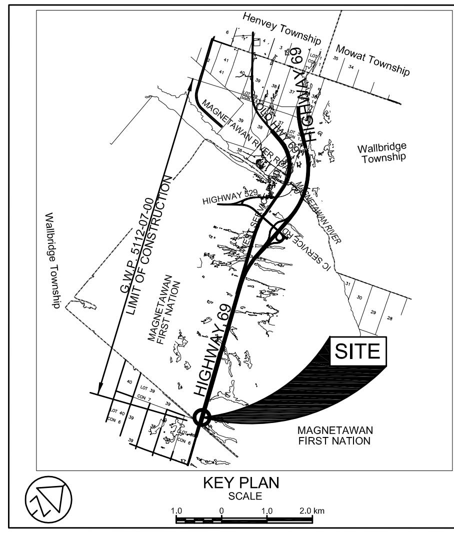
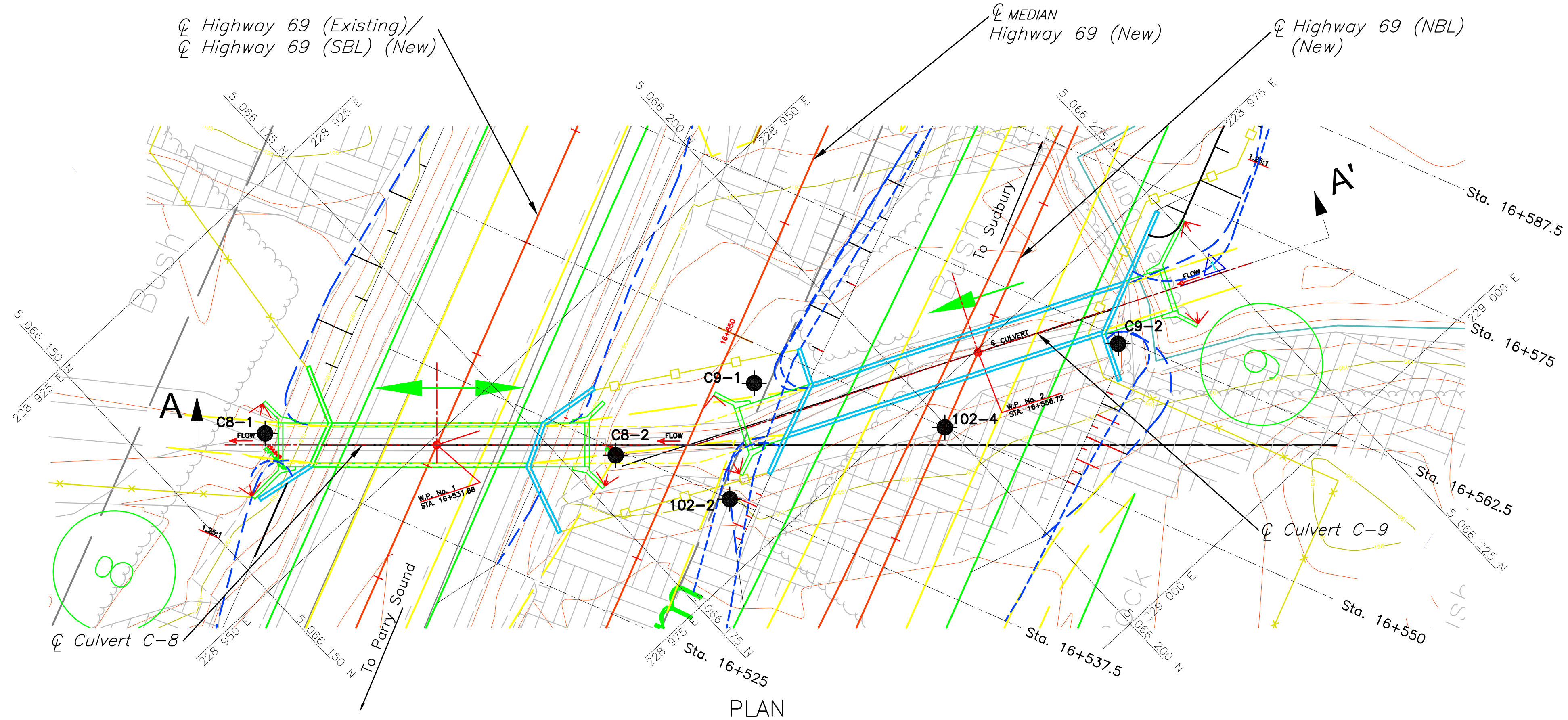
CONSULTING ENGINEERS



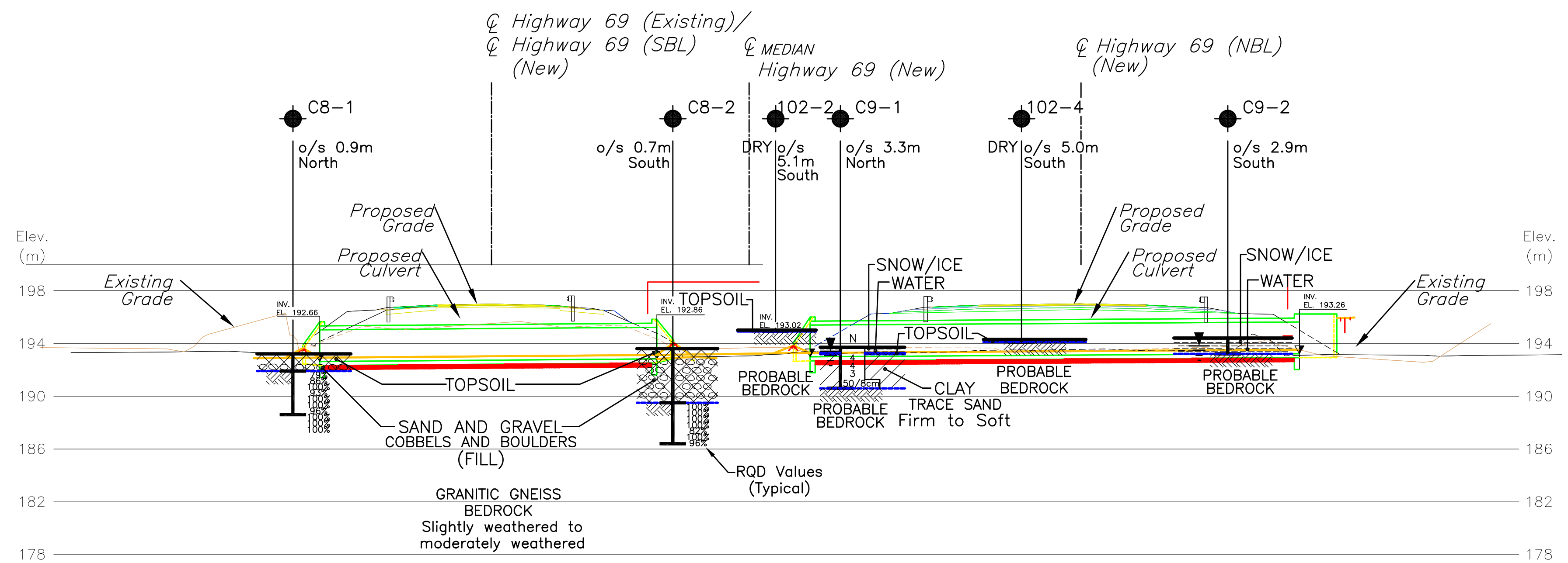
KEY PLAN
SCALE



PLAN

SCALE

5 0 5 10m



PROFILE A-A' ALONG CENTRELINES OF CULVERTS C-8 AT STA. 16+531.9 AND C-9 AT STA. 16+556.7

SCALE

5 0 5 10m

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

LEGEND

- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & Cone
- N — Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE — Blows/0.3m (60°Cone, 475 J/blow)
- WH — Penetration due to weight of rods and hammer
- WL at time of investigation Oct. 2011, March and Oct. 2013
- Water level not established
- Head
- ARTESIAN WATER Encountered
- PIEZOMETER

BH No	ELEVATION	COORDINATES NORTHINGS	COORDINATES EASTINGS
C8–1	193.2	5 066 158.6	228 940.4
C8–2	193.6	5 066 178.5	228 961.2
C9–1	193.7	5 066 192.0	228 967.3
C9–2	194.4	5 066 214.9	228 982.5
102–2	195.0	5 066 182.9	228 970.2
102–4	194.3	5 066 199.8	228 977.9

REGISTERED PROFESSIONAL ENGINEER
B. R. GRAY
APRIL 29, 2015
PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER
C M P Nascimento
April 29, 2015
PROVINCE OF ONTARIO

Reference AECOM Drawings: 60143751-BOX CULVERT_no. 8 & 9 _Sta.16+0986.2_1_GA.dwg dated March 2015

– NOTE –
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS DATE	BY	DESCRIPTION

Geocres No. 41H–147

HWY No 69			DIST 54
SUBM'D NA	CHECKED MK	DATE APR. 29, 2015	SITE C303
DRAWN NA	CHECKED GD	APPROVED BRG	DWG C8/C9–1

DRAWING NAME: 09TF044 Culverts 8 n 9.dwg MODIFIED: APRIL 2015
CREATED: FEBRUARY 2014

Culvert C-16 at Sta. 16+979.3, NBL

Figure 105-PC-2: Plasticity Chart

Figure 105-GS-2: Results of Grain Size Distribution Analysis

Record of Borehole Sheets: C16-1, 105-7 and 105-8

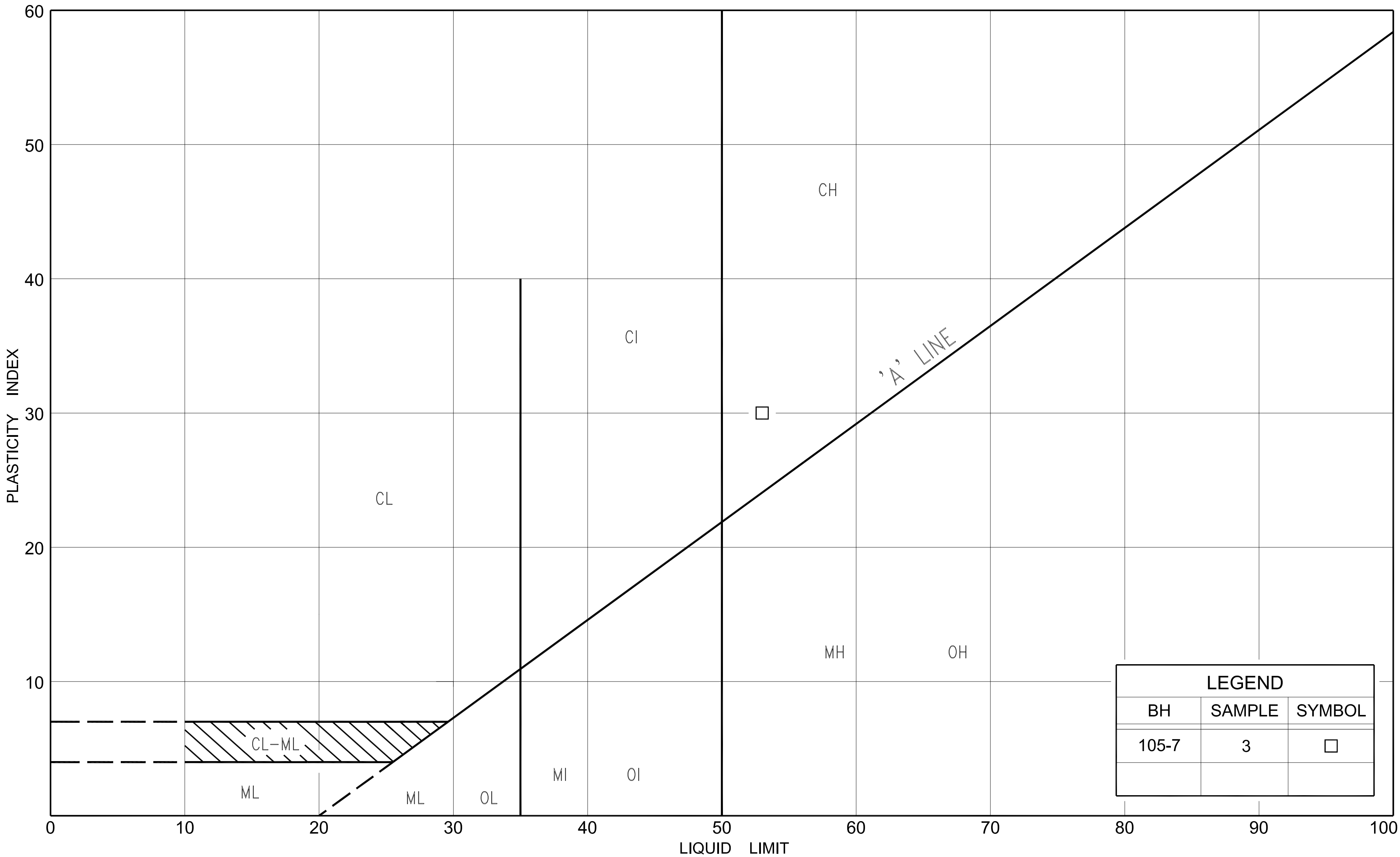
Culvert C-17at 16+991.7, SBL

Figure C17-GS-1: Results of Grain Size Distribution Analysis

Record of Borehole Sheets: C17-1 and 105-8

Record of Pavement Borehole Sheet: PV-1

Drawing C16/C17-1: Borehole Locations and Soil Strata

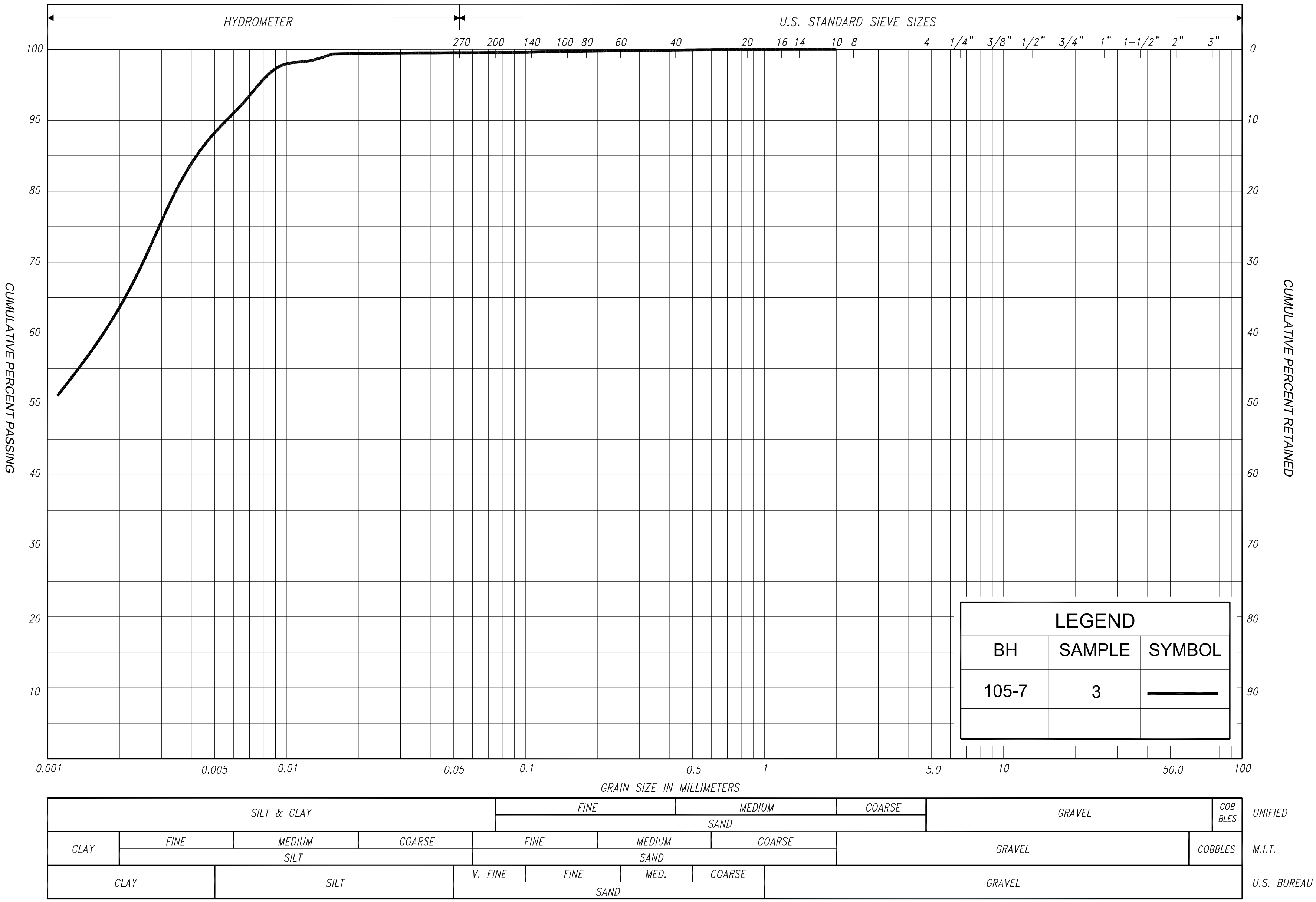


BH	SAMPLE	SYMBOL
105-7	3	□

PLASTICITY CHART

CLAY, trace sand

FIG No.	105-PC-2
HWY:	69
G.W.P. No.	5112-07-00



Ontario

GRAIN SIZE DISTRIBUTION

CLAY, trace sand

FIG No.	105-GS-2
HWY:	69
G.W.P. No.	5112-07-00

Ontario

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Foundation Design

RECORD OF BOREHOLE No. C16-1

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 16+968, o/s 35.0m Rt. Coords: 5 066 590.2 N; 228 827.5 E **ORIGINATED BY** H.D.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Continuous Flight Solid Stem Augers **COMPILED BY** G.D.

DATUM Geodetic **DATE** March 09, 2013 **CHECKED BY** B.R.G.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa	WATER CONTENT (%)	REMARKS
195.9	Ground Surface							
0.0	Peat, amorphous Dark brown							
195.4 / 0.5	Silty clay, rootlets Soft to firm Grey Wet							
		1	SS	WH**	195			
		2	SS	2	194			
		3	SS	2		5		
192.8 / 3.1		4	SS	2	193			
	End of borehole							
	Refusal on probable bedrock							

* 2013 03 09

Water level observed during drilling

Water level measured after drilling

■ Penetrometer test

** denotes penetration due to weight of rods and hammer

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+7, ×5: Numbers refer to Sensitivity — 20, 15, 5, 10 (%) STRAIN AT FAILURE

Ontario

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RECORD OF BOREHOLE No. 105-7

METRIC

G.W.P. 5112-07-00	**LOCATION** Hwy 69, Sta. 16+975, o/s 18.8m Rt. Coords: 5 066 590.2 N; 228 809.8 E		**ORIGINATED BY** F.P.
DIST Parry Sound **HWY** 69	**BOREHOLE TYPE** Continuous Flight Hollow Stem Augers		**COMPILED BY** G.D.
DATUM Geodetic	**DATE** February 10, 2012		**CHECKED BY** C.N.

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
196.1	Ground Surface										
0.0	Peat, fine fibrous Dark brown		1	SS	6	∇* ▼*	196				
195.0 1.1	Clayey silt, trace sand organics		2	SS	WH**		195				
194.5 1.6	Firm Grey Moist										
	Clay, trace sand Firm Grey/ reddish grey Moist		3	SS	2						0 1 36 63
			4	SS	WH		194				
	silt seams										
192.9 3.2			5	SS	10/8cm		193				
	End of borehole Refusal on probable bedrock Sample 5: Sampler bouncing										

* 2012 02 10

∇ Water level observed during drilling

▼ Water level measured after drilling

WH** denotes penetration due to weight of rods and hammer

ON MTO_VER3 NEW LOGO 09TF044.GPJ ON_MOT.GDT 7/9/2014 10:57:31 AM

+7, ×5 : Numbers refer to Sensitivity

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

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. 105-8

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 16+987.5 CL Coords: 5 066 594.2 N; 228 787.6 E **ORIGINATED BY** R.B.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Manual Probing **COMPILED BY** G.D.

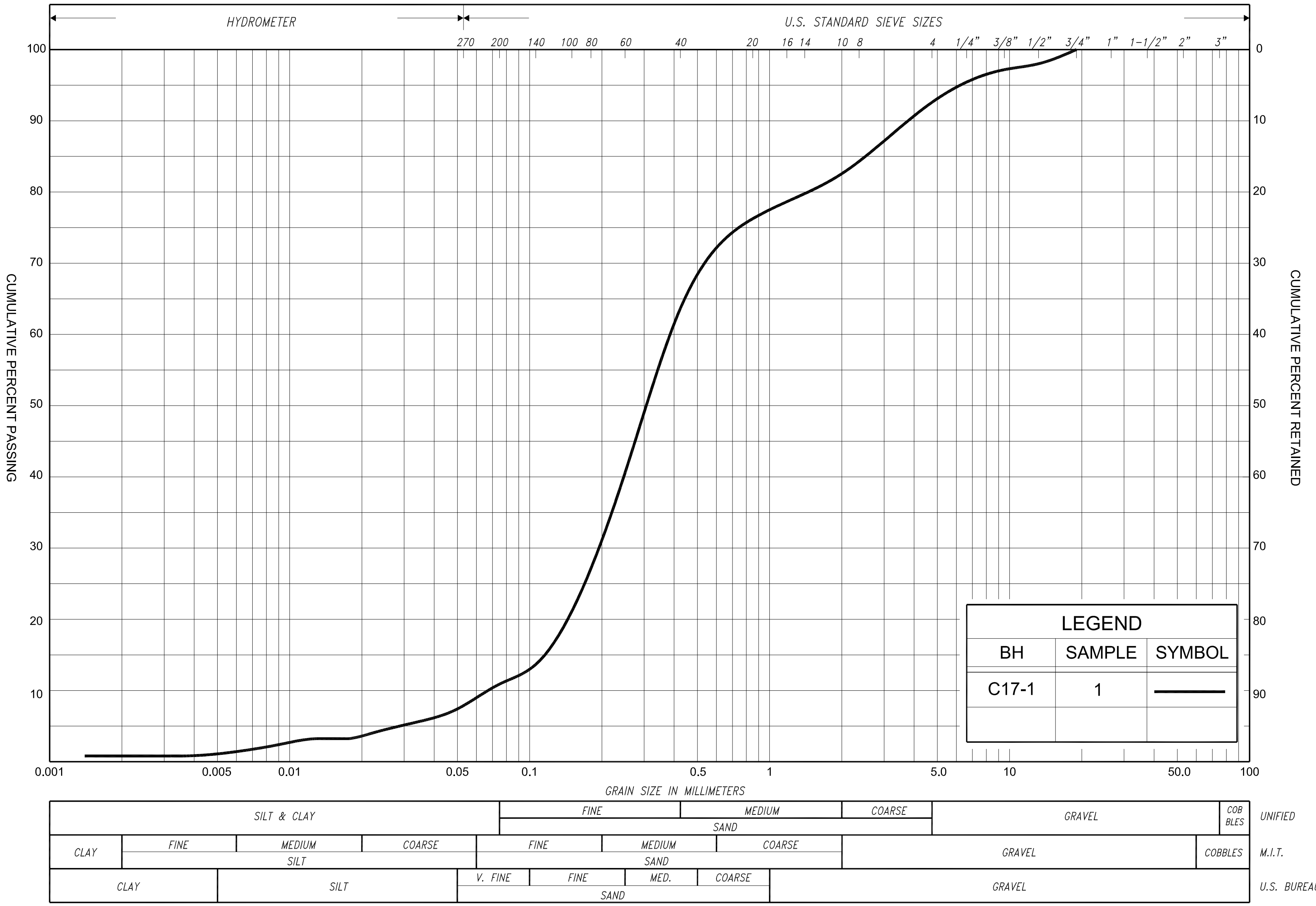
DATUM Geodetic **DATE** October 07, 2011 **CHECKED BY** C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
196.3	Ground Surface										
196.1 0.2	Peat, fine fibrous Dark brown/black Wet										
	End of borehole										
	Refusal on probable bedrock										
	* Borehole dry										

ON MTO_VER3 NEW LOGO 09TF044.GPJ ON_MOT.GDT 7/9/2014 10:57:31 AM

$+^{7}$, $\times^{5}$: Numbers refer to Sensitivity

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



Ontario

GRAIN SIZE DISTRIBUTION

SAND, trace to some silt, trace clay, trace gravel

FIG No.	C17-GS-1
HWY:	69
G.W.P. No.	5112-07-00

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. C17-1

METRIC

G.W.P. 5112-07-00 LOCATION Hwy 69, Sta. 16+991, o/s 31.0m Lt. Coords: 5 066 585.2 N; 228 757.7 E ORIGINATED BY A.L.

DIST Parry Sound HWY 69 BOREHOLE TYPE Tripod COMPILED BY G.D.

DATUM Geodetic DATE November 04, 2013 CHECKED BY B.R.G.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	GR	SA	SI	CL
196.7	Ground Surface									
0.0	Topsoil				▽*					
196.6 0.1	Sand, some silt trace clay, trace gravel organic inclusions Very loose Dark brown/brown Wet	1	SS	WH		196	7	82	10	1
		2	SS	1						
195.4 1.3	End of borehole Refusal on probable bedrock									

* 2013 11 04

▽ Water level observed during drilling

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE, 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m^3; REMARKS & GRAIN SIZE DISTRIBUTION (%)

+7, ×5: Numbers refer to Sensitivity

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

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. 105-8

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 16+987.5 CL Coords: 5 066 594.2 N; 228 787.6 E **ORIGINATED BY** R.B.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Manual Probing **COMPILED BY** G.D.

DATUM Geodetic **DATE** October 07, 2011 **CHECKED BY** C.N.

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
196.3	Ground Surface										
196.1 / 0.2	Peat, fine fibrous. Dark brown/black. Wet										
	End of borehole										
	Refusal on probable bedrock										
	* Borehole dry										

ON MTO_VER3 NEW LOGO 09TF044.GPJ ON_MOT.GDT 7/9/2014 10:57:31 AM

$+^{7}$, $\times^{5}$: Numbers refer to Sensitivity

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

Proposed Highway 69, Wallbridge Township, Sta 16+028 to 17+000
DATUM: Proposed Centreline Median

16+992.0 14.2 Lt C/L D+2.1 MSH
HD. At Proposed Foundations Engineering Culvert. On Existing Highway 69 NB MSH.

0	-	080	Asph
080	-	360	Gry Cr Sa And Gr Tr Si Moist
360	-	1.3	Lt Br Sa Tr Gr Tr Si Moist
1.3	-	2.3	Gry Sa Some Si Moist-Wet
		2.3	NFP Prob BR/Poss Bld Fr Wat @ 2.0

CONT No
GWP No 5112-07-00

CULVERTS C-16 AND C-17

HIGHWAY 69 FOUR-LANING

BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

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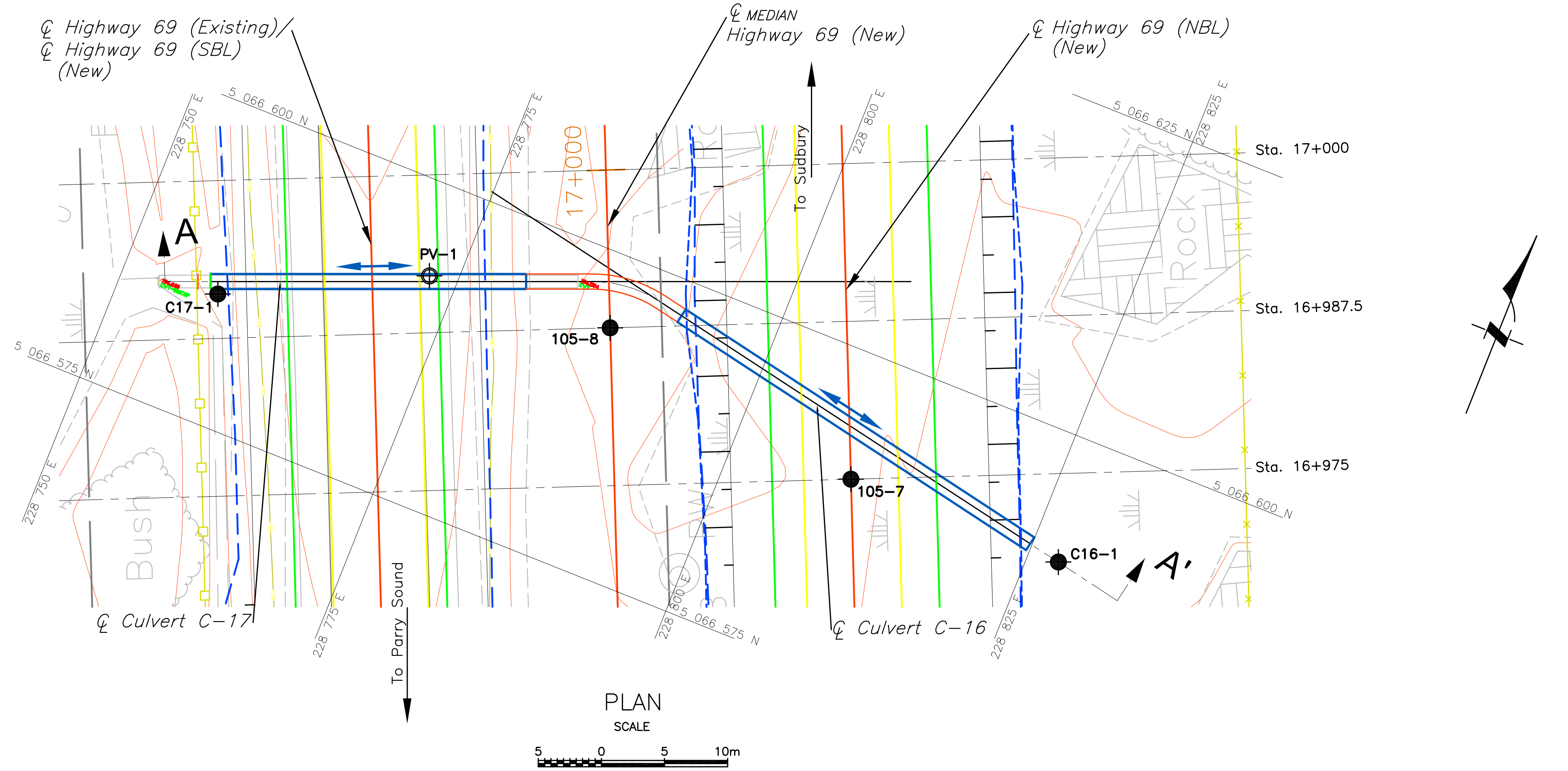
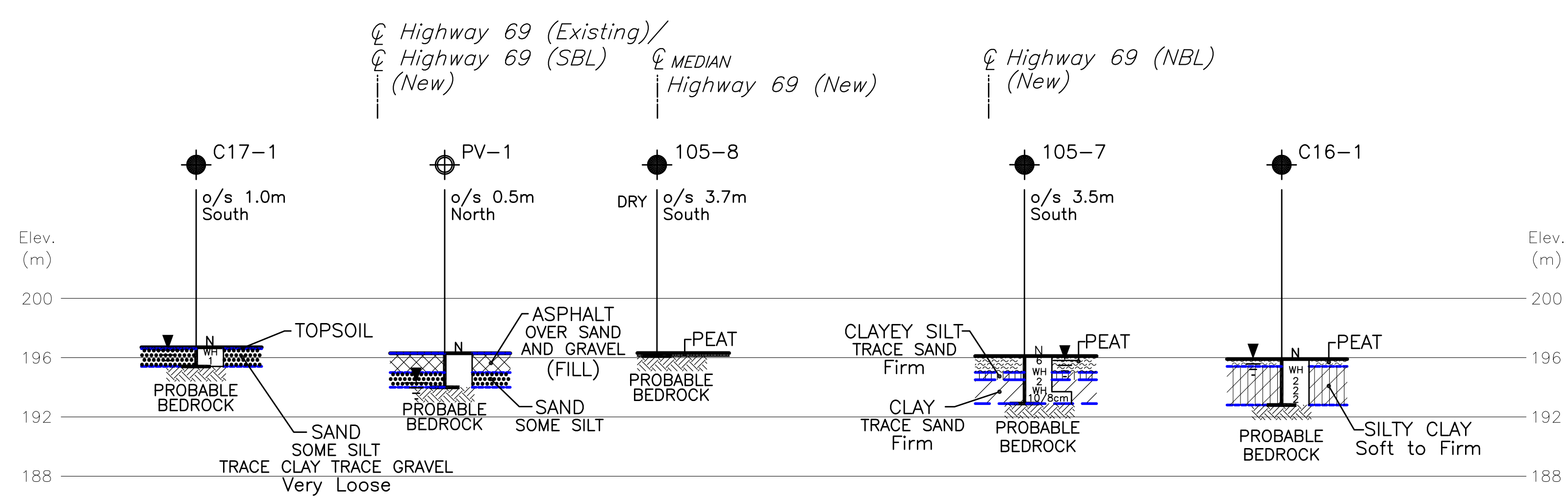


PLAN

SCALE

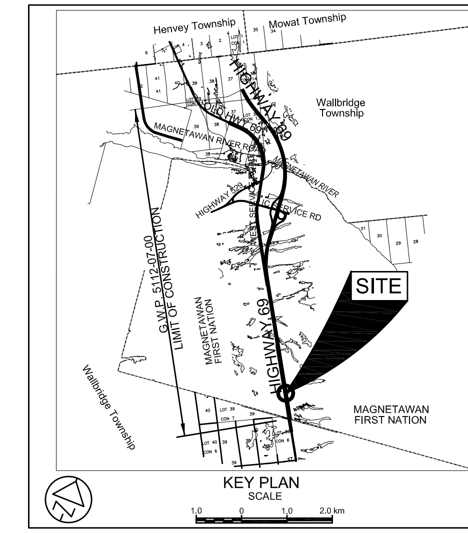
5 0 5 10m



PROFILE A-A' ALONG CENTRELINES OF CULVERTS C-16 AT STA. 16+979.3 AND C-17 AT STA. 16+991.7

SCALE

5 0 5 10m



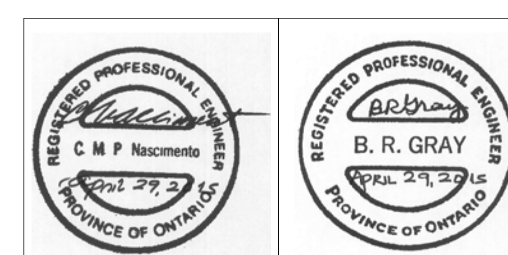
LEGEND

- Borehole
- Pavement Borehole
- Borehole & Cone
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60°Cone, 475 J/blow)
- WH Penetration due to weight of rods and hammer
- WL at time of investigation Oct. 2011, Feb. 2012, March and Nov. 2013
- Water level not established
- Head
- ARTESIAN WATER Encountered
- PIEZOMETER

BH No	ELEVATION	COORDINATES	
		NORTHINGS	EASTINGS
C16-1	195.9	5 066 590.2	228 827.5
C17-1	196.7	5 066 585.2	228 757.7
PV-1	196.3	5 066 592.7	228 772.8
105-7	196.1	5 066 590.2	228 809.8
105-8	196.3	5 066 594.2	228 787.6

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.



Reference AECOM Drawings: X-60143751-C-HWY 69-DESIGN.dwg; 6-60143751-C-Hwy 69-Base.dwg dated April 2015

– NOTE –

The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS	DATE	BY	DESCRIPTION

Geocres No. 41H-147

HWY No 69			DIST 54
SUBM'D NA	CHECKED MK	DATE APR. 29, 2015	SITE --
DRAWN NA	CHECKED GD	APPROVED BRG	DWG C16/C17-1

DRAWING NAME: 09TF044 Culverts 16 n 17.dwg
CREATED: FEBRUARY 2014 MODIFIED: APRIL 2015

Culvert C-18 at Sta. 17+108.3, SBL

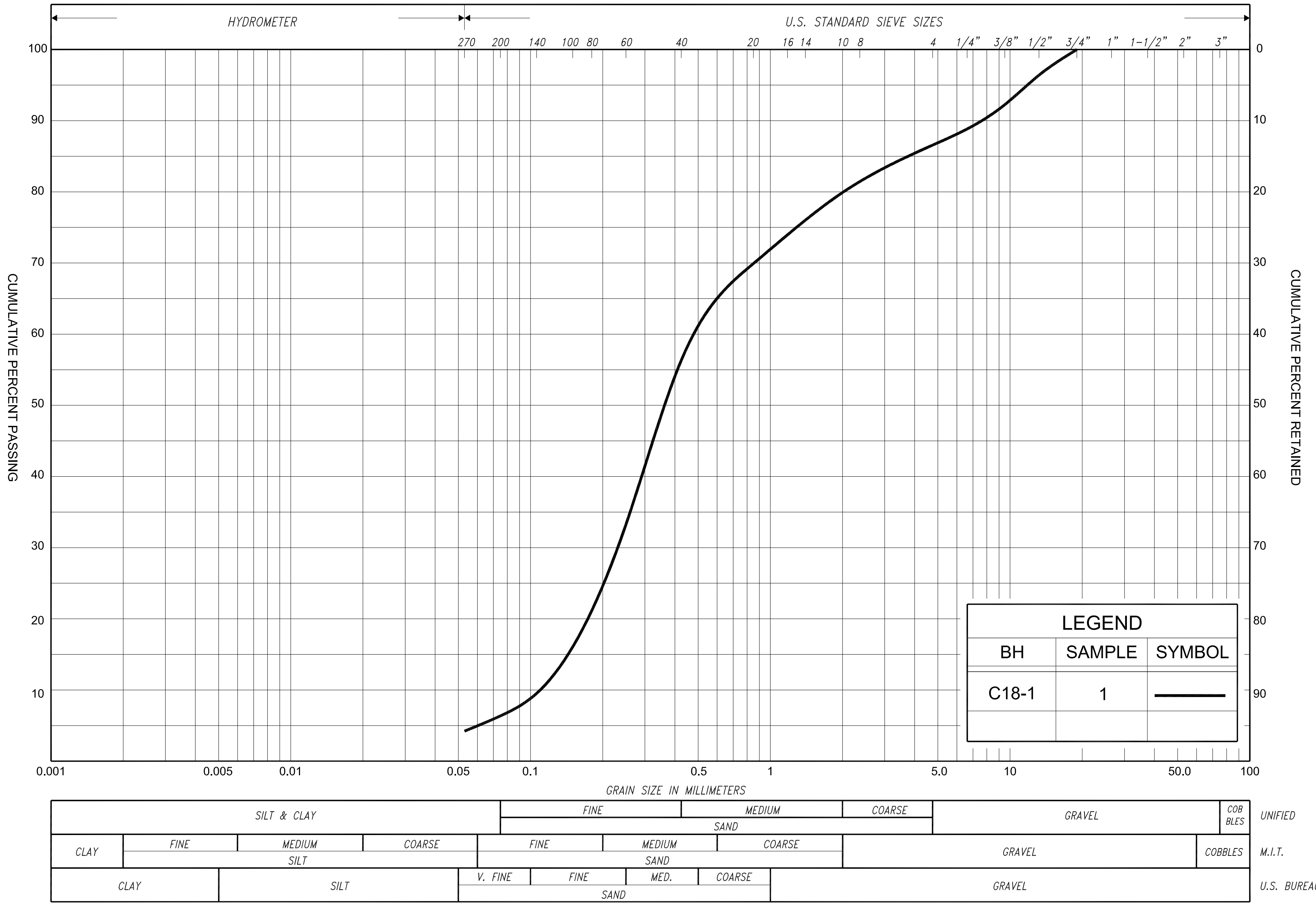
Figure C18-GS-1: Results of Grain Size Distribution Analysis

Record of Borehole Sheets: C18-1 and C18-2

Culvert C-19 at Sta. 17+127.1, NBL

Record of Borehole Sheets: C19-1 and C19-2

Drawing C18/C19-1: Borehole Locations and Soil Strata



Ontario

GRAIN SIZE DISTRIBUTION

SAND, some gravel, trace silt

FIG No.	C18-GS-1
HWY:	69
G.W.P. No.	5112-07-00

Ontario

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RECORD OF BOREHOLE No. C18-1

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 17+108, o/s 32.0m Lt. Coords: 5 066 692.2 N; 228 710.5 E **ORIGINATED BY** A.L.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Tripod + Hilti **COMPILED BY** G.D.

DATUM Geodetic **DATE** October 30, 2013 **CHECKED BY** B.R.G.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
197.2	Ground Surface						
197.0 / 0.2	Topsoil				▽*	197	
	Sand some gravel, trace silt organic inclusions Very loose Brown Wet boulders	1	SS	1			13 80 (7)
		2	SS	50/13cm			
196.0 / 1.2		3	RC	REC 100%		196	RQD 29%
	Granitic Gneiss bedrock Slightly weathered to moderately weathered High strength Good to excellent quality	4	RC	REC 100%			RQD 100%
		5	RC	REC 100%		195	RQD 100%
		6	RC	REC 100%		194	RQD 100%
193.3 / 3.9		7	RC	REC 100%			RQD 100%
	End of borehole						

* 2013 10 30

▽ Water level observed during drilling

Plot headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

$+^7, \times^5$: Numbers refer to Sensitivity 20 / 15 ○ 5 / 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No. C18-2

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 17+110, o/s 6.0m Lt. Coords: 5 066 704.4 N; 228 733.6 E **ORIGINATED BY** A.L.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Tripod **COMPILED BY** G.D.

DATUM Geodetic **DATE** October 29, 2013 **CHECKED BY** B.R.G.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
197.5	Ground Surface										
0.0	Topsoil		1	SS	1						
197.1 / 0.4	Silty sand, organic inclusions. Very loose, Dark brown, Wet					▽*	197				
196.9 / 0.6	End of borehole. Refusal on probable bedrock										

* 2013 10 29

▽ Water level observed during drilling

ON MTO_VER3 NEW LOGO 09TF044.GPJ ON_MOT.GDT 7/9/2014 11:00:22 AM

$+^{7}$, $\times^{5}$: Numbers refer to Sensitivity

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

Ontario

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RECORD OF BOREHOLE No. C19-1

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 17+120, o/s 2.0m Rt. Coords: 5 066 716.7 N; 228 737.0 E **ORIGINATED BY** S.A.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Continuous Flight Solid Stem Augers **COMPILED BY** G.D.

DATUM Geodetic **DATE** March 10, 2013 **CHECKED BY** B.R.G.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
197.0	Ground Surface										
0.0	Peat, amorphous, Dark brown, Frozen		1	SS	1						
196.4 / 0.6	Silty sand, organics, Dark brown, Wet		2	SS	50/15cm						
196.1 / 0.9	End of borehole Refusal on probable bedrock										

* 2013 03 10

▽ Water level observed during drilling

▼ Water level measured after drilling

$+^{7}$, $\times^{5}$: Numbers refer to Sensitivity

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

Ontario

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RECORD OF BOREHOLE No. C19-2

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 17+132, o/s 32.0m Rt. Coords: 5 066 739.6 N; 228 759.8 E **ORIGINATED BY** A.L.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Tripod **COMPILED BY** G.D.

DATUM Geodetic **DATE** October 29, 2013 **CHECKED BY** B.R.G.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
197.4	Ground Surface										
0.0	Topsoil		1	SS	51/28cm	▼*	197				
197.0 / 0.4	Silty clay, trace sand / Firm Brown Wet										
	End of borehole										
	Refusal on probable bedrock										

197.2
0.2

* 2013 10 29

▼ Water level measured after drilling

$+^7$, $\times^5$: Numbers refer to Sensitivity

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

CONT No
GWP No 5112-07-00

CULVERTS C-18 AND C-19

HIGHWAY 69 FOUR-LANING

BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

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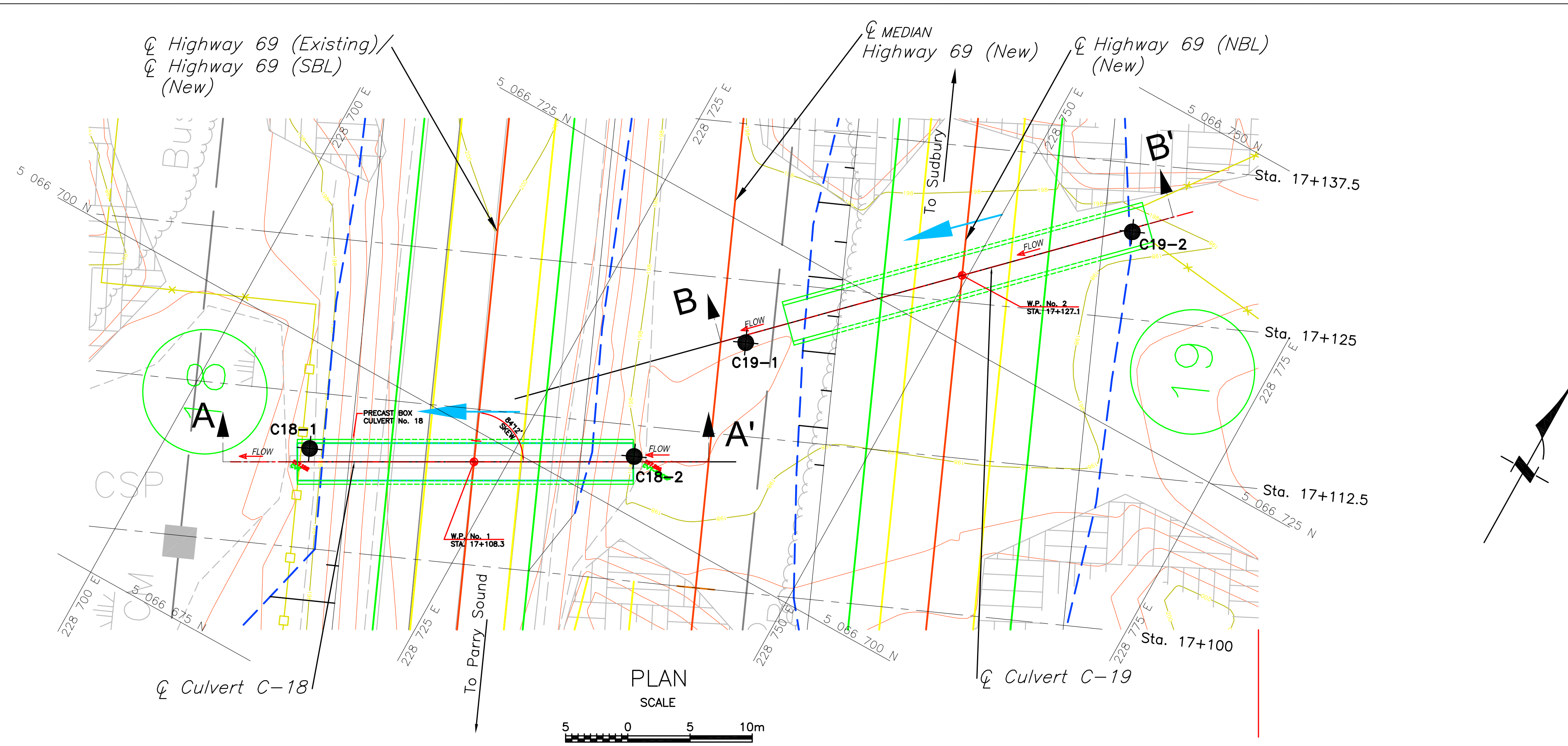
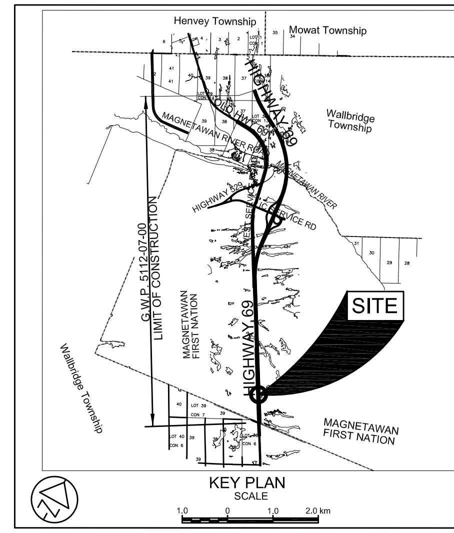
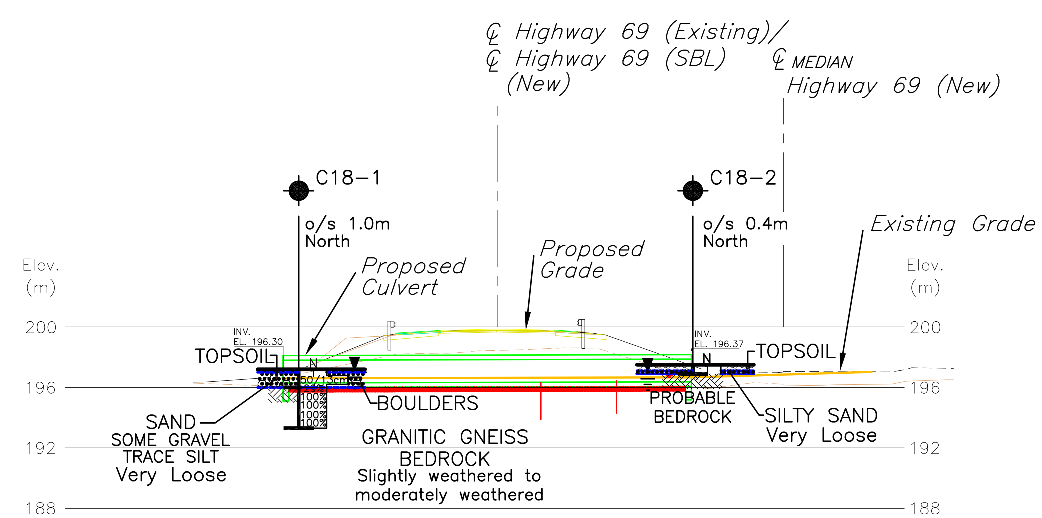




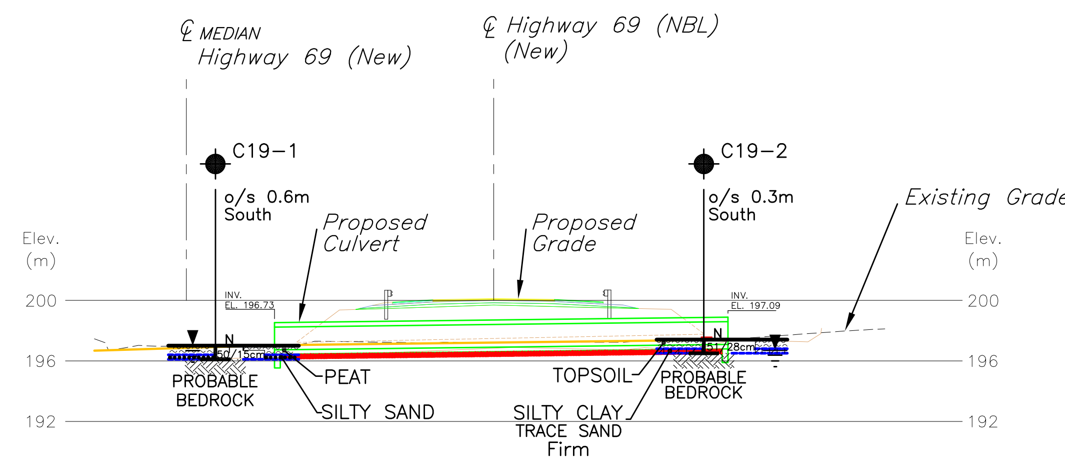
LEGEND

- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & Cone
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60°Cone, 475 J/blow)
- WH Penetration due to weight of rods and hammer
- WL at time of investigation March and Oct. 2013
- Water level not established
- Head
- ARTESIAN WATER Encountered
- PIEZOMETER

BH No	ELEVATION	COORDINATES NORTHINGS	COORDINATES EASTINGS
C18-1	197.2	5 066 692.2	228 710.5
C18-2	197.5	5 066 704.4	228 733.6
C19-1	197.0	5 066 716.7	228 737.0
C19-2	197.4	5 066 739.6	228 759.8



PROFILE A-A' ALONG CENTRELINE OF CULVERT C-18 AT STA. 17+108.3

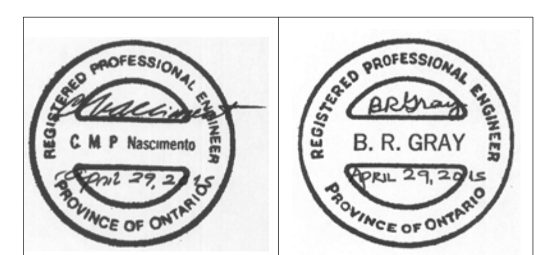


PROFILE B-B' ALONG CENTRELINE OF CULVERT C-19 AT STA. 17+127.1

SCALE
5 0 5 10m

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.



– NOTE –
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS	DATE	BY	DESCRIPTION

Geocres No. 41H-147

Reference AECOM Drawings: 60143751-BOX CULVERT_no18 SBL_sta 17+108.3 & no. 19 NBL_sta 17+127.1_1_GA.dwg dated March 2015

HWY No	69					DIST	54
SUBM'D	NA	CHECKED	MK	DATE	APR. 29, 2015	SITE	C308A
DRAWN	NA	CHECKED	GD	APPROVED	BRG	DWG	C18/C19-1

MINISTRY OF TRANSPORTATION, ONTARIO PR-D-707 88-05

APRIL 2015

DRAWING NAME: 09TF044 Culverts 18 n 19.dwg
CREATED: FEBRUARY 2014
MODIFIED:

Culvert C-20 at Sta. 17+542.7, NBL

Figure C20-PC-1: Plasticity Chart

Figures C20-GS-1, C20-GS-2 and C20-GS-3: Results of Grain Size Distribution Analyses

Record of Borehole Sheets: C20-1, C20-2 and C20-3

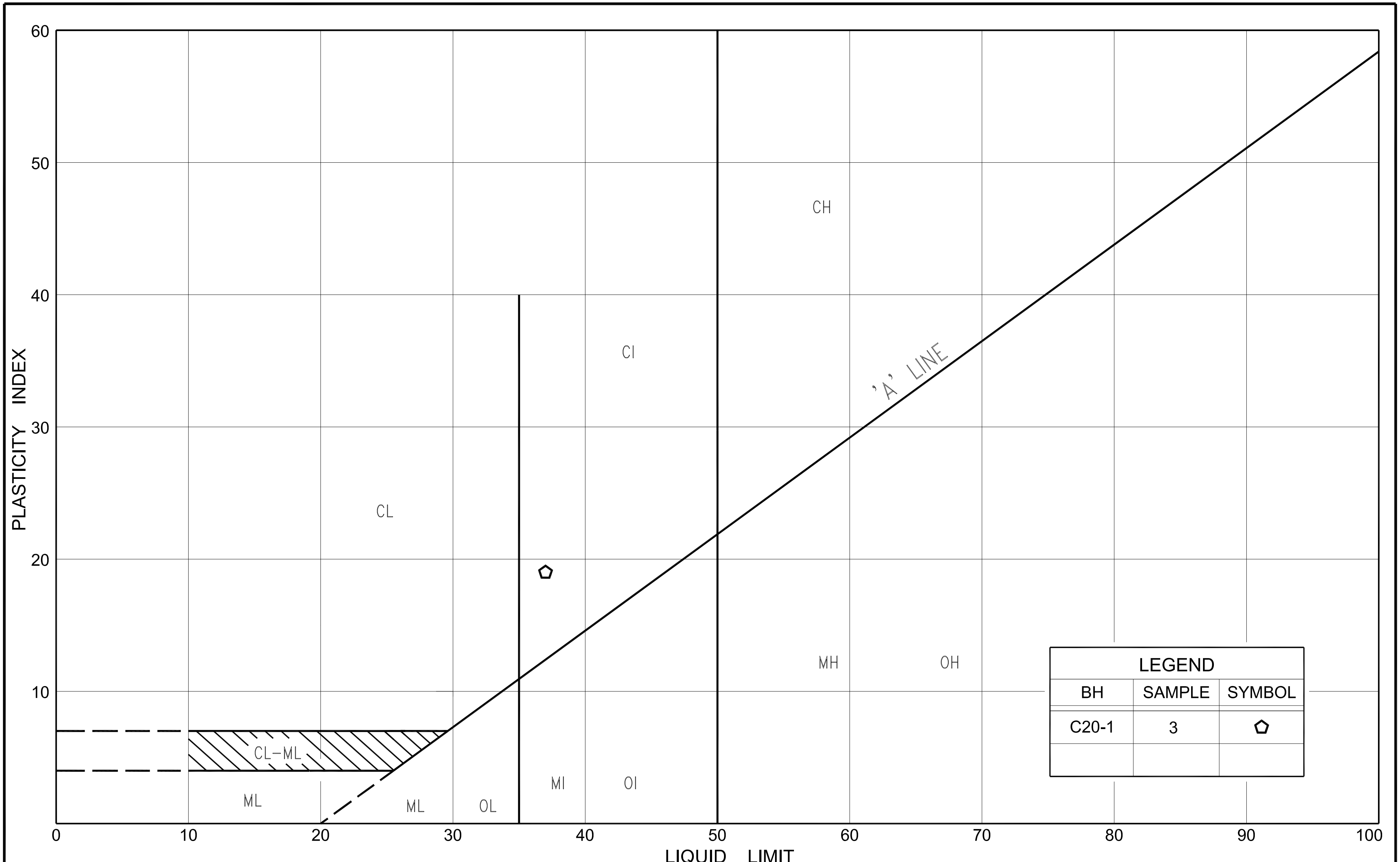
Culvert C-21 at Sta. 17+542.7, SBL

Figure C21-PC-1: Plasticity Chart

Figures C21-GS-1 and C21-GS-2: Results of Grain Size Distribution Analyses

Record of Borehole Sheets: C21-1 and C21-2

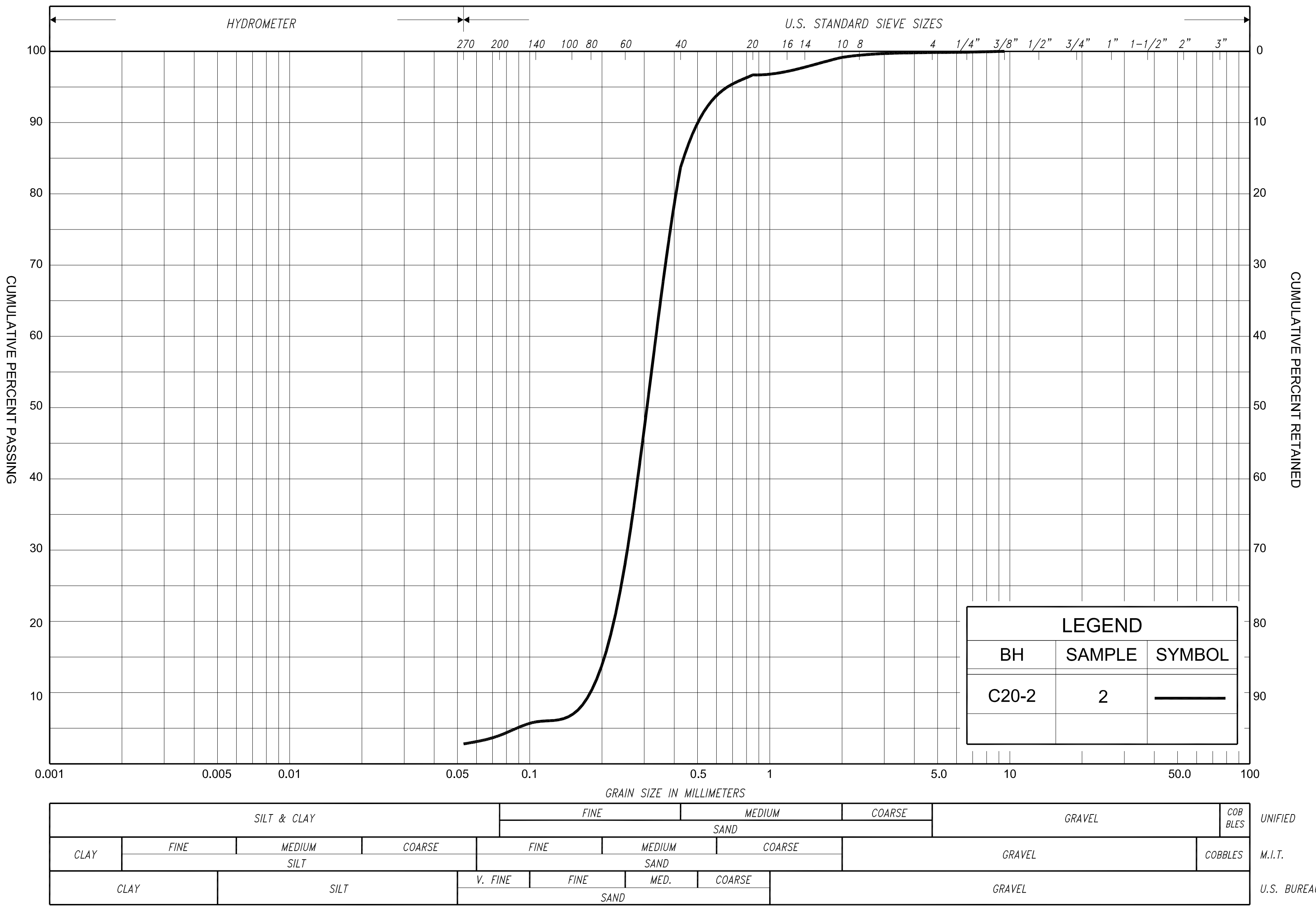
Drawing C20/C21-1: Borehole Locations and Soil Strata



PLASTICITY CHART

SILTY CLAY, trace sand

FIG No.	C20-PC-1
HWY:	69
G.W.P. No.	5112-07-00

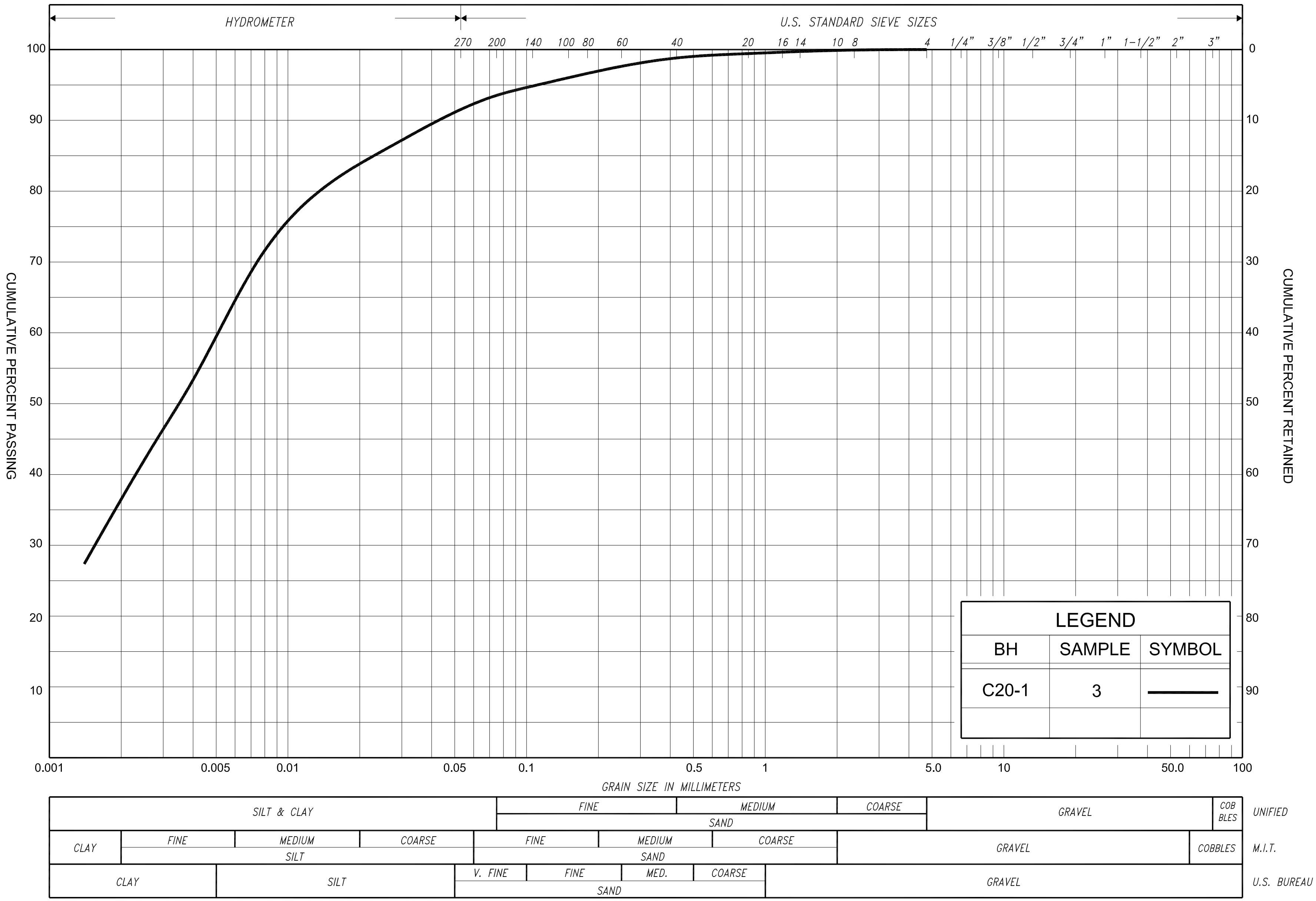


GRAIN SIZE DISTRIBUTION

ORGANIC SAND, trace silt

FIG No.	C20-GS-1
HWY:	69
G.W.P. No.	5112-07-00

Ontario

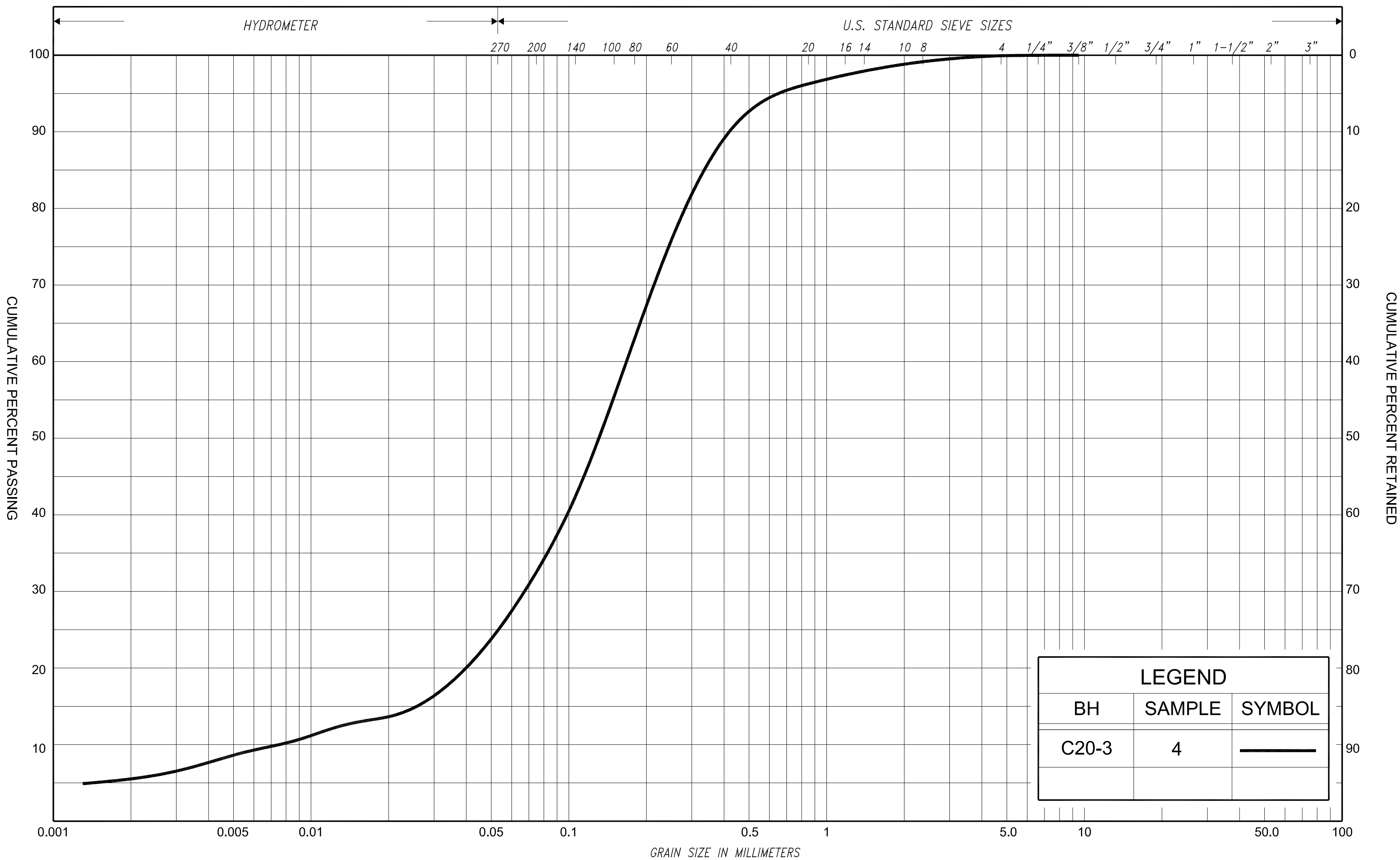


Ontario

GRAIN SIZE DISTRIBUTION

SILTY CLAY, trace sand

FIG No.	C20-GS-2
HWY:	69
G.W.P. No.	5112-07-00



SILT & CLAY			FINE SAND	MEDIUM SAND	COARSE SAND	GRAVEL	COBBLES	UNIFIED
CLAY	FINE SILT	MEDIUM SILT	COARSE SILT	FINE SAND	MEDIUM SAND	COARSE SAND	GRAVEL / COBBLES	M.I.T.
CLAY	SILT	V. FINE SAND	FINE SAND	MED. SAND	COARSE SAND	GRAVEL		U.S. BUREAU

Ontario

GRAIN SIZE DISTRIBUTION

SAND, with silt, trace clay

FIG No.	C20-GS-3
HWY:	69
G.W.P. No.	5112-07-00

Ontario

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RECORD OF BOREHOLE No. C20-1

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 17+544, o/s 9.0m Rt. Coords: 5 067 108.9 N; 228 575.7 E **ORIGINATED BY** A.L.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** 'N' Casing + Wash Boring **COMPILED BY** G.D.

DATUM Geodetic **DATE** March 08, 2013 **CHECKED BY** B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
197.7	Top of Snow/Ice										
0.0	Snow/Ice and water					▽* ▼*					
196.9 / 0.8	Organic sand, trace silt Compact Dark brown Wet		1	SS	12		197				
			2	SS	15		196				
195.5 / 2.2	Silty clay, trace sand Very stiff Grey Moist		3	SS	23		195		├o┤		0 7 56 37
194.7 / 3.0	End of borehole Refusal on probable bedrock										

* 2013 03 08

▽ Water level observed during drilling

▼ Water level measured after drilling

$+^7$, $\times^5$: Numbers refer to Sensitivity

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

Ontario

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RECORD OF BOREHOLE No. C20-2

METRIC

G.W.P. 5112-07-00 LOCATION Hwy 69, Sta. 17+542, o/s 19.0m Rt. Coords: 5 067 111.0 N; 228 585.7 E ORIGINATED BY A.L.

DIST Parry Sound HWY 69 BOREHOLE TYPE 'N' Casing + Wash Boring COMPILED BY G.D.

DATUM Geodetic DATE March 09, 2013 CHECKED BY B.R.G.

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE / SHEAR STRENGTH	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
197.3	Top of Snow/Ice									
0.0	Snow/Ice and water				▽* ▼*					
197.0 / 0.3	Peat, amorphous, Dark brown	1	SS	2		197				
196.7 / 0.6	Organic sand, trace silt rootlets, Loose to compact, Dark brown, Wet	2	SS	18		196		○	Org. 0.6%	0 96 (4)
		3	SS	11						
		4	SS	21		195				
194.6 / 2.7	Silty sand, trace clay, Compact, Grey, Wet									
194.1 / 3.2	Silty clay, trace sand, Firm, Grey, Moist	5	SS	55/18cm		194	■	○		
193.9 / 3.4	End of borehole									

Refusal on probable bedrock

Sample 5: Sampler bouncing

* 2013 03 09

▽ Water level observed during drilling

▼ Water level measured after drilling

■ Penetrometer test

+7, ×5: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No. C20-3

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 17+544, o/s 31.0m Rt. Coords: 5 067 117.6 N; 228 595.9 E **ORIGINATED BY** A.L.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** 'N' Casing + Wash Boring **COMPILED BY** G.D.

DATUM Geodetic **DATE** March 09, 2013 **CHECKED BY** B.R.G.

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	Water content (%)	Penetrometer	GR	SA	SI	CL
197.3	Top of Snow/Ice											
0.0	Snow/Ice and water				▽* ▼*	197						
196.4 / 0.9	Organic sand, trace silt rootlets. Compact, Dark brown, Wet	1	SS	22		196						
195.5 / 1.8	Silty clay, trace sand. Stiff to very stiff, Grey, Moist	2	SS	19								
	silty sand seams	3	SS	15		195						
194.3 / 3.0	Sand with silt, trace clay. Loose, Grey, Wet	4	SS	5		194			0	67	27	6
193.3 / 4.0	End of borehole	5	SS	50/3cm								

End of borehole

Refusal on probable bedrock

Sample 5: Sampler bouncing

* 2013 03 09

▽ Water level observed during drilling

▼ Water level measured after drilling

■ Penetrometer test

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

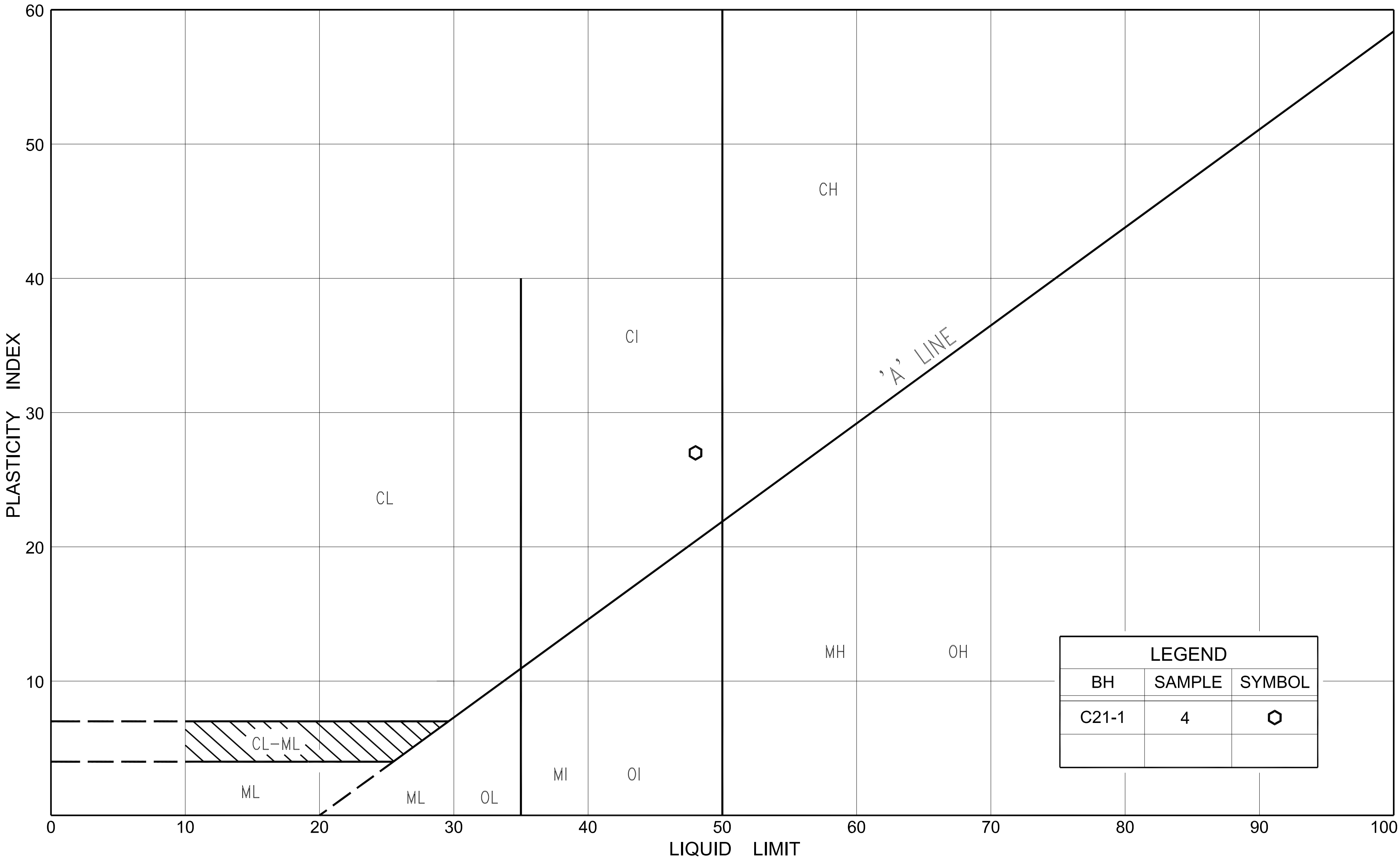
PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

$+^7$, $\times^5$: Numbers refer to Sensitivity

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



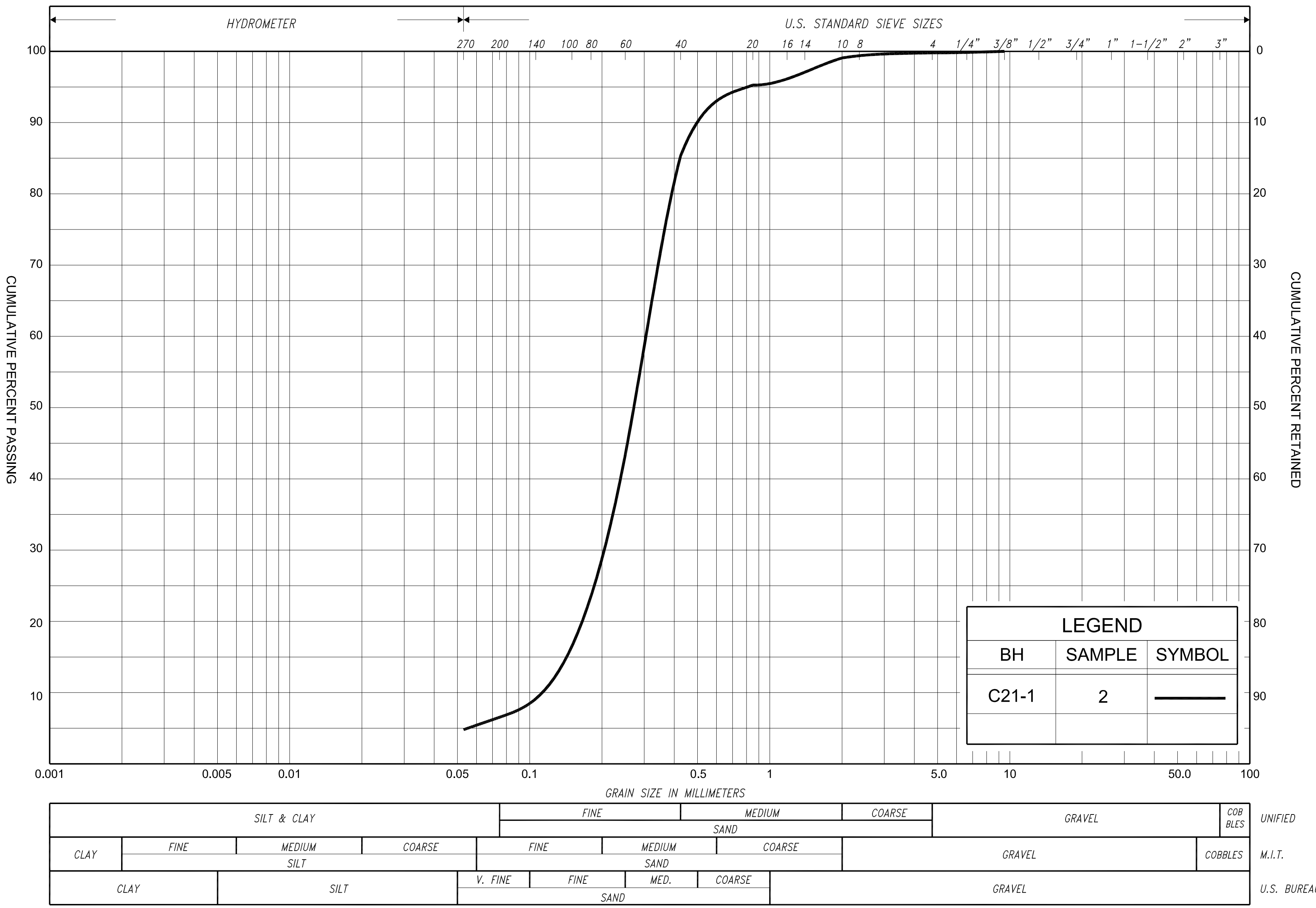
LEGEND		
BH	SAMPLE	SYMBOL
C21-1	4	⬡

Ontario

PLASTICITY CHART

SILTY CLAY, trace sand

FIG No.	C21-PC-1
HWY:	69
G.W.P. No.	5112-07-00

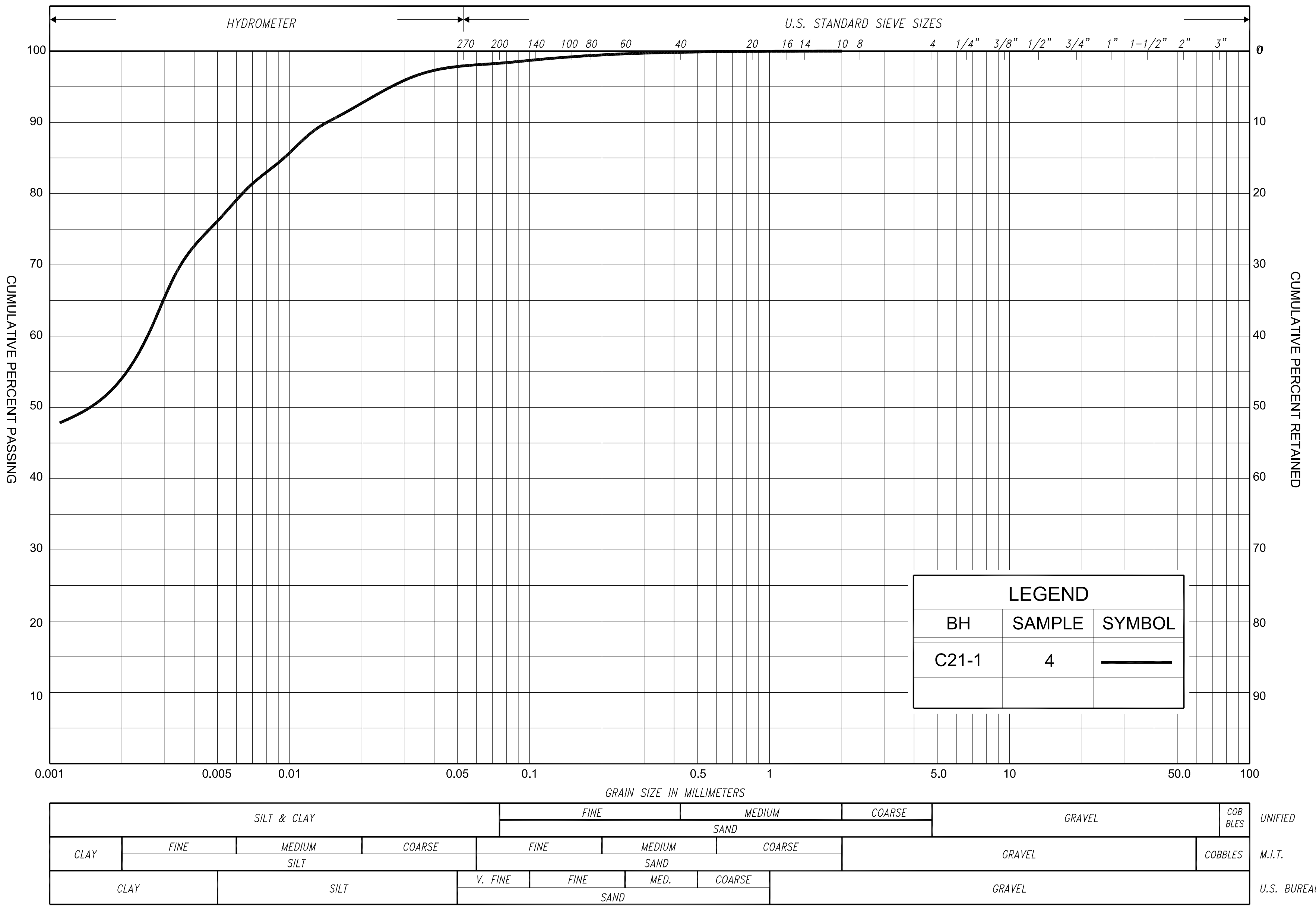


Ontario

GRAIN SIZE DISTRIBUTION

SAND, trace silt

FIG No.	C21-GS-1
HWY:	69
G.W.P. No.	5112-07-00



Ontario

GRAIN SIZE DISTRIBUTION

SILTY CLAY, trace sand

FIG No.	C21-GS-2
HWY:	69
G.W.P. No.	5112-07-00

RECORD OF BOREHOLE No. C21-1

METRIC

G.W.P. 5112-07-00	**LOCATION** Hwy 69, Sta. 17+542, o/s 29.0m Lt. Coords: 5 067 092.0 N; 228 541.6 E		**ORIGINATED BY** F.P.
DIST Parry Sound **HWY** 69	**BOREHOLE TYPE** Tripod + Hilti		**COMPILED BY** G.D.
DATUM Geodetic	**DATE** September 27 and 30, 2013		**CHECKED BY** B.R.G.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
198.2	Ground Surface								
0.0 / 197.9	Peat, coarse fibrous, Dark brown		1	SS	2		198	89	
0.3	Sand, trace silt, organics. Very loose to loose, Brown, Moist to wet		2	SS	4	▽*	197	○	0 93 (7)
196.8 / 1.4	Sandy silt, some clay, organics. Loose, Brown/grey, Moist to wet		3	SS	5			○	
196.0 / 2.2	Silty clay, trace sand. Stiff to very stiff, Grey, Moist		4	SS	8		196	├○┤ (■ penetrometer)	0 2 44 54
195.2 / 3.0	Sand, trace silt, trace gravel. Loose to compact, Grey, Wet. cobbles and boulders		5	SS	14		195	○	
193.9 / 4.3	Granitic Gneiss bedrock. Slightly weathered to moderately weathered. High strength. Fair to excellent quality		6	RC	REC 100%		194		RQD 90%
			7	RC	REC 100%		193		RQD 68%
			8	RC	REC 100%		192		RQD 100%
			9	RC	REC 98%		191		RQD 98%
190.8 / 7.4	End of borehole								

* 2013 09 90

▽ Water level observed during drilling

■ Penetrometer test

+7, ×5 : Numbers refer to Sensitivity

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

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

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RECORD OF BOREHOLE No. C21-2 — 1 of 1 — METRIC

G.W.P. 5112-07-00	LOCATION Hwy 69, Sta. 17+542, o/s 6.0m Lt. Coords: 5 067 101.1 N; 228 562.8 E
ORIGINATED BY F.P.	
DIST Parry Sound HWY 69	BOREHOLE TYPE Tripod + Hilti
COMPILED BY G.D.	
DATUM Geodetic	DATE October 01, 2013
CHECKED BY B.R.G.	

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%)
197.7	Ground Surface				▽*			
197.5 0.2	Peat, fine fibrous Dark brown	1	SS	WH**		197		
196.3 1.4	Sand, trace silt organics Very loose Brown Wet to compact	2	SS	12			○	
195.9 1.8	Clayey silt, organics Firm Grey Moist	3	SS	8		196	○	
195.6 2.1	Silt trace clay, trace sand Compact Grey Moist to wet					195		
194.4 3.3	Sand cobbles and boulders Dense Grey Wet							
	Granitic Gneiss bedrock Slightly weathered to moderately weathered High strength Good to excellent, locally very poor quality	4	RC	REC 100%				RQD 100%
		5	RC	REC 88%		194		RQD 88%
		6	RC	REC 83%				RQD 0%
		7	RC	REC 91%		193		RQD 86%
		8	RC	REC 93%		192		RQD 91%
191.2 6.5		9	RC	REC 98%				RQD 98%
	End of borehole							

* 2013 10 01

▽ Water level observed during drilling

WH** denotes penetration due to weight of rods and hammer

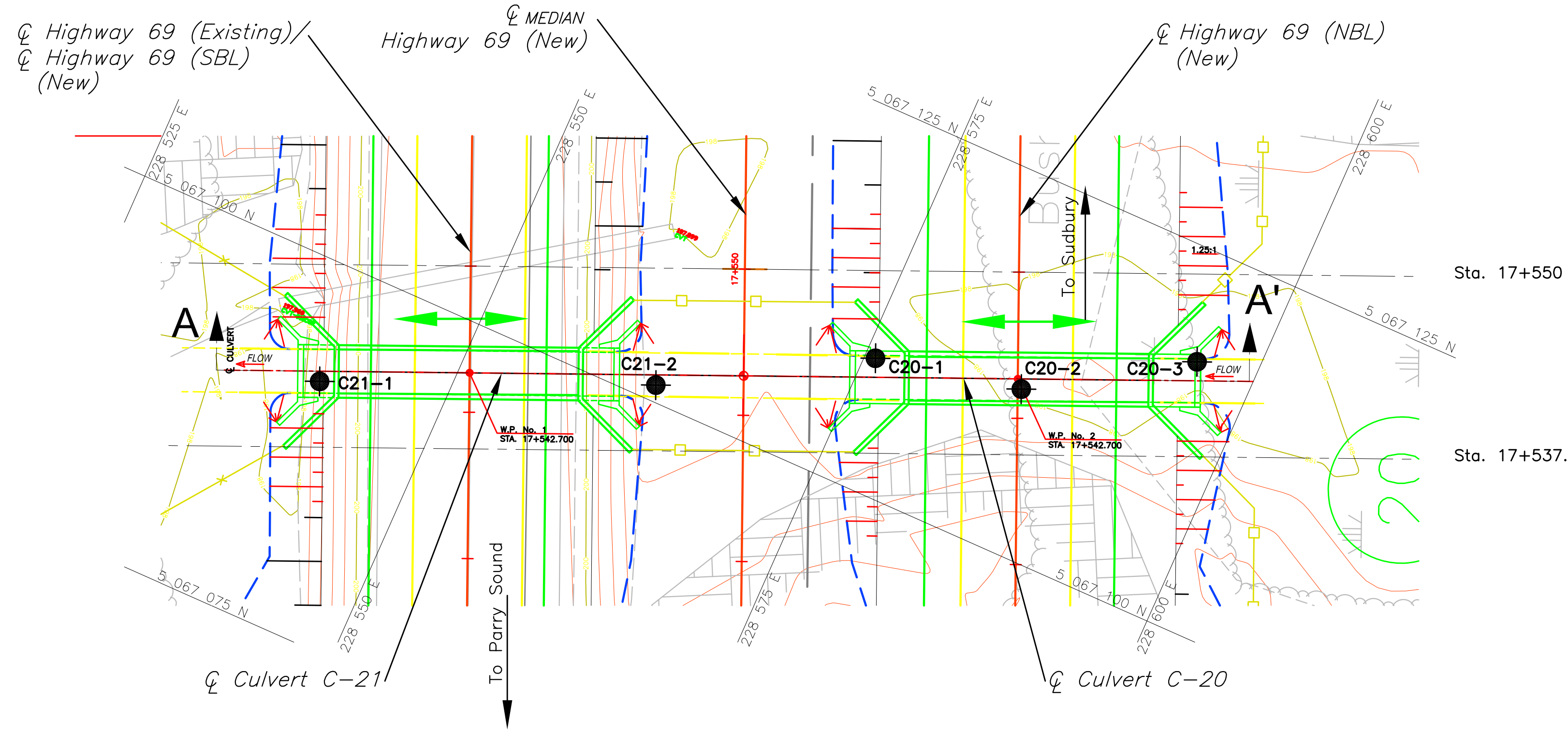
Column headings also include: SOIL PROFILE; SAMPLES; STRAT PLOT; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L (20 40 60); UNIT WEIGHT γ kN/m³; GR SA SI CL

+7, ×5: Numbers refer to Sensitivity

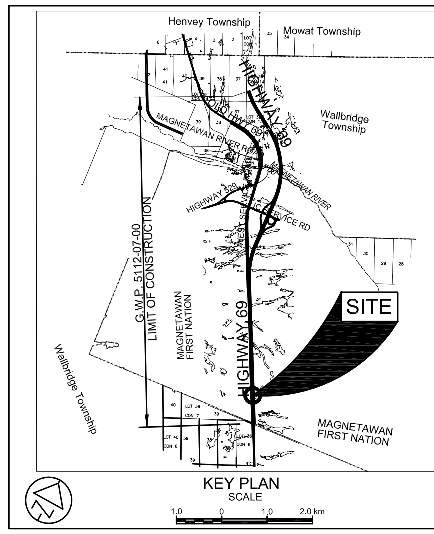
20 / 15—○—5 / 10 (%) STRAIN AT FAILURE

CONT No
GWP No 5112-07-00
CULVERTS C-20 AND C-21
HIGHWAY 69 FOUR-LANING
BOREHOLE LOCATIONS AND SOIL STRATA
SHEET

Peto MacCallum Ltd.
CONSULTING ENGINEERS



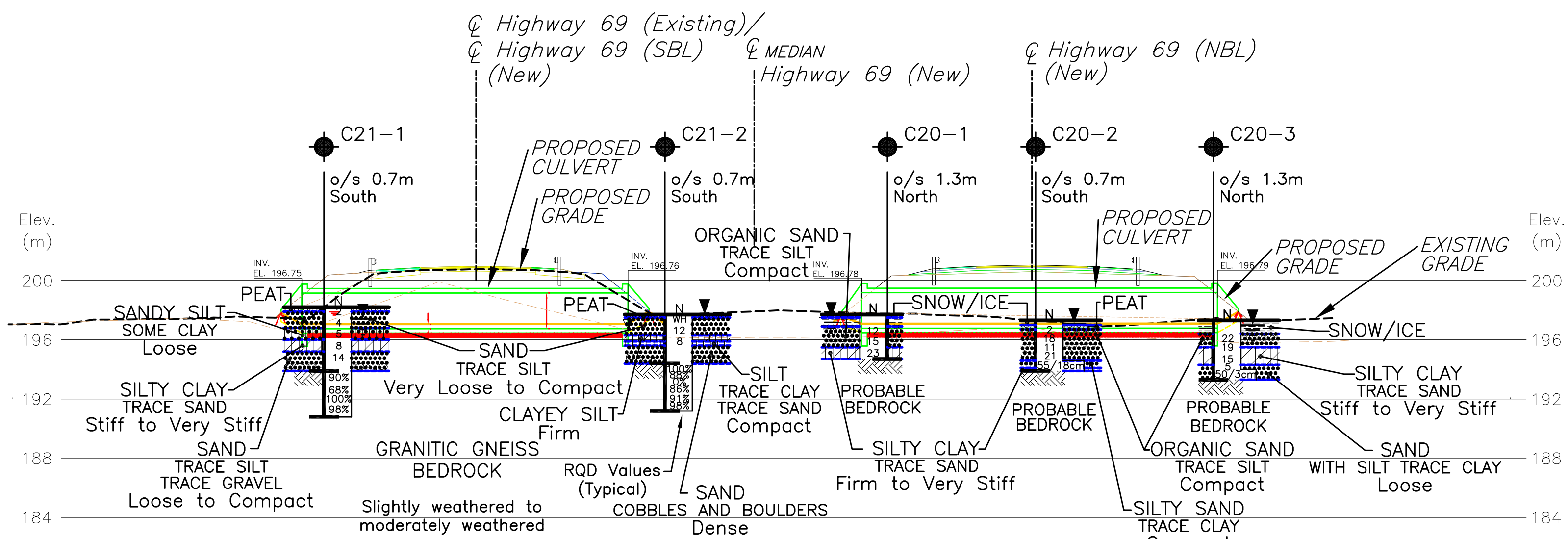
PLAN
SCALE
5 0 5 10m



LEGEND

- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & Cone
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60°Cone, 475 J/blow)
- WH Penetration due to weight of rods and hammer
- WL at time of investigation March, Sept. and Oct. 2013
- Water level not established
- Head
- ARTESIAN WATER Encountered
- PIEZOMETER

BH No	ELEVATION	COORDINATES NORTHINGS	COORDINATES EASTINGS
C20-1	197.7	5 067 108.9	228 575.7
C20-2	197.3	5 067 111.0	228 585.7
C20-3	197.3	5 067 117.6	228 595.9
C21-1	198.2	5 067 092.0	228 541.6
C21-2	197.7	5 067 101.1	228 562.8

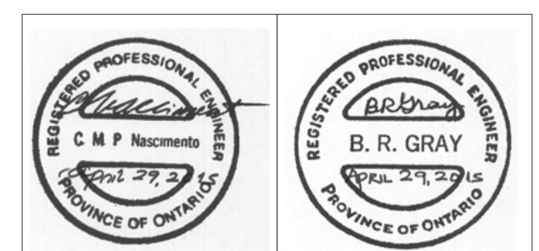


PROFILE A-A' ALONG CENTRELINES OF CULVERTS C-20 AND C-21 AT Sta. 17+542.7

SCALE
5 0 5 10m

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.



Reference AECOM Drawing: 60143751-BOX_CULVERT_no.20 NBL & no.21 SBL_sta 17+542.1_GA.dwg dated March 2015

– NOTE –
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS
DATE	BY	DESCRIPTION

Geocres No. 41H-147

HWY No 69			DIST 54
SUBM'D NA	CHECKED MK	DATE APR. 29, 2015	SITE C308
DRAWN NA	CHECKED GD	APPROVED BRG	DWG C20/C21-1

MINISTRY OF TRANSPORTATION, ONTARIO PR-D-707 88-05

DRAWING NAME: 09TF044 Culverts 20 n 21.dwg CREATED: MARCH 2014 MODIFIED: APRIL 2015

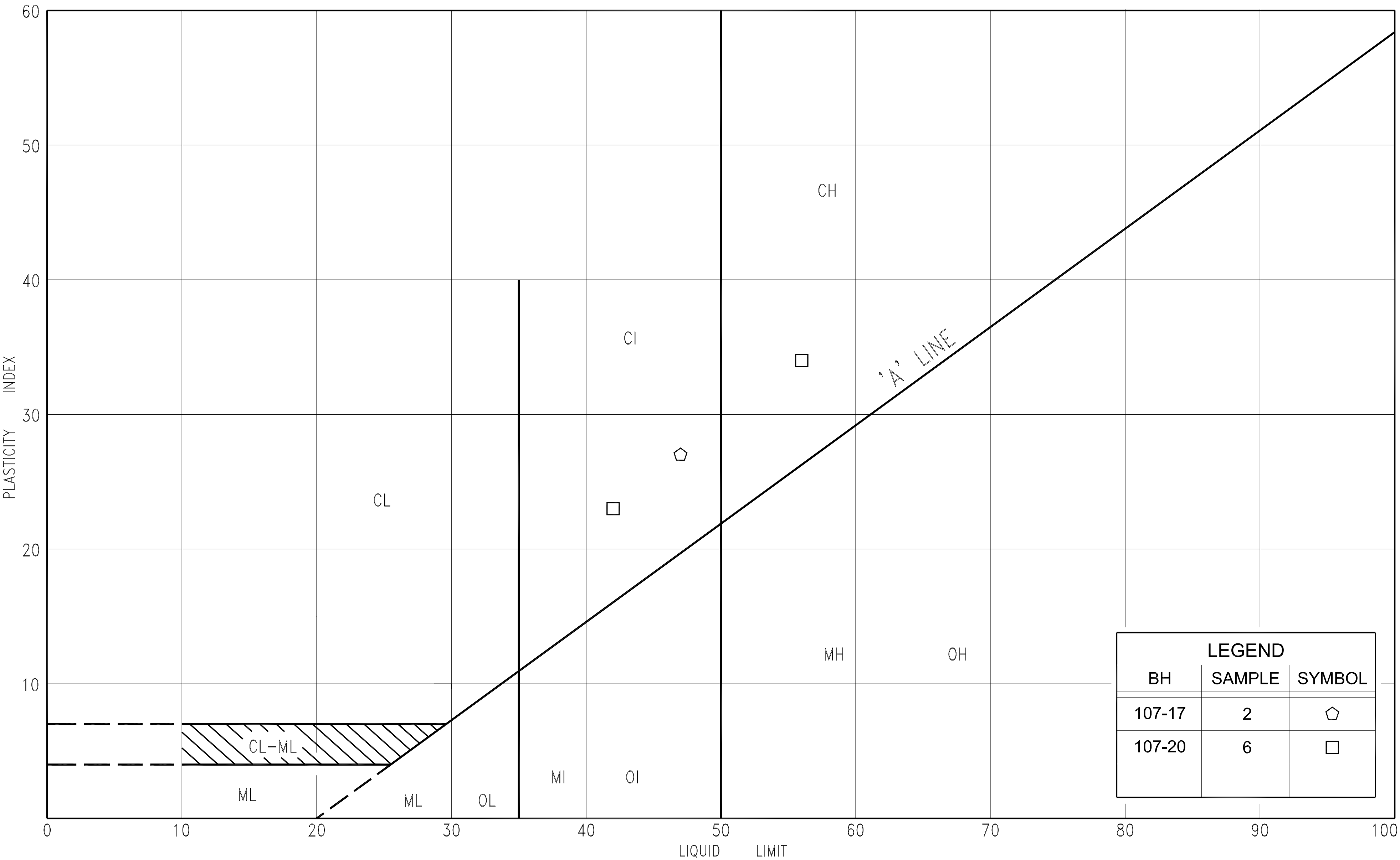
Culvert C-22 at Sta. 17+822.8, NBL

Figure 107-PC-1: Plasticity Chart

Figures C22-GS-1, 107-GS-2 and 107-GS-4: Results of Grain Size Distribution Analyses

Record of Borehole Sheets: C22-1, 107-19 and 107-20

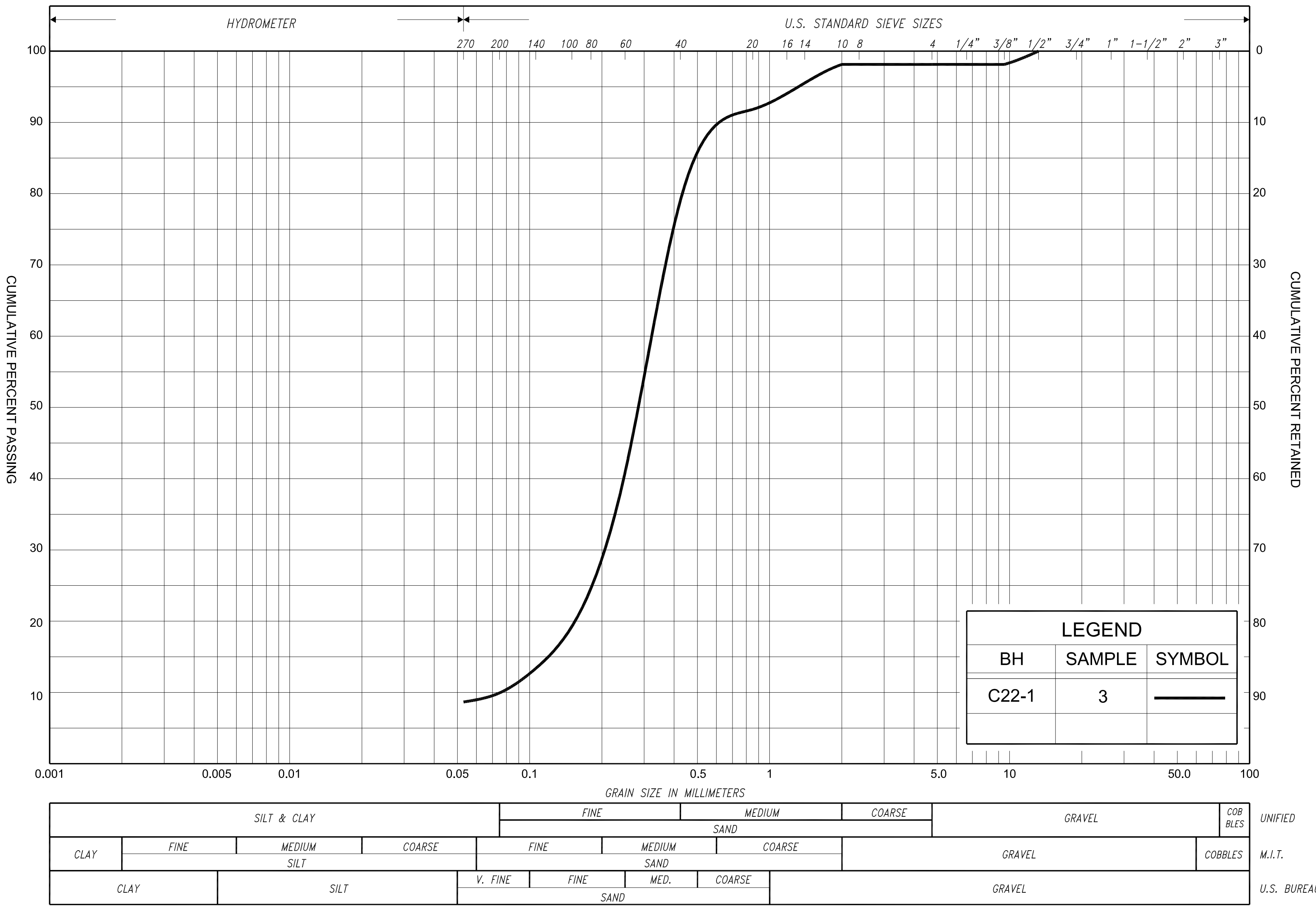
Drawing C22-1: Borehole Locations and Soil Strata



LEGEND

BH	SAMPLE	SYMBOL
107-17	2	⬠
107-20	6	□

Ontario	PLASTICITY CHART SILTY CLAY, trace sand	FIG No. 107-PC-1 HWY: 69 G.W.P. No. 5112-07-00

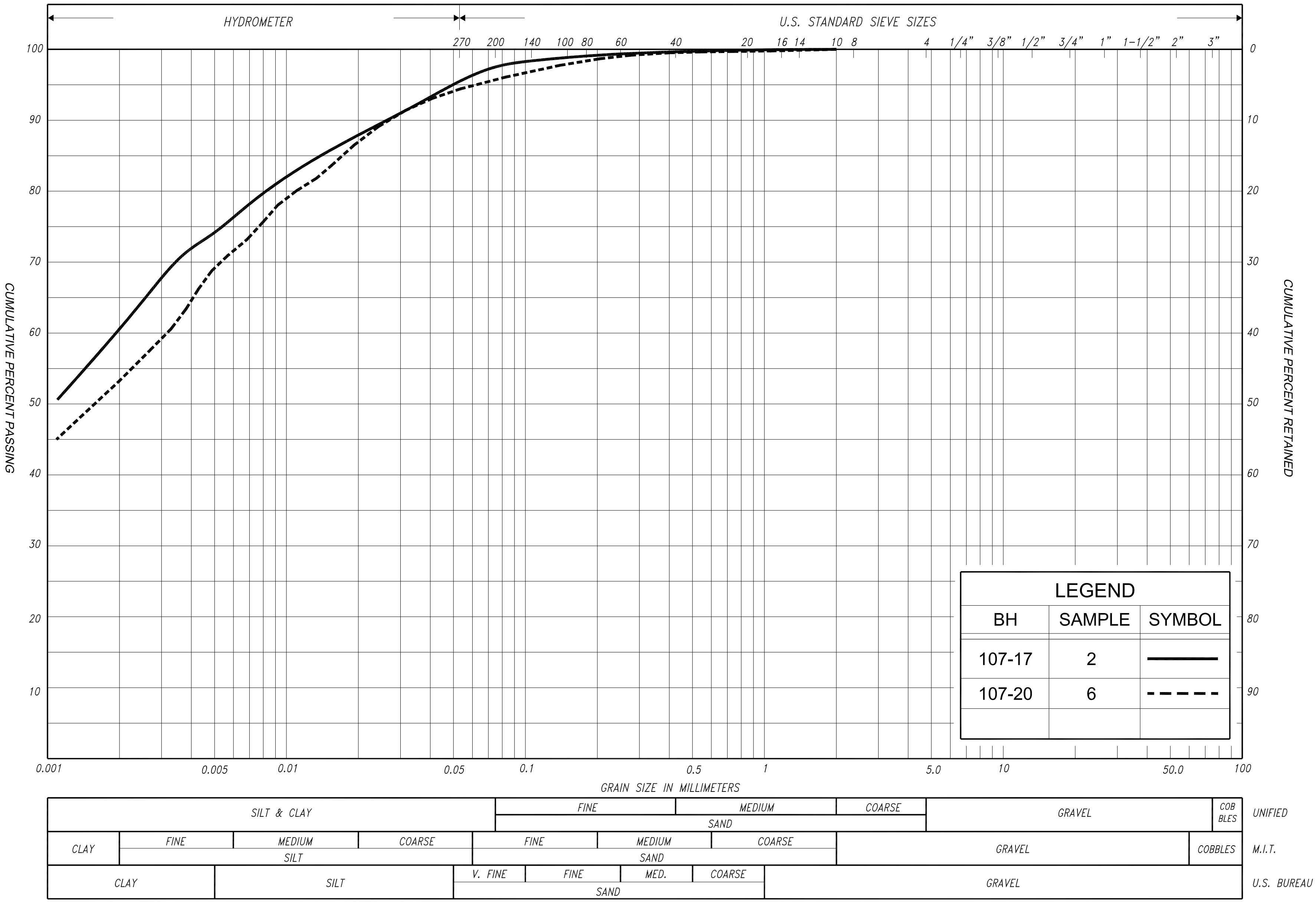


Ontario

GRAIN SIZE DISTRIBUTION

SAND, trace silt, trace gravel

FIG No.	C22-GS-1
HWY:	69
G.W.P. No.	5112-07-00

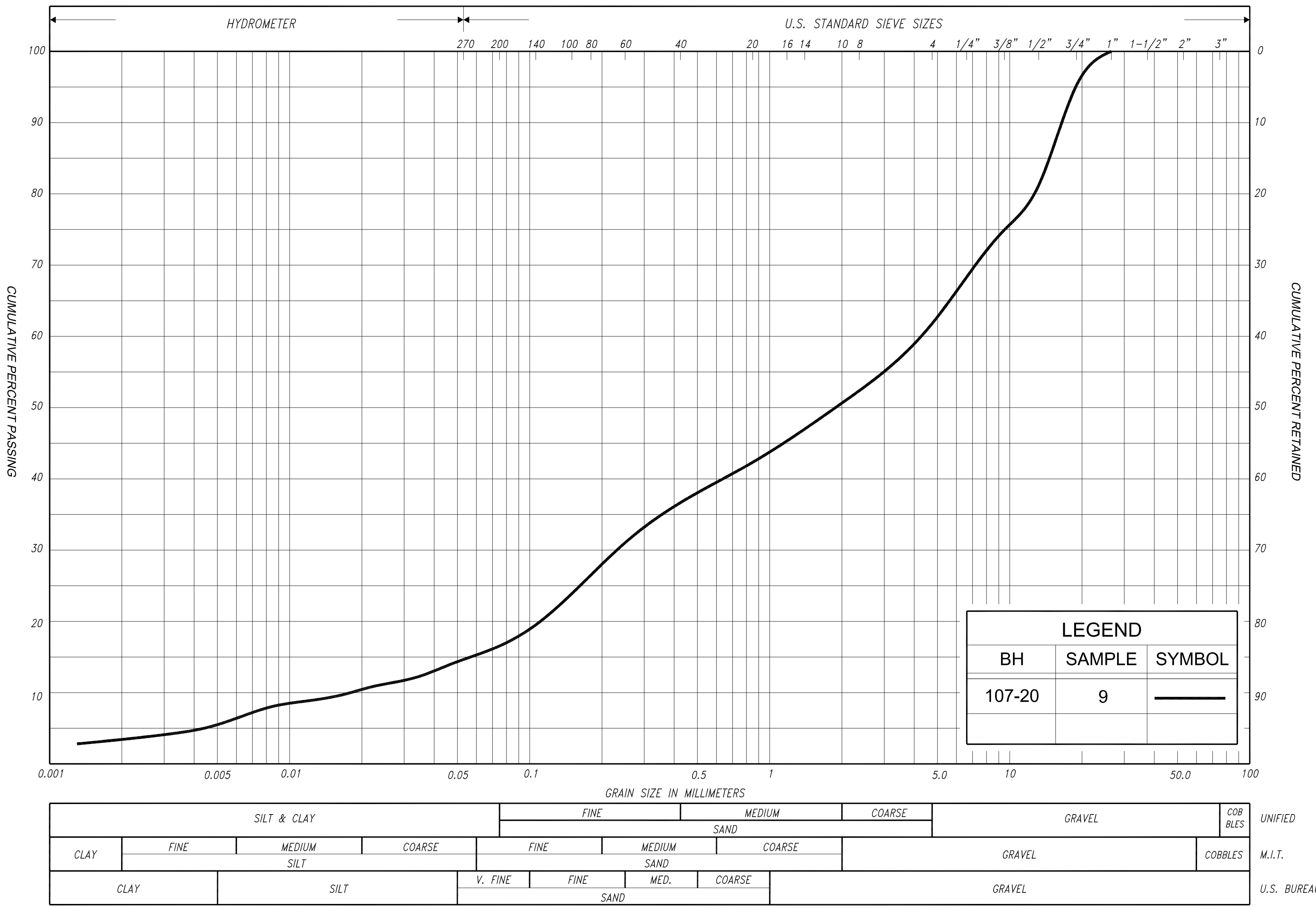


Ontario

GRAIN SIZE DISTRIBUTION

SILTY CLAY, trace sand

FIG No.	107-GS-2
HWY:	69
G.W.P. No.	5112-07-00



Ontario

GRAIN SIZE DISTRIBUTION

GRAVELLY SAND, some silt, trace clay

FIG No.	107-GS-4
HWY:	69
G.W.P. No.	5112-07-00

Ontario

Peto MacCallum Ltd.
CONSULTING ENGINEERS
Foundation Design

RECORD OF BOREHOLE No. C22-1 — 1 of 1 — METRIC

G.W.P. 5112-07-00 LOCATION Hwy 69, Sta. 17+830, o/s 5.0m Rt. Coords: 5 067 370.0 N; 228 458.9 ORIGINATED BY A.L.

DIST Parry Sound HWY 69 BOREHOLE TYPE Tripod + Wash Boring COMPILED BY G.D.

DATUM Geodetic DATE October 25, 2013 CHECKED BY B.R.G.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa / WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
198.0	Ground Surface							
197.9 / 0.0 / 0.1	Topsoil							
197.8 / 0.2	Silty sand rootlets and topsoil inclusions	1	SS	3	▽*			
197.2 / 0.8	Silty clay rootlets and topsoil inclusions	2	SS	1		197		
196.5 / 1.5	Firm Grey Moist to wet (FILL)							
	Peat, amorphous Dark brown	3	SS	2		196		2 88 (10)
	Sand trace to some silt trace gravel, organics Very loose Grey Wet	4	SS	2				
195.0 / 3.0	Silty clay, trace sand Soft to firm Grey Wet	5	SS	1		195		
		6	SS	WH**		194	99	
		7	SS	WH		193		
			FV				+ 5	
		8	SS	WH		192		
			FV			191	+ 4	
		9	SS	WH		190		
			FV				+ 7	
		10	SS	WH		189	90	
			FV			188	+ 5	
		11	SS	WH		187		
			FV				+ 7	
186.5 / 11.5	End of borehole Refusal on probable bedrock							

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

* 2013 10 25

▽ Water level observed during drilling

WH** denotes penetration due to weight of rods and hammer

ON MTO_VER3 NEW LOGO 09TF044.GPJ ON_MOT.GDT 7/23/2014 2:55:50 PM

+7, ×5 : Numbers refer to Sensitivity

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

Ontario

Peto MacCallum Ltd.
CONSULTING ENGINEERS
Foundation Design

RECORD OF BOREHOLE No. 107-19

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 17+812.5, o/s 40.0m Rt. Coords: 5 067 370.8 N; 228 473.5 E **ORIGINATED BY** J.H.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Tripod **COMPILED BY** G.D.

DATUM Geodetic **DATE** February 09, 2012 **CHECKED BY** C.N.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
197.6	Top of Snow/Ice										
0.0	Snow/Ice Water						197				
196.6 1.0	End of borehole Refusal on probable bedrock										

* 2012 02 09

▽ Water level observed during drilling

▼ Water level measured after drilling

+7, ×5 : Numbers refer to Sensitivity

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

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. 107-20

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 17+825, o/s 18.8m Rt. Coords: 5 067 367.8 N; 228 498.0 E **ORIGINATED BY** J.H.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Tripod 'N' Casing with Washbore **COMPILED BY** G.D.

DATUM Geodetic **DATE** February 10 & 13, 2012 **CHECKED BY** C.N.

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
197.6	Top of Snow/Ice											
0.0	Snow/Ice Water				197							
196.8 / 0.8	Peat, fine fibrous Black	1	SS	WH**			87					
		2	SS	WH	196		122					
195.4 / 2.2	Sandy silt organics to 2.5m Very loose Brown Wet	3	SS	WH	195							
		4	SS	WH								
194.3 / 3.3	Silty clay, trace sand Soft to firm Grey Wet		FV		194	+ 3						
		5	SS	WH	193							
		6	SS	WH					0	4	43	53
					192							
		7	TW	-	191							
					190							
		8	SS	WH								
			FV		189	+ 2						
188.9 / 8.7	Gravelly sand some silt, trace clay Very dense Grey Wet to moist	9	SS	53	188				38	45	14	3
188.0 / 9.6	End of borehole Refusal on probable bedrock											

* 2012 02 10 & 13

▽ Water level observed during drilling

▼ Water level measured after drilling

+7, ×5: Numbers refer to Sensitivity

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

CONT No
GWP No 5112-07-00

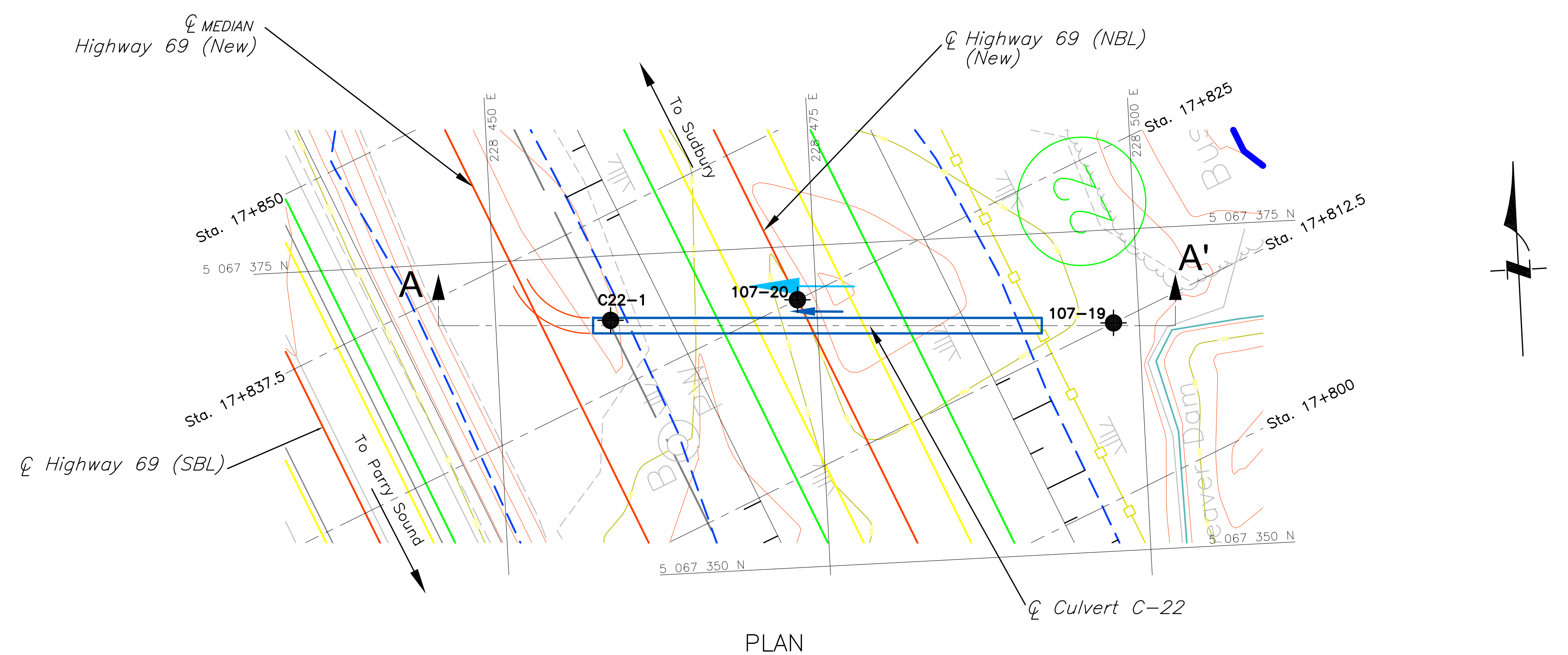
SHEET

CULVERT C-22

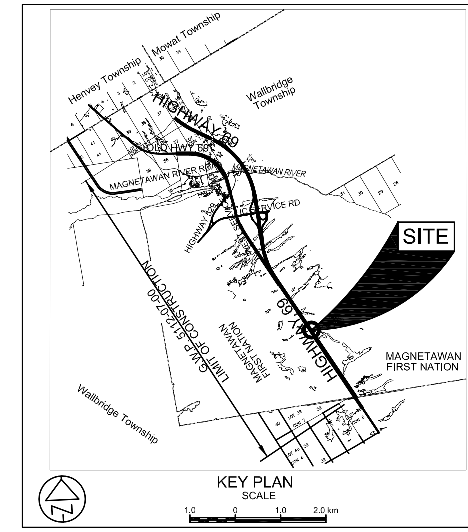
HIGHWAY 69 FOUR-LANING

BOREHOLE LOCATIONS AND SOIL STRATA

PML Peto MacCallum Ltd.
CONSULTING ENGINEERS



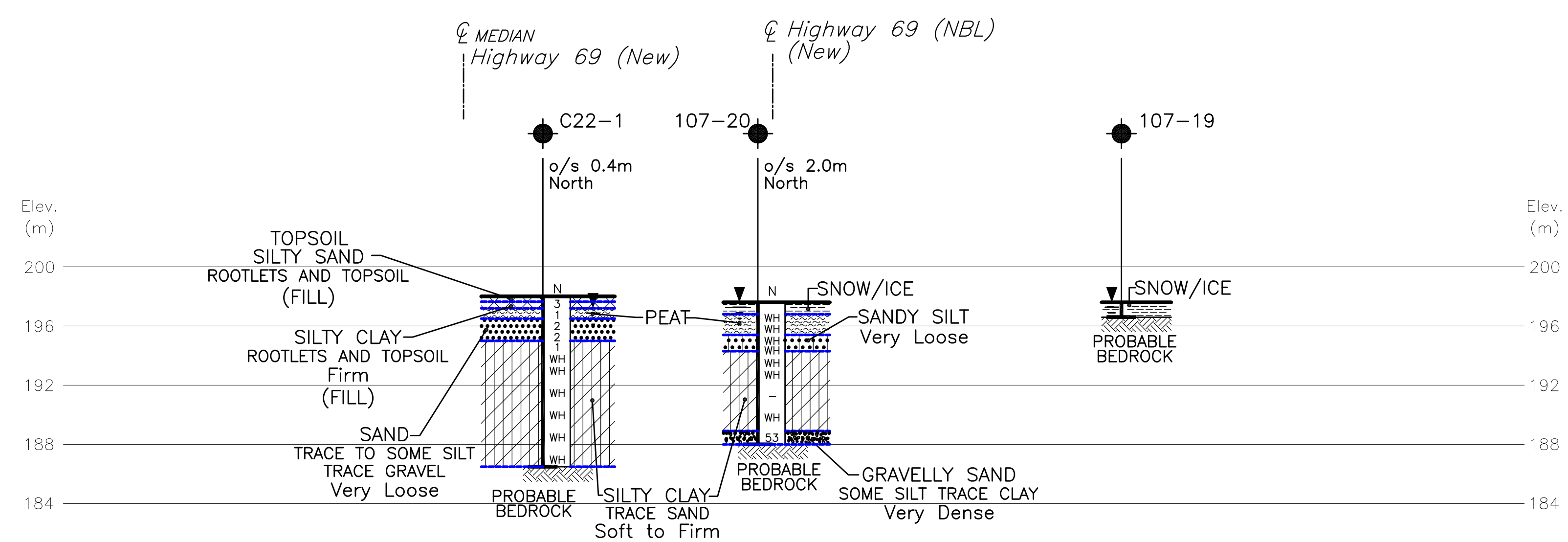
PLAN
SCALE
5 0 5 10m



LEGEND

- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & Cone
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60°Cone, 475 J/blow)
- WH Penetration due to weight of rods and hammer
- WL at time of investigation Feb. 2012 and Oct. 2013
- Water level not established
- Head
- ARTESIAN WATER Encountered
- PIEZOMETER

BH No	ELEVATION	COORDINATES NORTHINGS	COORDINATES EASTINGS
C22-1	198.0	5 067 370.0	228 458.9
107-19	197.6	5 067 370.8	228 473.5
107-20	197.6	5 067 367.8	228 498.0

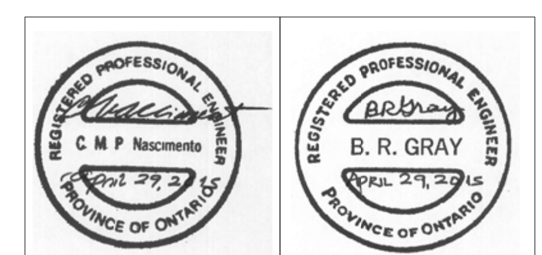


PROFILE A-A' ALONG CENTRELINE OF CULVERT C-22 Sta. 17+822.8

SCALE
5 0 5 10m

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.



Reference AECOM Drawings: X-60143751-C-HWY 69-DESIGN.dwg; 6-60143751-C-Hwy 69-Base.dwg dated April 2015

– NOTE –
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS DATE	BY	DESCRIPTION

Geocres No. 41H-147

HWY No 69			DIST 54
SUBM'D NA	CHECKED MK	DATE APR. 29, 2015	SITE --
DRAWN NA	CHECKED GD	APPROVED BRG	DWG C22-1

APRIL 2015
MODIFIED:
DRAWING NAME: 09TF044 Culvert 22.dwg
CREATED: MARCH 2014

Culvert C-23 at Sta. 17+864.5, NBL

Record of Borehole Sheets: C23-1, C23-2 and 107-27

Culvert C-24 at Sta. 17+864.5, SBL

Figure C24-PC-1: Plasticity Chart

Figure C24-GS-1: Results of Grain Size Distribution Analysis

Record of Borehole Sheets: C24-1 and C24-2

Record of Pavement Borehole Sheet: PV-2

Drawing C23/C24-1: Borehole Locations and Soil Strata

RECORD OF BOREHOLE No. C23-1

METRIC

G.W.P.	5112-07-00	**LOCATION**	Hwy 69, Sta. 17+864, o/s 10.0m Rt. Coords: 5 067 403.2 N; 228 450.1 E	**ORIGINATED BY**	A.L.
DIST	Parry Sound **HWY** 69	**BOREHOLE TYPE**	Manual Probing	**COMPILED BY**	G.D.
DATUM	Geodetic	**DATE**	October 28, 2013	**CHECKED BY**	B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
197.7	Top of Water										
197.5	Water										
0.2	Topsoil, with sand organic inclusions										
197.0 / 0.7	Dark brown Wet						197				
	End of borehole										
	Refusal on probable bedrock										

* 2013 10 28

▽ Water level observed during drilling

▼ Water level measured after drilling

$+^7$, $\times^5$: Numbers refer to Sensitivity

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

Ontario

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RECORD OF BOREHOLE No. C23-2

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 17+864, o/s 29.0m Rt. Coords: 5 067 410.7 N; 228 467.5 E **ORIGINATED BY** S.A.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Tripod + Wash Boring **COMPILED BY** M.K.

DATUM Geodetic **DATE** February 20, 2014 **CHECKED BY** B.R.G.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)
197.8	Top of Ice						
0.0	Ice and water	1	SS	WH**	▽*		
197.3 / 0.5	Peat, amorphous Dark brown /black, Wet	2	SS	WH		197	
196.0 / 1.8	Silty clay, organics Soft to firm, Grey, Moist	3	SS	2		196	~41 (o)
		4	SS	51/18cm			
195.2 / 2.6	End of borehole Refusal on probable bedrock Sample 4: Sampler bouncing						

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

* 2014 02 20

▽ Water level observed during drilling

▼ Water level measured after drilling

WH** denotes penetration due to weight of rods and hammer

NOTE: About 600mm of snow has been removed before drilling

+7, ×5 : Numbers refer to Sensitivity

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

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. 107-27

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 17+865, o/s 19.0m Rt. Coords: 5 067 407.7 N; 228 458.0 E **ORIGINATED BY** J.H.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Tripod 'N' Casing with Washbore **COMPILED BY** G.D.

DATUM Geodetic **DATE** February 14, 2012 **CHECKED BY** C.N.

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
197.7	Top of Snow/Ice										
0.0	Snow/Ice										
	Water										
197.0 0.7	Silty sand, trace clay organics Very dense Brown Wet		1	SS	100/15cm		197		○		
196.8 0.9	End of borehole Refusal on probable bedrock										

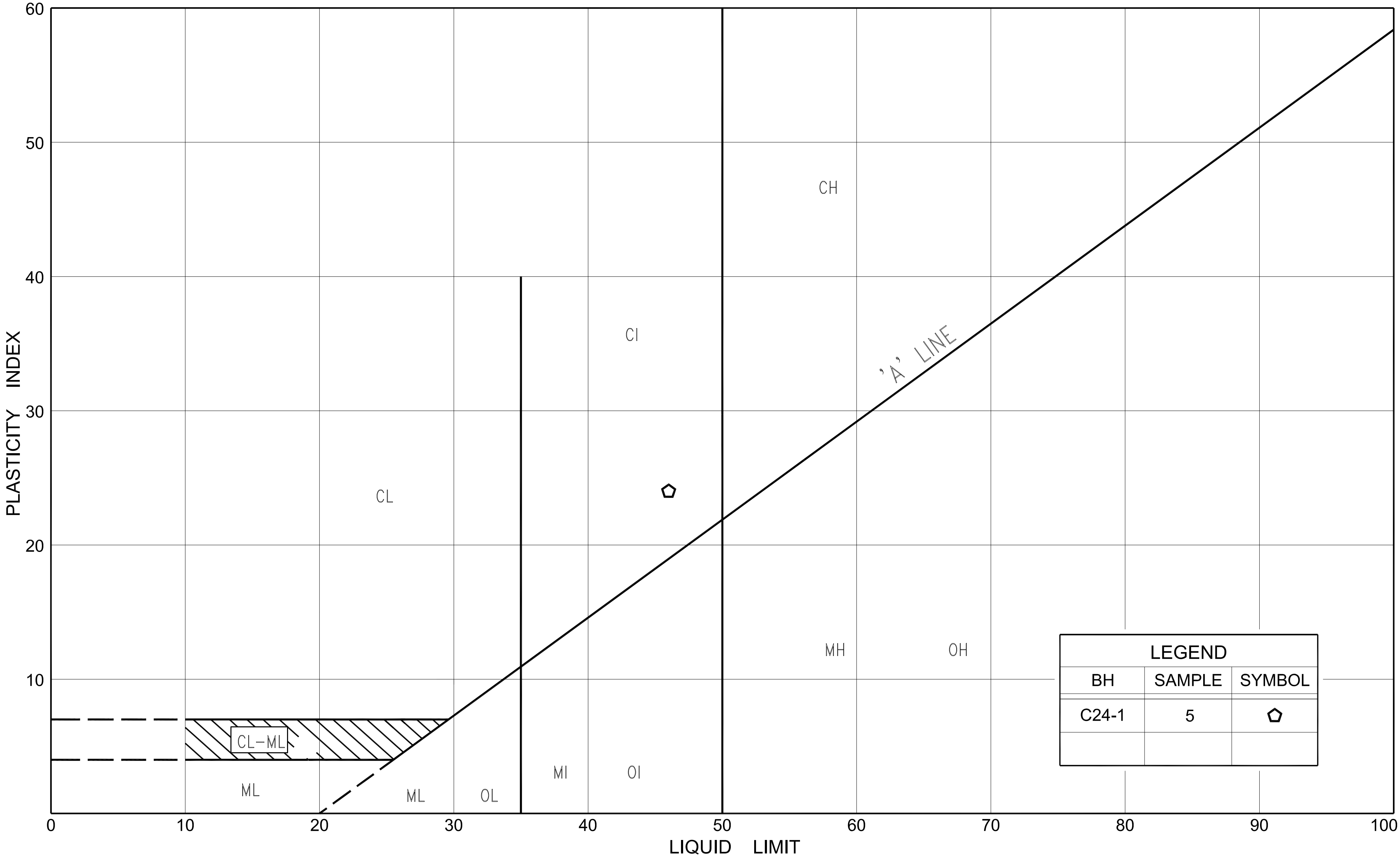
* 2012 02 14

▽ Water level observed during drilling

▼ Water level measured after drilling

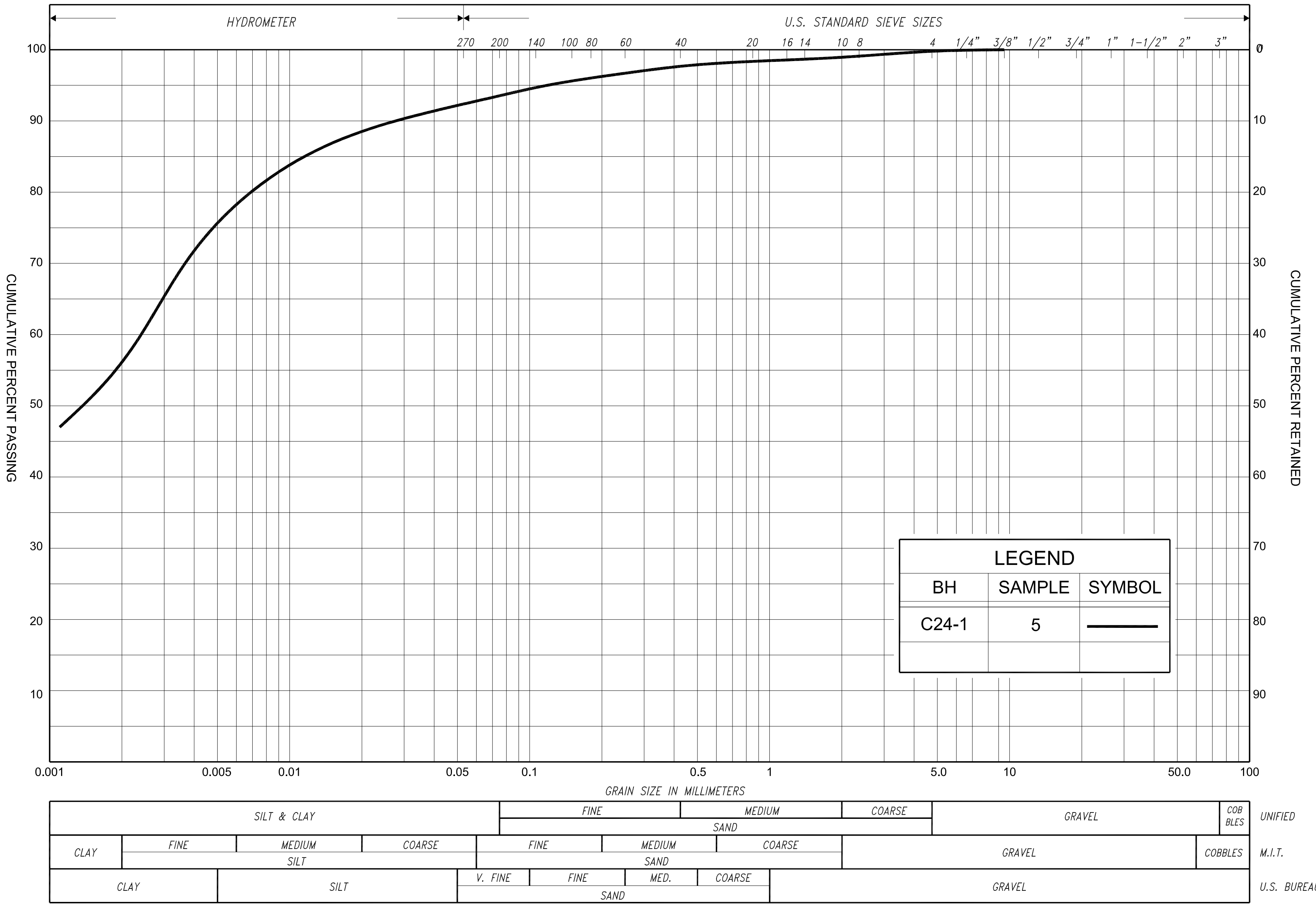
+7, ×5 : Numbers refer to Sensitivity

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



LEGEND		
BH	SAMPLE	SYMBOL
C24-1	5	⬠

Ontario	**PLASTICITY CHART** SILTY CLAY, trace sand	FIG No. C24-PC-1 HWY: 69 G.W.P. No. 5112-07-00



Ontario

GRAIN SIZE DISTRIBUTION

SILTY CLAY, trace sand

FIG No.	C24-GS-1
HWY:	69
G.W.P. No.	5112-07-00

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. C24-1

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 17+864, o/s 31.0m Lt. Coords: 5 067 387.0 N; 228 412.4 E **ORIGINATED BY** S.A.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Tripod + Wash Boring **COMPILED BY** M.K.

DATUM Geodetic **DATE** February 19, 2014 **CHECKED BY** B.R.G.

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	DYNAMIC CONE PENETRATION / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
197.9	Top of Ice								
197.7	Ice and water								
0.2	Peat, amorphous Dark brown /black Wet	1	SS	WH**			404		
	sand seams	2	SS	WH	197				
196.2 1.7	Sandy silt organic inclusions Very loose Grey Wet	3	SS	1	196		93		
195.5 2.4	Silty clay, trace sand Very soft Grey Wet to soft	4	SS	1	195	■			
			FV			+ 4			
		5	SS	WH	194	■			0 7 37 56
			FV		193	+ 2			
		6	SS	WH	192	■			
			FV			+ 3			
					191				
190.1 7.8	Silty sand, with gravel cobbles and boulders Compact to Grey Wet very dense	7	SS	60	190				
189.8 8.1	End of borehole								

End of borehole

Refusal on probable bedrock

Sample 7: Sampler bouncing

* 2014 02 19

▽ Water level observed during drilling

▼ Water level measured after drilling

■ Penetrometer test

WH** denotes penetration due to weight of rods and hammer

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; GROUND WATER CONDITIONS; STRAT PLOT

+7, ×5 : Numbers refer to Sensitivity   20 / 15–○–5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd.
CONSULTING ENGINEERS
Foundation Design

RECORD OF BOREHOLE No. C24-2

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 17+864, o/s 2.0m Lt. Coords: 5 067 398.4 N; 228 439.1 E **ORIGINATED BY** F.P.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Hilti **COMPILED BY** G.D.

DATUM Geodetic **DATE** October 09, 2013 **CHECKED BY** B.R.G.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
197.6	Ground Surface				*		
197.4 / 0.2	Peat, fine fibrous						
	Dark brown Sandy silt, organics	1	SS	1		197	
196.8 / 0.8	Brown cobbles and boulders (FILL)	2	SS	20/10cm			
196.0 / 1.6	Granitic Gneiss bedrock	3	RC	REC 100%		196	RQD 100%
	Slightly weathered to moderately weathered	4	RC	REC 100%			RQD 100%
	High strength Excellent quality	5	RC	REC 100%		195	RQD 96%
		6	RC	REC 100%			RQD 100%
		7	RC	REC 96%		194	RQD 96%
193.0 / 4.6		8	RC	REC 100%		193	RQD 100%
	End of borehole						

Column headings also printed: SOIL PROFILE; SAMPLES; STRAT PLOT; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m^3

* Borehole charged with drilling water

$+^7$, $\times^5$: Numbers refer to Sensitivity

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

Proposed Highway 69, Wallbridge Township, Sta 17+000 to 18+000
DATUM: Proposed Centreline Median

17+862.0 20.5 Lt C/L D+3.2 ROAD
HD. At Proposed Foundations Engineering
Culvert. On Existing Highway 69 SBL

0	-	310	Asph
310	-	490	Gry Cr Sa And Gr Tr Si Moist
490	-	970	Br Sa Tr Gr Tr Si Moist
		970	NFP RF

CONT No
GWP No 5112-07-00

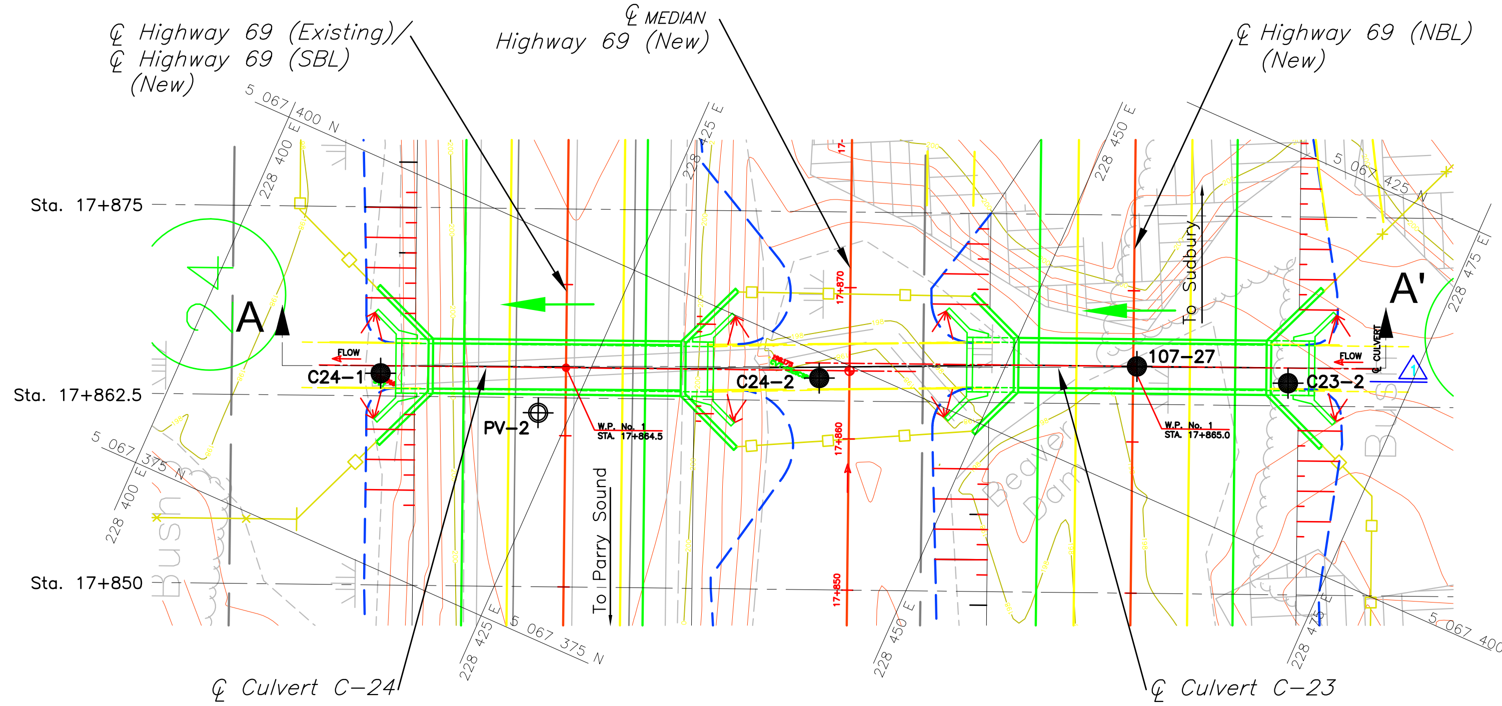
CULVERTS C-23 AND C-24

HIGHWAY 69 FOUR-LANING

BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

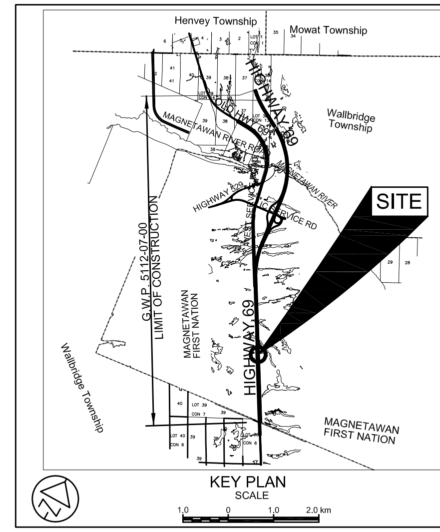
Peto MacCallum Ltd.
CONSULTING ENGINEERS



PLAN

SCALE

5 0 5 10m



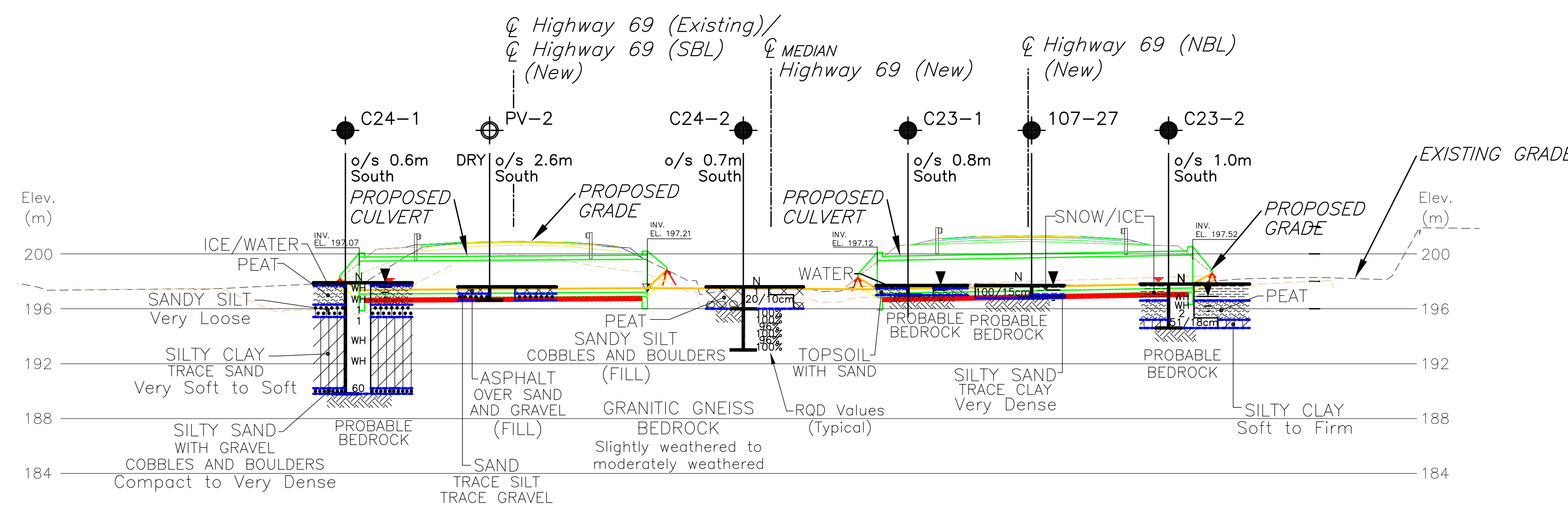
KEY PLAN

SCALE

LEGEND

Symbol	Description
	Borehole
	Pavement Borehole
	Borehole & Cone
N	Blows/0.3m (Std. Pen Test, 475 J/blow)
CONE	Blows/0.3m (60°Cone, 475 J/blow)
WH	Penetration due to weight of rods and hammer
	WL at time of investigation Feb. 2012, Oct. 2013 and Feb. 2014
	Water level not established
	Head
	ARTESIAN WATER Encountered
	PIEZOMETER

BH No	ELEVATION	COORDINATES NORTHINGS	COORDINATES EASTINGS
C23-1	197.7	5 067 403.2	228 450.1
C23-2	197.8	5 067 410.7	228 467.5
C24-1	197.9	5 067 387.0	228 412.4
C24-2	197.6	5 067 398.4	228 439.1
PV-2	197.6	5 067 389.3	228 422.9
107-27	197.7	5 067 407.7	228 458.0



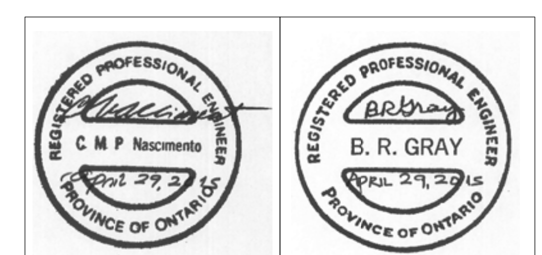
PROFILE A-A' ALONG CENTRELINE CULVERTS C-23 AND C-24 AT Sta 17+864.5

SCALE

5 0 5 10m

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.



Reference AECOM Drawing: 60143751-BOX CULVERT_no.23
NBL_Sta.17+865 & no.24 SBL_Sta 18+564.5_GA.dwg dated March 2015

– NOTE –

The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS DATE	BY	DESCRIPTION

Geocres No. 41H-147

HWY No 69			DIST 54
SUBM'D NA	CHECKED MK	DATE APR. 29, 2015	SITE C309
DRAWN NA	CHECKED BRG	APPROVED CN	DWG C23/C24-1

MINISTRY OF TRANSPORTATION, ONTARIO PR-D-707 88-05

DRAWING NAME: 09TF044 Culverts 23 n 24.dwg
CREATED: MARCH 2014
MODIFIED: APRIL 2015

Culvert C-25 at Sta. 18+235.3, NBL

Figure C25-PC-1: Plasticity Chart

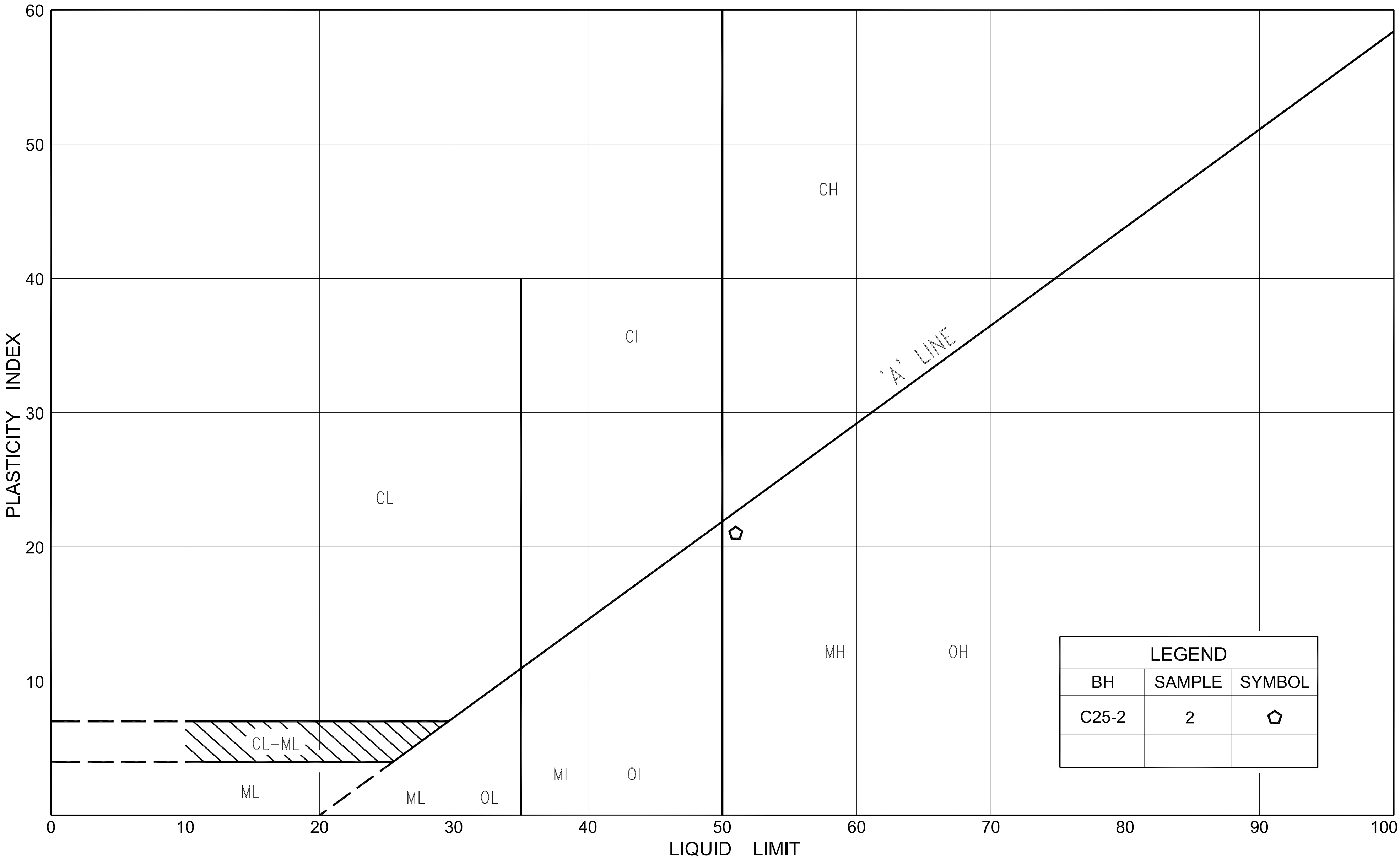
Figure C25-GS-1: Results of Grain Size Distribution Analysis

Record of Borehole Sheets: C25-1, C25-2, 108-3 and 108-7

Culvert C-26 at Sta. 18+249.5, SBL

Record of Borehole Sheets: C26-1 and C26-2

Drawing C25/C26-1: Borehole Locations and Soil Strata



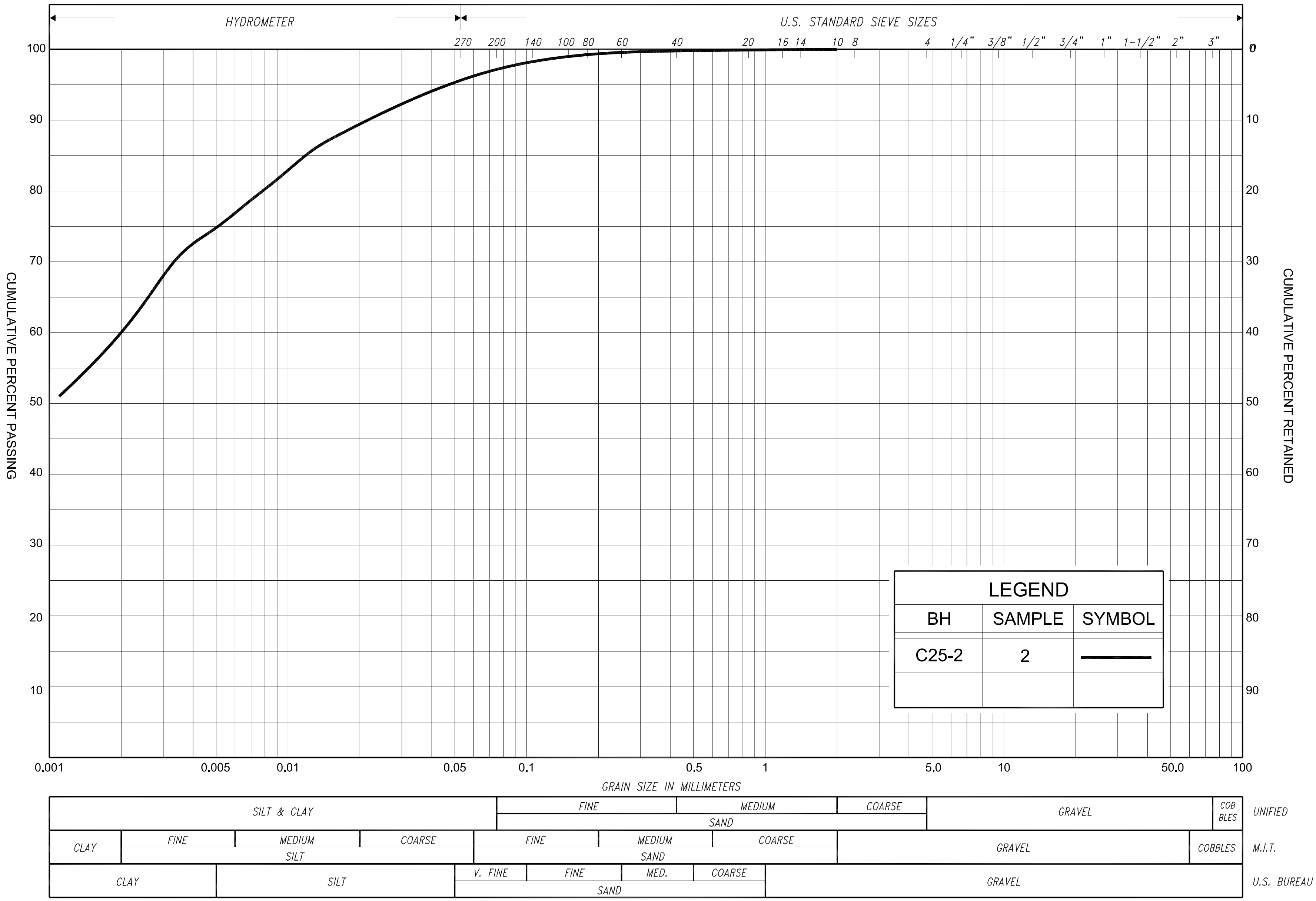
LEGEND		
BH	SAMPLE	SYMBOL
C25-2	2	⬠

Ontario

PLASTICITY CHART

CLAY, trace sand

FIG No.	C25-PC-1
HWY:	69
G.W.P. No.	5112-07-00



Ontario

GRAIN SIZE DISTRIBUTION

CLAY, trace sand

FIG No.	C25-GS-1
HWY:	69
G.W.P. No.	5112-07-00

RECORD OF BOREHOLE No. C25-1

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 18+240, o/s 11.0m Rt. Coords: 5 067 748.9 N; 228 302.3 E **ORIGINATED BY** A.L.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Manual Probing **COMPILED BY** G.D.

DATUM Geodetic **DATE** October 28, 2013 **CHECKED BY** B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
195.0	Ground Surface										
194.8 / 0.2	Topsoil										
	End of borehole Refusal on probable bedrock										
	* Borehole dry										

$+^7$, $\times^5$: Numbers refer to Sensitivity

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

Ontario

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RECORD OF BOREHOLE No. C25-2

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 18+230, o/s 28.0m Rt. Coords: 5 067 746.5 N; 228 321.8 E **ORIGINATED BY** F.P.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Tripod + Hilti **COMPILED BY** G.D.

DATUM Geodetic **DATE** September 24 and October 28, 2013 **CHECKED BY** B.R.G.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa / DCPT	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
195.2	Ground Surface						
0.0	Topsoil	1	SS	WH**			
194.8 / 0.4	Silty sand, organic inclusions						
194.5 / 0.7	Very loose, Dark brown, Wet	2	SS	4	Penetrometer ■		0 3 37 60
	Clay, trace sand; Firm to stiff, Mottled brown/grey, Moist		FV		+ 6 (field vane)		
193.1 / 2.1	Granitic Gneiss bedrock; Slightly weathered to moderately weathered; High strength\; Excellent quality	3	RC	REC 100%			RQD 100%
		4	RC	REC 96%			RQD 96%
		5	RC	REC 98%			RQD 96%
		6	RC	REC 92%			REC 92%
189.2 / 6.0	End of borehole						

* 2013 09 24

▽ Water level observed during drilling

■ Penetrometer test

WH** denotes penetration due to weight of rods and hammer

+7, ×5 : Numbers refer to Sensitivity

15–○–5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ontario

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Foundation Design

RECORD OF BOREHOLE No. 108-3

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 18+225, o/s 18.8m Rt. Coords: 5 067 738.2 N; 228 315.3 E **ORIGINATED BY** R.B.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Continuous Flight Hollow Stem Augers **COMPILED BY** G.D.

DATUM Geodetic **DATE** October 11, 2011 **CHECKED BY** C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
195.9	Ground Surface										
0.0	Topsoil										
195.6 0.3	End of borehole Refusal on probable bedrock * Borehole dry										

$+^7$, $\times^5$: Numbers refer to Sensitivity

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

Ontario

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RECORD OF BOREHOLE No. 108-7

METRIC

G.W.P. 5112-07-00	**LOCATION** Hwy 69, Sta. 18+250, o/s 18.8m Rt. Coords: 5 067 761.2 N; 228 305.4 E		**ORIGINATED BY** R.B.
DIST Parry Sound **HWY** 69	**BOREHOLE TYPE** Manual Probing		**COMPILED BY** G.D.
DATUM Geodetic	**DATE** October 11, 2011		**CHECKED BY** C.N.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
197.1	Ground Surface					*					
0.0	Topsoil						197				
196.8 / 0.3	End of borehole Refusal on probable bedrock * Borehole dry										

+7, ×5 : Numbers refer to Sensitivity

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

Ontario

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Foundation Design

RECORD OF BOREHOLE No. C26-1

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 18+253, o/s 35.0m Lt. Coords: 5 067 742.7 N; 228 254.9 E **ORIGINATED BY** F.P.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Tripod + Hilti **COMPILED BY** G.D.

DATUM Geodetic **DATE** September 25, 2013 **CHECKED BY** B.R.G.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%)
195.7	Ground Surface					
0.0	Topsoil					
195.4 / 0.3	Sand, trace gravel Compact Brown Moist	1	SS	10		
195.1 / 0.6	Clayey silt, trace sand organics Stiff Mottled grey/ brown Moist to wet	2	SS	6	▽*	
194.2 / 1.5		3	SS	10/5cm		
194.0 / 1.7	Silty sand Loose to compact Brown Wet					
	Granitic Gneiss bedrock Slightly weathered to moderately weathered High strength Fair becoming good to excellent quality	4	RC	REC 64%		RQD 64%
		5	RC	REC 88%		RQD 88%
		6	RC	REC 100%		RQD 100%
		7	RC	REC 100%		RQD 100%
190.4 / 5.3	End of borehole					

* 2013 09 25

▽ Water level observed during drilling

■ Penetrometer test

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m³

GR SA SI CL

ELEVATION SCALE: 195, 194, 193, 192, 191

+7, ×5 : Numbers refer to Sensitivity

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

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. C26-2

METRIC

G.W.P. 5112-07-00 LOCATION Hwy 69, Sta. 18+244 CL Coords: 5 067 748.2 N; 228 290.6 E ORIGINATED BY F.P.

DIST Parry Sound HWY 69 BOREHOLE TYPE Hilti COMPILED BY G.D.

DATUM Geodetic DATE September 26 and October 28, 2013 CHECKED BY B.R.G.

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
196.0	Ground Surface					
0.0	Topsoil	1	SS	WH**		
		2	SS	WH	195	
195.0 / 1.0	Silty sand, organics					
194.7 / 1.3	Loose Dark brown Wet					
	Granitic Gneiss bedrock Slightly weathered to moderately weathered High strength Fair to excellent quality	3	RC	REC 90%	194	RQD 63%
		4	RC	REC 100%		RQD 52%
		5	RC	REC 100%	193	RQD 100%
		6	RC	REC 94%	192	RQD 94%
191.1 / 4.9	End of borehole					

Column headings also include: STRAT PLOT; GROUND WATER CONDITIONS *; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m^3.

* Borehole charged with drilling water

WH** denotes penetration due to weight of rods and hammer

+7, ×5 : Numbers refer to Sensitivity

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

CONT No
GWP No 5112-07-00
CULVERTS C-25 AND C-26
HIGHWAY 69 FOUR-LANING
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

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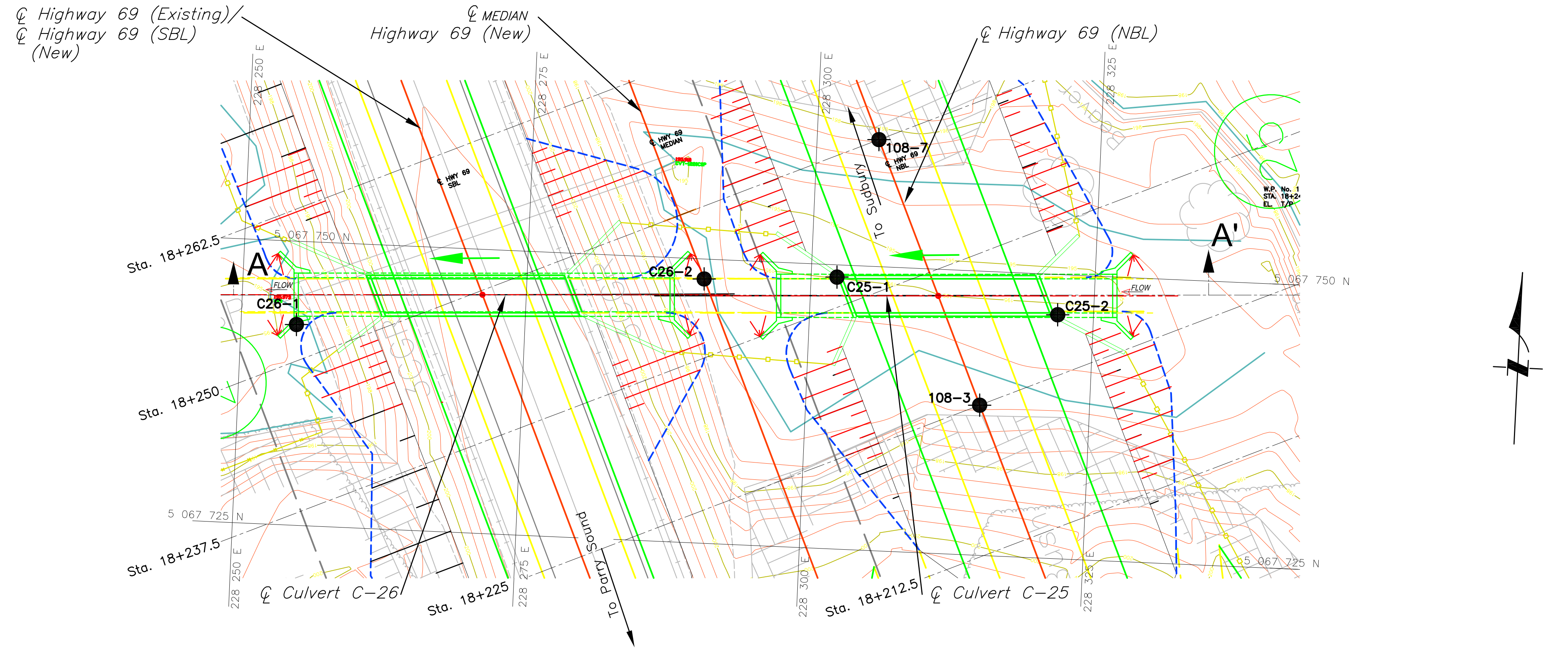
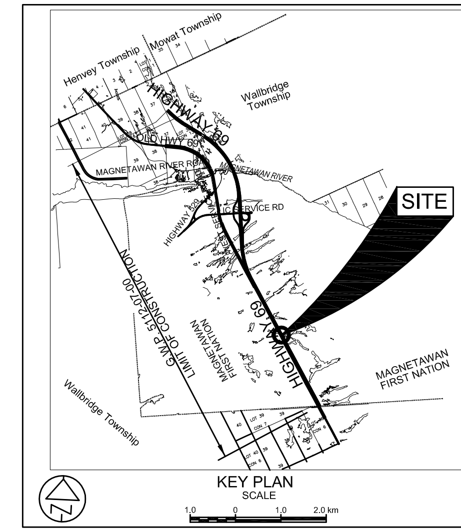
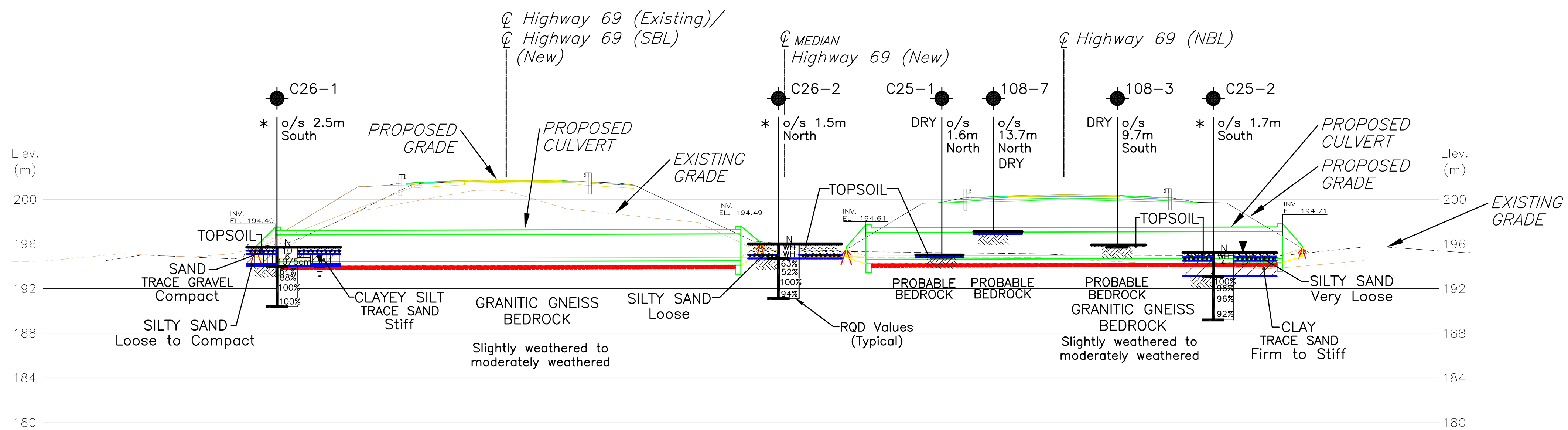
CONSULTING ENGINEERS



PLAN
SCALE
5 0 5 10m





PROFILE A-A' ALONG CENTRELINE OF CULVERTS C-25 AT Sta. 18+235.3 AND C-26 AT Sta. 18+249.5

SCALE
HORIZONTAL
4 0 4 8m
VERTICAL
5 0 5 10m

LEGEND

- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & Cone
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60°Cone, 475 J/blow)
- WH Penetration due to weight of rods and hammer
- WL at time of investigation Oct. 2011, Sept. and Oct. 2013
- * Water level not established
- Head
- ARTESIAN WATER Encountered
- PIEZOMETER

BH No	ELEVATION	COORDINATES NORTHINGS	COORDINATES EASTINGS
C25-1	195.0	5 067 748.9	228 302.3
C25-2	195.2	5 067 746.5	228 321.8
C26-1	195.7	5 067 742.7	228 254.9
C26-2	196.0	5 067 748.2	228 290.6
108-3	195.9	5 067 738.2	228 315.3
108-7	197.1	5 067 761.2	228 305.4

– NOTE –
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

REGISTERED PROFESSIONAL ENGINEER
C M P Nascimento
April 29, 2015
PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER
B. R. GRAY
APRIL 29, 2015
PROVINCE OF ONTARIO

Reference AECOM Drawing: 60143751-BOX CULVERT_no.25 NBL_Sta.18+235.3 & no.26 SBL_Sta 18+248.5_1_GA.dwg dated March 2015

REVISIONS	DATE	BY	DESCRIPTION

Geocres No. 41H-147

HWY No 69			DIST 54
SUBM'D NA	CHECKED MK	DATE APR. 29, 2015	SITE 310
DRAWN NA	CHECKED GD	APPROVED BRG	DWG C25/C26-1

MINISTRY OF TRANSPORTATION, ONTARIO PR-D-707 88-05

APRIL 2015

DRAWING NAME: 09TF044 Culverts 25 n 26.dwg
CREATED: MARCH 2014
MODIFIED:

Culvert C-28 at Sta. 18+585.0, NBL

Figure C28-PC-1: Plasticity Chart

Figure C28-GS-1: Results of Grain Size Distribution Analyses

Record of Borehole Sheets: C28-1, C28-2 and 109-1

Culvert C-29 at Sta. 18+585.0, SBL

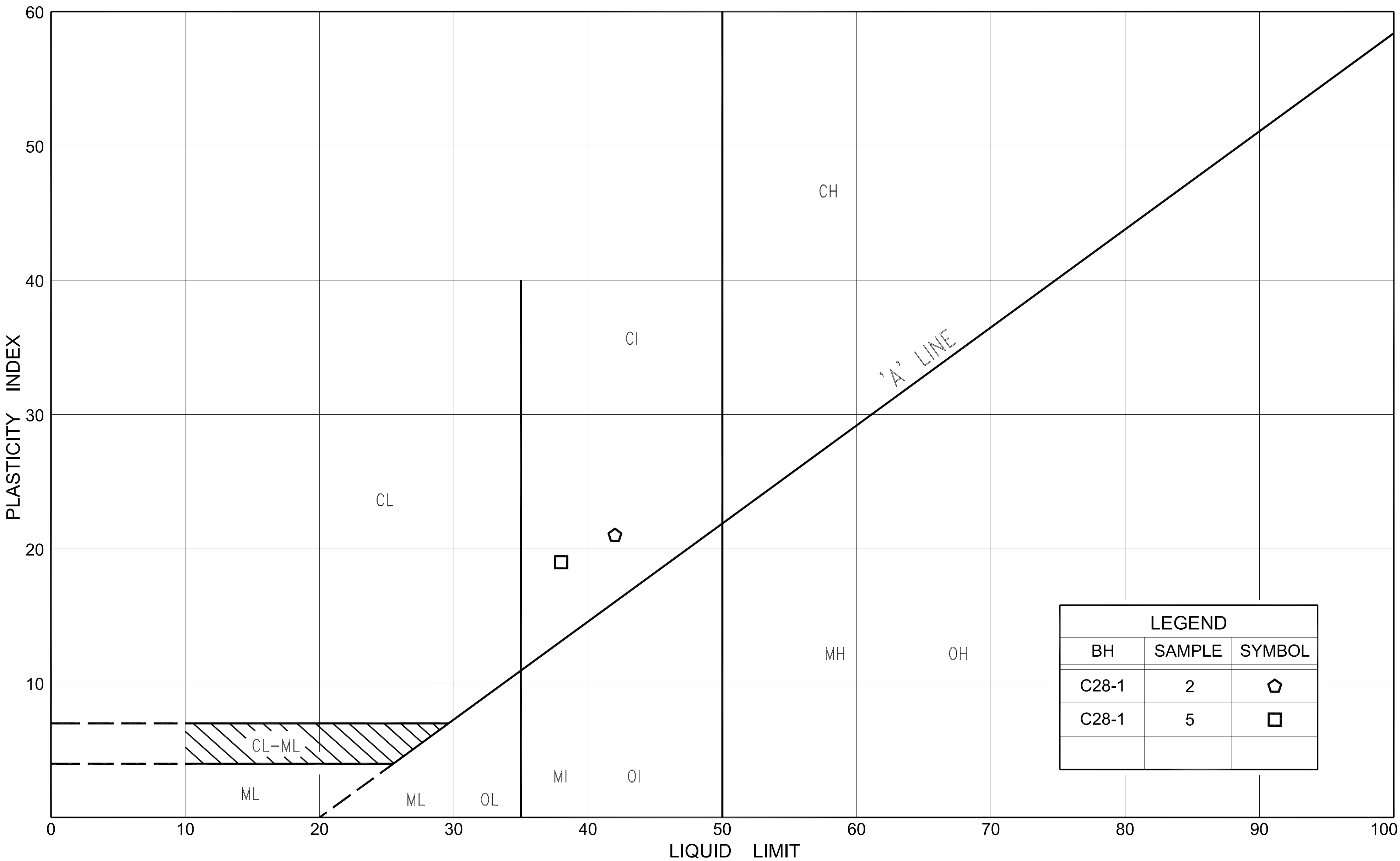
Figures C29-PC-1 and C29-PC-2: Plasticity Charts

Figures C29-GS-1 and C29-GS-2: Results of Grain Size Distribution Analyses

Record of Borehole Sheets: C29-1 and C29-2

Record of Pavement Borehole Sheet: PV-3

Drawing C28/C29-1: Borehole Locations and Soil Strata



LEGEND

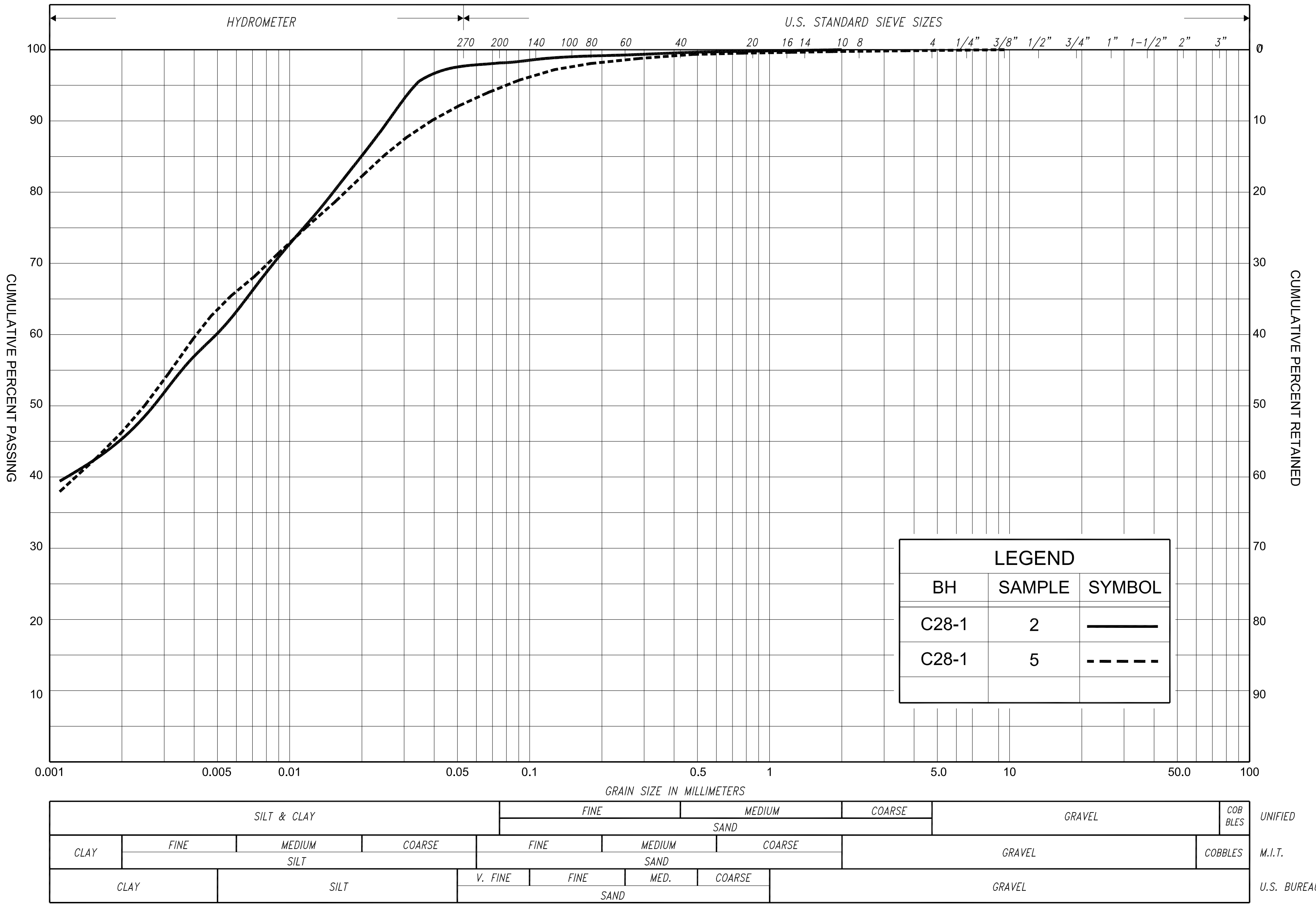
BH	SAMPLE	SYMBOL
C28-1	2	⬠
C28-1	5	□

Ontario

PLASTICITY CHART

SILTY CLAY, trace sand

FIG No.	C28-PC-1
HWY:	69
G.W.P. No.	5112-07-00



Ontario

GRAIN SIZE DISTRIBUTION

SILTY CLAY, trace sand

FIG No.	C28-GS-1
HWY:	69
G.W.P. No.	5112-07-00

Ontario

Peto MacCallum Ltd.
CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. C28-1

METRIC

G.W.P. 5112-07-00	**LOCATION** Hwy 69, Sta. 18+589, o/s 10.0m Rt. Coords: 5 068 069.1 N; 228 163.3 E
ORIGINATED BY A.L.	
DIST Parry Sound **HWY** 69	**BOREHOLE TYPE** 'N' Casing + Wash Boring + Dynamic Cone Penetration Test
COMPILED BY M.K.	
DATUM Geodetic	**DATE** February 28, March 2 & 3, 2014
CHECKED BY B.R.G.	

SOIL PROFILE | SAMPLES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) | SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100) | PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	Field vane (sensitivity)	GR	SA	SI	CL
189.0	Top of Ice									
0.0	Ice and water									
188.1 / 0.9	Peat				188					
187.8 / 1.2	Silty sand, organics; Loose, Grey, Wet	1	SS	5						
187.6 / 1.4	Silty clay, trace sand; Stiff to soft, Grey, Moist to wet	2	SS	5	187		0	2	53	45
			FV			4				
		3	SS	2	186					
			FV		185	3				
		4	SS	2	184					
			FV			3				
		5	SS	1	183		0	5	49	46
			FV		182	4				
		6	SS	3	181					
			FV			4				
		7	SS	2	180					
			FV		179	3				
		8	SS	4	178					
			FV			2				
		9	SS	2	177					
			FV		176	3				
175.8 / 13.2	End of borehole; Probable silty clay; Soft				175					

Cont'd

+7, ×5 : Numbers refer to Sensitivity

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

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. C28-1

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 18+589, o/s 10.0m Rt. Coords: 5 068 069.1 N; 228 163.3 E **ORIGINATED BY** A.L.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** 'N' Casing + Wash Boring + Dynamic Cone Penetration Test **COMPILED BY** M.K.

DATUM Geodetic **DATE** February 28, March 2 & 3, 2014 **CHECKED BY** B.R.G.

SOIL PROFILE			SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				
174.0											
173.9 15.1	End of dynamic cone penetration test Refusal on probable bedock							120/15cm			

* 2014 02 28/03 02 & 03

▽ Water level observed during drilling

▼ Water level measured after drilling

■ Penetrometer test

$+^7$, $\times^5$: Numbers refer to Sensitivity

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

Ontario

Peto MacCallum Ltd.
CONSULTING ENGINEERS
Foundation Design

RECORD OF BOREHOLE No. C28-2

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 18+585, o/s 30.0m Rt. Coords: 5 068 073.3 N; 228 183.3 E **ORIGINATED BY** F.P.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Hilti **COMPILED BY** G.D.

DATUM Geodetic **DATE** October 09, 2013 **CHECKED BY** B.R.G.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L; WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.2	Ground Surface										
0.0	Granitic Gneiss bedrock		1	RC	REC 100%		193				RQD 100%
	Slightly weathered to moderately weathered		2	RC	REC 98%						RQD 94%
	High strength										
	Fair to excellent, locally poor quality		3	RC	REC 89%		192				RQD 67%
			4	RC	REC 62%						RQD 31%
			5	RC	REC 100%		191				RQD 100%
			6	RC	REC 100%						RQD 75%
			7	RC	REC 100%		190				RQD 100%
189.7 / 3.5	End of borehole										

* Borehole charged with drilling water

$+^7$, $\times^5$: Numbers refer to Sensitivity

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

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. 109-1

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 18+580, o/s 18.8m Rt. Coords: 5 068 064.3 N; 228 174.9 E **ORIGINATED BY** F.P.

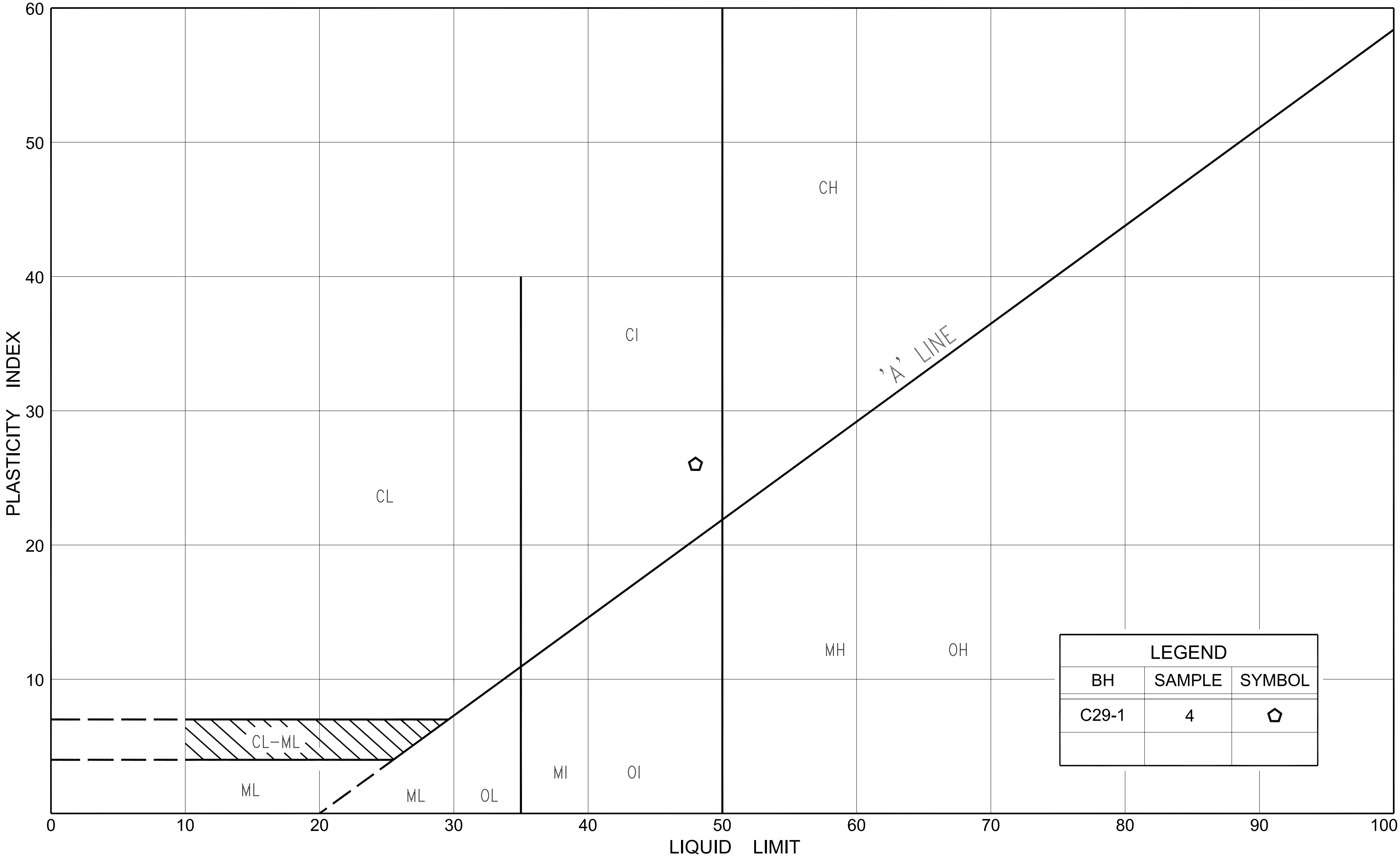
DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Tripod 'N' Casing with Washbore **COMPILED BY** G.D.

DATUM Geodetic **DATE** February 16, 2012 **CHECKED BY** C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
193.1	Ground Surface										
0.0	Bedrock at surface										
	* Borehole dry										

$+^7, \times^5$: Numbers refer to Sensitivity

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

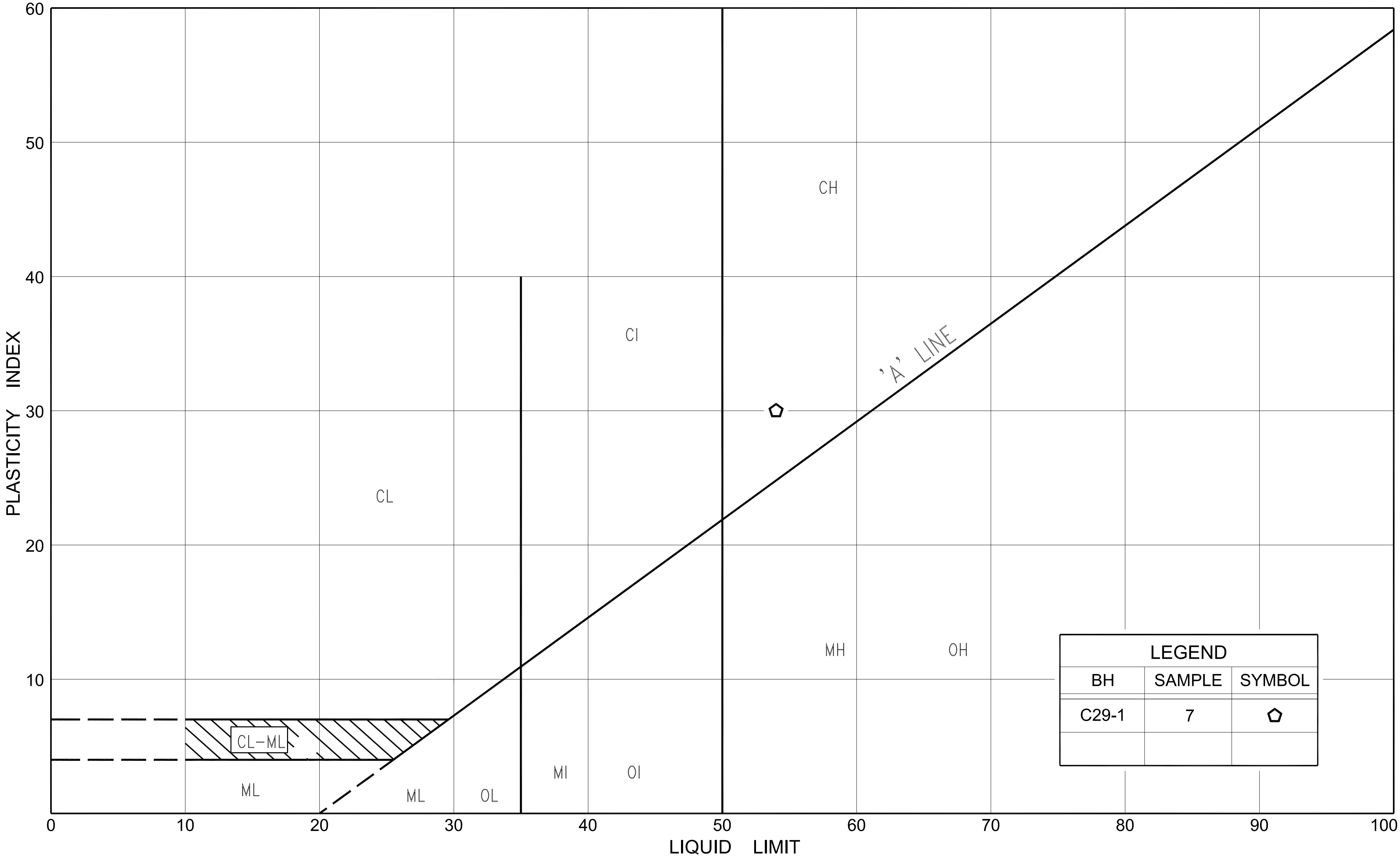


Ontario

PLASTICITY CHART

SILTY CLAY, trace sand

FIG No.	C29-PC-1
HWY:	69
G.W.P. No.	5112-07-00



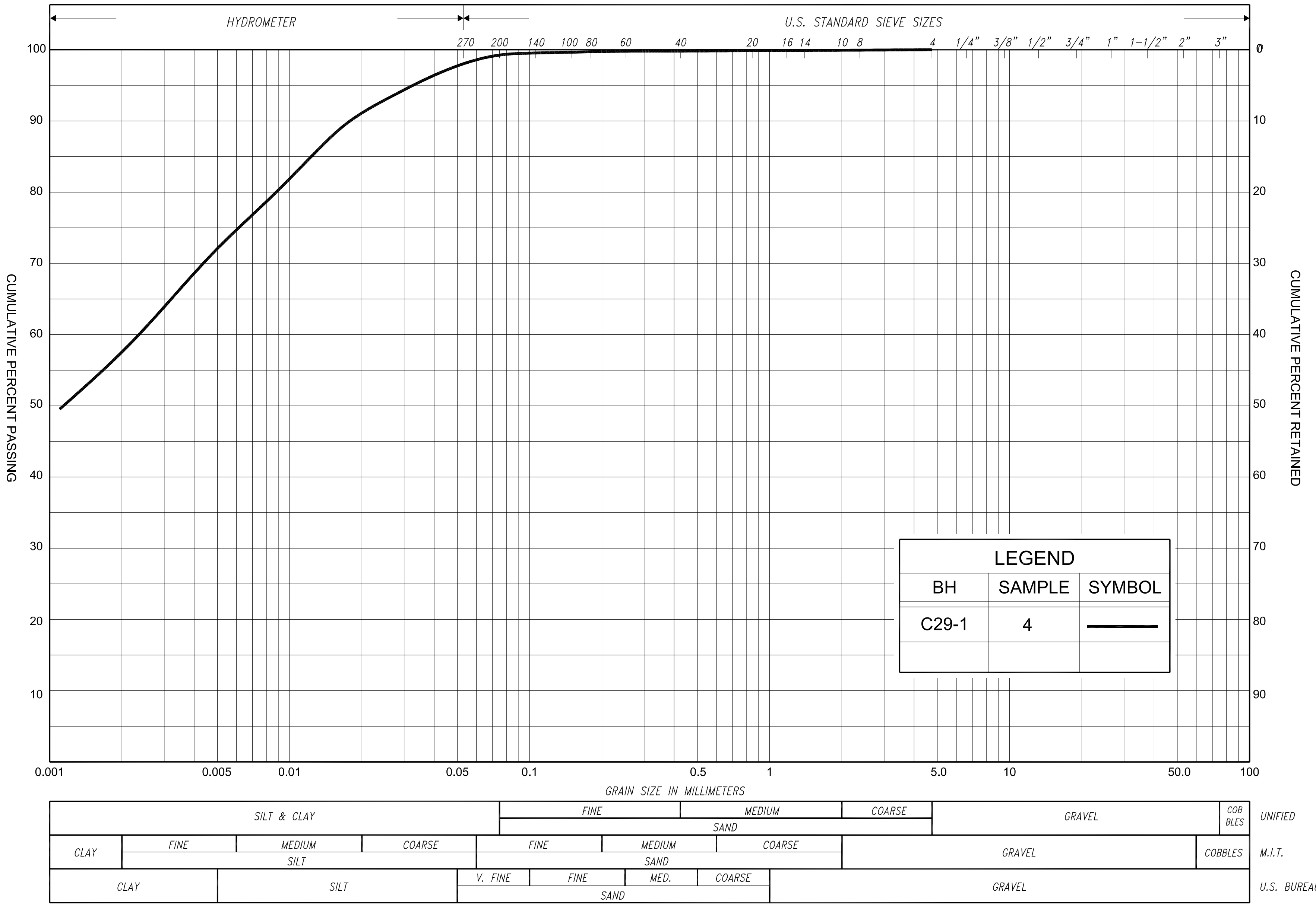
LEGEND		
BH	SAMPLE	SYMBOL
C29-1	7	⬠

Ontario

PLASTICITY CHART

CLAY, trace sand

FIG No.	C29-PC-2
HWY:	69
G.W.P. No.	5112-07-00

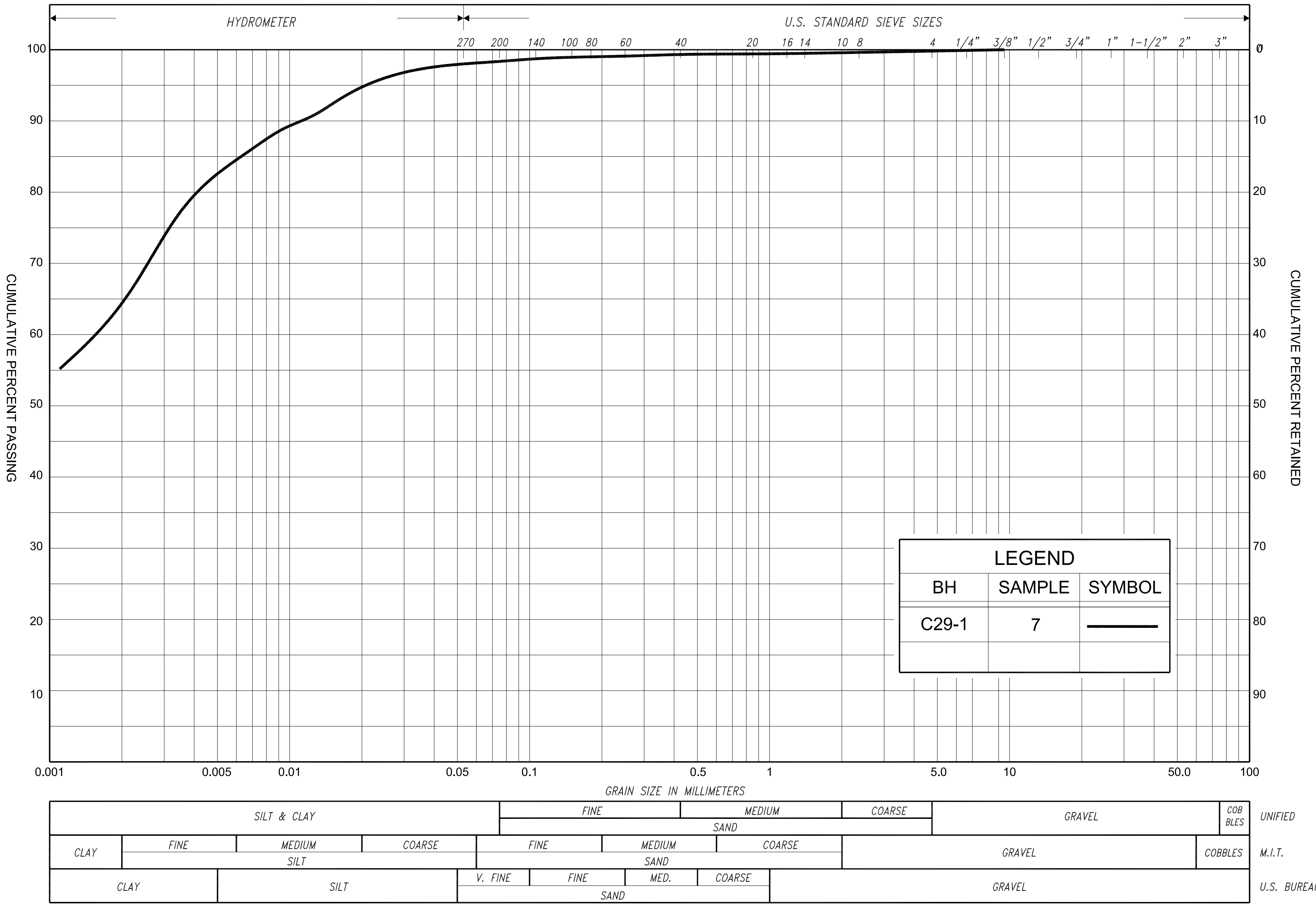


Ontario

GRAIN SIZE DISTRIBUTION

SILTY CLAY, trace sand

FIG No.	C29-GS-1
HWY:	69
G.W.P. No.	5112-07-00



Ontario

GRAIN SIZE DISTRIBUTION

CLAY, trace sand

FIG No.	C29-GS-2
HWY:	69
G.W.P. No.	5112-07-00

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. C29-1

METRIC

G.W.P. 5112-07-00 LOCATION Hwy 69, Sta. 18+582, o/s 32.0m Lt. Coords: 5 068 046.0 N; 228 127.5 E ORIGINATED BY S.A.

DIST Parry Sound HWY 69 BOREHOLE TYPE Tripod + Wash Boring COMPILED BY M.K.

DATUM Geodetic DATE February 25, 2014 CHECKED BY B.R.G.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	Penetrometer (kPa)	Field vane (kPa) / sensitivity	Water content	REMARKS GR SA SI CL
191.5	Top of Ice							
0.0	Ice							
191.2 / 0.3	Peat, amorphous, Dark brown, Moist	1	SS	1			○	
191.1 / 0.4	Clayey silt, trace sand, organics to 1.2m. Firm, Brown, Moist, sandy silt seams	2	SS	7			○	
189.7 / 1.8	Silty clay, trace sand. Firm to stiff, Grey, Moist to wet	3	SS	4	■		○	
			FV			+ 10		
		4	SS	WH**	■		Wp–w–WL	0 1 41 58
			FV			+ 5		
		5	SS	WH	■		○	
			FV			+ 3		
		6	SS	3	■		○	
			FV			+ 6		
184.0 / 7.5	Clay, trace sand. Firm, Grey, Wet	7	SS	1	■		Wp–WL ○	0 2 34 64
182.4 / 9.1	End of borehole. Refusal on probable bedrock							

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (191, 190, 189, 188, 187, 186, 185, 184, 183); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

* 2014 02 25

▼ Water level measured after drilling

■ Penetrometer test

WH** denotes penetration due to weight of rods and hammer

NOTE: About 600mm of snow has been removed before drilling

+7, ×5 : Numbers refer to Sensitivity

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

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. C29-2

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 18+585 CL Coords: 5 068 061.4 N; 228 155.7 E **ORIGINATED BY** A.L.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Manual Probing **COMPILED BY** M.K.

DATUM Geodetic **DATE** March 04, 2014 **CHECKED BY** B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
189.7	Ground Surface										
0.0	Rockfill at surface										
	* Borehole dry										

+7, ×5 : Numbers refer to Sensitivity

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

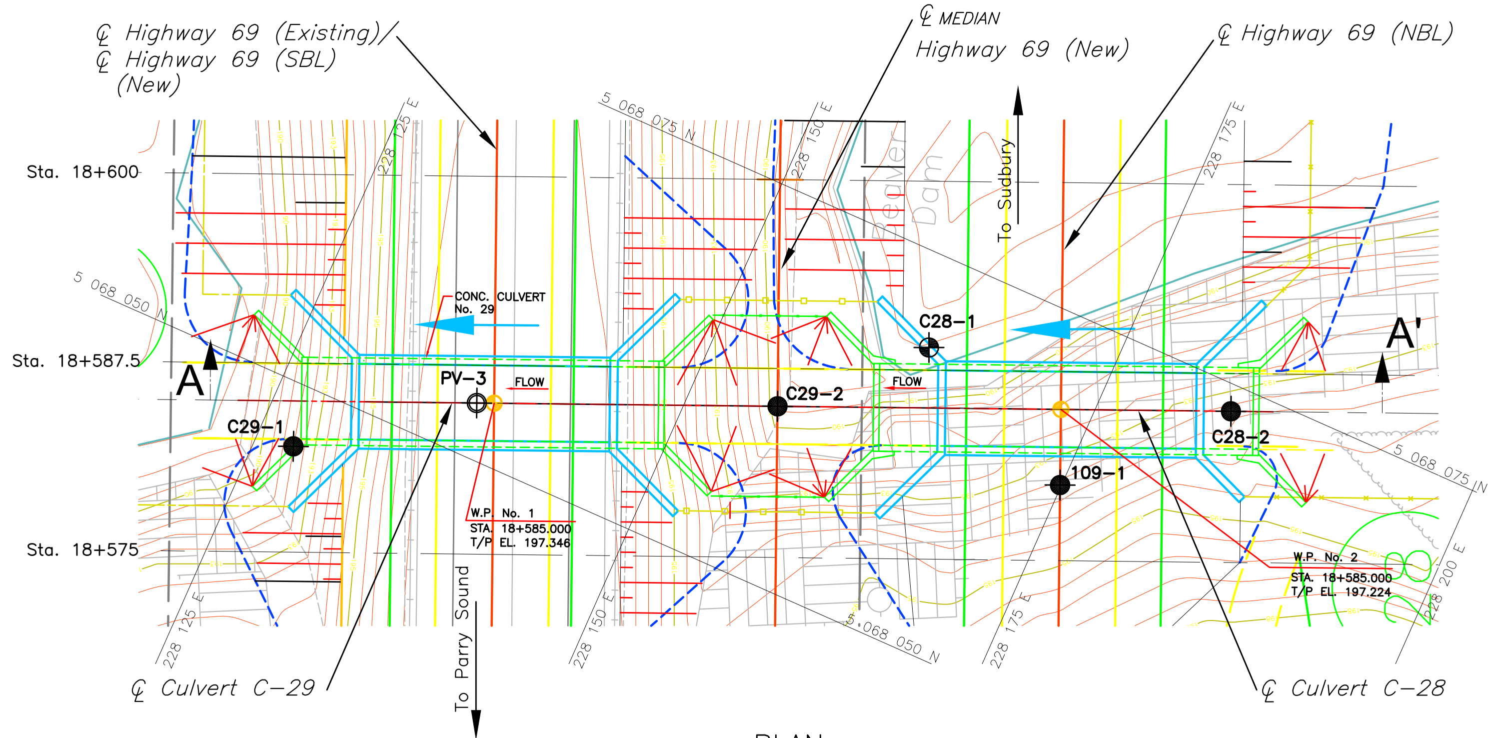
Proposed Highway 69, Wallbridge Township, Sta 18+000 to 19+000
DATUM: Proposed Centreline Median

18+585.0 19.9 Lt C/L D+7.4 ROAD
HD. At Proposed Foundations Engineering
Culvert. On Existing Highway 69 SBL

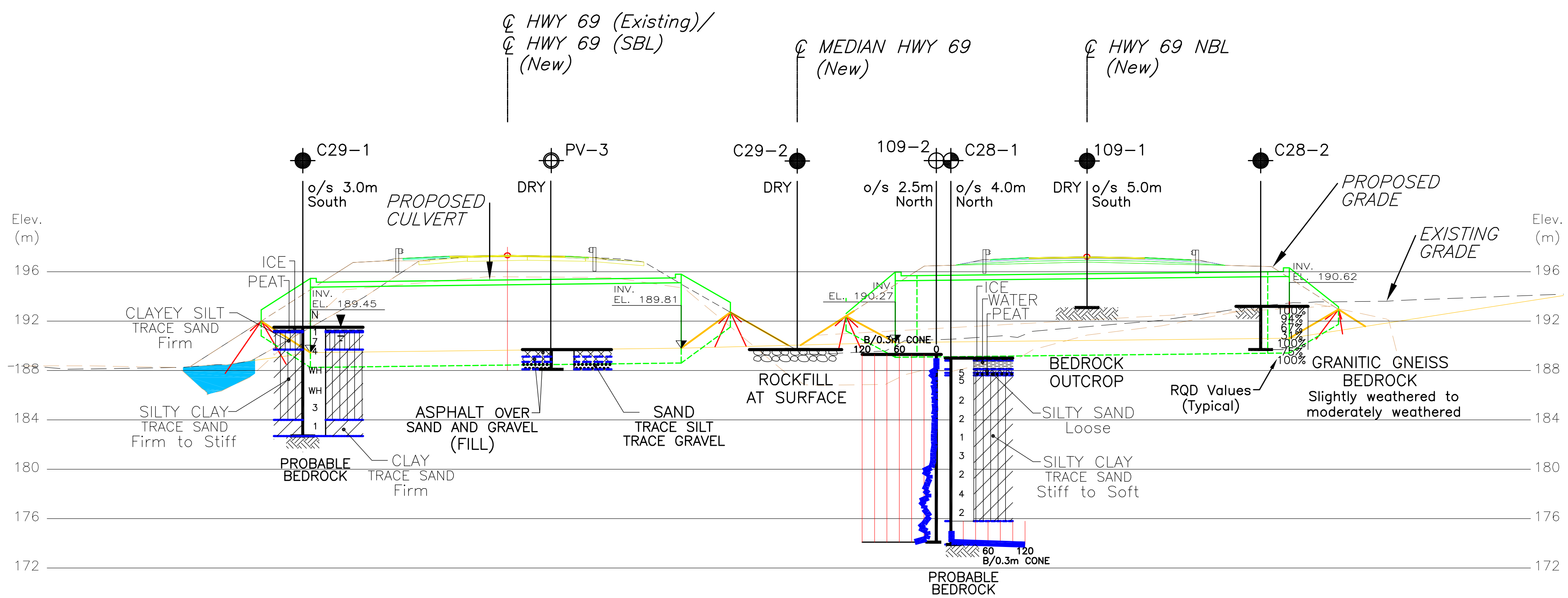
0	-	420	Asph
420	-	580	Gry Cr Sa And Gr Tr Si Moist
580	-	750	Asph
750	-	1.0	Gry Cr Sa And Gr Tr Si Moist
1.0	-	1.6	Br Sa Tr Gr Tr Si Moist
		1.6	NFP RF

CONT No
GWP No 5112-07-00
CULVERTS C-28 AND C-29
HIGHWAY 69 FOUR-LANING
BOREHOLE LOCATIONS AND SOIL STRATA
SHEET

Peto MacCallum Ltd.
CONSULTING ENGINEERS

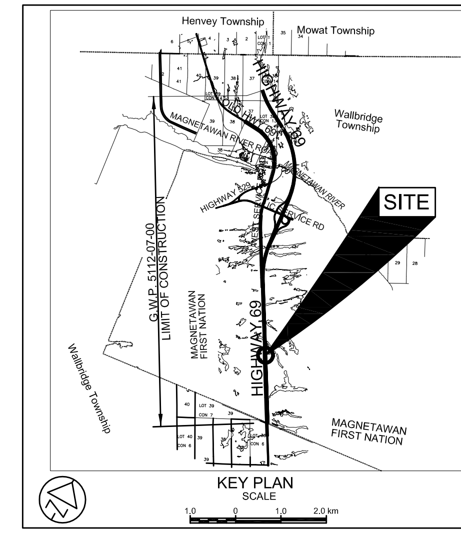


PLAN
SCALE
5 0 5 10m



PROFILE A-A' ALONG CENTRELINES OF CULVERTS C-28 AND C-29 AT STA. 18+585

SCALE
HORIZONTAL
4 0 4 8m
VERTICAL
5 0 5 10m

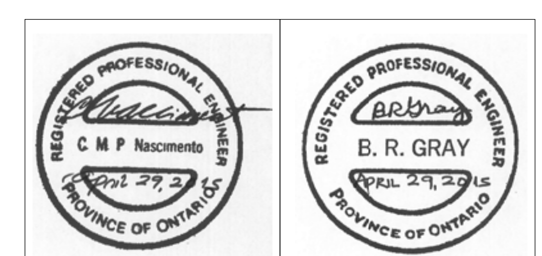


KEY PLAN
SCALE

LEGEND

- Borehole
- Pavement Borehole
- Borehole & Cone
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60°Cone, 475 J/blow)
- WH Penetration due to weight of rods and hammer
- WL at time of investigation Feb. 2012, Oct. 2013, Feb. and Mar. 2014
- Water level not established
- Head
- ARTESIAN WATER Encountered
- PIEZOMETER

BH No	ELEVATION	COORDINATES NORTHINGS	COORDINATES EASTINGS
C28-1	189.0	5 068 069.1	228 163.3
C28-2	193.2	5 068 073.3	228 183.3
C29-1	191.5	5 068 046.0	228 127.5
C29-2	189.7	5 068 061.4	228 155.7
PV-3	189.7	5 068 053.6	228 137.4
109-1	193.1	5 068 064.3	228 174.9



– NOTE –
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS DATE	BY	DESCRIPTION

Georces No. 41H-147

HWY No 69			DIST 54
SUBM'D NA	CHECKED MK	DATE APR. 29, 2015	SITE --
DRAWN NA	CHECKED GD	APPROVED BRG	DWG C28/C29-1

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

Reference AECOM Drawings:
60143751-CULVERT-no.28_NBL_Sta 18+585+GA.dwg and
60143751-CULVERT-no.29_NBL_Sta 18+585+GA.dwg dated March 2015

MINISTRY OF TRANSPORTATION, ONTARIO PR-D-707 88-05

DRAWING NAME: 09TF044 Culverts 28 n 29.dwg
CREATED: APRIL 2015
MODIFIED:

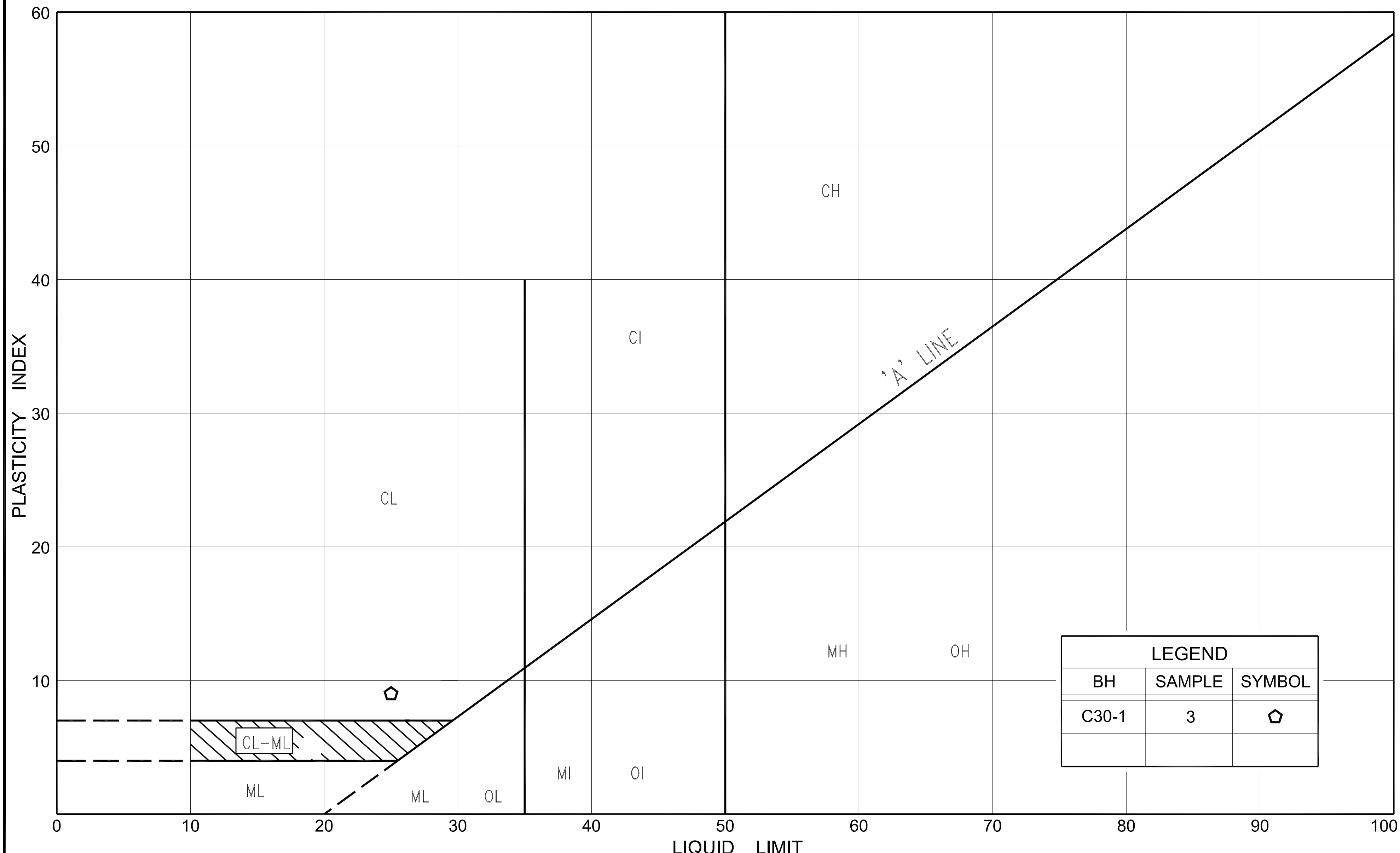
Culvert C-30 at Sta. 18+612.9, Median

Figures C30-PC-1 and C30-PC-2: Plasticity Charts

Figures C30-GS-1 and C30-GS-2: Results of Grain Size Distribution Analyses

Record of Borehole Sheets: C30-1, C30-2 and 109-8

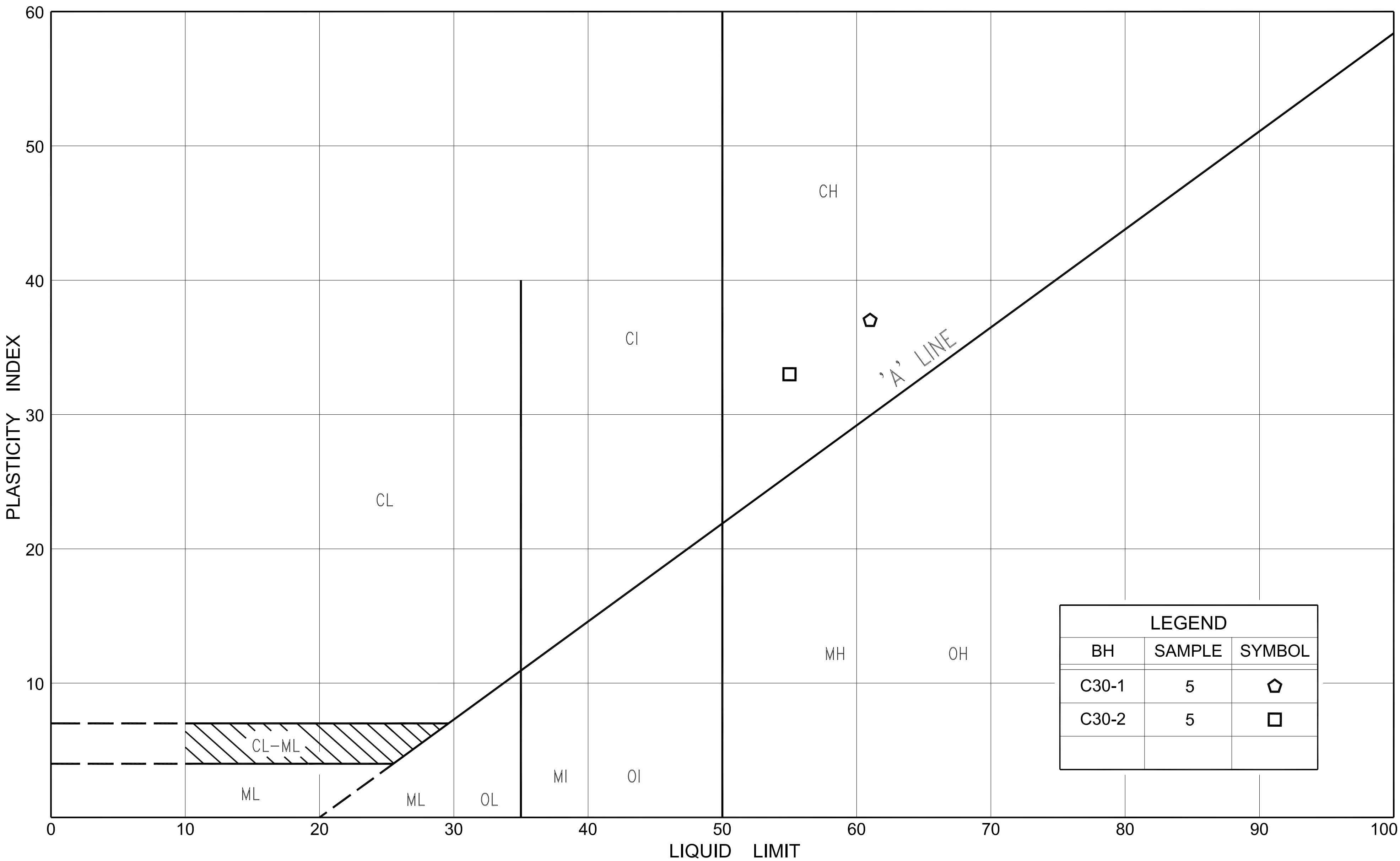
Drawing C30-1: Borehole Locations and Soil Strata



PLASTICITY CHART

CLAYEY SILT, trace sand

FIG No.	C30-PC-1
HWY:	69
G.W.P. No.	5112-07-00

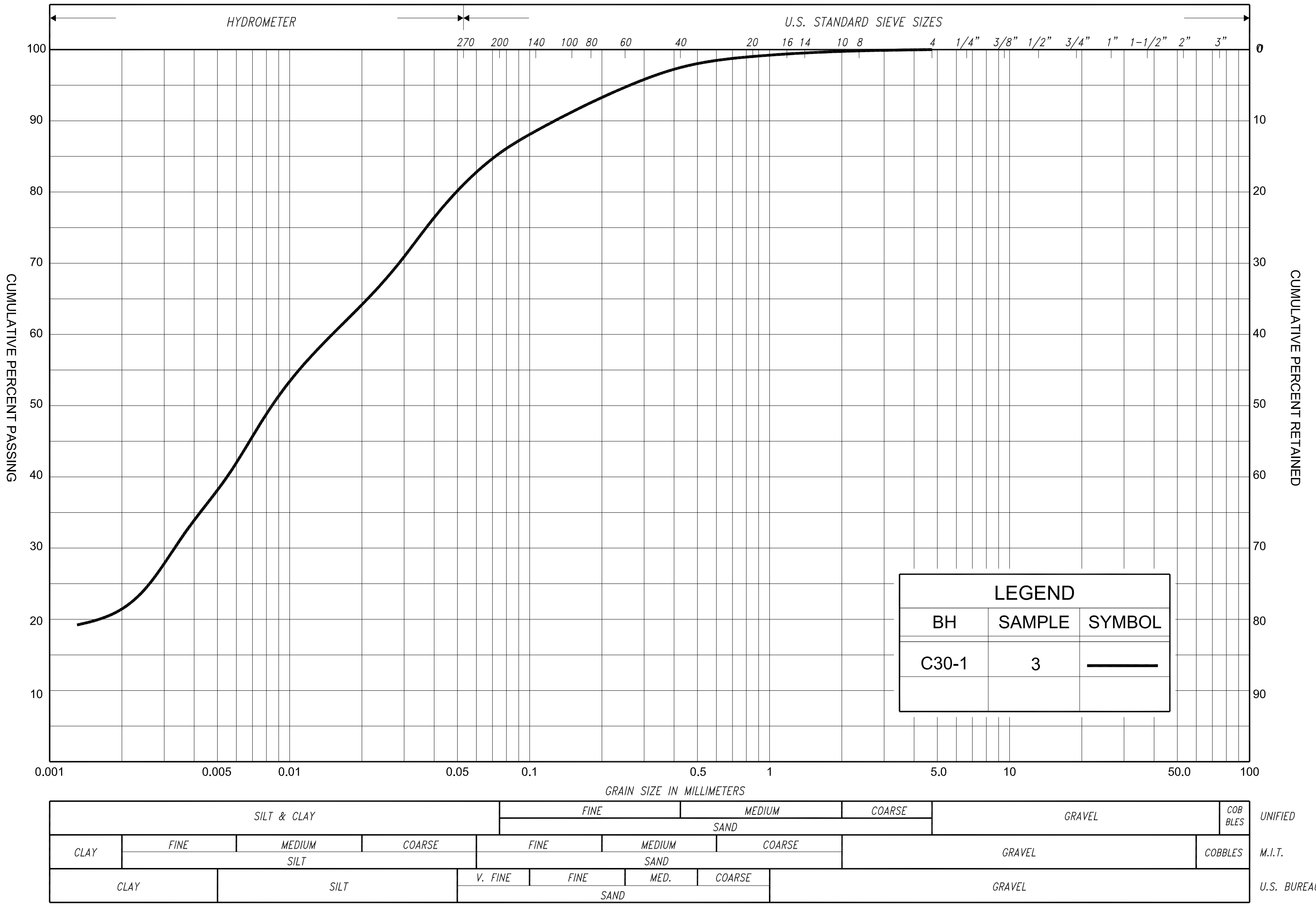


Ontario

PLASTICITY CHART

CLAY, trace sand

FIG No.	C30-PC-2
HWY:	69
G.W.P. No.	5112-07-00

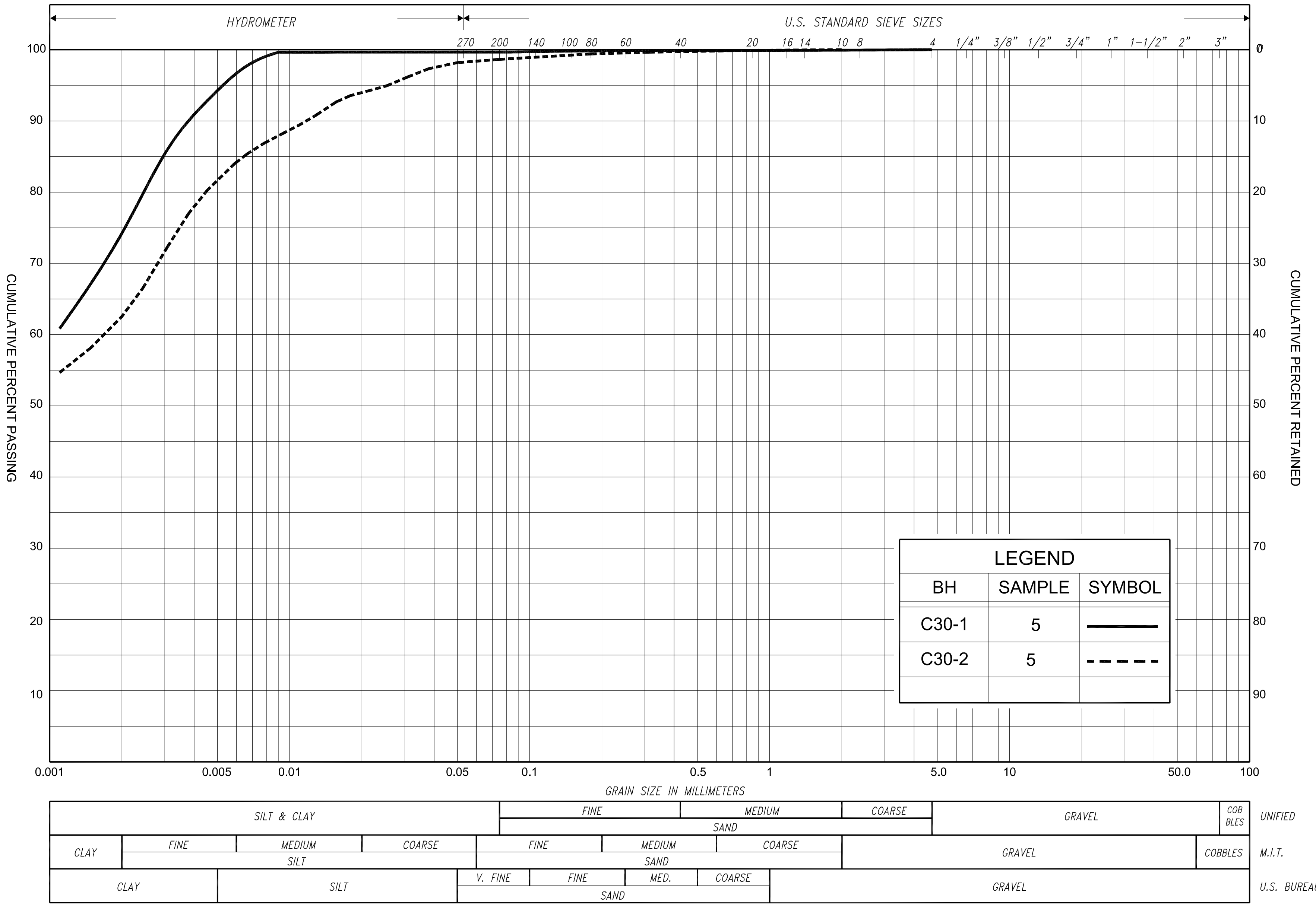


Ontario

GRAIN SIZE DISTRIBUTION

CLAYEY SILT, trace sand

FIG No.	C30-GS-1
HWY:	69
G.W.P. No.	5112-07-00



Ontario

GRAIN SIZE DISTRIBUTION

CLAY, trace sand

FIG No.	C30-GS-2
HWY:	69
G.W.P. No.	5112-07-00

Ontario

Peto MacCallum Ltd.
CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. C30-1

METRIC

G.W.P. 5112-07-00
LOCATION Hwy 69, Sta. 18+607, o/s 40.0m Lt. Coords: 5 068 065.8 N; 228 110.3 E
ORIGINATED BY S.A.

DIST Parry Sound HWY 69
BOREHOLE TYPE Tripod + Wash Boring
COMPILED BY M.K.

DATUM Geodetic
DATE February 24, 2014
CHECKED BY B.R.G.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
188.4	Top of Snow						
188.2 / 0.2	Ice						
188.0 / 0.4	Peat, amorphous, Dark brown	1	SS	WH**	∇*	188	
	Clayey silt, some sand organics to 1.0m; Stiff, Dark brown/brown, Moist to wet	2	SS	3		187	
		3	SS	2			0 14 64 22
			FV			186	
185.2 / 3.2	Clay; Firm, Grey, Moist to wet	4	SS	WH		185	
			FV			184	
		5	SS	1			0 0 26 74
			FV			183	
182.3 / 6.1	End of borehole; Refusal on probable bedrock						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

Plotted values: sample 1 water content 141; field vane sensitivity values 5, 3, 2.

* 2014 02 24

∇ Water level observed during drilling

▼ Water level measured after drilling

■ Penetrometer test

WH** denotes penetration due to weight of rods and hammer

NOTE: About 600mm of snow has been removed before drilling

$+^7$, $\times^5$: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No. C30-2

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 18+621, o/s 45.0m Rt. Coords: 5 068 112.3 N; 228 182.8 E **ORIGINATED BY** A.L.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** 'N' Casing + Wash Boring **COMPILED BY** G.D.

DATUM Geodetic **DATE** March 10 and 12, 2013 **CHECKED BY** B.R.G.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
188.5	Top of ice								
0.0	Ice and water				▽* ▼*	188			
187.6 / 0.9	Peat, amorphous. Dark brown					187			
		1	SS	2					
186.3 / 2.2	Silty clay, trace sand. Firm to soft, Grey, Moist to wet	2	SS	4		186	■	○	
			FV				+ 7		
184.8 / 3.7	Clay, trace sand. Soft to very soft, Grey, Wet					185			
		3	SS	2			■	○	
			FV			184	+ 4		
		4	SS	2		183		○	
		5	TW	PM		182	○	├──┤ ○	0 1 36 63
			FV				+ 3		
		6	SS	2		181		86 ○	
			FV			180	+ 3		
		7	SS	1		179		82 ○	
178.7 / 9.8	silty sand seams. End of borehole								

* 2013 03 10 & 12

▽ Water level observed during drilling

▼ Water level measured after drilling

■ Penetrometer test

+7, ×5 : Numbers refer to Sensitivity

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

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. 109-8

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 18+612.5, o/s 12.0m Rt. Coords: 5 068 091.4 N; 228 155.9 E **ORIGINATED BY** F.P.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Tripod 'N' Casing with Washbore **COMPILED BY** G.D.

DATUM Geodetic **DATE** February 16, 2012 **CHECKED BY** C.N.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
189.3	Top of Ice					
0.0	Ice				▽* ▼*	189
188.7	Water					
0.6	Peat, fine fibrous Dark brown	1	SS	1		188
187.7						
1.6	Silty clay trace sand, trace gravel organics to 3.0m Firm Grey Moist to wet	2	SS	3		187
		3	SS	3		186
		4	SS	3		
			FV			
184.9		5	SS	20/10cm		185
4.4	End of borehole Refusal on probable bedrock					

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

Field vane value: 6

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

* 2012 02 16

▽ Water level observed during drilling

▼ Water level measured after drilling

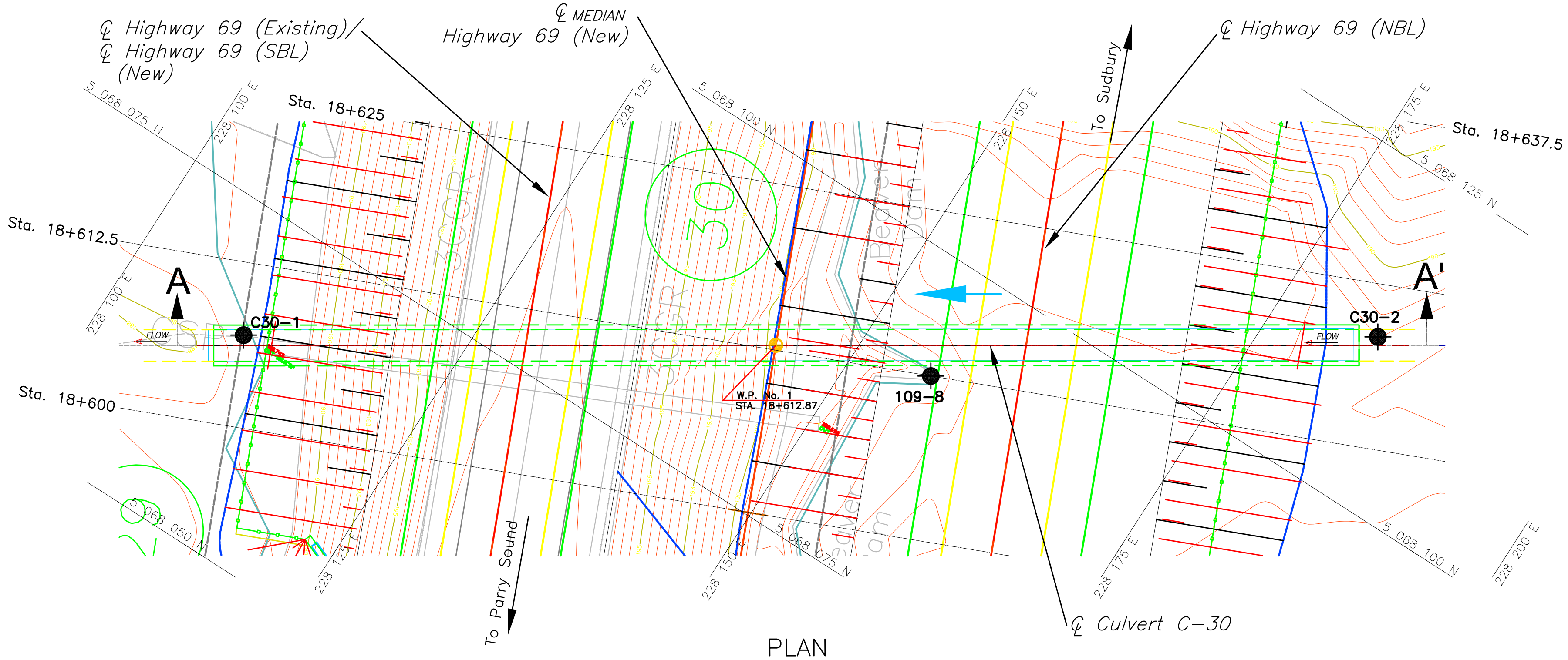
■ Penetrometer test

+7, ×5 : Numbers refer to Sensitivity

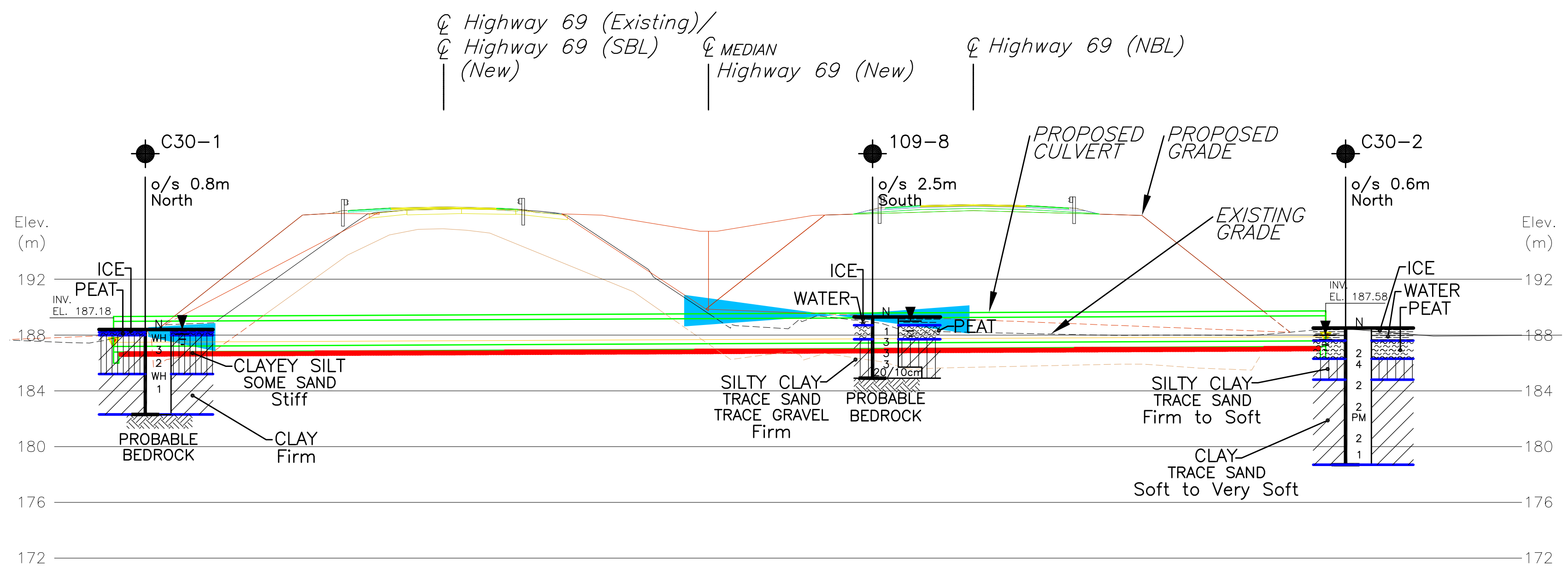
20, 15, 5, 10 (%) STRAIN AT FAILURE

CONT No
GWP No 5112-07-00
CULVERT C-30
HIGHWAY 69 FOUR-LANING
BOREHOLE LOCATIONS AND SOIL STRATA
SHEET

Peto MacCallum Ltd.
CONSULTING ENGINEERS

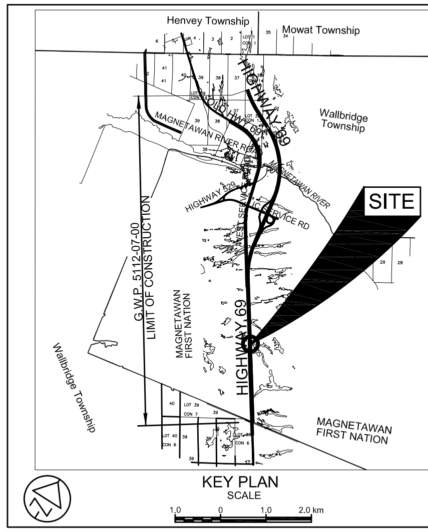


PLAN
SCALE 5 0 5 10m



PROFILE A-A' ALONG CENTRELINE OF CULVERT C-30 AT STA. 18+612.9

SCALE 5 0 5 10m



KEY PLAN
SCALE

LEGEND

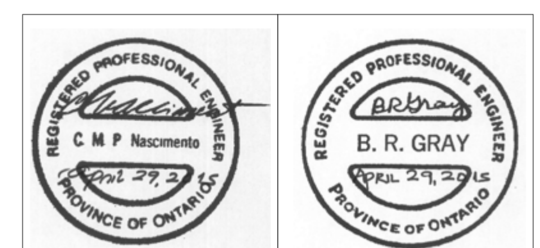
- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & Cone
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60°Cone, 475 J/blow)
- WH Penetration due to weight of rods and hammer
- WL at time of investigation Feb. 2012, Mar. 2013 and Feb. 2014
- PM Pushed mechanically
- Water level not established
- Head
- ARTESIAN WATER Encountered
- PIEZOMETER

BH No	ELEVATION	COORDINATES NORTHINGS	COORDINATES EASTINGS
C30-1	188.4	5 068 065.8	228 110.3
C30-2	188.5	5 068 112.3	228 182.8
109-8	189.3	5 068 091.4	228 155.9

– NOTE –
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.



Reference AECOM Drawing:
60143751-CULVERT-no.30_Sta 18+612.87_1_GA.dwg dated March 2015

REVISIONS	DATE	BY	DESCRIPTION

Geocres No. 41H-147

HWY No 69				DIST 54	
SUBM'D NA	CHECKED MK	DATE APR. 29, 2015		SITE 311	
DRAWN NA	CHECKED GD	APPROVED BRG		DWG C30-1	

MINISTRY OF TRANSPORTATION, ONTARIO PR-D-707 88-05
APRIL 2015
DRAWING NAME: 09TF044 Culvert 30.dwg
CREATED: MARCH 2014
MODIFIED:

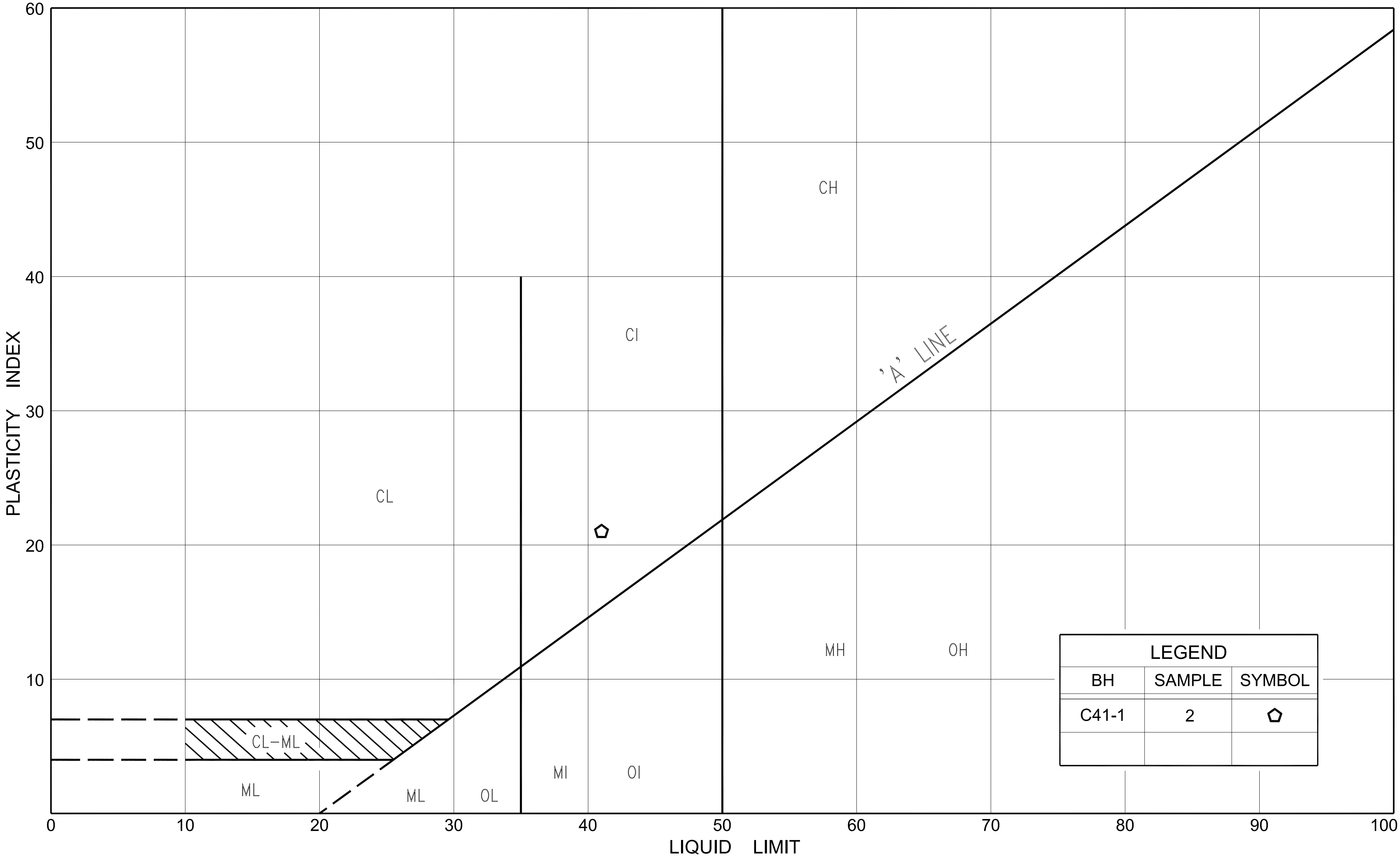
Culvert C-41 at Sta. 19+385.3, Median

Figures C41-PC-1, 112-PC-1 and 112-PC-3: Plasticity Charts

Figures C41-GS-1, 112-GS-2 and 112-GS-4: Results of Grain Size Distribution Analyses

Record of Borehole Sheets: C41-1, 112-6 and 112-7

Drawing C41-1: Borehole Locations and Soil Strata



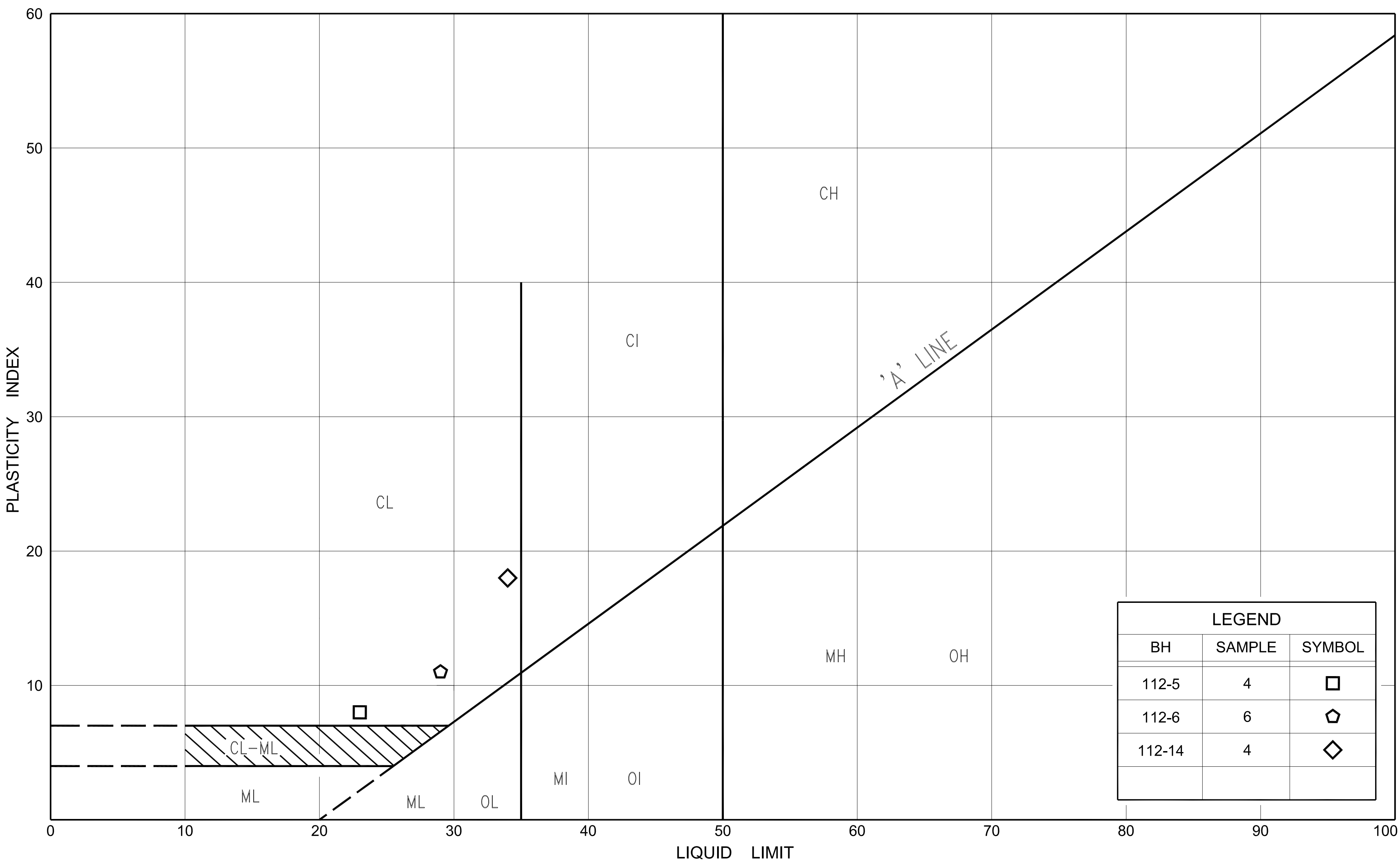
BH	SAMPLE	SYMBOL
C41-1	2	⬠

Ontario

PLASTICITY CHART

SILTY CLAY, trace sand

FIG No.	C41-PC-1
HWY:	69
G.W.P. No.	5112-07-00



LEGEND

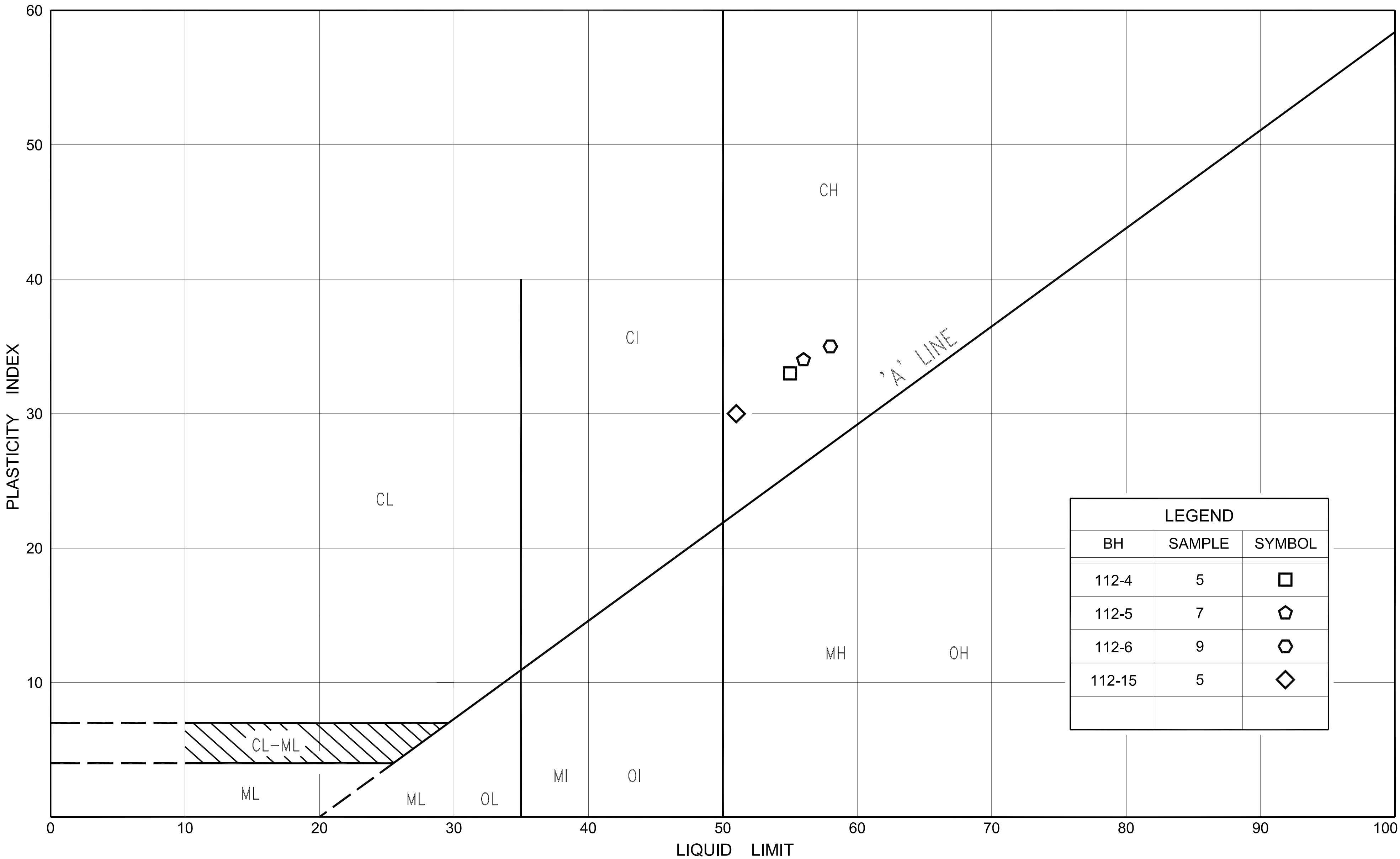
BH	SAMPLE	SYMBOL
112-5	4	□
112-6	6	⬠
112-14	4	◇

Ontario

PLASTICITY CHART

CLAYEY SILT, trace sand to sandy

FIG No.	112-PC-1
HWY:	69
G.W.P. No.	5112-07-00



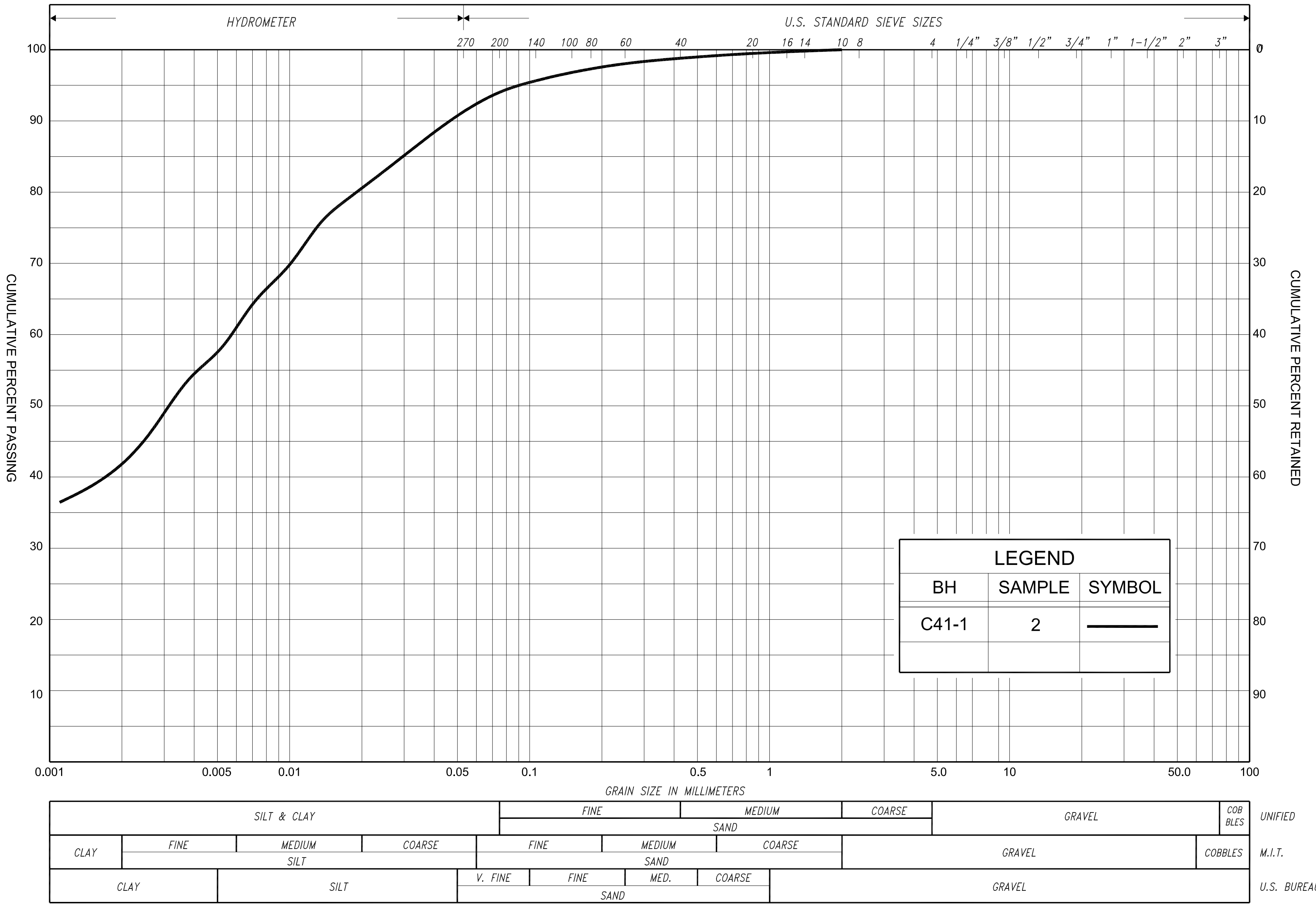
LEGEND		
BH	SAMPLE	SYMBOL
112-4	5	□
112-5	7	⬠
112-6	9	⬡
112-15	5	◇

Ontario

PLASTICITY CHART

CLAY, trace sand

FIG No.	112-PC-3
HWY:	69
G.W.P. No.	5112-07-00

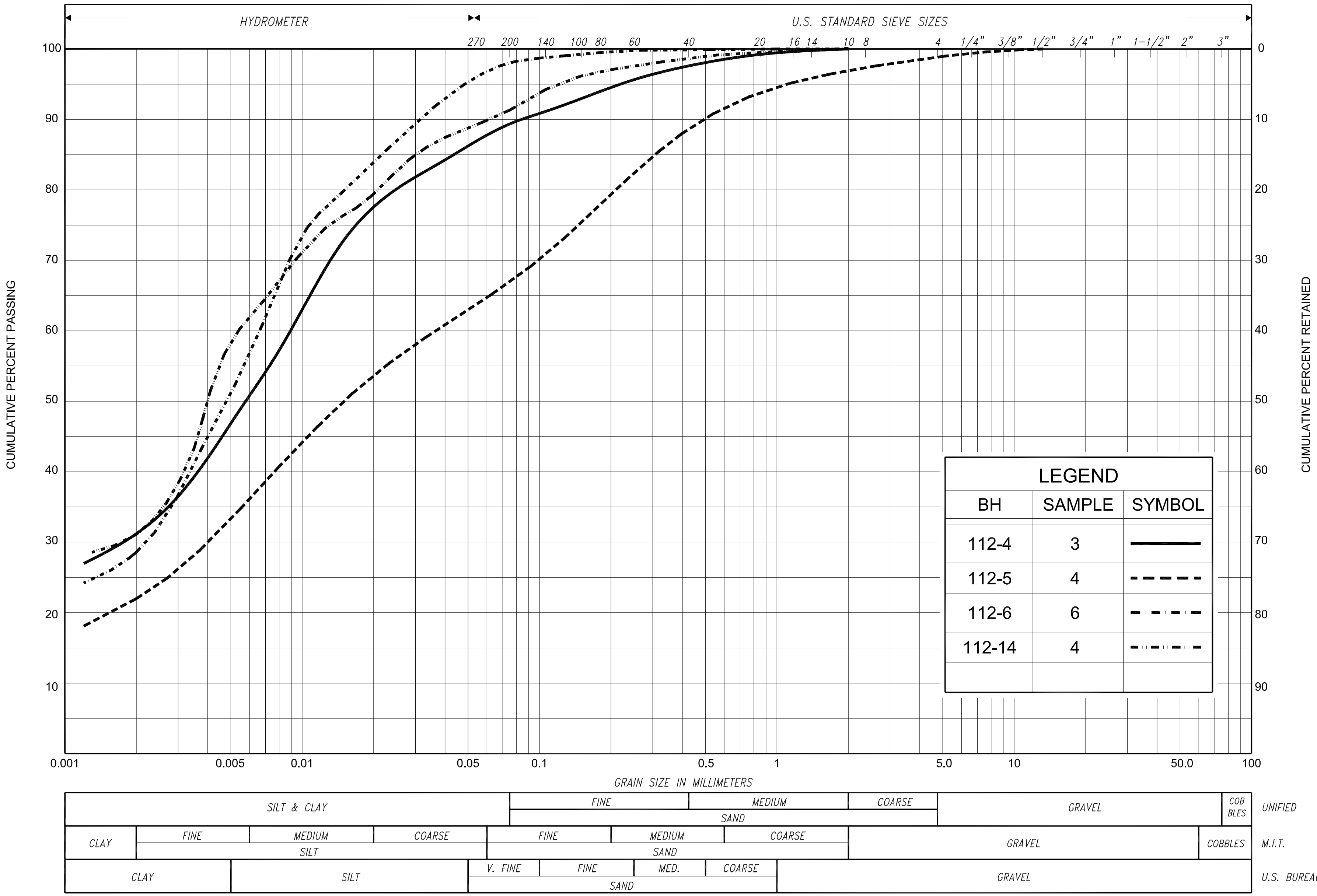


Ontario

GRAIN SIZE DISTRIBUTION

SILTY CLAY, trace sand

FIG No.	C41-GS-1
HWY:	69
G.W.P. No.	5112-07-00

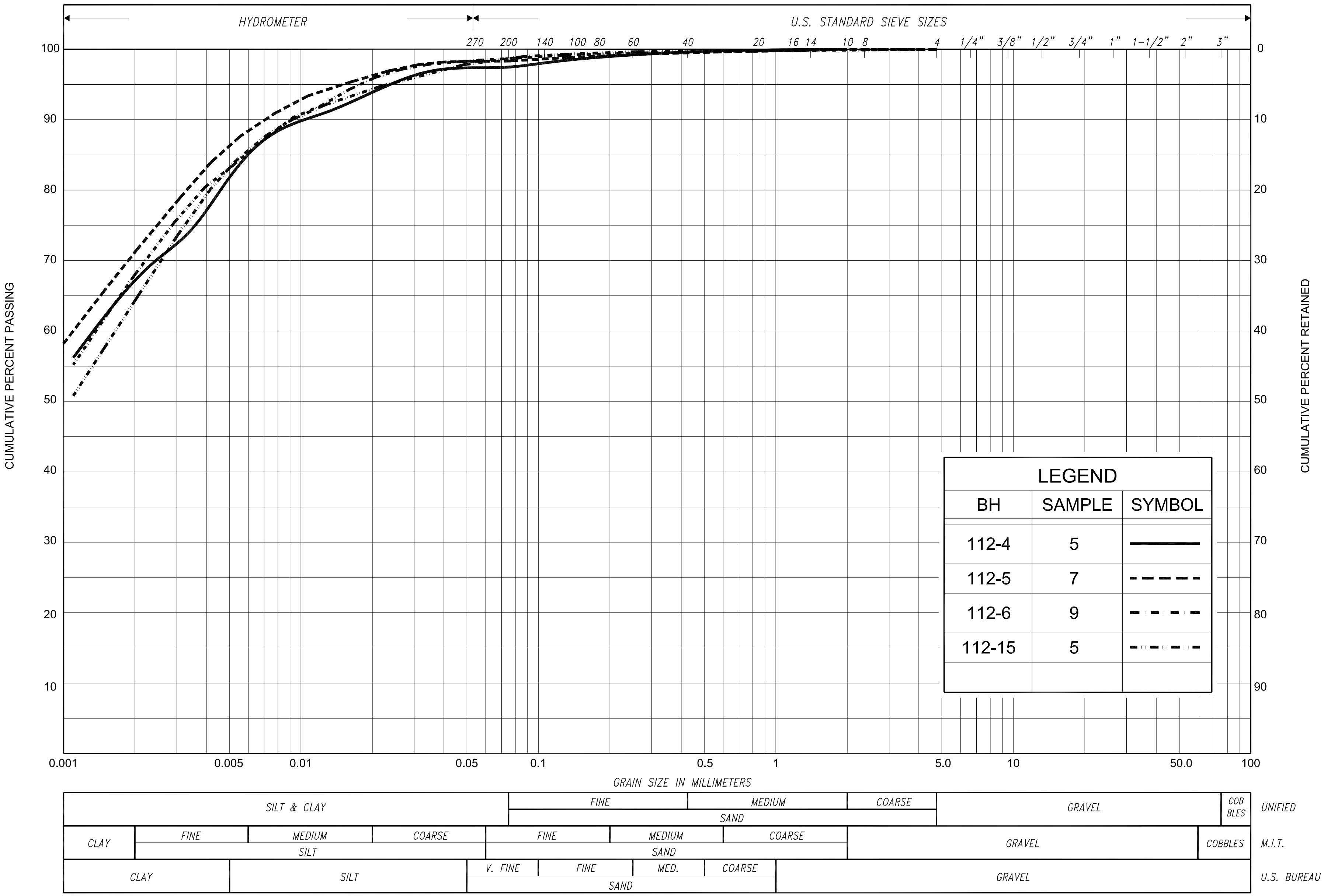


Ontario

GRAIN SIZE DISTRIBUTION

CLAYEY SILT, trace sand to sandy

FIG No.	112-GS-2
HWY:	69
G.W.P. No.	5112-07-00



Ontario

GRAIN SIZE DISTRIBUTION

CLAY, trace sand

FIG No.	112-GS-4
HWY:	69
G.W.P. No.	5112-07-00

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. C41-1

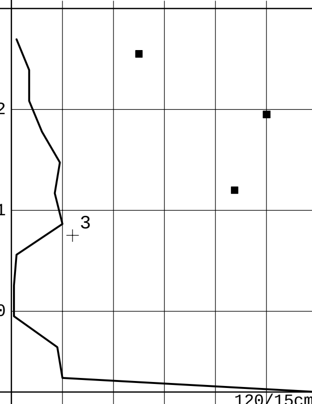
METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 19+388, o/s 45.0m Lt. Coords: 5 068 789.7 N; 227 804.9 E **ORIGINATED BY** A.L.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** 'N' Casing + Wash Boring + Dynamic Cone Penetration Test **COMPILED BY** M.K.

DATUM Geodetic **DATE** March 04 and 05, 2014 **CHECKED BY** B.R.G.

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.0	Ground Surface				*					
192.9 / 0.1	Peat									
192.7 / 0.3	Organic silty sand; Loose, Grey, Wet	1	SS	5						
	Silty clay, trace sand; Stiff to firm, Mottled brown/grey, Moist to wet	2	SS	18		192				0 6 52 42
		3	SS	13		191				
			FV				3 +			
190.3 / 2.7	Sand and gravel; Compact, Grey, Wet					190				
		4	SS	13						
189.2 / 3.8	End of borehole and dynamic cone penetration test; Refusal on probable bedrock						120/15cm			



* Borehole dry

Legend: SHEAR STRENGTH kPa — ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE. PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L.

$+^7$, $\times^5$: Numbers refer to Sensitivity; 20 / 15–○–5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd.
CONSULTING ENGINEERS
Foundation Design

RECORD OF BOREHOLE No. 112-6

METRIC

G.W.P. 5112-07-00
LOCATION Hwy 69 Realigned, Sta. 19+384, o/s 40.0m Rt. Coords: 5 068 808.9 N; 227 856.6 E
ORIGINATED BY F.P.

DIST Parry Sound **HWY** 69
BOREHOLE TYPE Tripod + Washbore
COMPILED BY G.D.

DATUM Geodetic
DATE February 12, 2013
CHECKED BY B.R.G.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa (FV / sensitivity)	WATER CONTENT (%)	GR SA SI CL
188.8	Top of Snow/Ice								
188.6 / 0.2	Snow/Ice								
188.3 / 0.5	Peat, coarse fibrous; Dark brown	1	SS	1	▽* ▼*				
	Organic silt, clayey silt layers; Very loose, Dark grey, Wet	2	SS	3		188			
187.4 / 1.4	Clayey silt, trace sand layers of amorphous peat to 2.9m depth; Firm to very soft, Grey, Wet	3	SS	2		187		84	
			FV				10		
		4	SS	3		186			
			FV				6		
		5	SS	1		185			
			FV				8		
		6	TW	PM					0 2 69 29
			FV				7		
184.3 / 4.5	Clay, trace sand; Soft to firm, Grey, Wet	7	SS	1		184			
			FV				7		
		8	SS	1		183			
			FV			182	7		
		9	SS	2		181			0 1 31 68
			FV				6		
		10	SS	2		180		84	
			FV			179	6		
177.9 / 10.9	Sand, trace gravel; Compact, Grey, Wet	11	SS	24		178			
177.7 / 11.1	End of borehole; Refusal on probable bedrock								

* 2013 02 12

▽ Water level observed during drilling

▼ Water level measured after drilling

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

ON MTO_VER3 NEW LOGO 09TF044.GPJ ON_MOT.GDT 7/9/2014 12:10:05 PM

+7, ×5 : Numbers refer to Sensitivity

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

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. 112-7

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69 Realigned, Sta. 19+391, o/s 10.0m Rt. Coords: 5 068 810.7 N; 227 887.4 E **ORIGINATED BY** F.P.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Tripod and Dynamic Cone Penetration Test **COMPILED BY** G.D.

DATUM Geodetic **DATE** February 28, 2012 **CHECKED BY** C.N.

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE / SHEAR STRENGTH (kPa)	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
188.7	Top of Snow/Ice									
0.0	Snow/Ice				▽*					
188.1 / 0.6	Peat, fine fibrous organic silty clay layers, Dark brown	1	SS	3		188		○		
187.5 / 1.2	Silty clay, trace sand organics; Firm to soft, Dark grey, Wet					187				
		2	SS	2		186				
			FV			185	+ 3			
	sand seams	3	SS	30		184		81 ○		
183.4 / 5.3	End of borehole. Refusal on probable bedrock									

* 2012 02 28

▽ Water level observed during drilling

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

Wp PLASTIC LIMIT, w NATURAL MOISTURE CONTENT, WL LIQUID LIMIT

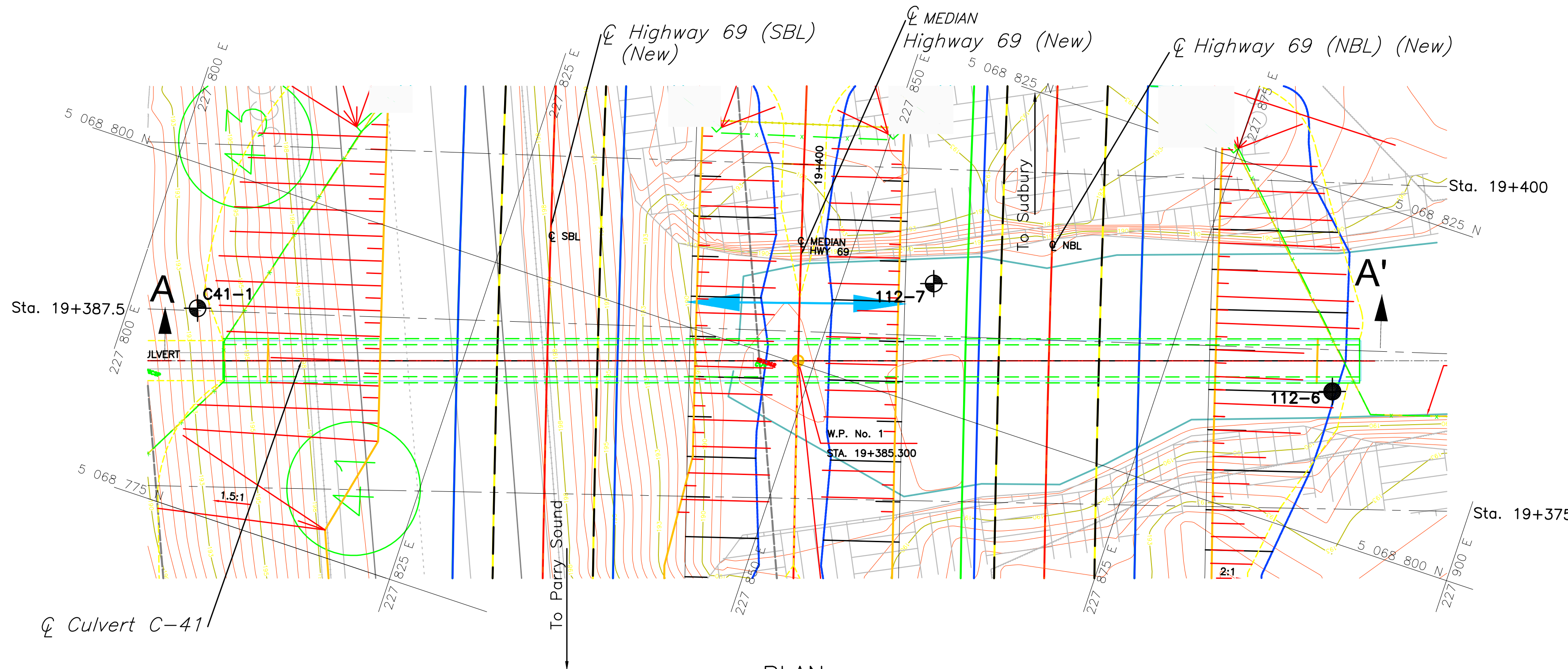
+7, ×5: Numbers refer to Sensitivity

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

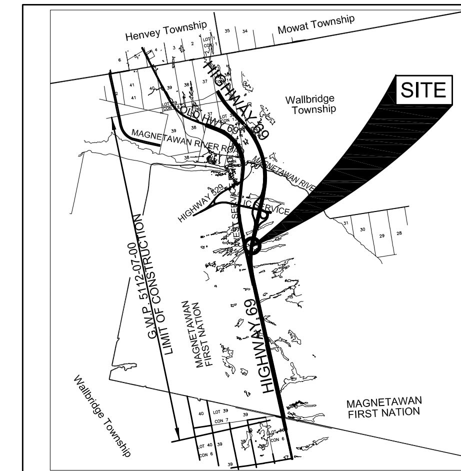
CONT No
GWP No 5112-07-00
SHEET

CULVERT C-41
HIGHWAY 69 FOUR-LANING
BOREHOLE LOCATIONS AND SOIL STRATA

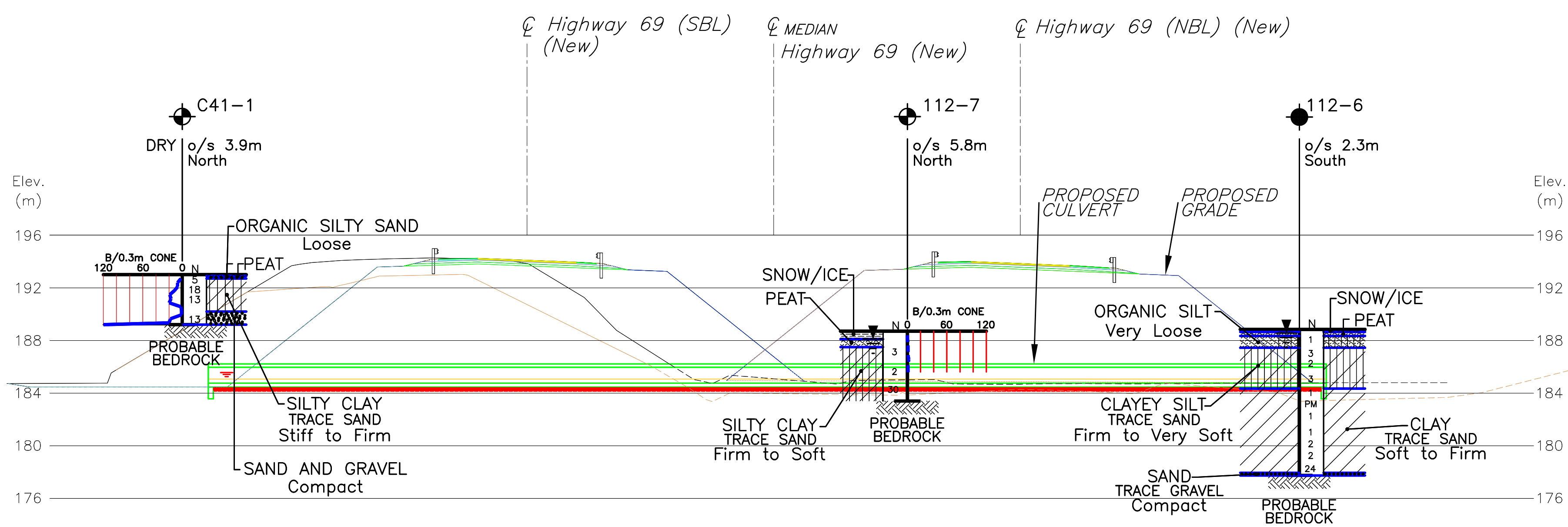
Peto MacCallum Ltd.
CONSULTING ENGINEERS



PLAN
SCALE
5 0 5 10m



KEY PLAN
SCALE
1.0 0 1.0 2.0 km



PROFILE A-A' ALONG CENTRELINE OF CULVERT C-41 AT STA. 19+385.3

SCALE
5 0 5 10m

LEGEND

- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & Cone
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60°Cone, 475 J/blow)
- WH Penetration due to weight of rods and hammer
- WL at time of investigation Feb. 2012, Feb. 2013 and Mar. 2014
- Water level not established
- Head
- ARTESIAN WATER Encountered
- PIEZOMETER

BH No	ELEVATION	COORDINATES NORTHINGS	COORDINATES EASTINGS
C41-1	193.0	5 068 789.7	227 804.9
112-6	188.8	5 068 808.9	227 856.6
112-7	188.7	5 068 810.7	227 887.4

– NOTE –
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

REGISTERED PROFESSIONAL ENGINEER C M P Nascimento PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER B. R. GRAY PROVINCE OF ONTARIO

Reference AECOM Drawing: 60143751-CULVERT-no.41-Sta 19+385.3_GA.dwg dated March 2015.

REVISIONS DATE	BY	DESCRIPTION

Geocres No. 41H-147

HWY No 69			DIST 54
SUBM'D NA	CHECKED MK	DATE APR. 29, 2015	SITE C316
DRAWN NA	CHECKED GD	APPROVED BRG	DWG C41-1

DRAWING NAME: 09TF044 Culvert 41.dwg
CREATED: APRIL 2015
MODIFIED:

MINISTRY OF TRANSPORTATION, ONTARIO PR-D-707 88-05

Culvert C-42 at Sta. 19+410.0, NBL

Figure 112-PC-2: Plasticity Chart

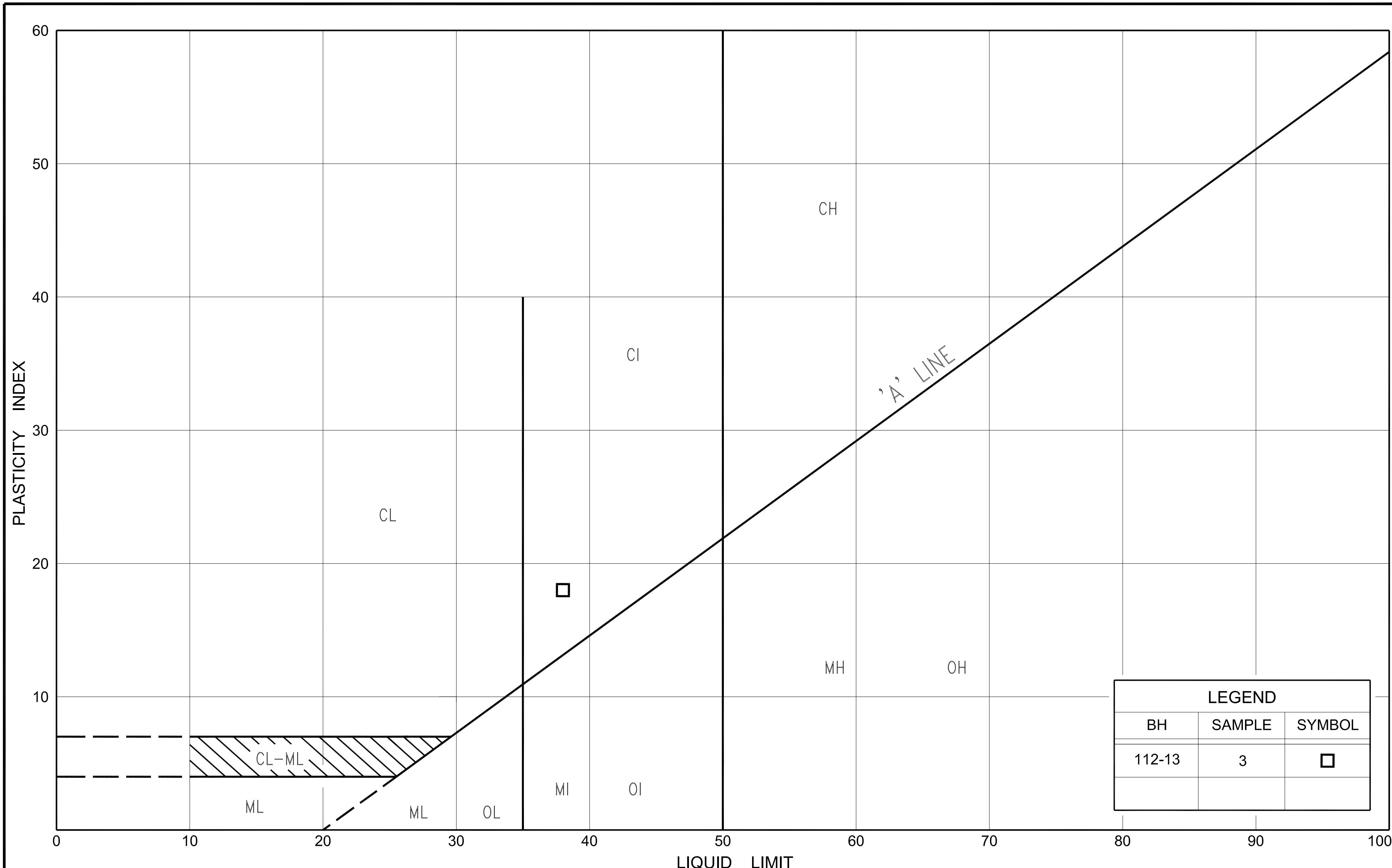
Figure 112-GS-3: Results of Grain Size Distribution Analysis

Record of Borehole Sheets: C42-1, 112-10, 112-11 and 112-13

Culvert C-43 at Sta. 19+410.0, SBL

Record of Borehole Sheets: C43-1 and C43-2

Drawing C42/43-1: Borehole Locations and Soil Strata

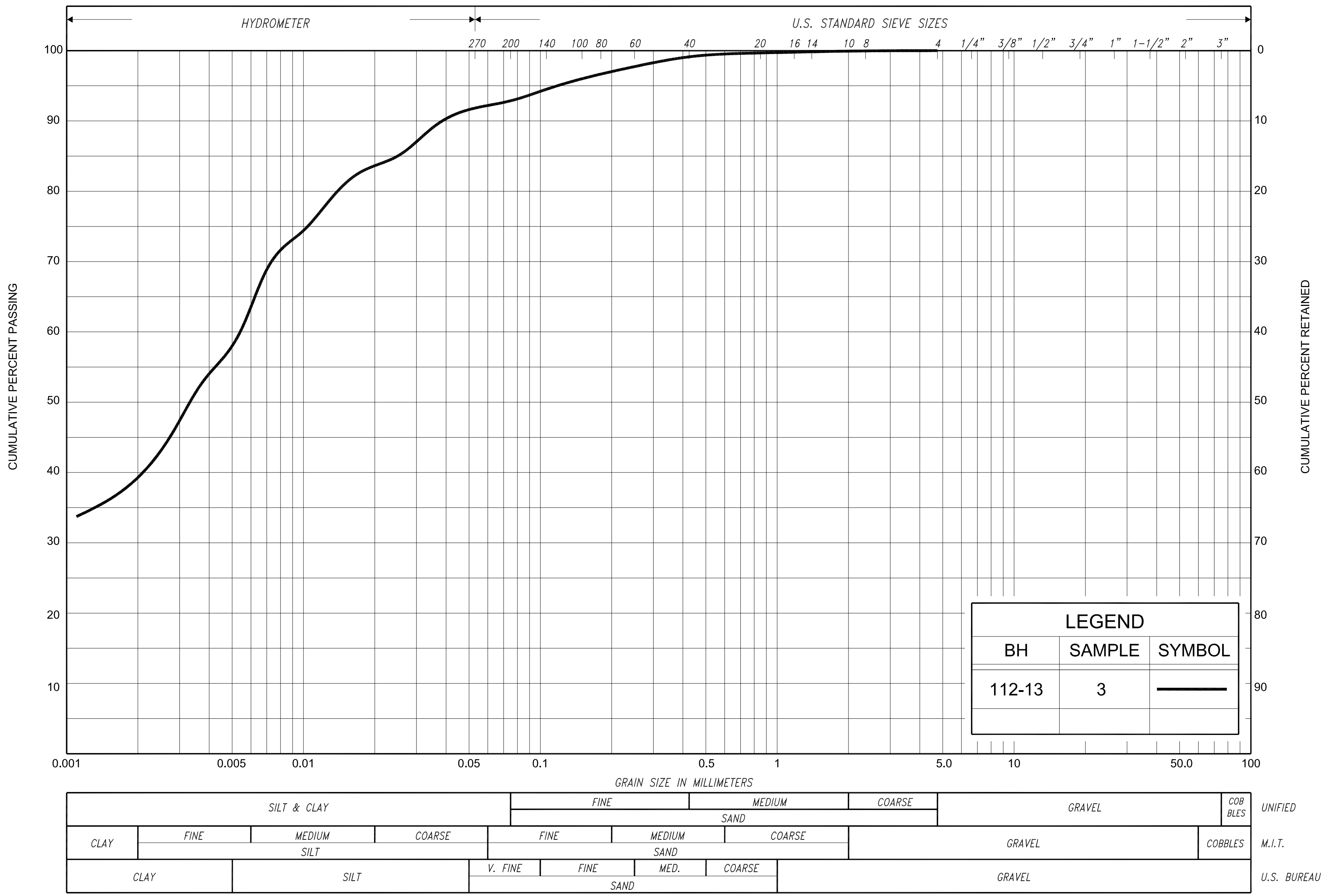


Ontario

PLASTICITY CHART

SILTY CLAY, trace sand

FIG No.	112-PC-2
HWY:	69
G.W.P. No.	5112-07-00



Ontario	GRAIN SIZE DISTRIBUTION	FIG No. 112-GS-3
		HWY: 69
	SILTY CLAY, trace sand	G.W.P. No. 5112-07-00

Ontario

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Foundation Design

RECORD OF BOREHOLE No. C42-1

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 19+407, o/s 27.0m Rt. Coords: 5 068 828.6 N; 227 868.5 E **ORIGINATED BY** F.P.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Hilti **COMPILED BY** G.D.

DATUM Geodetic **DATE** October 10, 2013 **CHECKED BY** B.R.G.

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
192.2	Ground Surface										
0.0	Granitic Gneiss bedrock Slightly weathered to moderately weathered High strength Good to excellent quality		1	RC	REC 83%		192				RQD 83%
			2	RC	REC 100%						RQD 98%
			3	RC	REC 100%		191				RQD 100%
			4	RC	REC 96%		190				RQD 85%
			5	RC	REC 96%						RQD 96%
189.2 3.0	End of borehole * Borehole charged with drilling water										

$+^{7}$, $\times^{5}$: Numbers refer to Sensitivity

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

Ontario

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RECORD OF BOREHOLE No. 112-10

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69 Realigned, Sta. 19+412.5, o/s 3.5m Rt. Coords: 5 068 817.1 N; 227 818.4 E **ORIGINATED BY** K.D.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Manual Probing **COMPILED BY** G.D.

DATUM Geodetic **DATE** September 24, 2012 **CHECKED BY** B.R.G.

SOIL PROFILE			SAMPLES						DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE					GR SA SI CL
193.7	Ground Surface											
0.0	Bedrock at surface											
	* Borehole dry											

ON MTO_VER3 NEW LOGO 09TF044.GPJ ON_MOT.GDT 7/9/2014 12:16:15 PM

$+^{7}$, $\times^{5}$: Numbers refer to Sensitivity

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

Ontario

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Foundation Design

RECORD OF BOREHOLE No. 112-11

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69 Realigned, Sta. 19+412.5, o/s 35.5m Rt. Coords: 5 068 836.1 N; 227 875.1 E **ORIGINATED BY** K.D.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Manual Probing **COMPILED BY** G.D.

DATUM Geodetic **DATE** September 24, 2012 **CHECKED BY** B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
191.6	Ground Surface										
0.0	Topsoil										
191.5 0.1	End of borehole Refusal on probable bedrock										

* Borehole dry

$+^{7}, \times^{5}$: Numbers refer to Sensitivity

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

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. 112-13

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69 Realigned, Sta. 19+425, o/s 19.0m Rt. Coords: 5 068 843.4 N; 227 855.9 E **ORIGINATED BY** F.P.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Tripod **COMPILED BY** G.D.

DATUM Geodetic **DATE** February 12 and 19, 2013 **CHECKED BY** B.R.G.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
191.1	Top of Snow/Ice				▼*								
0.0	Snow/Ice					191							
190.8 / 0.3	Topsoil												
190.5 / 0.6	Silty clay, trace sand organics to 1.4m Stiff Mottled grey/brown Moist	1	SS	6									
		2	SS	7	▽*	190							
		3	SS	6			175 ■			0	7	54	39
189.0 / 2.1	End of borehole Refusal on probable bedrock					189							

* 2013 02 12 and 19

▽ Water level observed during drilling

▼ Water level measured after drilling

■ Penetrometer test

Legend: ○ UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × LAB VANE; PLASTIC LIMIT w_P; NATURAL MOISTURE CONTENT w; LIQUID LIMIT w_L

+7, ×5 : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No. C43-1

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 19+410, o/s 24.3m Lt. Coords: 5 068 817.1 N; 227 818.4 E **ORIGINATED BY** J.H.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Manual Probing **COMPILED BY** M.K.

DATUM Geodetic **DATE** July 18, 2012 **CHECKED BY** B.R.G.

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	STRAT PLOT	SAMPLES – NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L – WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
198.2	Ground Surface										
0.0	290mm asphalt over sand and gravel, trace silt						198				
197.4 / 0.8	Sand trace silt, trace gravel Brown Moist (FILL)										
	End of borehole										
	Refusal on probable rockfill										
	* Borehole dry										

$+^{7}$, $\times^{5}$: Numbers refer to Sensitivity

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

Ontario

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RECORD OF BOREHOLE No. C43-2

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 19+407, o/s 10.0m Lt. Coords: 5 068 818.2 N; 227 833.0 E **ORIGINATED BY** F.P.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Hilti **COMPILED BY** G.D.

DATUM Geodetic **DATE** October 09, 2013 **CHECKED BY** B.R.G.

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.3	Ground Surface										
0.0	Granitic Gneiss bedrock; Slightly weathered to moderately weathered; High strength; Fair to excellent quality		1	RC	REC 100%		194				REC 100%
			2	RC	REC 93%						RQD 81%
			3	RC	REC 100%		193				RQD 81%
			4	RC	REC 100%						RQD 65%
			5	RC	REC 100%		192				RQD 88%
			6	RC	REC 86%						RQD 86%
			7	RC	REC 98%		191				RQD 98%
190.7 / 3.6	End of borehole										

* Borehole charged with drilling water

$+^7$, $\times^5$: Numbers refer to Sensitivity

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

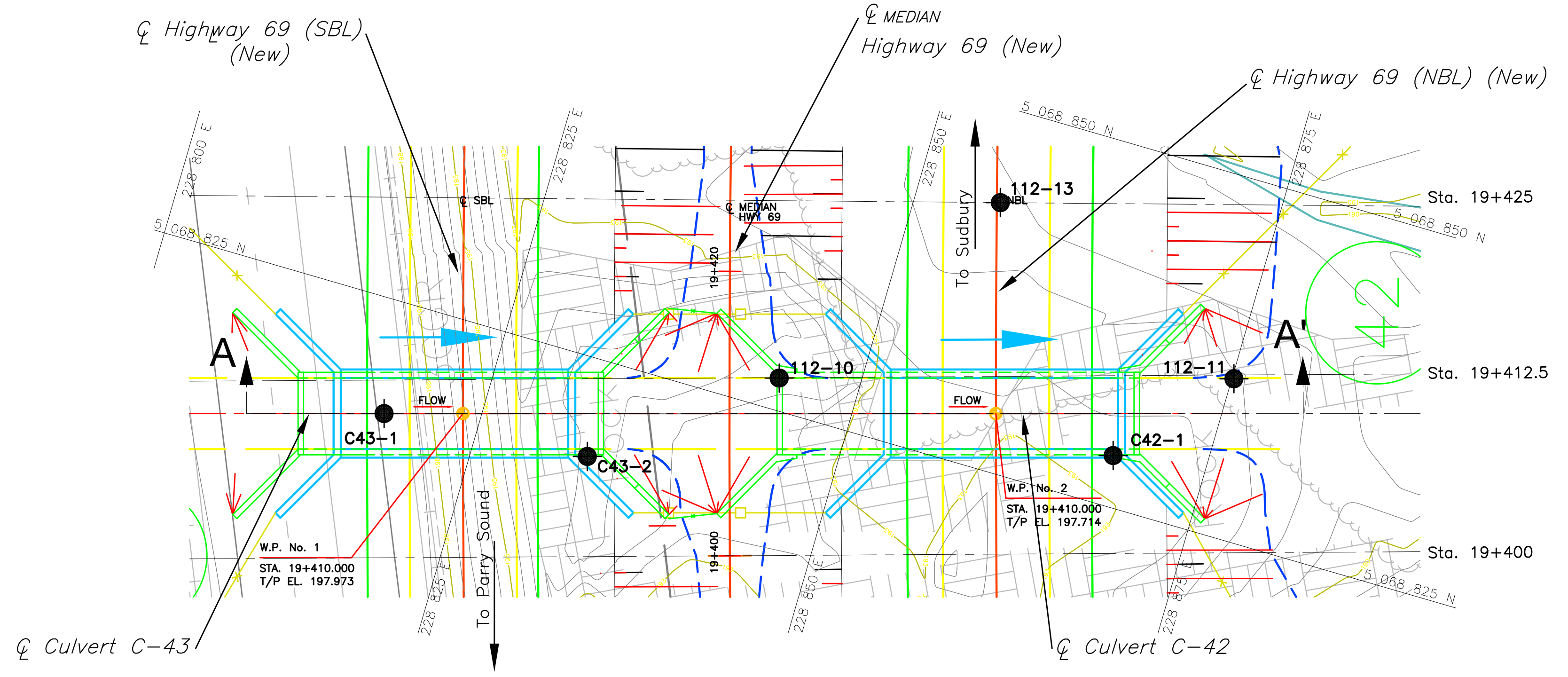
CONT No
GWP No 5112-07-00
SHEET

CULVERTS C-42 AND C-43

HIGHWAY 69 FOUR-LANING

BOREHOLE LOCATIONS AND SOIL STRATA

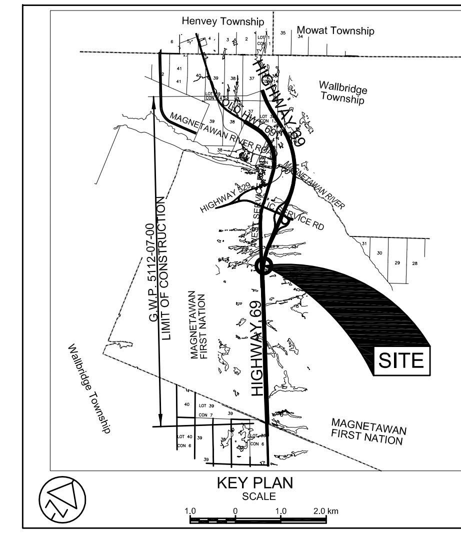
Peto MacCallum Ltd.
CONSULTING ENGINEERS



PLAN

SCALE

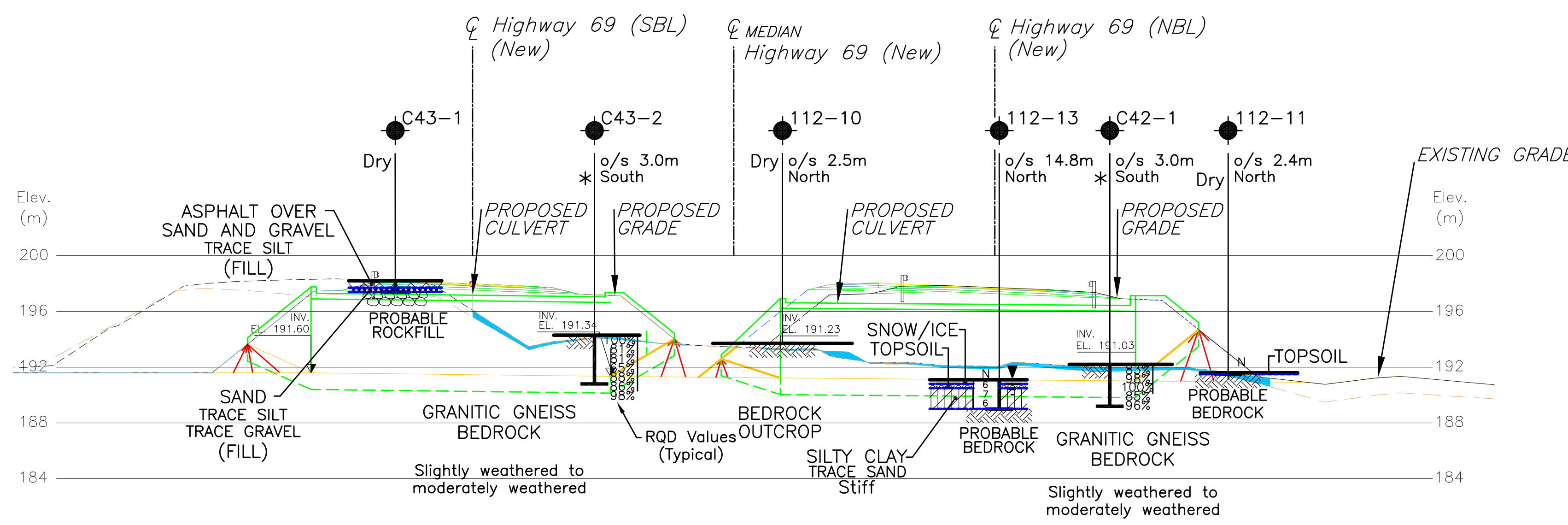
5 0 5 10m



KEY PLAN

SCALE

1.0 0 1.0 2.0 km



PROFILE A-A' ALONG CENTRELINES OF CULVERTS C-42 AND C-43 AT STA. 19+410.0

SCALE

5 0 5 10m

LEGEND

- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & Cone

N Blows/0.3m (Std. Pen Test, 475 J/blow)

CONE Blows/0.3m (60°Cone, 475 J/blow)

WH Penetration due to weight of rods and hammer

WL at time of investigation July 2012, Sep. 2012, Feb. and Oct. 2013

* Water level not established

Head

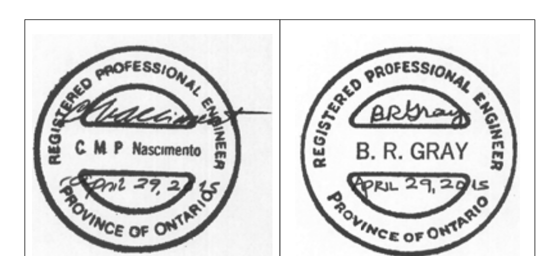
ARTESIAN WATER Encountered

PIEZOMETER

BH No	ELEVATION	COORDINATES	
		NORTHINGS	EASTINGS
C42-1	192.2	5 068 828.6	227 868.5
C43-1	198.2	5 068 817.1	227 818.4
C43-2	194.3	5 068 818.2	227 833.0
112-10	193.7	5 068 817.1	227 818.4
112-11	191.6	5 068 836.1	227 875.1
112-13	191.1	5 068 843.4	227 855.9

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.



Reference AECOM Drawings: 60143751-CULVERT_no. 42_NBL_Sta.19+410_GA.dwg & 60143751-CULVERT_no.43_Sta.19+416_GA.dwg dated March 2015

– NOTE –
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS DATE	BY	DESCRIPTION

Geocres No. 41H-147

HWY No 69			DIST 54
SUBM'D NA	CHECKED MK	DATE APR. 29, 2015	SITE --
DRAWN NA	CHECKED GD	APPROVED BRG	DWG C42/C43-1

DRAWING NAME: 09TF044 Culverts 42 n 43.dwg
CREATED: MARCH 2014
MODIFIED: APRIL 2015

MINISTRY OF TRANSPORTATION, ONTARIO PR-D-707 88-05

Culvert C-46 at Sta. 19+887.0, SBL

Record of Borehole Sheets: C46-1, C46-2, 114-5 and 114-9

Culvert C-47 at Sta. 19+893.4, NBL

Record of Borehole Sheets: C47-1, C47-2 and C47-3

DrawingC46/C47-1: Borehole Locations and Soil Strata

RECORD OF BOREHOLE No. C46-1

METRIC

Ontario — Peto MacCallum Ltd. CONSULTING ENGINEERS — Foundation Design

G.W.P. 5112-07-00	**LOCATION** Hwy 69, Sta. 19+883, o/s 31.0m Lt. Coords: 5 069 290.4 N; 227 743.3 E		**ORIGINATED BY** A.L.
DIST Parry Sound	**HWY** 69	**BOREHOLE TYPE** Hilti	**COMPILED BY** G.D.
DATUM Geodetic	**DATE** October 24, 2013		**CHECKED BY** B.R.G.

ELEV / DEPTH	SOIL PROFILE — DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.4	Ground Surface										
0.0	Granitic Gneiss bedrock Slightly weathered to moderately weathered High strength Excellent quality		1	RC	REC 100%						RQD 100%
			2	RC	REC 100%		194				RQD 100%
			3	RC	REC 100%		193				RQD 90%
			4	RC	REC 100%		192				RQD 95%
191.3			5	RC	REC 100%						RQD 95%
3.1	End of borehole										
	* Borehole charged with drilling water										

$+^{7}$, $\times^{5}$: Numbers refer to Sensitivity   15–○–5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. C46-2

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 19+886, o/s 10.0m Lt. Coords: 5 069 293.5 N; 227 764.3 E **ORIGINATED BY** A.L.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Hilti **COMPILED BY** G.D.

DATUM Geodetic **DATE** October 23 and 24, 2013 **CHECKED BY** B.R.G.

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.4	Ground Surface										
0.0	Boulders		1	RC	REC 100%		194				RQD 50%
193.9 / 0.5	Granitic Gneiss bedrock Slightly weathered to moderately weathered High strength Poor becoming good quality		2	RC	REC 100%						RQD 30%
			3	RC	REC 100%		193				RQD 89%
			4	RC	REC 100%		192				RQD 88%
			5	RC	REC 100%						RQD 88%
			6	RC	REC 100%		191				RQD 88%
190.7 / 3.7	End of borehole										

* Borehole charged with drilling water

+7, ×5 : Numbers refer to Sensitivity

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

Ontario

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Foundation Design

RECORD OF BOREHOLE No. 114-5

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 19+886 o/s 18.8 m Lt. Coords: 5 069 294.9 N; 227 731.3 E **ORIGINATED BY** S.A.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Manual Probing **COMPILED BY** G.D.

DATUM Geodetic **DATE** March 12, 2013 **CHECKED BY** B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
193.6	Ground Surface										
0.0	Bedrock at surface										
	* Borehole dry										

$+^{7}$, $\times^{5}$: Numbers refer to Sensitivity

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

Ontario

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Foundation Design

RECORD OF BOREHOLE No. 114-9

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 19+895, o/s 18.8 m Lt. Coords: 5 069 302.6 N; 227 755.5 E **ORIGINATED BY** F.P.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Manual Probing **COMPILED BY** G.D.

DATUM Geodetic **DATE** February 07, 2013 **CHECKED BY** B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	*					
195.3	Ground Surface										
0.0	Bedrock at surface										
	* Borehole dry										

$+^{7}$, $\times^{5}$: Numbers refer to Sensitivity

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

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. C47-1

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 19+892, o/s 10.0m Rt. Coords: 5 069 299.5 N; 227 784.3 E **ORIGINATED BY** S.A.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Tripod **COMPILED BY** G.D.

DATUM Geodetic **DATE** March 15, 2013 **CHECKED BY** B.R.G.

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
195.5	Top of Ice										
0.0	Ice and water					▽* ▼*	195				
							194				
193.2 2.3	End of borehole Refusal on probable bedrock										

* 2013 03 15

▽ Water level observed during drilling

▼ Water level measured after drilling

+7 , ×5 : Numbers refer to Sensitivity

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

Ontario

Peto MacCallum Ltd.
CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. C47-2

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 19+893.5, o/s 18.8m Rt. Coords: 5 069 301.0 N; 227 793.0 E **ORIGINATED BY** S.A.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Tripod **COMPILED BY** G.D.

DATUM Geodetic **DATE** March 14, 2013 **CHECKED BY** B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
194.8	Top of Ice										
0.0	Ice and water					▽* ▼*	194				
							193				
							192				
							191				
190.5 4.3	Silty sand, organics		1	SS	50/15cm						
190.2 4.6	Loose Dark brown Wet										
	End of borehole Refusal on probable bedrock										

* 2013 03 14

▽ Water level observed during drilling

▼ Water level measured after drilling

$+^7$, $\times^5$: Numbers refer to Sensitivity

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

Ontario

Peto MacCallum Ltd.
CONSULTING ENGINEERS
Foundation Design

RECORD OF BOREHOLE No. C47-3

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 19+895, o/s 29.0m Rt. Coords: 5 069 302.4 N; 227 803.3 E **ORIGINATED BY** S.A.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Tripod **COMPILED BY** G.D.

DATUM Geodetic **DATE** March 15, 2013 **CHECKED BY** B.R.G.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.2	Top of Ice										
0.0	Ice and water					▽* ▼*	194				
							193				
							192				
191.4 2.8	End of borehole Refusal on probable bedrock										

* 2013 03 15

▽ Water level observed during drilling

▼ Water level measured after drilling

$+^{7}$, $\times^{5}$: Numbers refer to Sensitivity

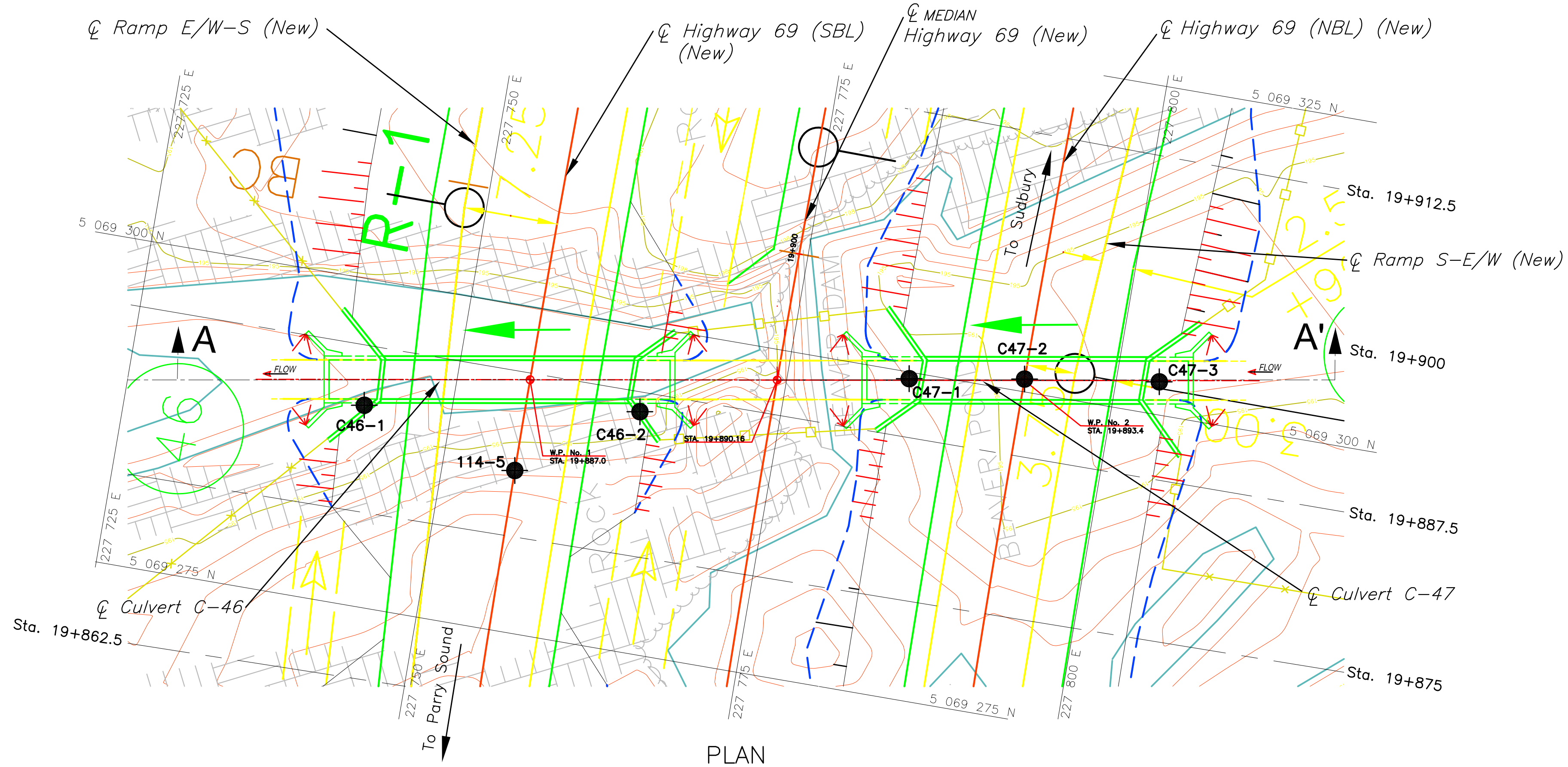
20 / 15 —○— 5 / 10 (%) STRAIN AT FAILURE

CONT No
GWP No 5112-07-00

CULVERTS C-46 AND C-47
HIGHWAY 69 FOUR-LANING
BOREHOLE LOCATIONS AND SOIL STRATA

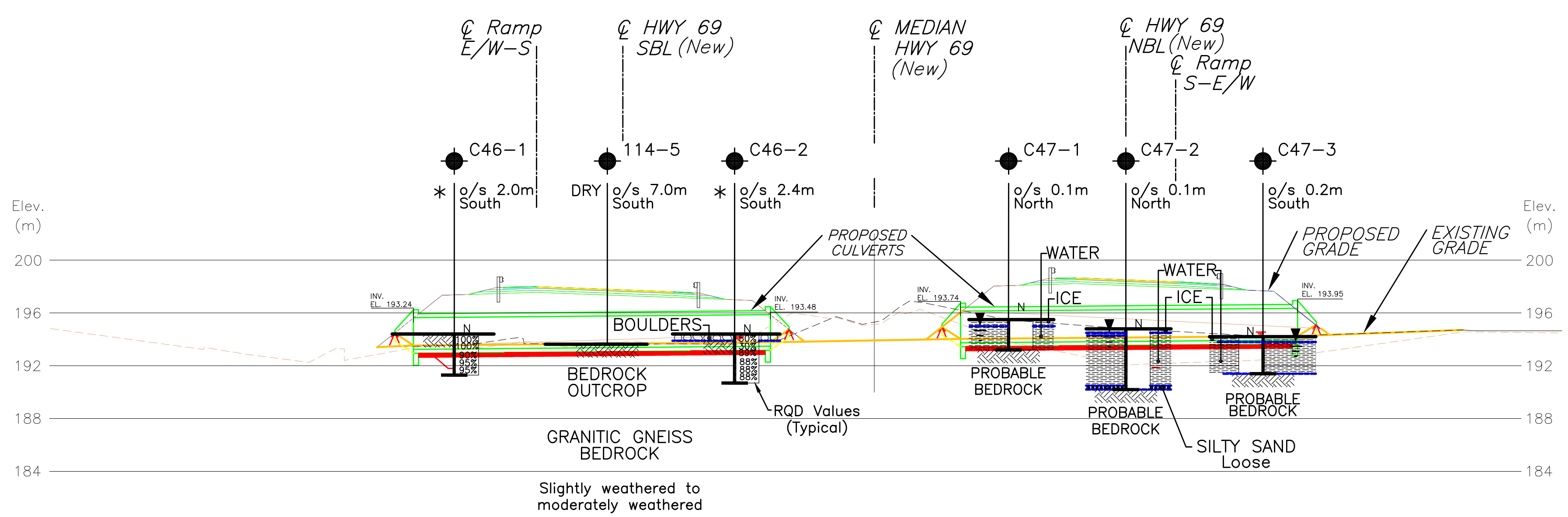
SHEET

Peto MacCallum Ltd. CONSULTING ENGINEERS



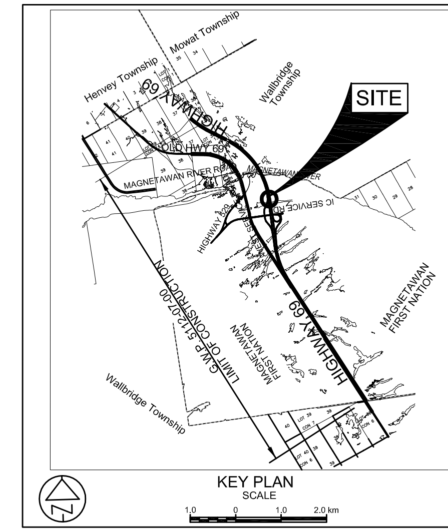
PLAN

SCALE 5 0 5 10m



PROFILE A-A' ALONG CENTRELINES OF CULVERTS C-46 AT STA. 19+887.0 AND C-47 AT STA. 19+893.4

SCALE 5 0 5 10m



KEY PLAN

LEGEND

- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & Cone
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60°Cone, 475 J/blow)
- WH Penetration due to weight of rods and hammer
- WL at time of investigation Feb, March and Oct. 2013
- Water level not established
- Head
- ARTESIAN WATER Encountered
- PIEZOMETER

BH No	ELEVATION	COORDINATES NORTHINGS	COORDINATES EASTINGS
C46-1	194.4	5 069 290.4	227 743.3
C46-2	194.4	5 069 293.5	227 764.3
C47-1	195.5	5 069 299.5	227 784.3
C47-2	194.8	5 069 301.0	227 793.0
C47-3	194.2	5 069 302.4	227 803.3
114-5	193.6	5 069 294.9	227 731.3
114-9	195.3	5 069 302.6	227 755.5

– NOTE –
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

REGISTERED PROFESSIONAL ENGINEER C M P Nascimento Apr 29, 2015 PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER B. R. GRAY APRIL 29, 2015 PROVINCE OF ONTARIO

Reference AECOM Drawing: 60173751-BOX CULVERT-no.46 SBL_sta 19+887.0_no.47 NBL_sta 19+893.4_1_GA.dwg dated March 2015

REVISIONS	DATE	BY	DESCRIPTION

Geocres No. 41H-147

HWY No 69			DIST 54
SUBM'D NA	CHECKED MK	DATE APR. 29, 2015	SITE C318
DRAWN NA	CHECKED GD	APPROVED BRG	DWG C46/C47-1

MINISTRY OF TRANSPORTATION, ONTARIO PR-D-707 88-05

APRIL 2015

DRAWING NAME: 09TF044 Culverts 46 n 47.dwg
CREATED: MAY 2014
MODIFIED:

Culvert C-48 at Sta. 20+226.0, SBL

Figure C48-PC-1: Plasticity Chart

Figure C48-GS-1: Results of Grain Size Distribution Analysis

Record of Borehole Sheets: C48-1, C48-2 and 115-10

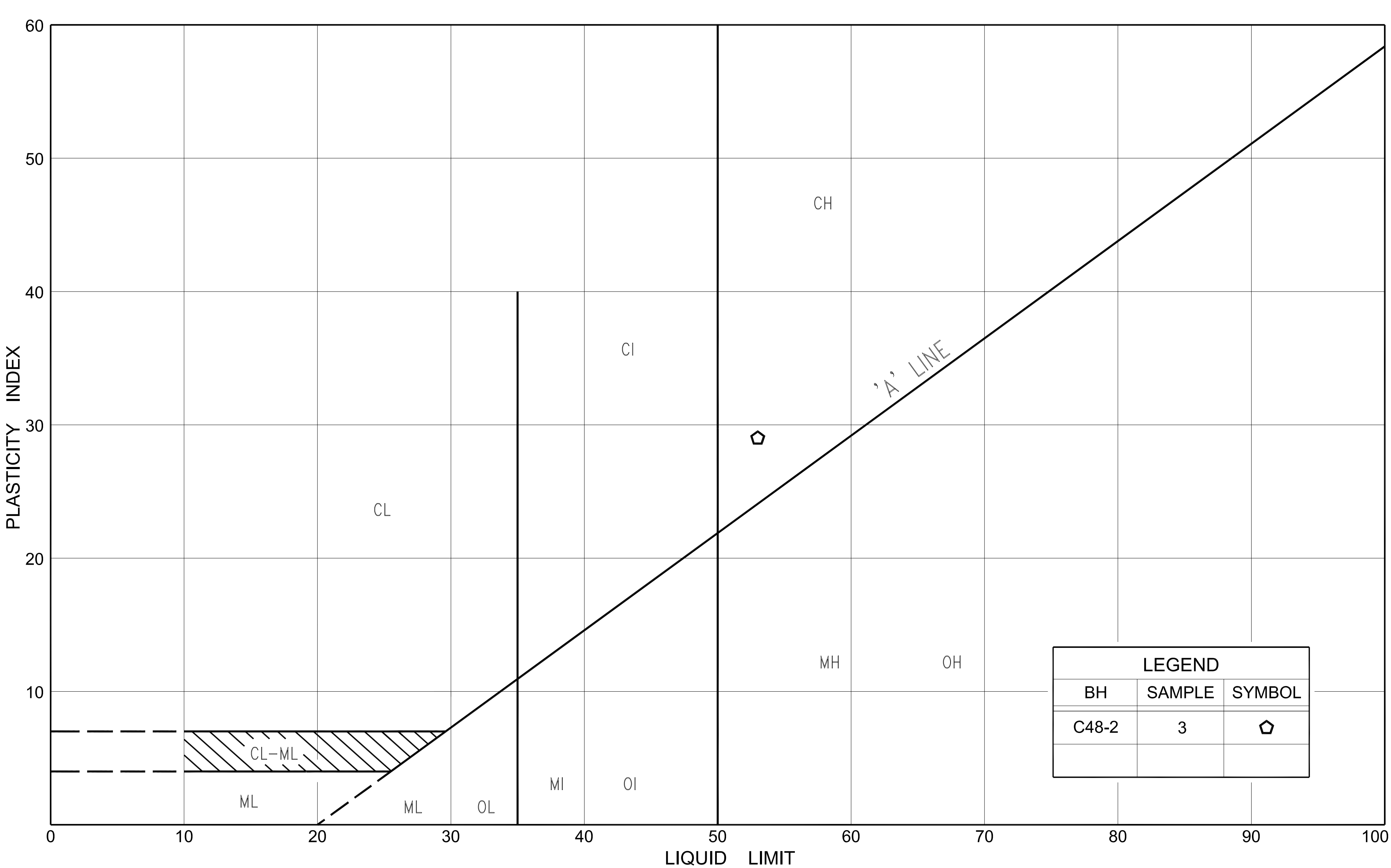
Culvert C-49 at Sta. 20+245.1, NBL

Figures C49-PC-1, C49-PC-2, 115-PC-1 and 115-PC-3: Plasticity Charts

Figures C49-GS-1, C49-GS-2, 115-GS-1 and 115-GS-3: Results of Grain Size Distribution Analyses

Record of Borehole Sheets: C49-1, C49-2 and 115-16

Drawing C48/C49-1: Borehole Locations and Soil Strata

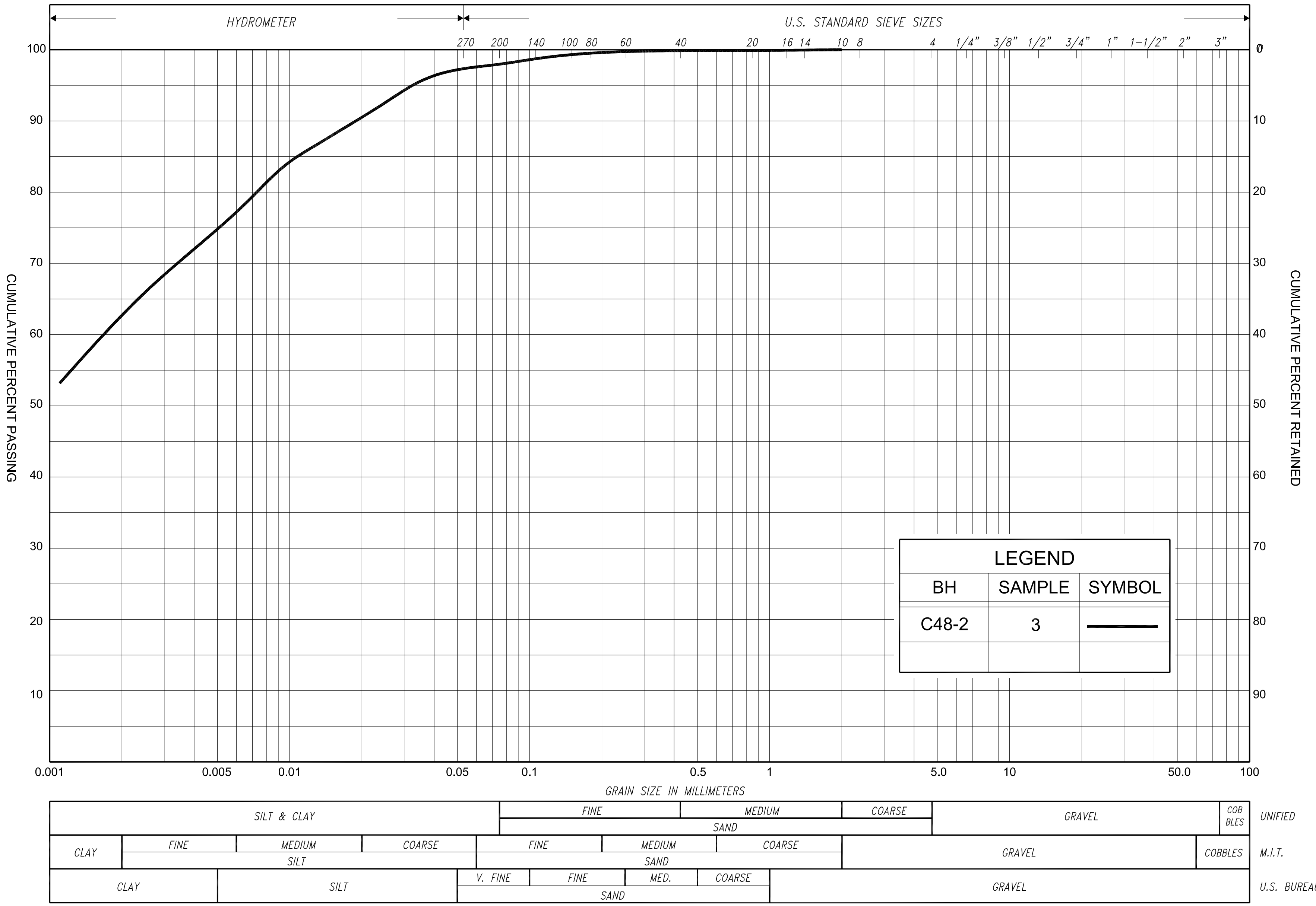


Ontario

PLASTICITY CHART

CLAY, trace sand

FIG No.	C48-PC-1
HWY:	69
G.W.P. No.	5112-07-00



Ontario

GRAIN SIZE DISTRIBUTION

CLAY, trace sand

FIG No.	C48-GS-1
HWY:	69
G.W.P. No.	5112-07-00

Ontario

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CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. C48-1

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 20+217, o/s 34.0m Lt. Coords: 5 069 625.5 N; 227 750.0 E **ORIGINATED BY** A.L.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** 'N' Casing **COMPILED BY** M.K.

DATUM Geodetic **DATE** February 26, 2014 **CHECKED BY** B.R.G.

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.8	Ground Surface										
194.6 / 0.2	Peat										
	Silty sand, organics		1	SS	2						
194.2 / 0.6	Very loose Grey Wet										
	End of borehole										
	Refusal on probable bedrock										
	* Borehole dry										
	NOTE: Auger probes were carried out at Sta. 20+217, o/s 36.0m Lt; Sta. 20+218, o/s 32.0m Lt. and Sta. 20+219, o/s 30.0m Lt. and refusal was met at 0.6m, 0.7 and 0.9m depth respectively										

ON MTO_VER3 NEW LOGO 09TF044.GPJ ON_MOT.GDT 7/9/2014 12:27:27 PM

$+^{7}$, $\times^{5}$: Numbers refer to Sensitivity

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

Ontario

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RECORD OF BOREHOLE No. C48-2

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 20+232, o/s 10.0m Lt. Coords: 5 069 639.7 N; 227 774.5 E **ORIGINATED BY** A.L.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** 'N' Casing + Wash Boring **COMPILED BY** M.K.

DATUM Geodetic **DATE** February 25, 2014 **CHECKED BY** B.R.G.

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
194.9	Ground Surface				*								
0.0	Peat												
194.8 0.1	Silty sand, organics Very loose to loose Grey Wet	1	SS	3									
194.0 0.9	Clay, trace sand Very stiff to firm Greyish brown Moist to wet	2	SS	9		194	125	○					
			FV				+6						
		3	SS	13		193	125	⊢○⊣		0	2	35	63
		4	SS	4			■	○					
			FV			192	+4						
191.7 3.2	End of borehole Refusal on probable bedrock												

* Borehole dry

■ Penetrometer test

Legend: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L

+7, ×5 : Numbers refer to Sensitivity

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

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. 115-10

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 20+225, 19.0 Lt. Coords: 5 069 633.0 N; 227 765.5 E **ORIGINATED BY** F.P.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Tripod and 'N' Casing **COMPILED BY** G.D.

DATUM Geodetic **DATE** January 28, 2013 **CHECKED BY** B.R.G.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	NATURAL MOISTURE CONTENT w (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
195.3	Top of Ice									
0.0	Ice					▽* ▼*	195			
194.7 / 0.6	Water									
194.4 / 0.9	Organic silty sand Very loose Dark grey Wet		1	SS	WH**			~28		
193.6 / 1.7	Silty clay, trace sand organics Firm Mottled brown/grey Moist						194			
193.3 / 2.0	Sand, trace gravel Loose to compact Brown Wet		2	SS	16/28cm			~20		
	End of borehole									
	Refusal on probable bedrock									
	Sample 2: Sampler bouncing									

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

* 2013 01 28

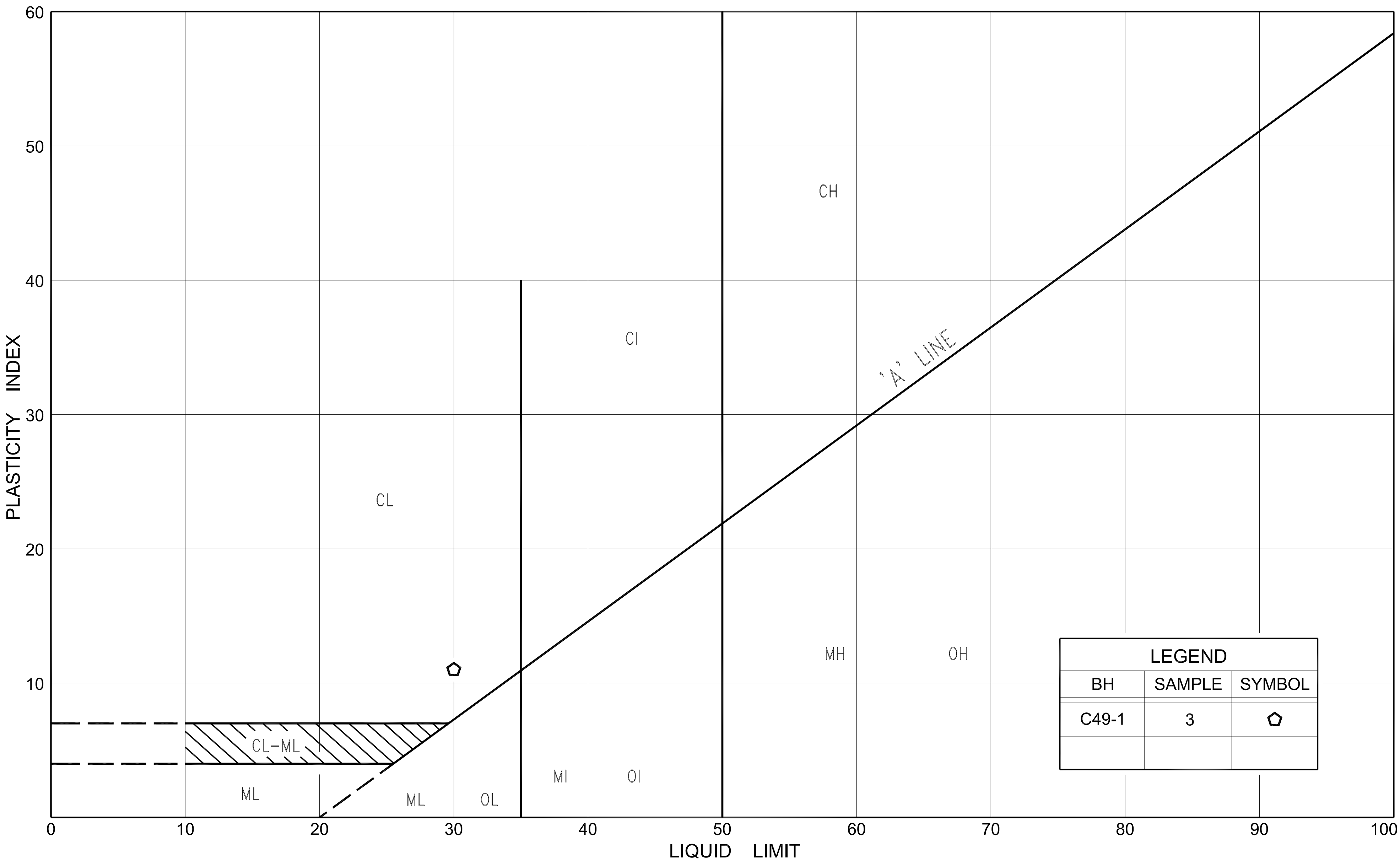
▽ Water level observed during drilling

▼ Water level measured after drilling

WH** denotes penetration due to weight of rods and hammer

+7, ×5 : Numbers refer to Sensitivity

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



LEGEND

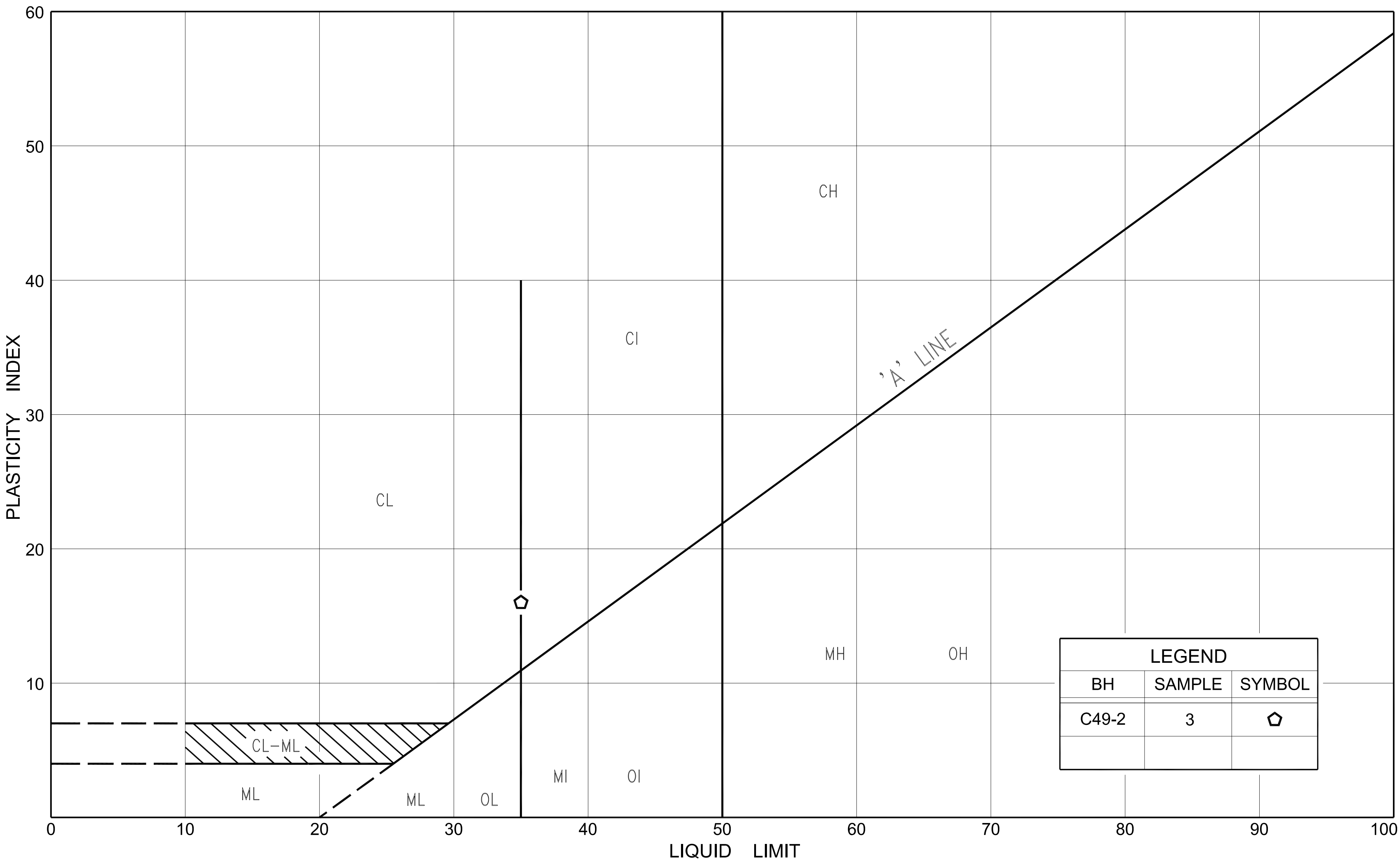
BH	SAMPLE	SYMBOL
C49-1	3	⬠

Ontario

PLASTICITY CHART

CLAYEY SILT, trace sand

FIG No.	C49-PC-1
HWY:	69
G.W.P. No.	5112-07-00

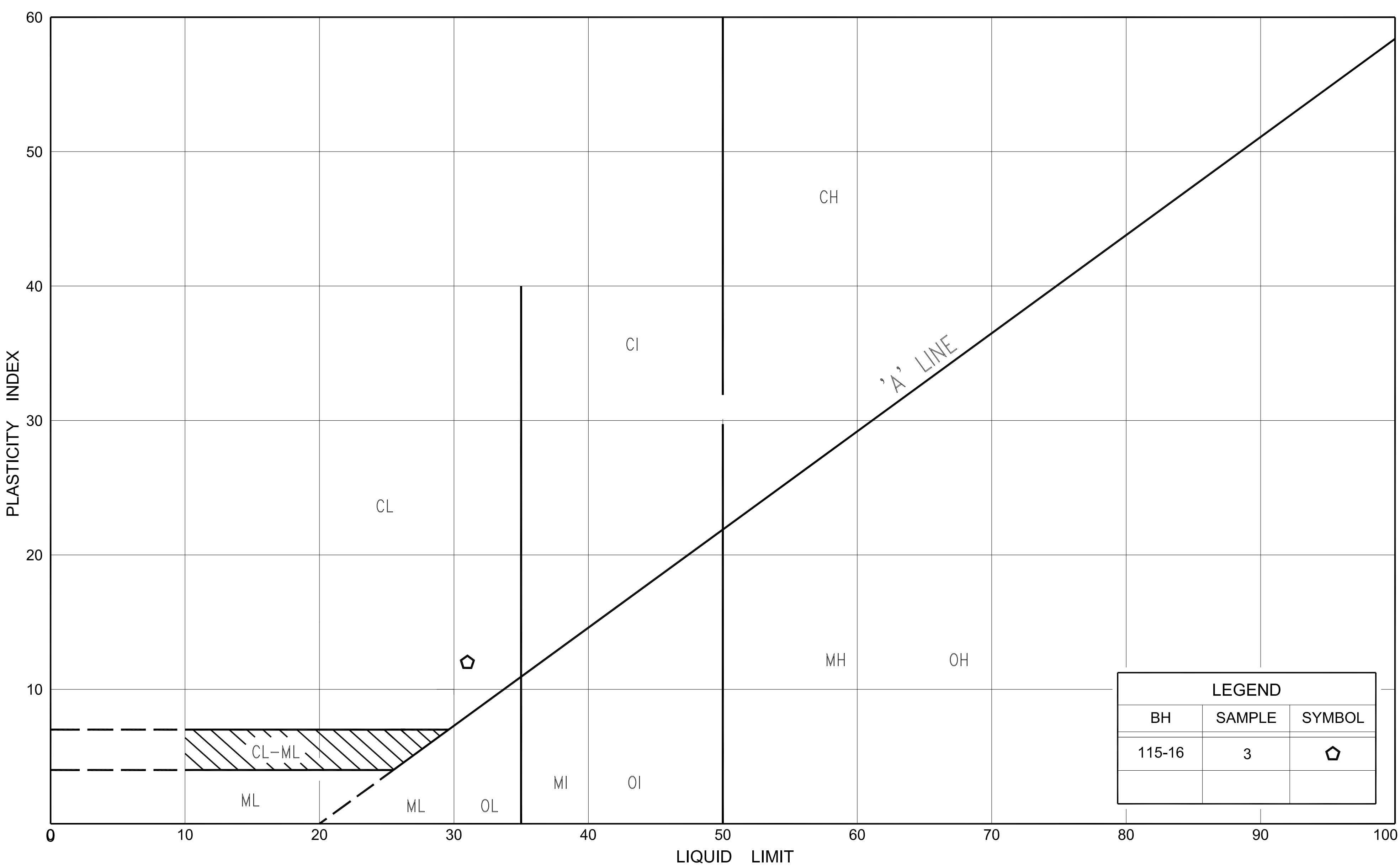


Ontario

PLASTICITY CHART

SILTY CLAY, trace sand

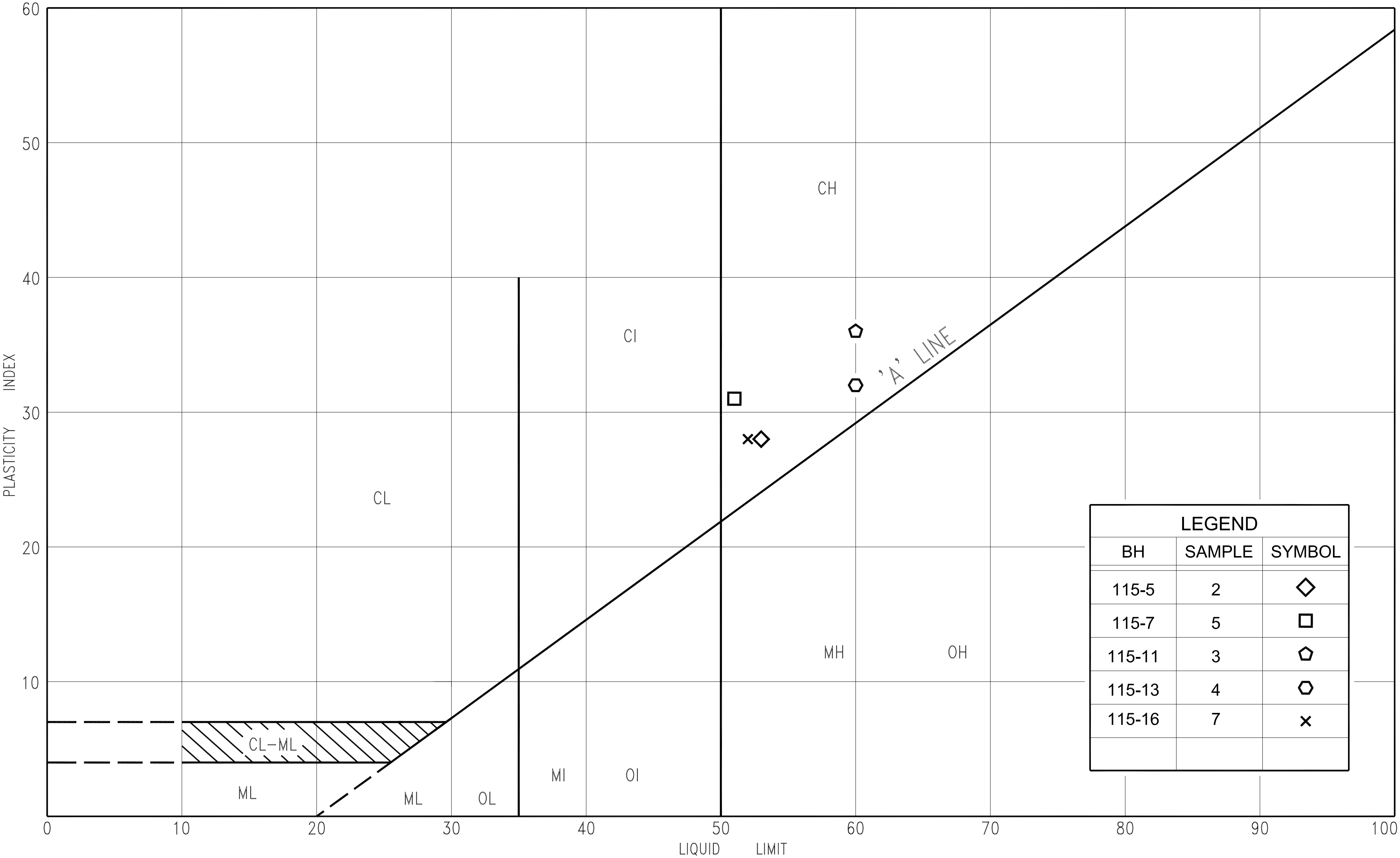
FIG No.	C49-PC-2
HWY:	69
G.W.P. No.	5112-07-00



PLASTICITY CHART

CLAYEY SILT, trace sand

FIG No.	115-PC-1
HWY:	69
G.W.P. No.	5112-07-00



LEGEND

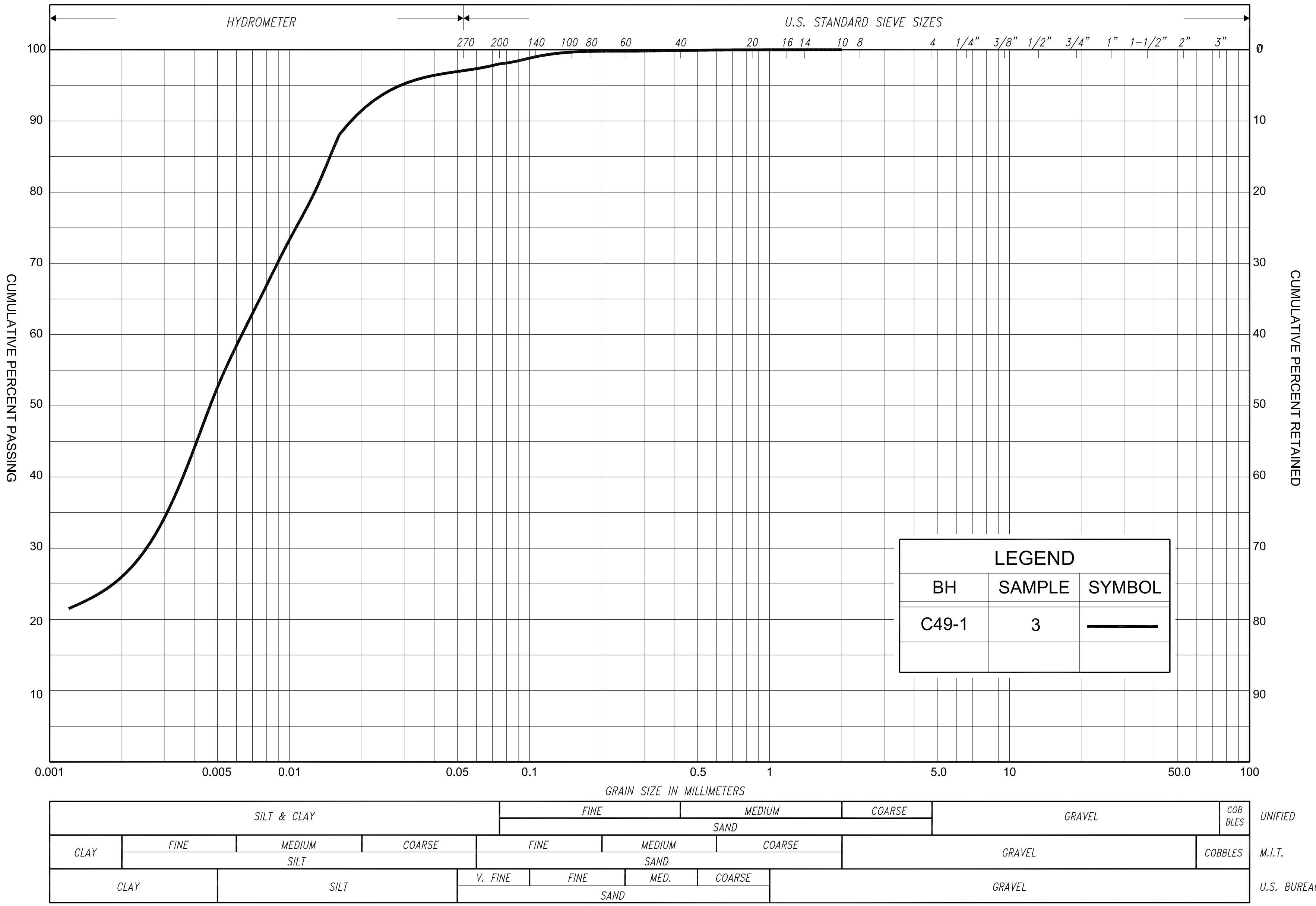
BH	SAMPLE	SYMBOL
115-5	2	◇
115-7	5	□
115-11	3	⬠
115-13	4	⬡
115-16	7	×

Ontario

PLASTICITY CHART

CLAY, trace sand

FIG No.	115-PC-3
HWY:	69
G.W.P. No.	5112-07-00

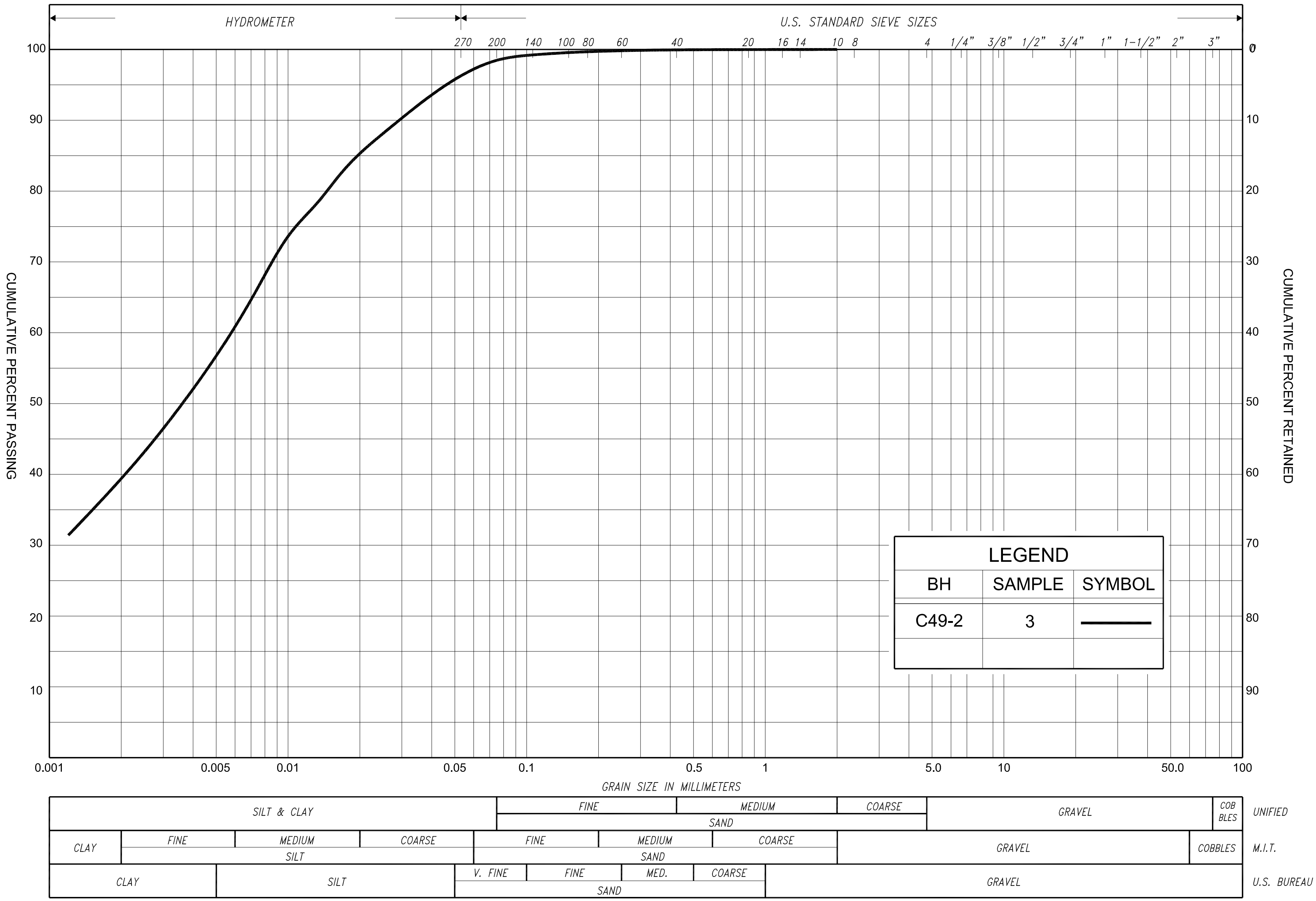


Ontario

GRAIN SIZE DISTRIBUTION

CLAYEY SILT, trace sand

FIG No.	C49-GS-1
HWY:	69
G.W.P. No.	5112-07-00

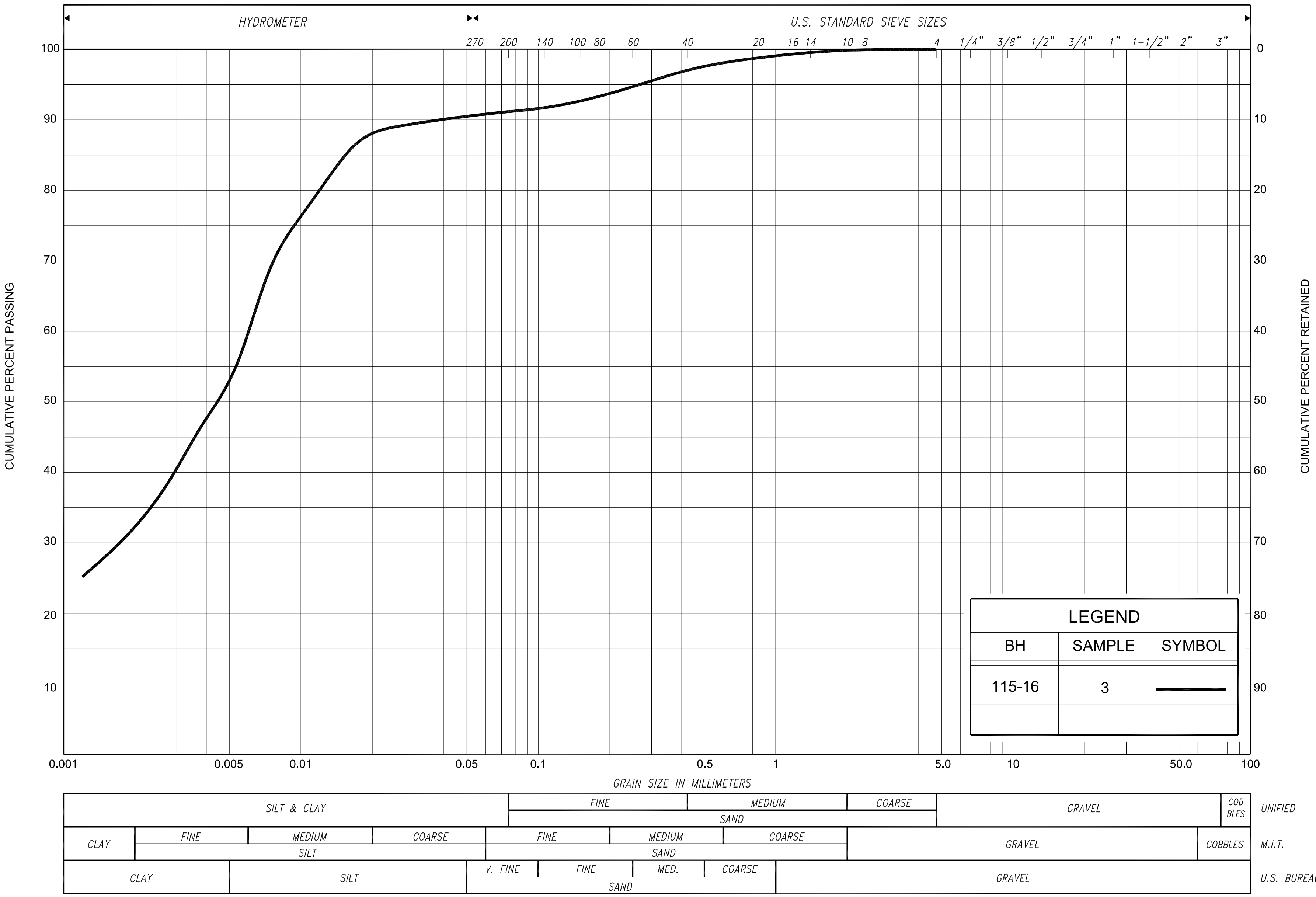


Ontario

GRAIN SIZE DISTRIBUTION

SILTY CLAY, trace sand

FIG No.	C49-GS-2
HWY:	69
G.W.P. No.	5112-07-00

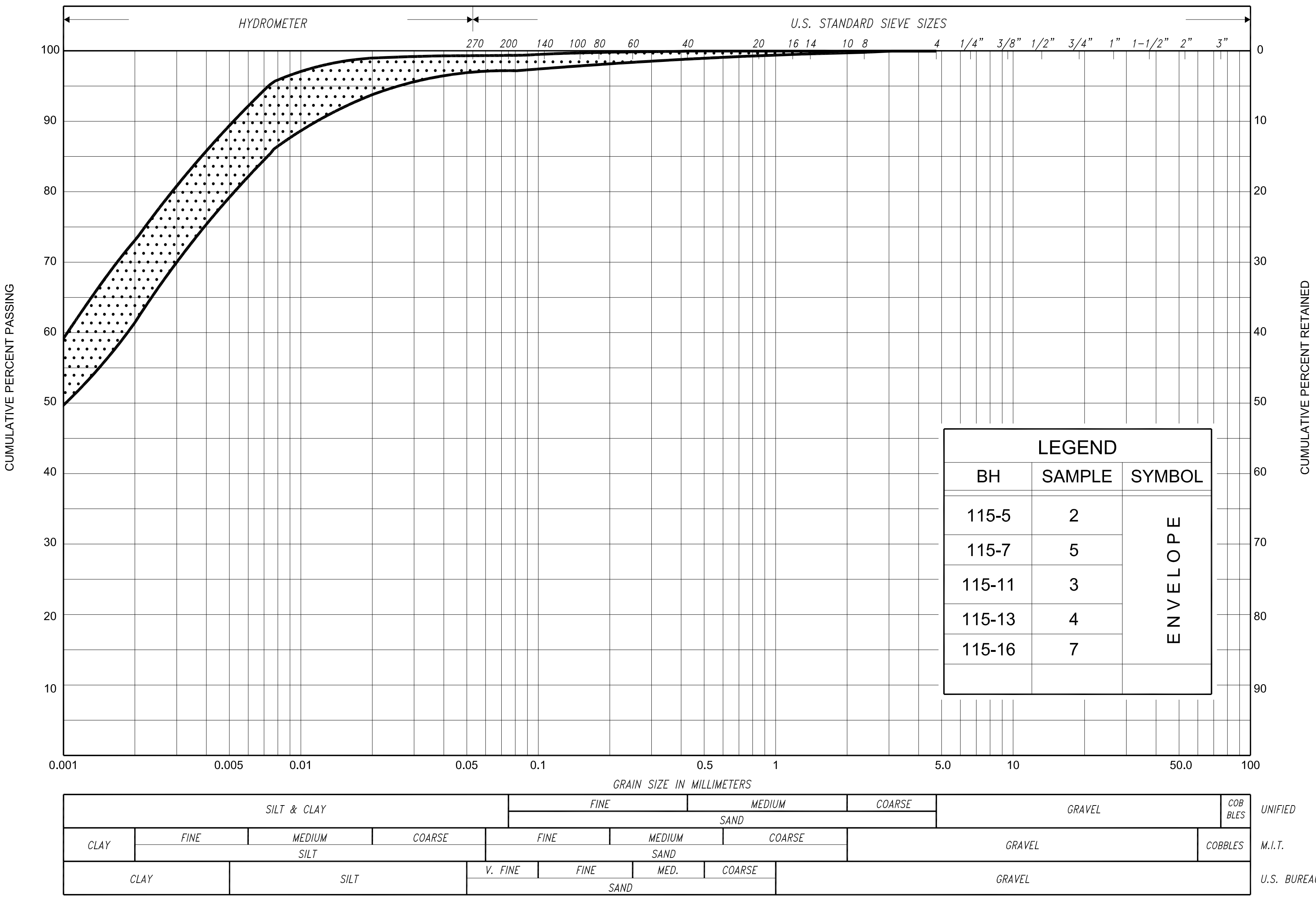


Ontario

GRAIN SIZE DISTRIBUTION

CLAYEY SILT, trace sand

FIG No.	115-GS-1
HWY:	69
G.W.P. No.	5112-07-00



Ontario

GRAIN SIZE DISTRIBUTION

CLAY, trace sand

FIG No.	115-GS-3
HWY:	69
G.W.P. No.	5112-07-00

Ontario

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RECORD OF BOREHOLE No. C49-1

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 20+239, o/s 10.0m Rt. Coords: 5 069 646.0 N; 227 794.7 E **ORIGINATED BY** A.L.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** 'N' Casing + Wash Boring **COMPILED BY** M.K.

DATUM Geodetic **DATE** February 24 and 25, 2014 **CHECKED BY** B.R.G.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.7	Top of Snow/Ice				*		
0.0	Snow / Ice						
194.2 / 0.5	Peat					194	
194.1 / 0.6	Silty sand, organics; Loose, Grey, Wet	1	SS	5			
193.5 / 1.2	Clayey silt, trace sand; Very stiff to firm, Greyish brown, Moist to wet	2	SS	5			
			FV			193	
		3	SS	11		192	0 2 72 26
			FV				
191.2 / 3.5	Silty clay, trace sand; Firm, Grey, Moist to wet					191	
		4	SS	3			
			FV			190	
		5	SS	4		189	
			FV				
						188	
		6	SS	52/13cm			
187.4 / 7.3	End of borehole Refusal on probable bedrock Sample 6: Sampler bouncing						

Plot values (Shear strength, kPa / Water content, %): Sample 2 penetrometer ■ ≈100 kPa, water content ≈38%; Field vane at 193.0 ≈ 75 kPa, sensitivity 3; Penetrometer at 192.0: 125; Sample 3 water content ≈ 35% (w_P ≈ 29); Field vane at 191.6 ≈ 22 kPa, sensitivity 3; Sample 4 water content ≈ 40%; Field vane at 190.1 ≈ 22 kPa, sensitivity 3; Sample 5 water content ≈ 41%; Field vane at 188.8 ≈ 30 kPa, sensitivity 4; Sample 6 water content ≈ 56%.

* Borehole dry

■ Penetrometer test

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100
PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ kN/m³

+7, ×5: Numbers refer to Sensitivity

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

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RECORD OF BOREHOLE No. C49-2

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 20+257, o/s 41.0m Rt. Coords: 5 069 663.0 N; 227 826.3 E **ORIGINATED BY** A.L.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** 'N' Casing + Wash Boring + Dynamic Cone Penetration Test **COMPILED BY** M.K.

DATUM Geodetic **DATE** February 26 and 27, 2014 **CHECKED BY** B.R.G.

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%) (w_P – w – w_L)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.6	Ground Surface				*					
194.4 / 0.2	Peat									
194.3 / 0.3	Silty sand, organics / Loose Grey Wet	1	SS	2		194				
	Clayey silt, trace sand / Very stiff to stiff Mottled brown/grey Moist	2	SS	7			■ 125			
			FV			193	+ 10			
192.4 / 2.2	Silty clay, trace sand / Firm to soft Grey Wet	3	SS	6		192	■			0 2 59 39
			FV				+ 3			
		4	SS	2		191				
			FV				+ 3			
190.1 / 4.5	End of dynamic cone penetration test					190	50/15cm			
189.5 / 5.1	End of borehole / Refusal on probable bedrock	6	SS	46						

* Borehole dry

■ Penetrometer test

$+^7$, $\times^5$: Numbers refer to Sensitivity

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

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RECORD OF BOREHOLE No. 115-16

METRIC

G.W.P. 5112-07-00	**LOCATION** Hwy 69, Sta. 20+250, o/s 18.8 m Rt. Coords: 5 069 656.7 N; 227 803.8 E		**ORIGINATED BY** F.P.
DIST Parry Sound	**HWY** 69	**BOREHOLE TYPE** Tripod and 'N' Casing	**COMPILED BY** G.D.
DATUM Geodetic	**DATE** January 24 and 25, 2013		**CHECKED BY** B.R.G.

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.7	Top of Ice				
0.0	Ice / Water				
193.7 / 1.0	Peat, amorphous, Dark brown	1	SS	1	
193.3 / 1.4	Organic clayey silt, Firm, Mottled brown/grey, Moist	2	SS	2	
192.5 / 2.2	Clayey silt, trace sand, Very stiff to stiff, Mottled brown/grey, Moist	3	SS	6	0 9 59 32
			FV		
		4	SS	7	
			FV		
190.4 / 4.3	Clay, trace sand, Firm to soft, Grey, Moist to wet	5	SS	2	
			FV		
		6	SS	1	
			FV		
	Brown	7	SS	1	0 1 28 71
			FV		
186.2 / 8.5	Sand, trace gravel, Compact, Grey, Wet	8	SS	50/8cm	
185.9 / 8.8	End of borehole				

GROUND WATER CONDITIONS: ▽* ▼*

ELEVATION SCALE: 194, 193, 192, 191, 190, 189, 188, 187, 186

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

Plotted values: 162, 26, 125, 26, 4, 13, 8

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; 85

UNIT WEIGHT γ kN/m³

End of borehole

Refusal on probable bedrock

Sample 8: Sampler bouncing

* 2013 01 24 & 25

▽ Water level observed during drilling

▼ Water level measured after drilling

■ Penetrometer test

+7, ×5 : Numbers refer to Sensitivity

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

CONT No GWP No 5112-07-00	SHEET

CULVERTS C-48 AND C-49

HIGHWAY 69 FOUR-LANING

BOREHOLE LOCATIONS AND SOIL STRATA

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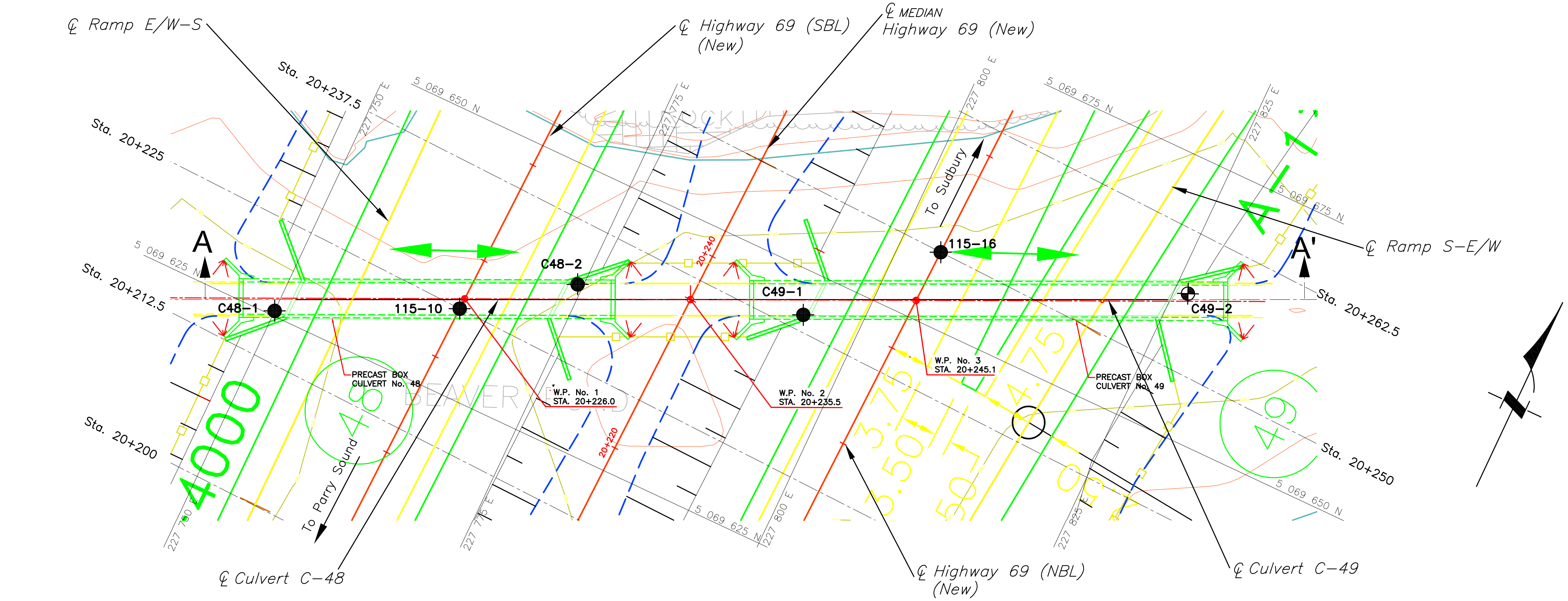
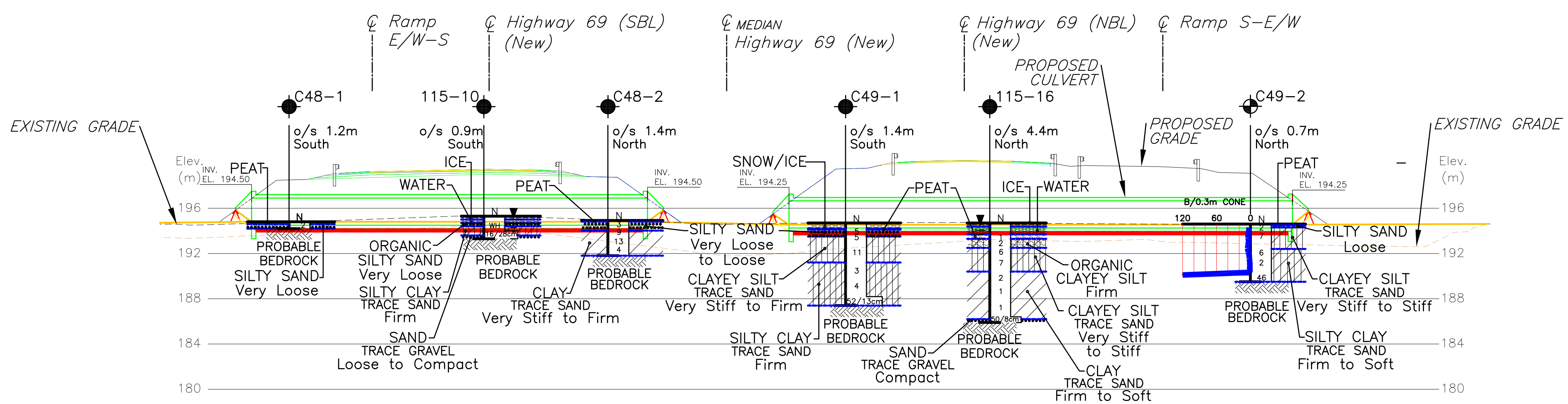


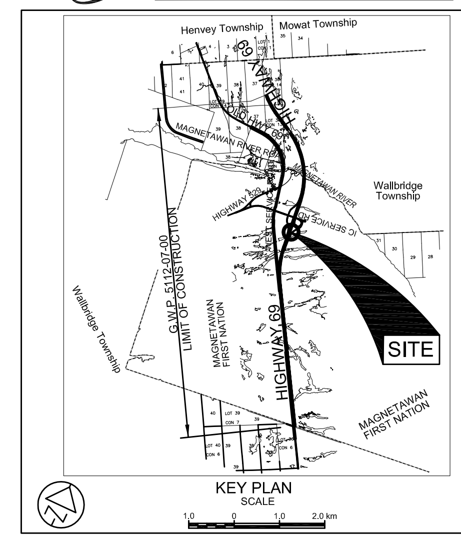
PLAN

SCALE 5 0 5 10m



PROFILE A-A' ALONG CENTRELINES OF CULVERTS C-48 AT STA. 20+226.0 AND C-49 AT STA. 20+245.1

SCALE 5 0 5 10m



KEY PLAN

SCALE 1.0 0 1.0 2.0 km

LEGEND

- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & Cone
- N — Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE — Blows/0.3m (60°Cone, 475 J/blow)
- WH — Penetration due to weight of rods and hammer
- WL at time of investigation Jan. 2013 and Feb, 2014
- Water level not established
- Head
- ARTESIAN WATER Encountered
- PIEZOMETER

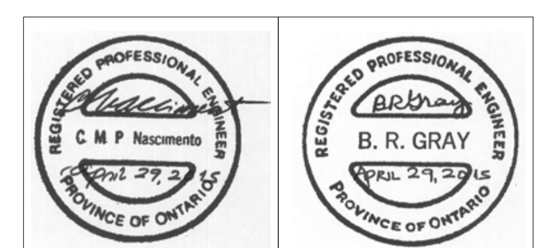
BH No	ELEVATION	COORDINATES NORTHINGS	COORDINATES EASTINGS
C48-1	194.8	5 069 625.5	227 750.0
C48-2	194.9	5 069 639.7	227 774.5
C49-1	194.7	5 069 646.0	227 794.7
C49-2	194.6	5 069 663.0	227 826.3
115-10	195.3	5 069 633.0	227 765.5
115-16	194.7	5 069 656.7	227 803.8

– NOTE –

The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.



Reference AECOM Drawing: 60143751-BOX CULVERT_no.48 SBL_sta.20+226.0_no.49 NBL_sta 20+245.1_1_GA.dwg dated March 2015

REVISIONS	DATE	BY	DESCRIPTION

Geocres No. 41H-147

HWY No 69				DIST 54
SUBM'D NA	CHECKED MK	DATE APR. 29, 2015		SITE C319
DRAWN NA	CHECKED GD	APPROVED BRG		DWG C48/C49-1

DRAWING NAME: 09TF044 Culverts 48 n 49.dwg
CREATED: APRIL 2014 MODIFIED: APRIL 2015

MINISTRY OF TRANSPORTATION, ONTARIO PR-D-707 88-05

Culvert C-51 at Sta. 20+935.5, NBL

Figure C51-PC-1: Plasticity Chart

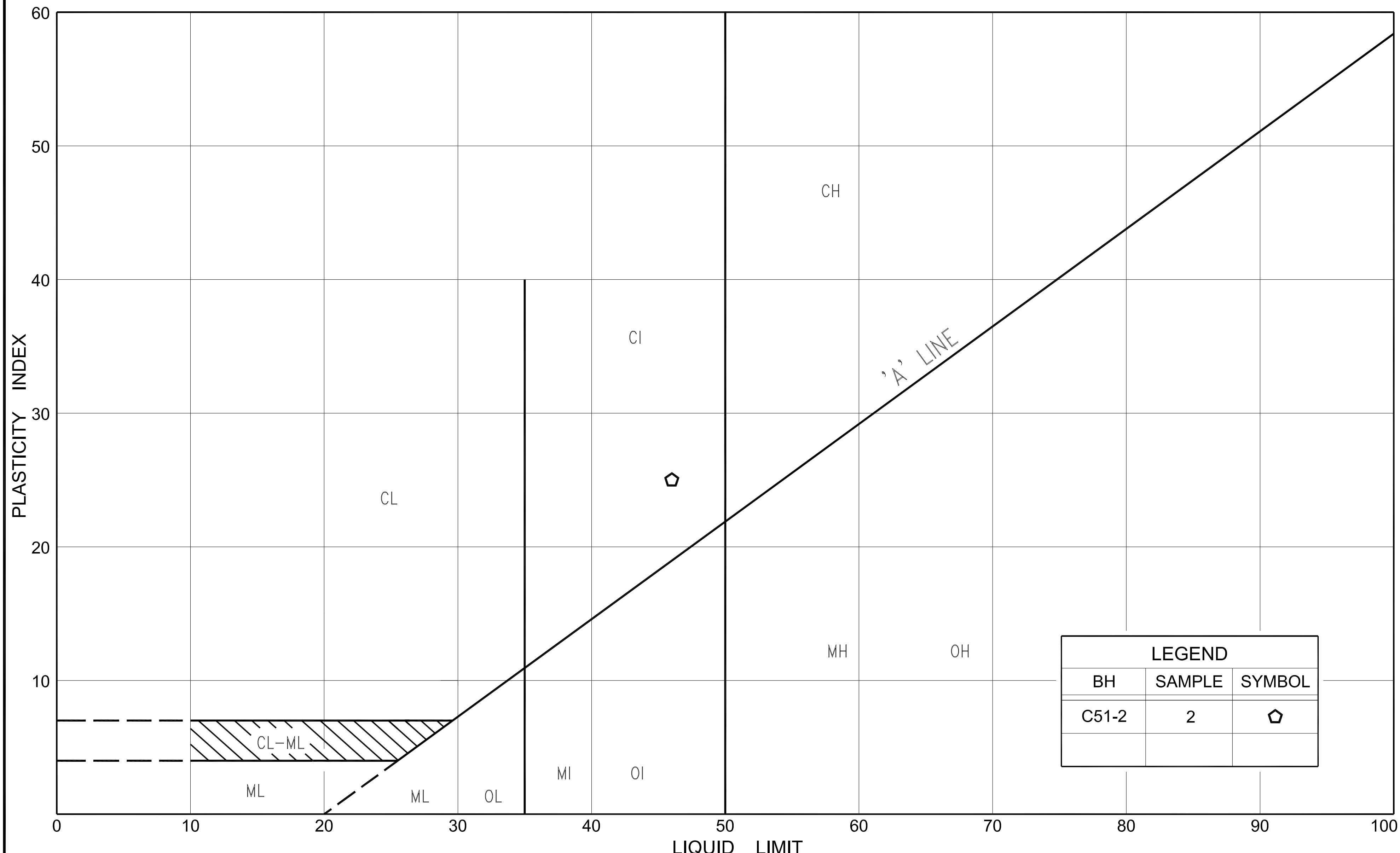
Figures C51-GS-1 and C51-GS-2: Results of Grain Size Distribution Analyses

Record of Borehole Sheets: C51-1, C51-2, C51-3 and 116-22

Culvert C-52 at Sta. 20+935.5, SBL

Record of Borehole Sheets: C52-1, C52-2 and 116-21

Drawing C51/C52-1: Borehole Locations and Soil Strata

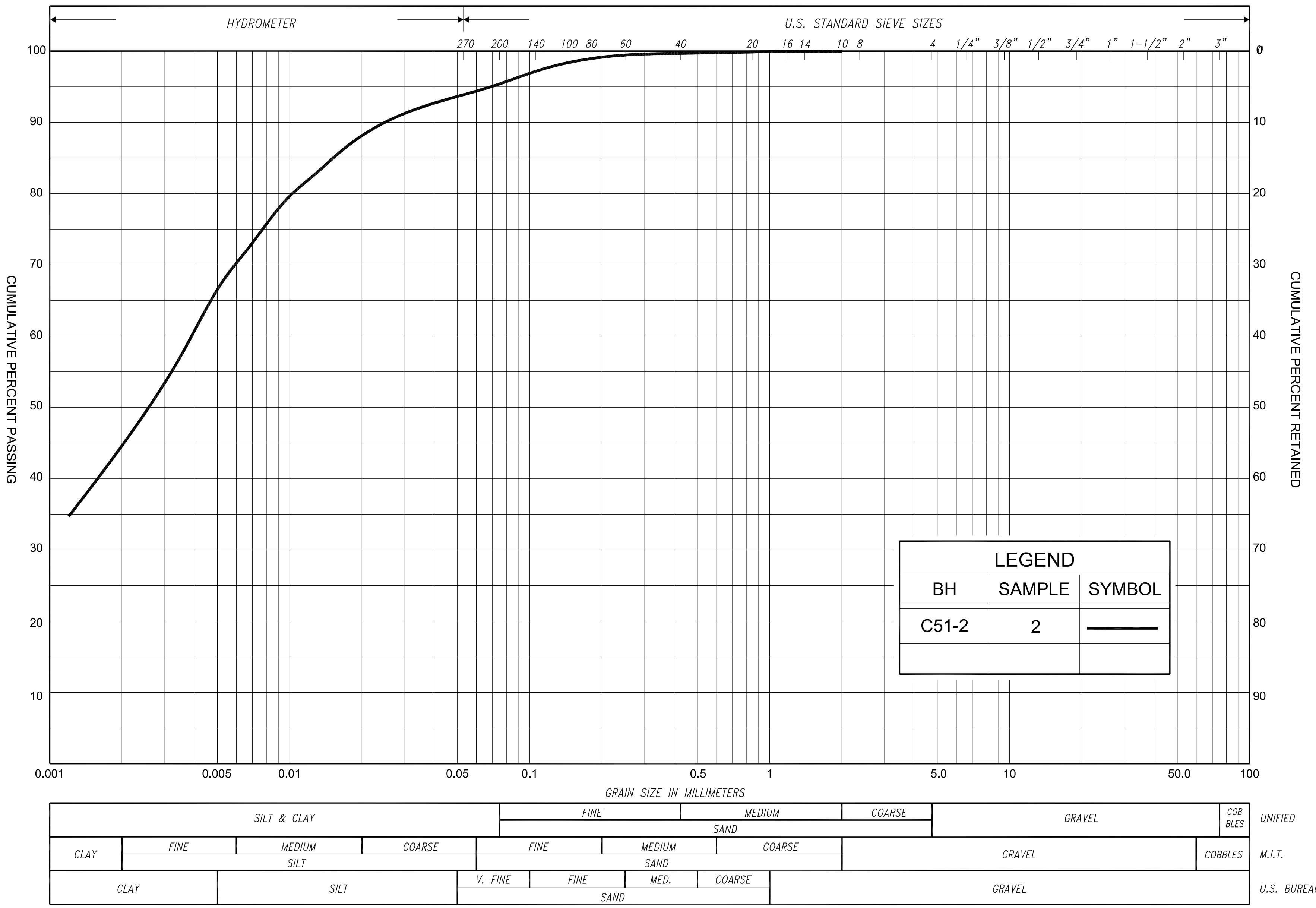


PLASTICITY CHART

SILTY CLAY, trace sand

Ontario

FIG No.	C51-PC-1
HWY:	69
G.W.P. No.	5112-07-00



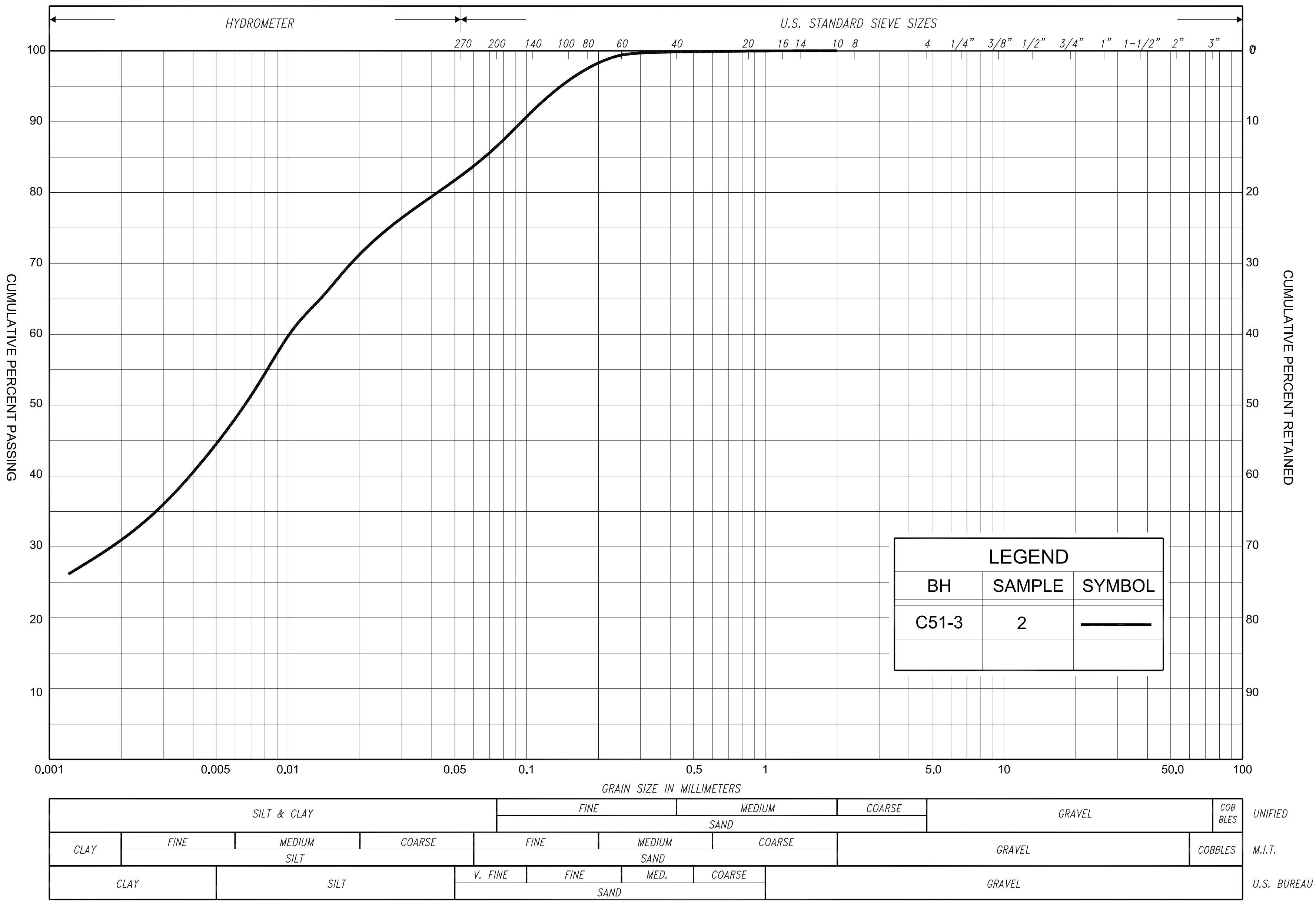
LEGEND		
BH	SAMPLE	SYMBOL
C51-2	2	———

Ontario

GRAIN SIZE DISTRIBUTION

SILTY CLAY, trace sand

FIG No.	C51-GS-1
HWY:	69
G.W.P. No.	5112-07-00



Ontario

GRAIN SIZE DISTRIBUTION

CLAYEY SILT, some sand

FIG No.	C51-GS-2
HWY:	69
G.W.P. No.	5112-07-00

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RECORD OF BOREHOLE No. C51-1

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 20+936, o/s 10.0m Rt. Coords: 5 070 342.6 N; 227 817.7 E **ORIGINATED BY** F.P.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Tripod **COMPILED BY** G.D.

DATUM Geodetic **DATE** October 17, 2013 **CHECKED BY** B.R.G.

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.2	Ground Surface					*					
0.0 192.9 0.3	Peat, amorphous Dark brown						193				
192.4 0.8	Silty sand, organics Brown										
192.0 1.2	Silty clay, trace sand Brown						192				
	End of borehole Refusal on probable bedrock										

* Borehole dry

$+^{7}$, $\times^{5}$: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No. C51-2

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 20+936, o/s 14.0m Rt. Coords: 5 070 342.5 N; 227 821.7 E **ORIGINATED BY** F.P.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Continuous Flight Solid Stem Augers **COMPILED BY** G.D.

DATUM Geodetic **DATE** July 31, 2013 **CHECKED BY** B.R.G.

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
193.1	Ground Surface												
192.9 0.2	Peat, fine fibrous Dark brown				▽* ▼*	193							
192.5 0.6	Sand, trace silt organics Very loose Grey Wet	1	SS	WH**									
191.6 1.5	Silty clay, trace sand Firm to very stiff Grey Moist	2	SS	9		192				0	4	51	45
			FV				+2						
	End of borehole Refusal on probable bedrock												

* 2013 07 31

▽ Water level observed during drilling

▼ Water level measured after drilling

WH** denotes penetration due to weight of rods and hammer

Legend: PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE

+7, ×5 : Numbers refer to Sensitivity

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

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RECORD OF BOREHOLE No. C51-3

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 20+936, o/s 27.0m Rt. Coords: 5 070 342.1 N; 227 834.6 E **ORIGINATED BY** F.P.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Tripod + Hilti **COMPILED BY** G.D.

DATUM Geodetic **DATE** October 17 and 18, 2013 **CHECKED BY** B.R.G.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
192.9	Ground Surface				*		
0.0	Peat, fine fibrous Dark brown	1	SS	2			
192.6 / 0.3	Silty sand, organics Very loose Grey Wet to loose					192	
192.1 / 0.8	Clayey silt, some sand Stiff Grey Moist to wet	2	SS	13			0 13 56 31
		3	SS	7		191	
190.8 / 2.1	Granitic Gneiss bedrock Slightly weathered to moderately weathered High strength Good to excellent quality	4	RC	REC 100%			RQD 100%
		5	RC	REC 100%			RQD 100%
		6	RC	REC 100%		190	RQD 90%
		7	RC	REC 96%			RQD 88%
		8	RC	REC 97%		189	RQD 79%
		9	RC	REC 100%		188	RQD 80%
		10	RC	REC 96%			RQD 75%
187.3 / 5.6	End of borehole						

* Borehole charged with drilling water

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

+7, ×5 : Numbers refer to Sensitivity

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

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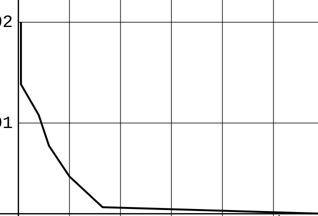
RECORD OF DYNAMIC CONE No. 116-22 METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 20+937.5, o/s 42.0 m Rt. Coords: 5 070 343.1 N; 227 849.7 E **ORIGINATED BY** A.L.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Dynamic Cone Penetration Test **COMPILED BY** G.D.

DATUM Geodetic **DATE** February 24, 2013 **CHECKED BY** B.R.G.

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	STRAT PLOT	SAMPLES – NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L – WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
192.3	Top of Snow/Ice										
0.0	Snow/Ice						192				
	Probable peat										
	Probable organic sand Loose to compact						191				
190.1 2.2	End of dynamic cone penetration test Refusal on probable bedrock							120/10cm			



$+^7$, $\times^5$: Numbers refer to Sensitivity

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

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RECORD OF BOREHOLE No. C52-1

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 20+935, o/s 29.0m Lt. Coords: 5 070 342.9 N; 227 778.6 E **ORIGINATED BY** A.L.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Hilti **COMPILED BY** G.D.

DATUM Geodetic **DATE** October 21 and 22, 2013 **CHECKED BY** B.R.G.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%)
193.6	Ground Surface				*		
193.5 0.1	Topsoil						
193.2 0.4	Silty sand, organics Brown Moist	1	AS	-			
	Granitic Gneiss bedrock	2	RC	REC 100%		193	RQD 60%
	Slightly weathered to moderately weathered	3	RC	REC 100%			RQD 70%
	High strength	4	RC	REC 100%		192	RQD 94%
	Fair becoming good to excellent quality	5	RC	REC 100%		191	RQD 80%
		6	RC	REC 100%		190	RQD 100%
189.9 3.7	End of borehole						

Column headings also include: SOIL PROFILE; SAMPLES; STRAT PLOT; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; GR SA SI CL

* Borehole charged with drilling water

+7, ×5 : Numbers refer to Sensitivity

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

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RECORD OF BOREHOLE No. C52-2

METRIC

G.W.P. 5112-07-00	**LOCATION** Hwy 69, Sta. 20+935, o/s 14.0m Lt. Coords: 5 070 342.4 N; 227 793.6 E		**ORIGINATED BY** F.P.
DIST Parry Sound **HWY** 69	**BOREHOLE TYPE** Manual Probing		**COMPILED BY** G.D.
DATUM Geodetic	**DATE** July 31, 2013		**CHECKED BY** B.R.G.

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER (SAMPLES)	TYPE	"N" VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.7	Ground Surface										
193.6 0.1	Topsoil										
193.3 0.4	Silty sand Brown Moist		1	BS	-						
	End of borehole Refusal on probable bedrock										

* Borehole dry

$+^7$, $\times^5$: Numbers refer to Sensitivity

20
15 —○— 5 (%) STRAIN AT FAILURE
10

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RECORD OF BOREHOLE No. 116-21

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 20+937.5 CL Coords: 5 070 344.5 N; 227 807.7 E **ORIGINATED BY** A.L.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Continuous Flight Hollow Stem Augers **COMPILED BY** G.D.

DATUM Geodetic **DATE** February 07, 2013 **CHECKED BY** B.R.G.

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.5	Ground Surface					*					
193.4 / 0.1	Topsoil										
	Organic sand, trace silt; Very loose to loose, Dark brown, Moist to wet		1	SS	2		193		○ (approx. 35)		
192.7 / 0.8	Clayey silt, trace sand; Stiff, Greyish brown, Moist		2	SS	50/5cm			■ (approx. 75)			
192.5 / 1.0	End of borehole; Refusal on probable bedrock										

* Borehole dry

■ Penetrometer test

Legend: SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE. PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L.

$+^7$, $\times^5$: Numbers refer to Sensitivity

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

CONT No
GWP No 5112-07-00

CULVERTS C-51 AND C-52

HIGHWAY 69 FOUR-LANING

BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

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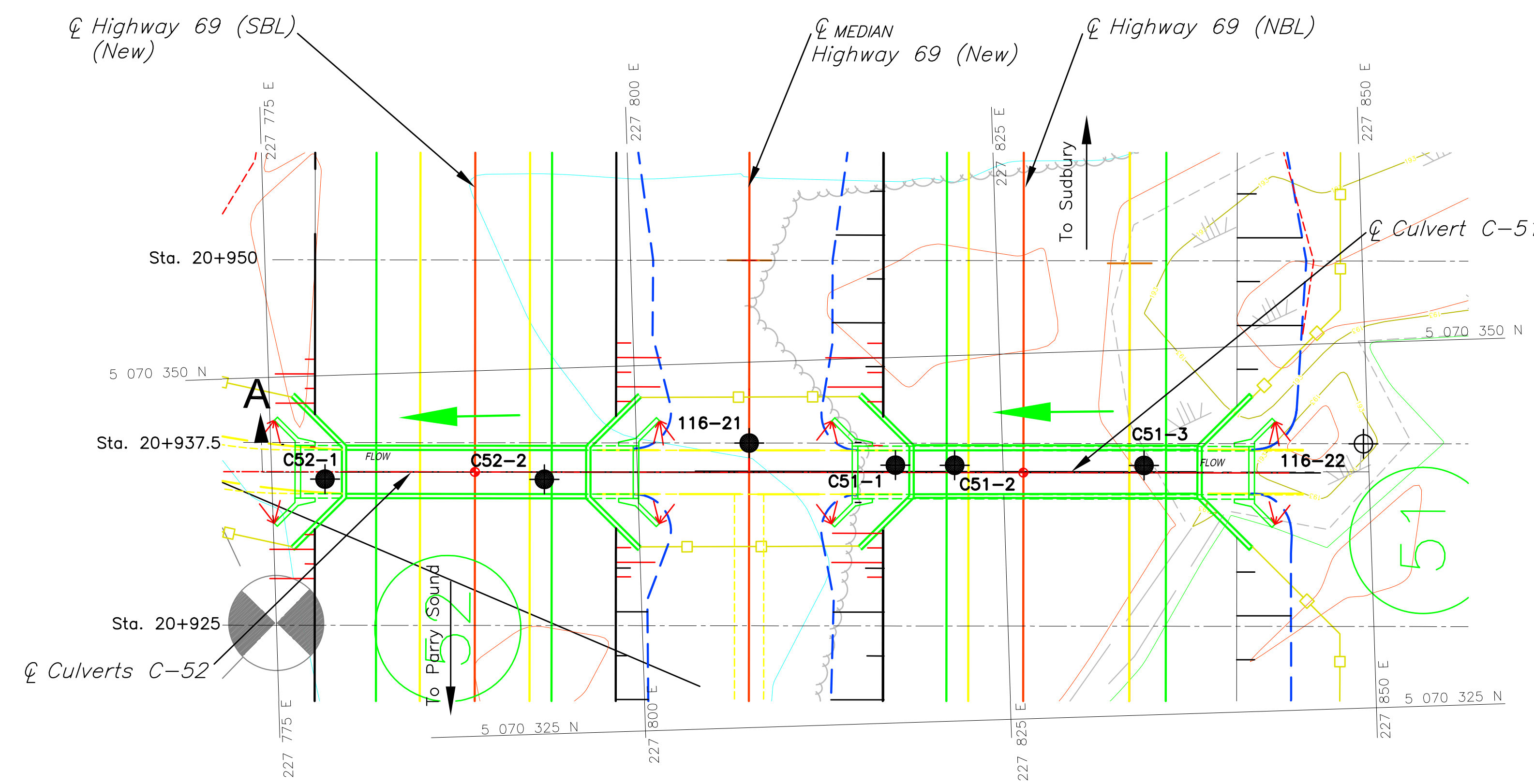
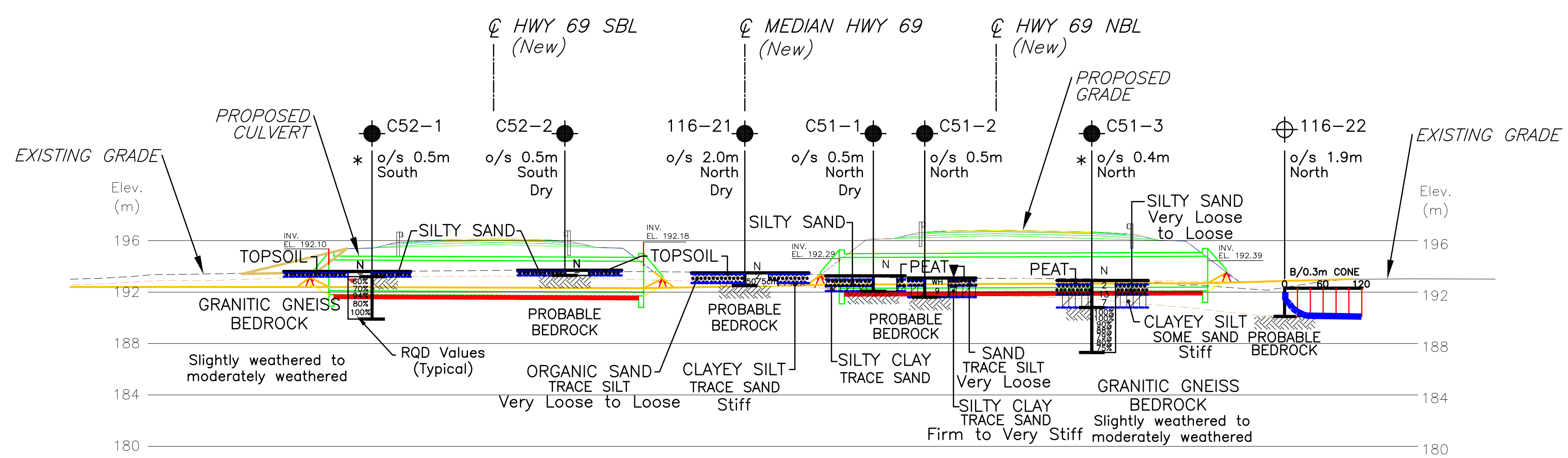


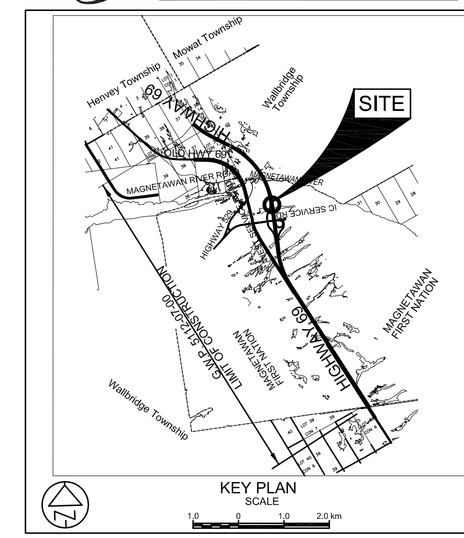
PLAN

SCALE 5 0 5 10m



PROFILE A-A' ALONG CENTRELINES OF CULVERTS C-51 AND C-52 AT STA. 20+935.5

SCALE 5 0 5 10m

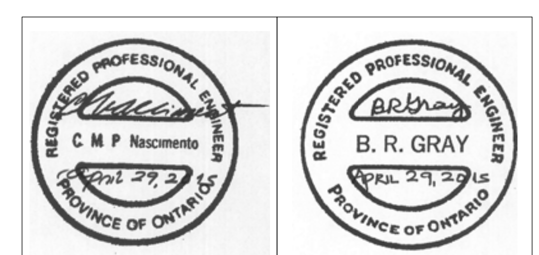


KEY PLAN

LEGEND

- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & Cone
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60°Cone, 475 J/blow)
- WH Penetration due to weight of rods and hammer
- WL at time of investigation July and Oct. 2013
- * Water level not established
- Head
- ARTESIAN WATER Encountered
- PIEZOMETER

BH No	ELEVATION	COORDINATES NORTHINGS	EASTINGS
C51-1	193.2	5 070 342.6	227 817.7
C51-2	193.1	5 070 342.5	227 821.7
C51-3	192.9	5 070 342.1	227 834.6
C52-1	193.6	5 070 342.9	227 778.6
C52-2	193.7	5 070 342.4	227 793.6
116-21	193.5	5 070 344.5	227 807.7
116-22	192.3	5 070 343.1	227 849.7



Reference AECOM Drawing: 60143751-BOX CULVERT_no.51 SBL_sta 20+935.5_no.52 NBL_sta 20+935.5_1_GA.dwg dated March 2015

– NOTE –
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS DATE	BY	DESCRIPTION

Geocres No. 41H-147

HWY No 69			DIST 54
SUBM'D NA	CHECKED MK	DATE APR. 29, 2015	SITE C321
DRAWN NA	CHECKED GD	APPROVED BRG	DWG C51/C52-1

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

Culvert C-53 at Sta. 21+816.4, SBL

Record of Borehole Sheets: C53-1 and C53-2

Culvert C-54 at Sta. 21+827.4, NBL

Figure C54-PC-1: Plasticity Chart

Figure C54-GS-1: Results of Grain Size Distribution Analysis

Record of Borehole Sheets: C54-1, C54-2 and C54-3

Drawing C53/C54-1: Borehole Locations and Soil Strata

Ontario

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RECORD OF BOREHOLE No. C53-1

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 21+814, o/s 29.0m Lt. Coords: 5 071 188.4 N; 227 638.5 E **ORIGINATED BY** F.P.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Hilti **COMPILED BY** G.D.

DATUM Geodetic **DATE** August 19, 2013 **CHECKED BY** B.R.G.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%)
194.0	Ground Surface					
	Topsoil					
193.9 0.1	Granitic Gneiss bedrock Slightly weathered to moderately weathered High strength Fair to excellent quality	1	RC	REC 100%		RQD 73%
		2	RC	REC 97%	193	RQD 93%
		3	RC	REC 97%	192	RQD 77%
		4	RC	REC 98%	191	RQD 98%
		5	RC	REC 98%		RQD 88%
190.4 3.6	End of borehole					

* Borehole charged with drilling water

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m^3; GR SA SI CL

$+^7$, $\times^5$: Numbers refer to Sensitivity

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

Ontario

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RECORD OF BOREHOLE No. C53-2

METRIC

G.W.P. 5112-07-00
LOCATION Hwy 69, Sta. 21+817, o/s 9.0m Lt. Coords: 5 071 199.3 N; 227 655.6 E
ORIGINATED BY F.P.

DIST Parry Sound **HWY** 69
BOREHOLE TYPE Manual Probing
COMPILED BY M.K.

DATUM Geodetic
DATE February 14, 2014
CHECKED BY B.R.G.

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.6	Top of Ice										
194.4 0.2	Ice and water					▽* ▼*					
194.0 0.6	Peat, fine fibrous Dark brown						194				
	End of borehole Refusal on probable bedrock										

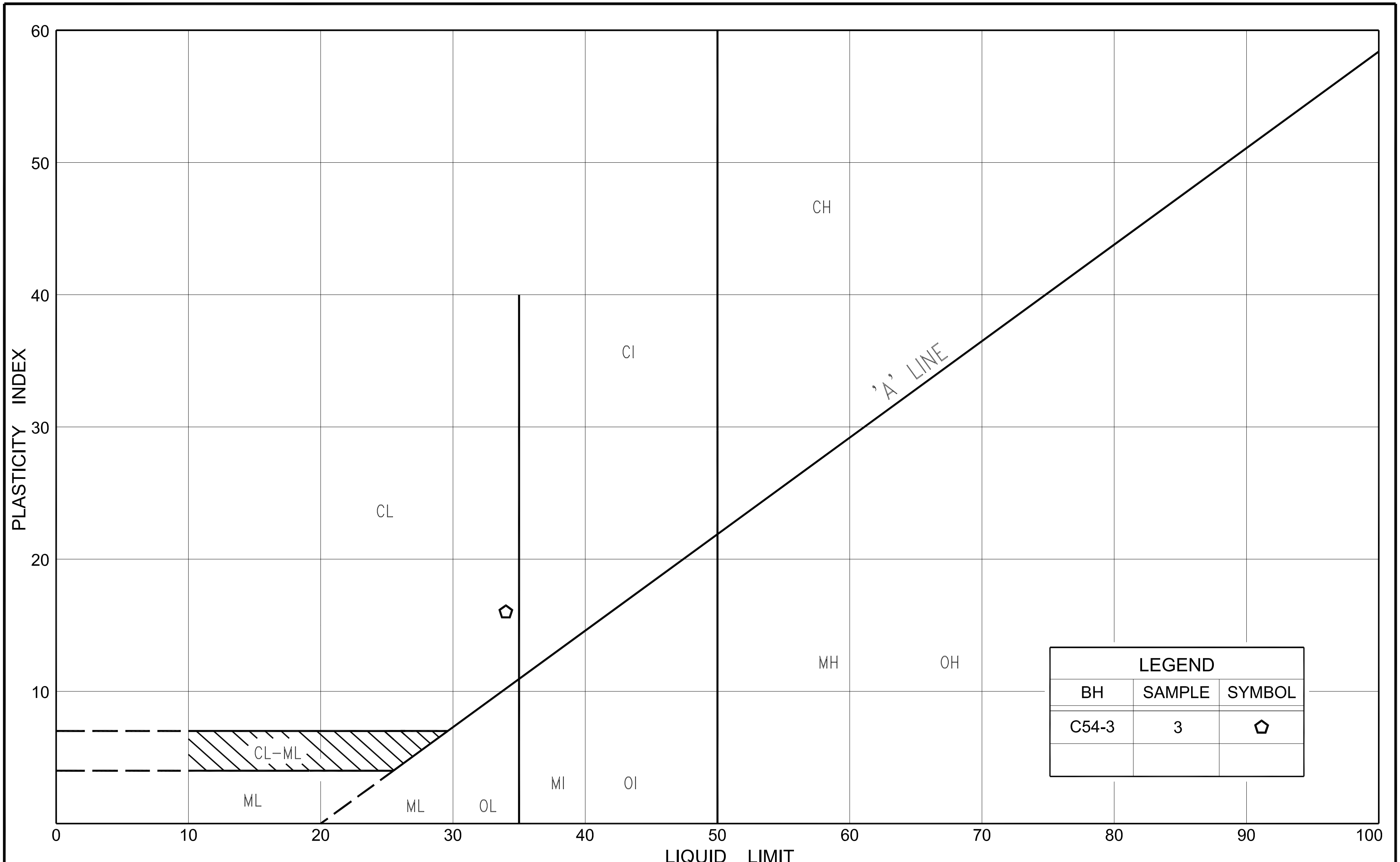
* 2014 02 14

▽ Water level observed during drilling

▼ Water level measured after drilling

$+^7$, $\times^5$: Numbers refer to Sensitivity

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

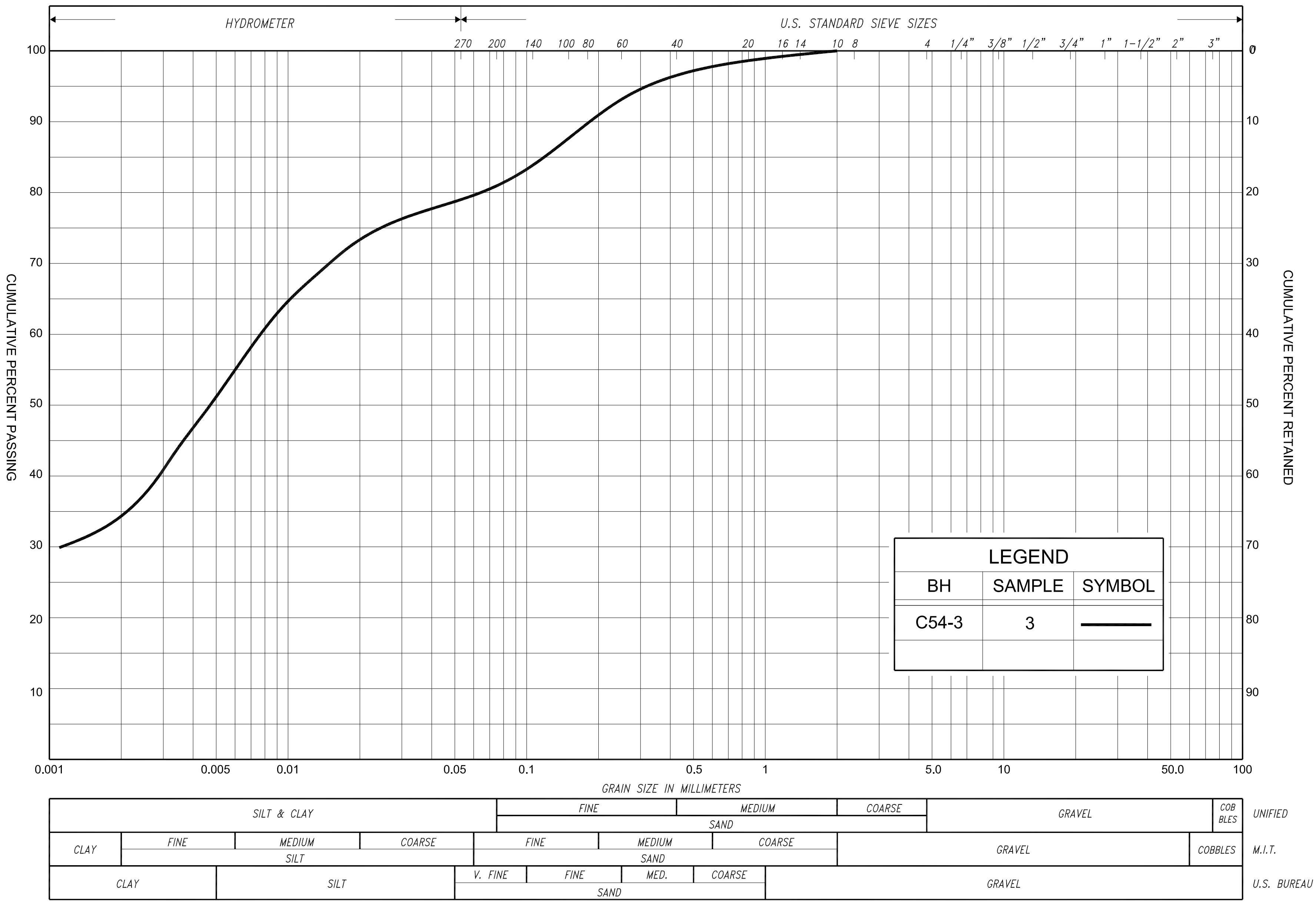


PLASTICITY CHART

CLAYEY SILT, some sand

FIG No.	C54-PC-1
HWY:	69
G.W.P. No.	5112-07-00

Ontario



Ontario

GRAIN SIZE DISTRIBUTION

CLAYEY SILT, some sand

FIG No.	C54-GS-1
HWY:	69
G.W.P. No.	5112-07-00

RECORD OF BOREHOLE No. C54-1

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 21+824, o/s 10.0m Rt. Coords: 5 071 213.5 N; 227 670.0 E **ORIGINATED BY** F.P.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Manual Probing **COMPILED BY** M.K.

DATUM Geodetic **DATE** February 14, 2014 **CHECKED BY** B.R.G.

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.7	Top of Ice										
0.0	Ice and water					▽* ▼*					
193.2 0.5	Peat, fine fibrous Dark brown						193				
192.8 0.9	Organic sand Dark grey										
192.6 1.1	End of borehole Refusal on probable bedrock										

* 2014 02 14

▽ Water level observed during drilling

▼ Water level measured after drilling

NOTE: Three more probes were driven at Sta. 21+820, o/s 10.0m Rt, Sta. 21+822, o/s 10.0m Rt. and Sta. 21+823, o/s 10.0m Rt and refusal was met at 0.5m, 0.6m and 0.9m respectively.

$+^7$, $\times^5$: Numbers refer to Sensitivity

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

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RECORD OF BOREHOLE No. C54-2

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 21+832, o/s 29.0m Rt. Coords: 5 071 228.7 N; 227 684.0 E **ORIGINATED BY** F.P.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Power Auger **COMPILED BY** M.K.

DATUM Geodetic **DATE** February 14, 2014 **CHECKED BY** B.R.G.

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
194.0	Top of Ice										
0.0	Ice and water					▽* ▼*					
193.5 0.5	Peat, fine fibrous Dark brown		1	AS	-						
193.1 0.9	Organic sand Dark grey Wet		2	AS	-		193				
192.8 1.2	End of borehole										

* 2014 02 14

▽ Water level observed during drilling

▼ Water level measured after drilling

$+^7$, $\times^5$: Numbers refer to Sensitivity

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

Ontario

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RECORD OF BOREHOLE No. C54-3

METRIC

G.W.P. 5112-07-00	**LOCATION** Hwy 69, Sta. 21+837, o/s 29.0m Rt. Coords: 5 071 233.3 N; 227 681.8 E		**ORIGINATED BY** F.P.
DIST Parry Sound	**HWY** 69	**BOREHOLE TYPE** Tripod + Casings	**COMPILED BY** M.K.
DATUM Geodetic	**DATE** February 15, 2014		**CHECKED BY** B.R.G.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
194.6	Top of Snow/Ice				*							
0.0 / 194.2	Snow / Ice	1	SS	3								
0.4 / 193.9	Peat, fine fibrous Dark brown					194						
0.7 / 193.4	Sand, organics Dense Grey Wet	2	SS	36								
1.2 / 192.8	Clayey silt, some sand Very stiff Mottled brown/grey Moist	3	SS	65/23cm		193			0	19	47	34
1.8 / 192.7	Sand, trace gravel Dense Grey Wet											
1.9	End of borehole Refusal on probable bedrock											

* Borehole dry

Plot legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE, 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; REMARKS & GRAIN SIZE DISTRIBUTION (%)

$+^7$, $\times^5$: Numbers refer to Sensitivity; 20 / 15 –○– 5 / 10 (%) STRAIN AT FAILURE

CONT No
GWP No 5112-07-00

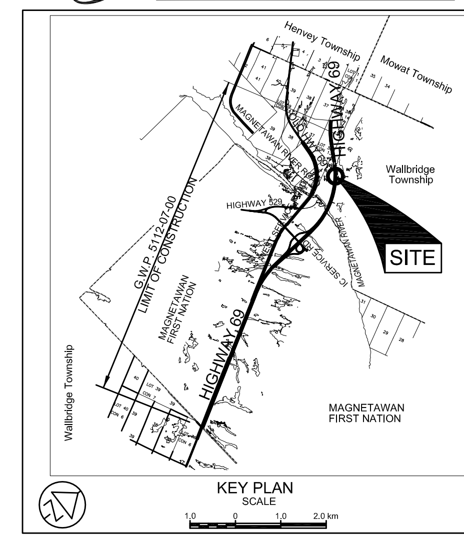
SHEET

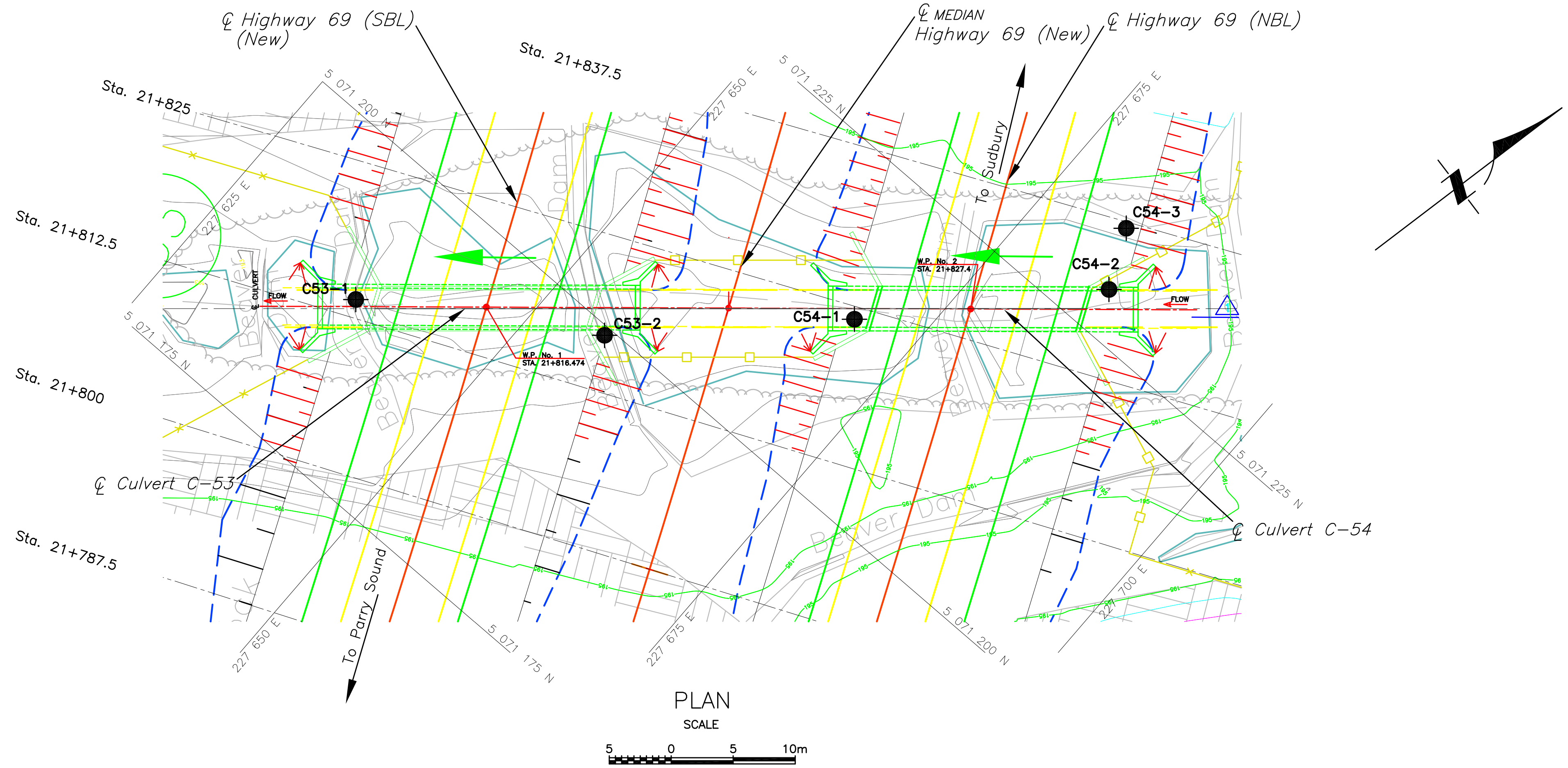
CULVERTS C-53 AND C-54

HIGHWAY 69 FOUR-LANING

BOREHOLE LOCATIONS AND SOIL STRATA

PML Peto MacCallum Ltd.
CONSULTING ENGINEERS

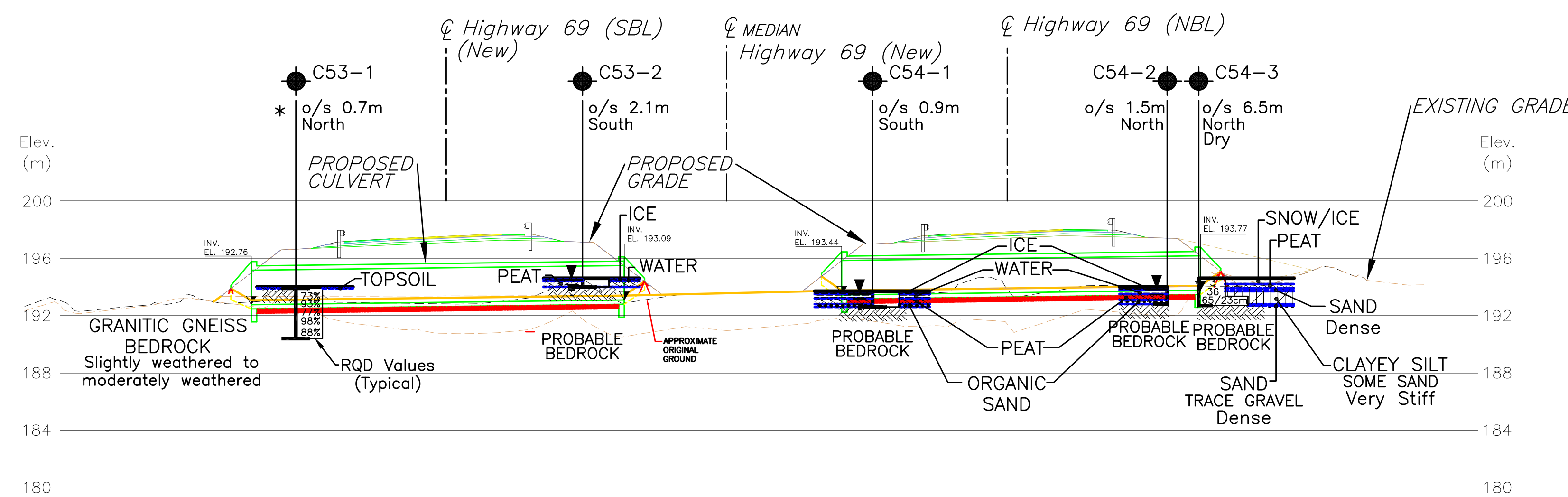




PLAN

SCALE

5 0 5 10m



PROFILE A-A' ALONG CENTRELINES OF CULVERTS C-53 AT STA. 21+816.4 AND C-54 AT STA. 21+827.4

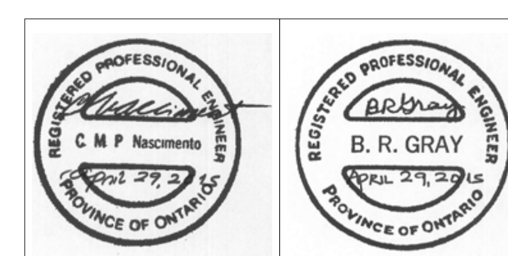
SCALE

5 0 5 10m

LEGEND

- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & Cone
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60°Cone, 475 J/blow)
- WH Penetration due to weight of rods and hammer
- WL at time of investigation Aug.2013 and Feb. 2014
- Head
- ARTESIAN WATER Encountered
- PIEZOMETER

BH No	ELEVATION	COORDINATES NORTHINGS	EASTINGS
C53-1	194.0	5 071 188.4	227 638.5
C53-2	194.6	5 071 199.3	227 655.6
C54-1	193.7	5 071 213.5	227 670.0
C54-2	194.0	5 071 228.7	227 684.0
C54-3	194.6	5 071 233.3	227 681.8



Reference AECOM Drawings:
60143751-BOX CULVERT_no.53 SBL_Sta.21+816.4 &
no.54_Sta.827.4_1_GA.dwg dated March 2015

– NOTE –
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS | DATE | BY | DESCRIPTION

Geocres No. 41H-147

HWY No	69			DIST	54
SUBM'D	NA	CHECKED MK	DATE APR. 29, 2015	SITE	C322
DRAWN	NA	CHECKED GD	APPROVED BRG	DWG	C53/C54-1

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

DRAWING NAME: 09TF044 Culverts 53 n 54.dwg
CREATED: MARCH 2014
MODIFIED: APRIL 2015

MINISTRY OF TRANSPORTATION, ONTARIO PR-D-707 88-05

Culvert C-65 at Sta. 22+675.0, NBL

Record of Borehole Sheets: C65-1 and C65-2

Culvert C-66 at Sta. 22+675.0, SBL

Figure C66-PC-1: Plasticity Chart

Figure C66-GS-1: Results of Grain Size Distribution Analysis

Record of Borehole Sheets: C66-1, C66-2 and 121-12

Drawing C65/C66-1: Borehole Locations and Soil Strata

RECORD OF DYNAMIC CONE No. C65-1 1 of 1 METRIC

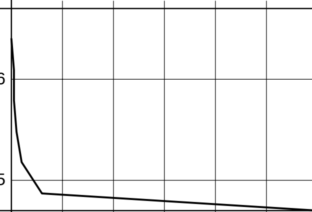
Coords: 5 071 874.7 N; 227 140.6 E

G.W.P. 5112-07-00 LOCATION Hwy 69, Sta. 22+675, o/s 10.0m Rt. ORIGINATED BY F.P.

DIST Parry Sound HWY 69 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY M.K.

DATUM Geodetic DATE February 13, 2014 CHECKED BY B.R.G.

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
196.7	Top of Snow/Ice										
0.0	Snow / Ice										
	Probable peat						196				
	Probable clayey silt Firm										
	Probable silty sand						195				
194.7	Compact										
2.0	End of dynamic cone penetration test							120/15cm			
	Refusal on probable bedrock										



+7, ×5 : Numbers refer to Sensitivity

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

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RECORD OF BOREHOLE No. C65-2

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 22+675, o/s 29.0m Rt. Coords: 5 071 889.9 N; 227 152.1 E **ORIGINATED BY** F.P.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Tripod + Casings **COMPILED BY** M.K.

DATUM Geodetic **DATE** February 13, 2014 **CHECKED BY** B.R.G.

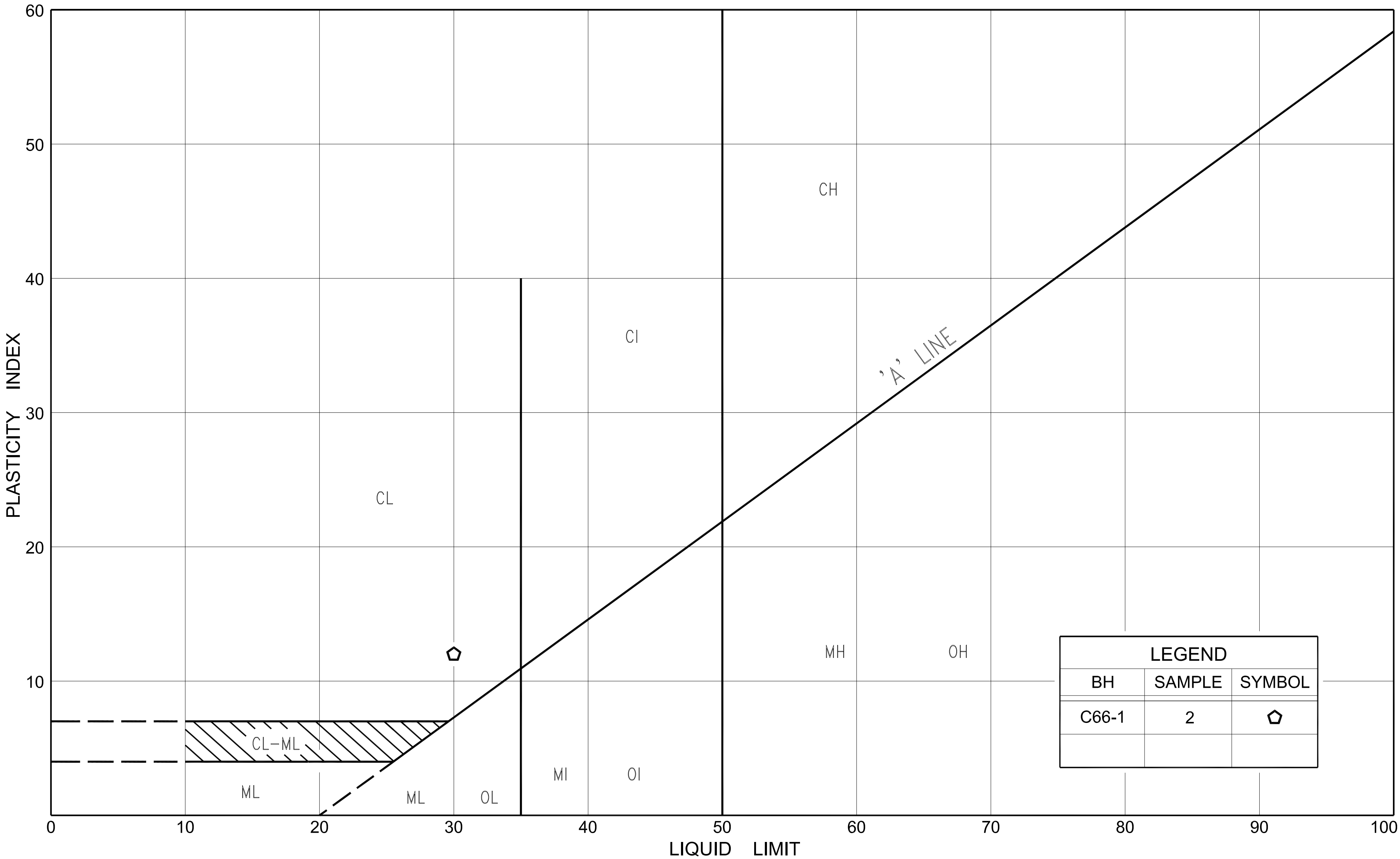
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
196.8	Top of Snow/Ice										
0.0	Snow / Ice					▼*					
196.4 0.4	Peat, fine fibrous Dark brown		1	SS	8		196				
195.9 0.9	Silty sand, trace gravel Dense Brown Wet		2	SS	50/15cm						
195.6 1.2	End of borehole Refusal on probable bedrock										

* 2014 02 13

▼ Water level measured after drilling

$+^{7}$, $\times^{5}$: Numbers refer to Sensitivity

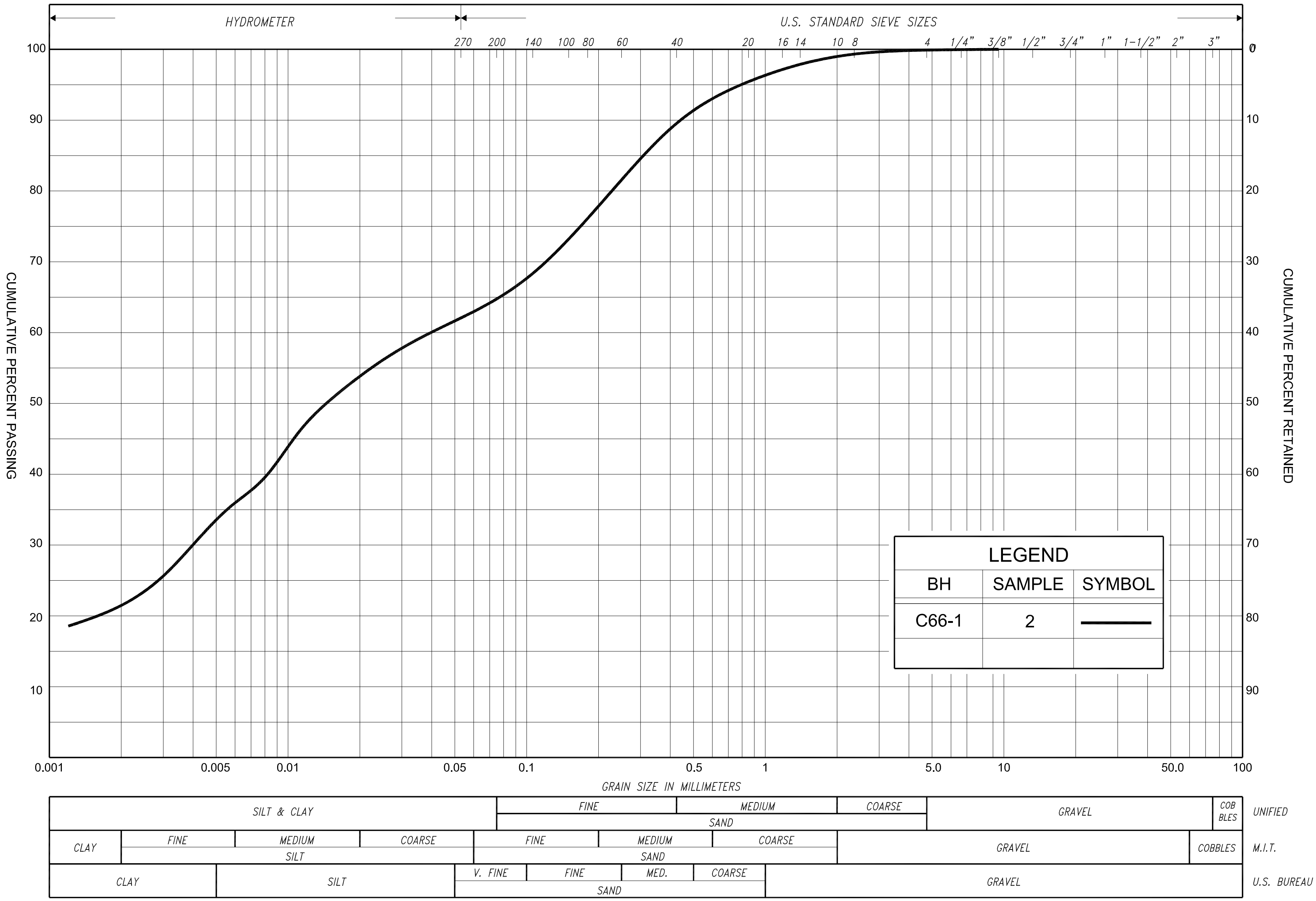
15–○–5 (20 above, 10 below) (%) STRAIN AT FAILURE



PLASTICITY CHART

CLAYEY SILT, sandy

FIG No.	C66-PC-1
HWY:	69
G.W.P. No.	5112-07-00



Ontario

GRAIN SIZE DISTRIBUTION

CLAYEY SILT, sandy

FIG No.	C66-GS-1
HWY:	69
G.W.P. No.	5112-07-00

Ontario | Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. C66-1

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 22+675, o/s 29.0m Lt. Coords: 5 071 843.6 N; 227 117.1 E **ORIGINATED BY** F.P.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Tripod + Casings **COMPILED BY** M.K.

DATUM Geodetic **DATE** February 12 and 13, 2014 **CHECKED BY** B.R.G.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
195.3	Top of Snow/Ice							
0.0	Snow / Ice				▽* ▼*	195		
194.7 / 0.6	Peat, fine fibrous, Dark brown							
194.5 / 0.8	Clayey silt, trace sand, organics to 1.4m; Firm to very stiff; Dark brown; Moist to wet; sandy	1	SS	3		194		
193.5 / 1.8		2	SS	35				0 35 43 22
193.2 / 2.1	Sand, trace gravel; Dense to very dense; Dark brown; Wet							
	End of borehole							
	Refusal on probable bedrock							

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

WATER CONTENT (%): w_P w w_L; 20 40 60

UNIT WEIGHT γ kN/m³

* 2014 02 12 & 13

▽ Water level observed during drilling

▼ Water level measured after drilling

ON MTO_VER3 NEW LOGO 09TF044.GPJ ON_MOT.GDT 7/9/2014 1:11:39 PM

+7, ×5 : Numbers refer to Sensitivity

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

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. C66-2

METRIC

G.W.P. 5112-07-00	**LOCATION** Hwy 69, Sta. 22+675, o/s 10.0m Lt. Coords: 5 071 858.8 N; 227 128.5 E		**ORIGINATED BY** F.P.
DIST Parry Sound	**HWY** 69	**BOREHOLE TYPE** Tripod + Casings	**COMPILED BY** M.K.
DATUM Geodetic	**DATE** February 11, 2014		**CHECKED BY** B.R.G.

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
196.5	Top of Snow/Ice										
0.0	Snow / Ice					▽*					
196.2 / 0.3 / 196.0 / 0.5	Peat, fine fibrous Dark brown		1	SS	3		196				
195.7 / 0.8	Organic sand Very loose Grey Wet		2	SS	50/5cm	▼*					
195.5 / 1.0	Clayey silt trace sand, trace gravel organics Very stiff Grey Moist to hard										
	End of borehole										
	Refusal on probable bedrock										

* 2014 02 11

▽ Water level observed during drilling

▼ Water level measured after drilling

NOTE:
Second attempt was carried out at 2.0m Rt of borehole C66-2, refusal was met at 0.8m

$+^7$, $\times^5$: Numbers refer to Sensitivity

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

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. 121-12

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69, Sta. 22+675, o/s 18.8 m Lt. Coords: 5 071 851.8 N; 227 123.2 E **ORIGINATED BY** S.A.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Tripod + Casing **COMPILED BY** G.D.

DATUM Geodetic **DATE** February 10, 2013 **CHECKED BY** B.R.G.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%)
196.4	Top of Ice							
196.2 / 0.2	Ice				▽* ▼*			
195.9 / 0.5	Water	1	SS	WH**		196	○	
	Peat, amorphous Dark brown							
195.2 / 1.2	Silty sand, trace gravel Loose Grey Wet	2	SS	6				
	End of borehole Refusal on probable bedrock							

SOIL PROFILE | SAMPLES | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 | SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE 20 40 60 80 100 | PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L | WATER CONTENT (%) 20 40 60 | UNIT WEIGHT γ kN/m³ | GR SA SI CL

* 2013 02 10

▽ Water level observed during drilling

▼ Water level measured after drilling

WH** denotes penetration due to weight of rods and hammer

$+^7$, $\times^5$: Numbers refer to Sensitivity

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

CONT No

GWP No 5112-07-00

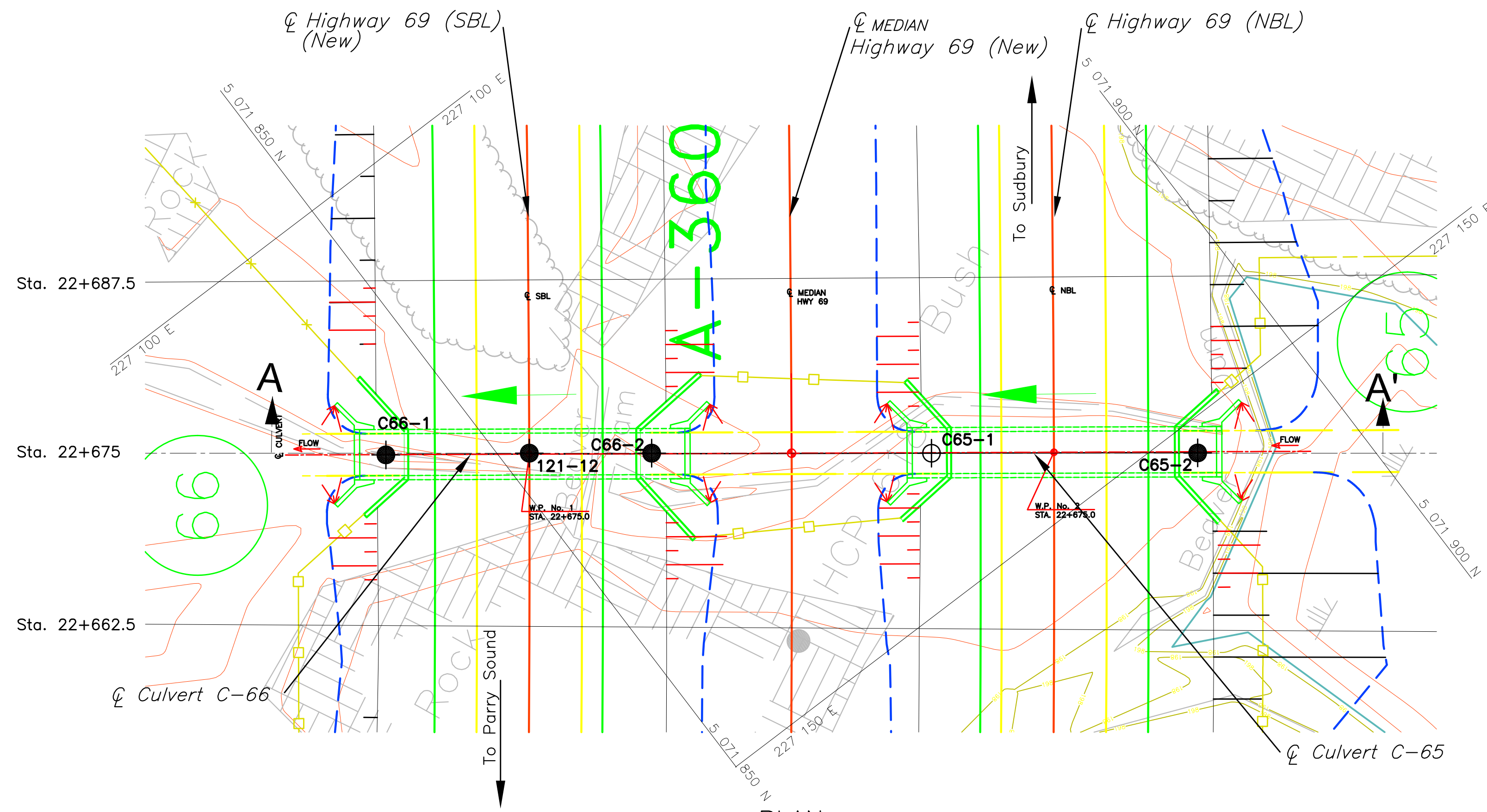
SHEET

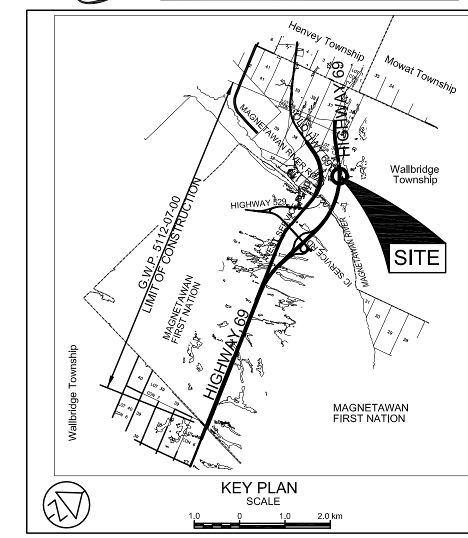
CULVERTS C-65 AND C-66

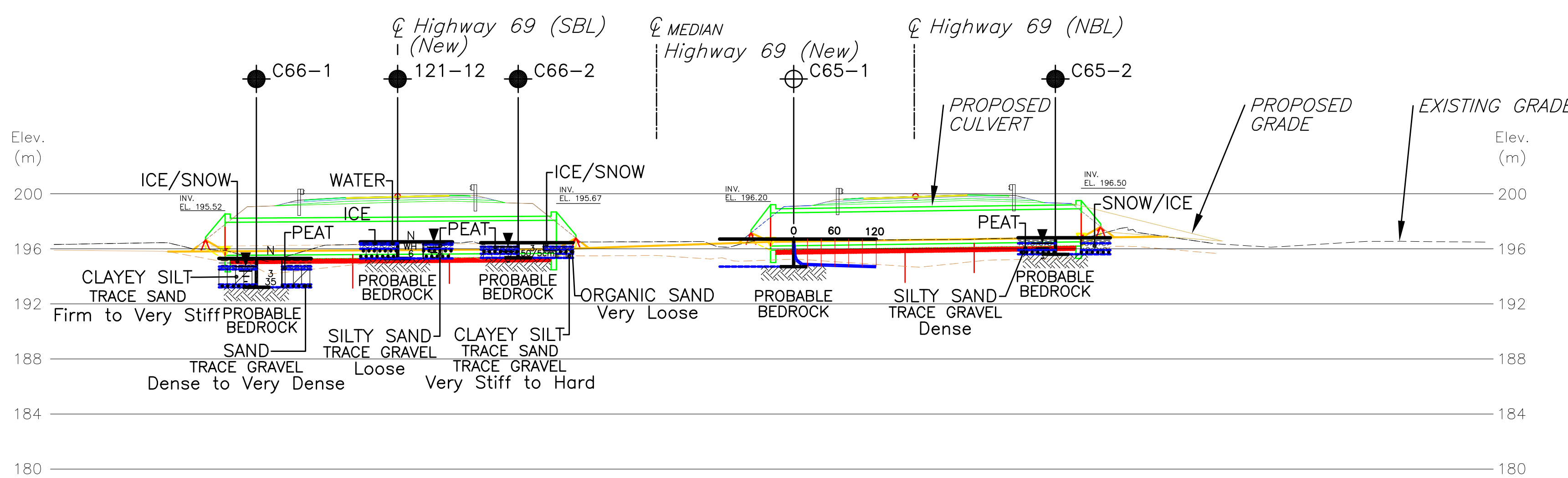
HIGHWAY 69 FOUR-LANING

BOREHOLE LOCATIONS AND SOIL STRATA

Peto MacCallum Ltd.
CONSULTING ENGINEERS







PROFILE A-A' ALONG CENTRELINES CULVERTS C-65 AND C-66 AT STA. 22+675.0

SCALE

5 0 5 10m

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

LEGEND

- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & Cone
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60°Cone, 475 J/blow)
- WH Penetration due to weight of rods and hammer
- WL at time of investigation Feb. 2013 and Feb. 2014
- Head
- ARTESIAN WATER Encountered
- PIEZOMETER

BH No	ELEVATION	COORDINATES NORTHINGS	COORDINATES EASTINGS
C65-1	196.7	5 071 874.7	227 140.6
C65-2	196.8	5 071 889.9	227 152.1
C66-1	195.3	5 071 843.6	227 117.1
C66-2	196.5	5 071 858.8	227 128.5
121-12	196.4	5 071 851.8	227 123.2

– NOTE –

The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REGISTERED PROFESSIONAL ENGINEER C M P Nascimento April 29, 2015 PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER B. R. GRAY APRIL 29, 2015 PROVINCE OF ONTARIO

REVISIONS

DATE	BY	DESCRIPTION

Geocres No. 41H-147

HWY No 69			DIST 54
SUBM'D NA	CHECKED MK	DATE APR. 29, 2015	SITE --
DRAWN NA	CHECKED GD	APPROVED BRG	DWG C65/C66-1

Reference AECOM Drawing: 60143751-BOX CULVERT_no.65 NBL_ sta 22+675.0_10.66 SBL_sta 22+675.0_1_GA.dwg dated March 2015

MINISTRY OF TRANSPORTATION, ONTARIO PR-D-707 88-05

APRIL 2015

DRAWING NAME: 09TF044 Culverts 65 n 66.dwg
CREATED: APRIL 2014
MODIFIED:

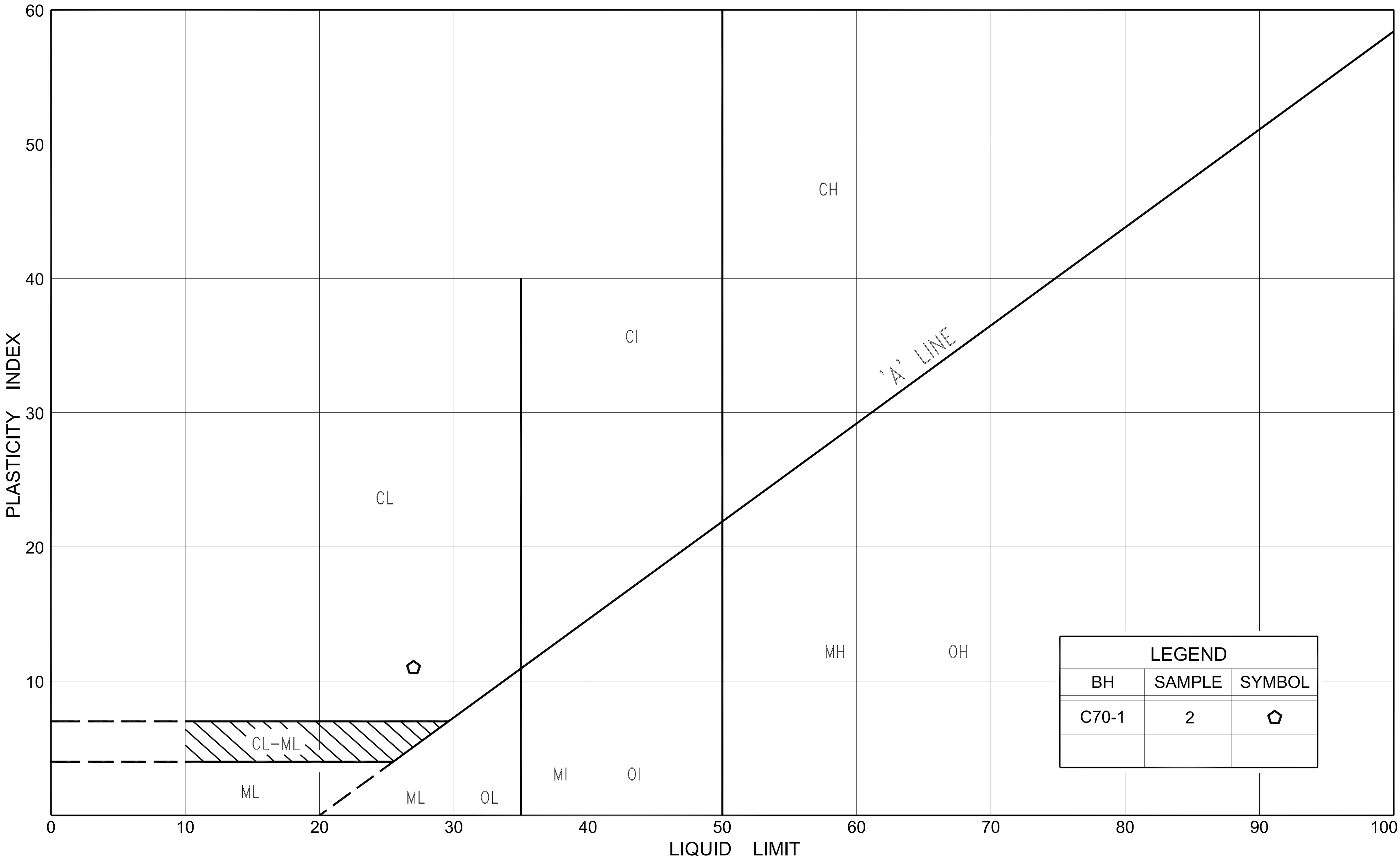
Culvert C-70 at Sta. 20+940.0, N-E/W Ramp Chainage

Figures C70-PC-1, C70-PC-2 and NEW-PC-2: Plasticity Charts

Figures C70-GS-1, C70-GS-2 and NEW-GS-2: Results of Grain Size Distribution Analyses

Record of Borehole Sheets: C70-1, C70-2 and NEW-16

Drawing C70-1: Borehole Locations and Soil Strata

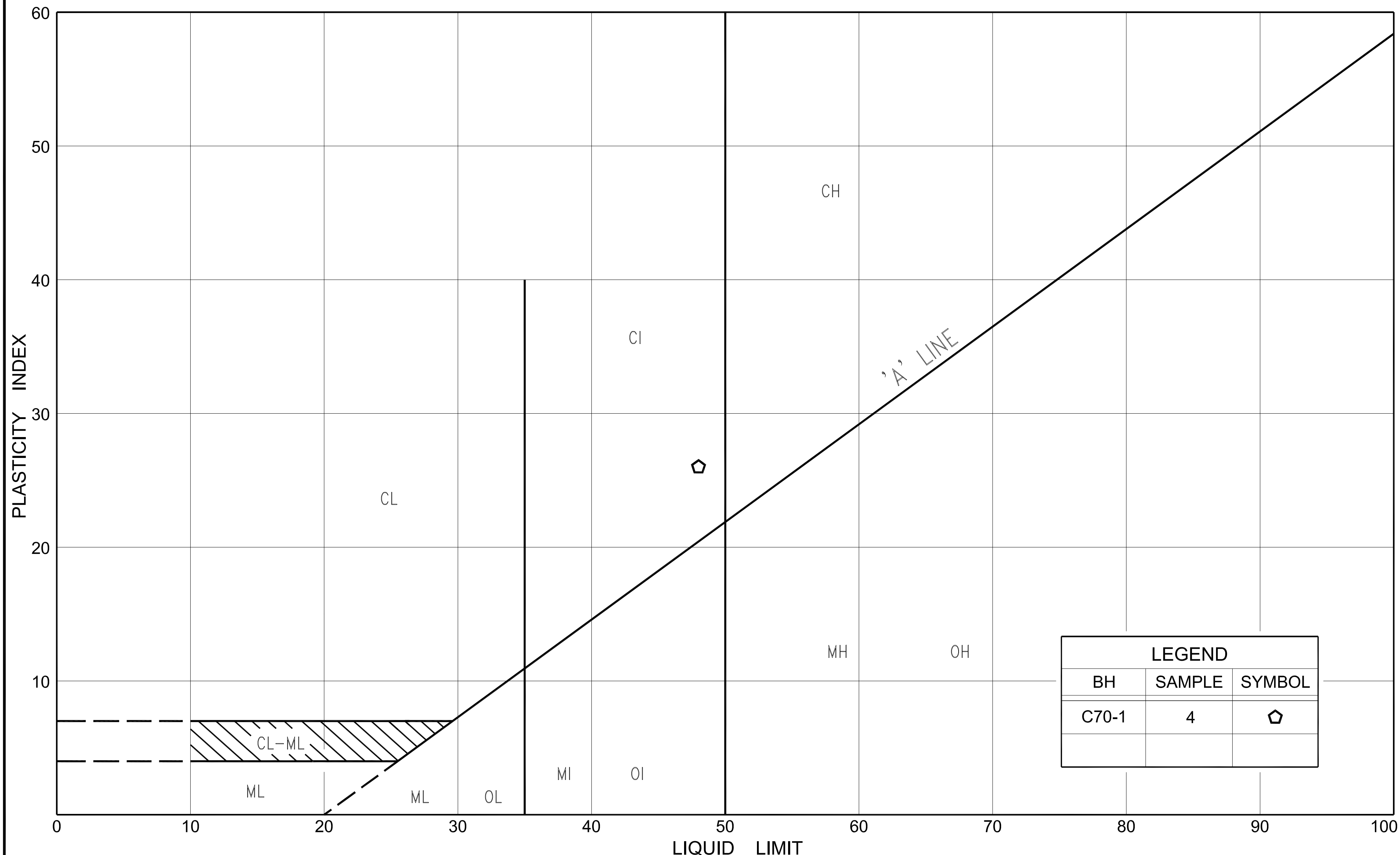


PLASTICITY CHART

CLAYEY SILT, some sand

FIG No.	C70-PC-1
HWY:	69
G.W.P. No.	5112-07-00

Ontario

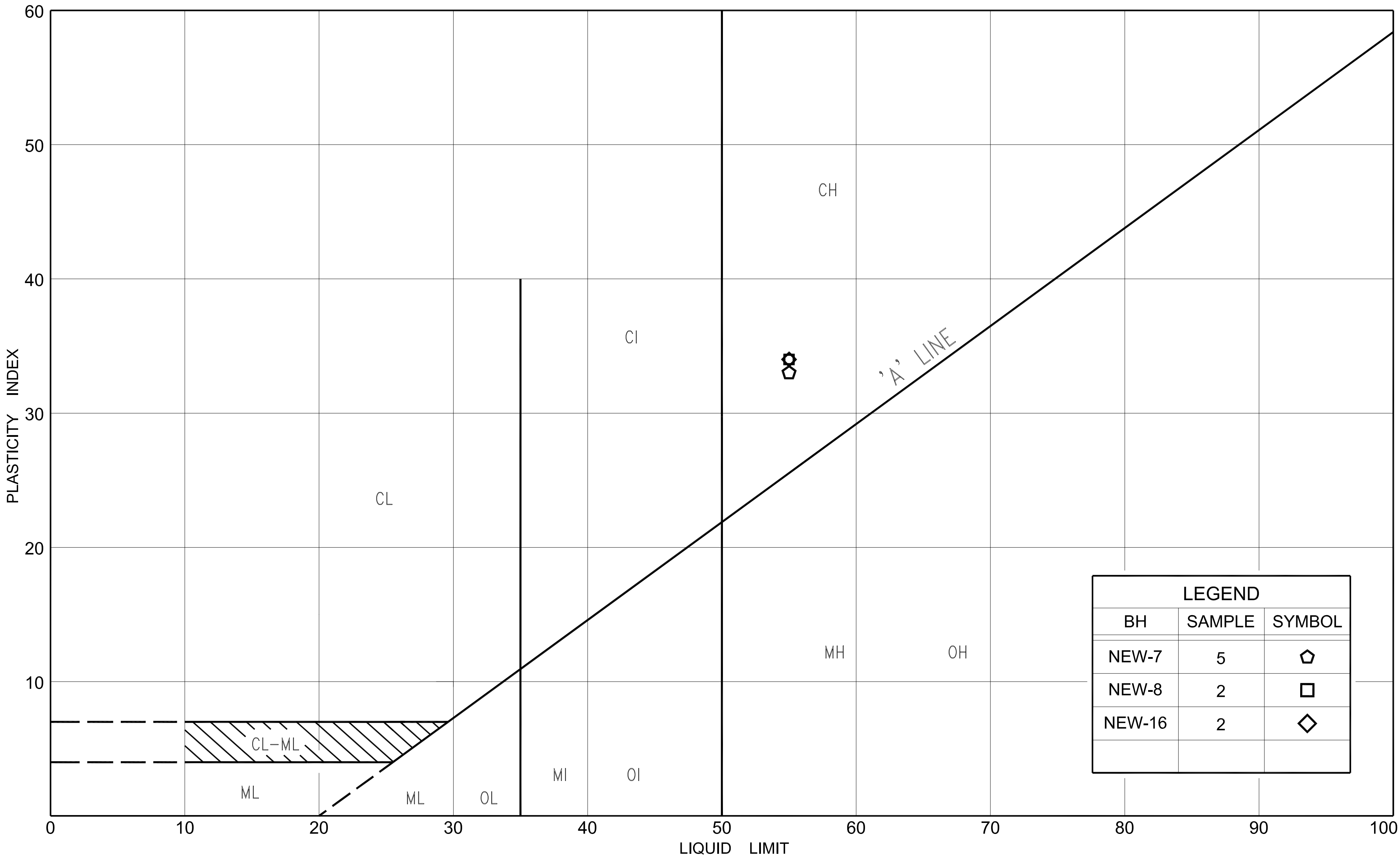


Ontario

PLASTICITY CHART

SILTY CLAY, trace sand

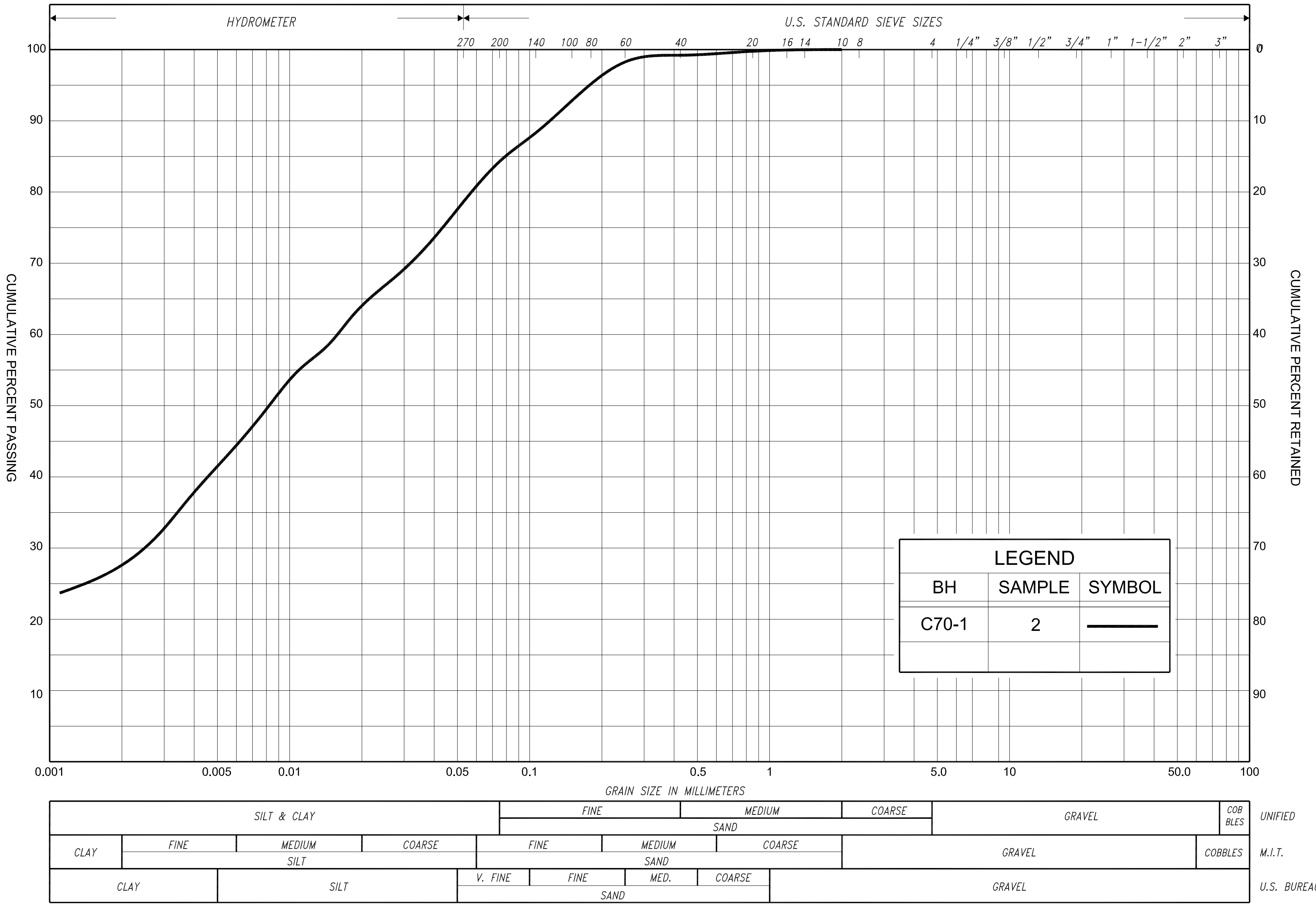
FIG No.	C70-PC-2
HWY:	69
G.W.P. No.	5112-07-00



PLASTICITY CHART

CLAY, trace sand

FIG No.	NEW-PC-2
HWY:	69
G.W.P. No.	5112-07-00

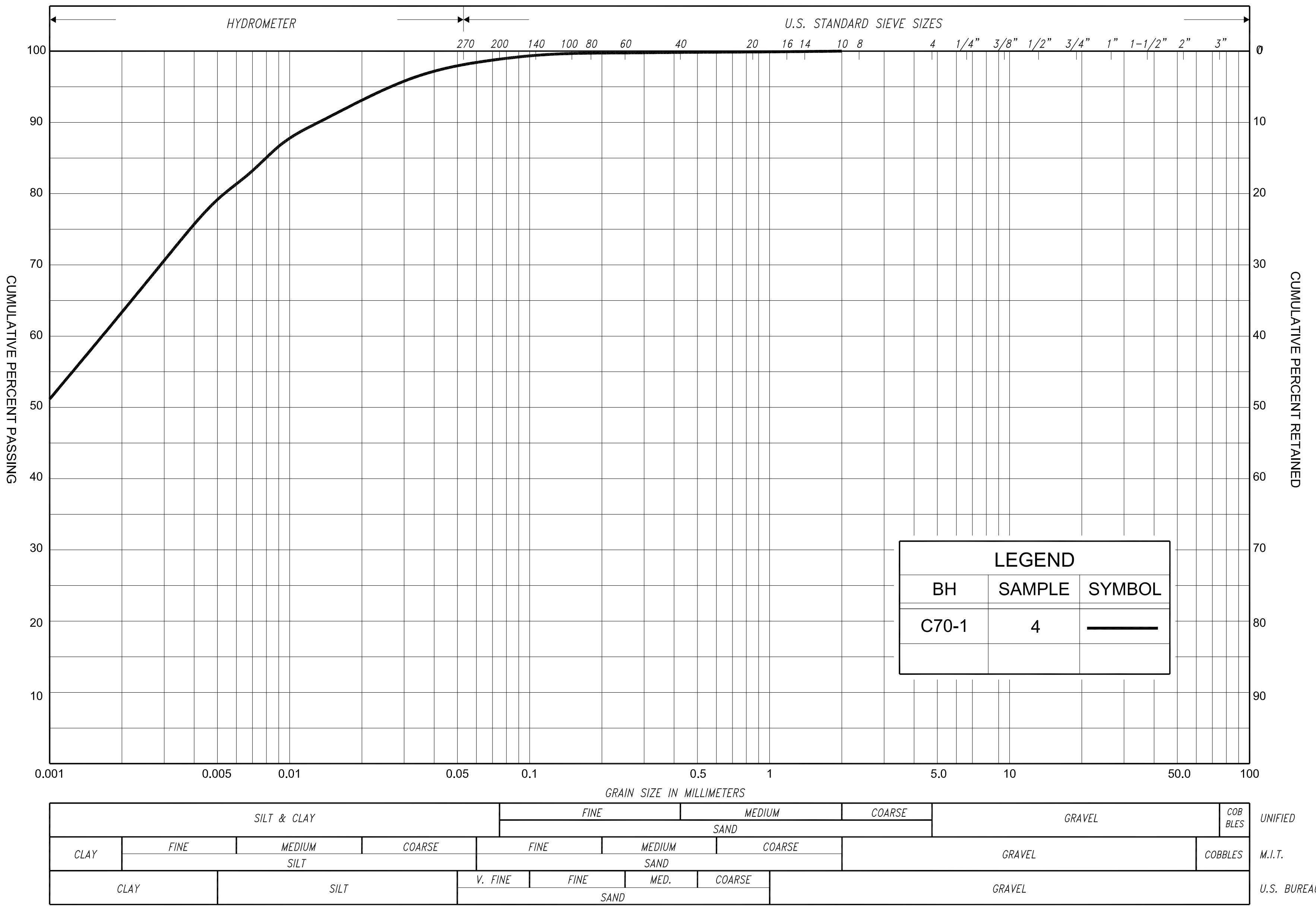


Ontario

GRAIN SIZE DISTRIBUTION

CLAYEY SILT, some sand

FIG No.	C70-GS-1
HWY:	69
G.W.P. No.	5112-07-00

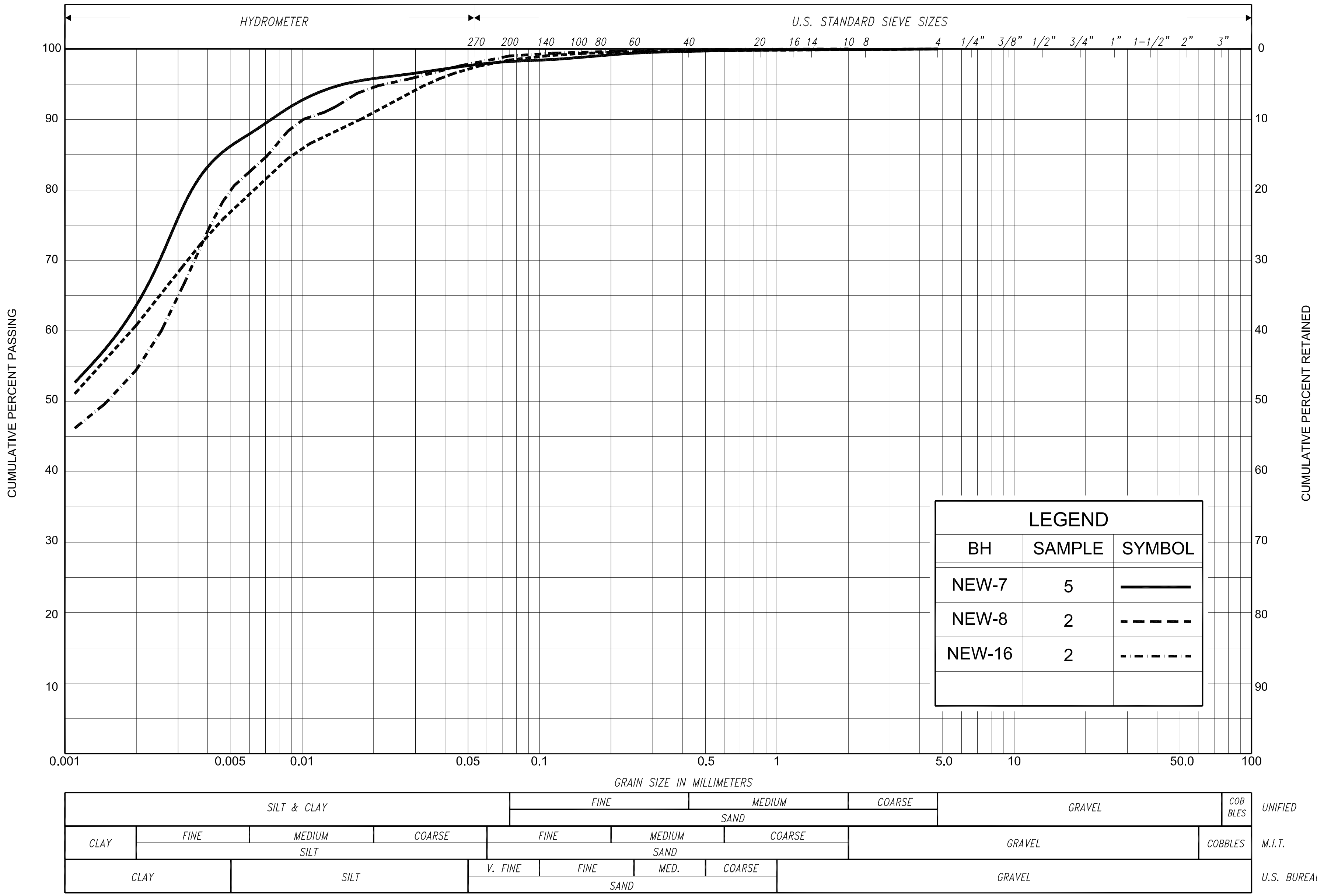


Ontario

GRAIN SIZE DISTRIBUTION

SILTY CLAY, trace sand

FIG No.	C70-GS-2
HWY:	69
G.W.P. No.	5112-07-00



Ontario

GRAIN SIZE DISTRIBUTION

CLAY, trace sand

FIG No.	NEW-GS-2
HWY:	69
G.W.P. No.	5112-07-00

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. C70-1

METRIC

G.W.P. 5112-07-00 **LOCATION** Hwy 69 N-E/W Ramp, Sta. 20+940, o/s 7.0m Lt. Coords: 5 070 354.4 N; 227 747.0 E **ORIGINATED BY** F.P.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Manual Probing **COMPILED BY** M.K.

DATUM Geodetic **DATE** February 17 and 18, 2014 **CHECKED BY** B.R.G.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
192.2	Top of Ice				*				
0.0	Ice					192			
191.9 / 0.3	Peat, fine fibrous, Dark brown	1	SS	6					
191.7 / 0.5	Organic silt, trace clay, Loose, Grey, Moist								
191.3 / 0.9	Clayey silt, some sand, Stiff, Mottled brown/grey, Moist to wet	2	SS	16		191	■		0 16 56 28
			FV				+15		
190.1 / 2.1	Silty clay, trace sand, Stiff to soft, Grey, Moist to wet					190			
		3	SS	12			■		
			FV				+4		
		4	SS	4		189			0 1 36 63
			FV				+2		
187.9 / 4.3	Sand, trace gravel, Dense, Grey, Wet					188			
187.5 / 4.7		5	SS	50/10cm					

End of borehole

Refusal on probable bedrock

Sample 5: Sampler bouncing

* Borehole dry

■ Penetrometer test

+7, ×5 : Numbers refer to Sensitivity

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

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. C70-2

METRIC

G.W.P. 5112-07-00
LOCATION Hwy 69 N-E/W Ramp, Sta. 20+940, o/s 9.0m Rt. Coords: 5 070 347.6 N; 227 761.5 E
ORIGINATED BY A.L.

DIST Parry Sound **HWY** 69
BOREHOLE TYPE Tripod
COMPILED BY G.D.

DATUM Geodetic
DATE October 22 and 23, 2013
CHECKED BY B.R.G.

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.1	Ground Surface										
193.0 / 0.1	Topsoil						193				
	Silty sand, rootlets and topsoil inclusions		1	SS	2	▽*			○		
192.2 / 0.9	Very loose to loose Brown / Grey Moist to wet		2	SS	20		192		○		
191.7 / 1.4	Silty clay, trace sand. Very stiff Greyish brown Moist										
	End of borehole										
	Refusal on probable bedrock										

* 2013 10 23

▽ Water level observed during drilling

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT scale 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE, scale 20 40 60 80 100. PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) scale 20 40 60.

$+^{7}$, $\times^{5}$: Numbers refer to Sensitivity

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

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No. NEW-16

METRIC

G.W.P. 5112-07-00 **LOCATION** Ramp N-E/W, Sta. 20+950, o/s 2.0 m Lt. Coords: 5 070 361.4 N; 227 755.5 E **ORIGINATED BY** A.L.

DIST Parry Sound **HWY** 69 **BOREHOLE TYPE** Tripod + 'N' Casing **COMPILED BY** G.D.

DATUM Geodetic **DATE** February 12 and 13, 2013 **CHECKED BY** B.R.G.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
192.5	Ground Surface				*								
0.0	Peat, amorphous; Dark brown	1	SS	7									
192.2 / 0.3	Organic sand, trace silt; Compact, Dark brown, Wet					192							
191.8 / 0.7	Clay, trace sand; Stiff to very stiff, Brown/grey, Moist	2	SS	13			175 ■	wP–w–wL		0	1	44	55
						191							
190.7 / 1.8	Silty sand, trace gravel; Dense to very dense, Grey, Wet	3	SS	36				○					
190.3 / 2.2	Sand and gravel, trace silt; Very dense, Grey, Wet	4	SS	50/10cm		190							
		5	SS	50/8cm									
189.2 / 3.3	End of borehole												

Refusal on probable bedrock

Samples 4 and 5: Sampler bouncing

* Borehole dry

■ Penetrometer test

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L

○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE

+7, ×5: Numbers refer to Sensitivity

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

CONT No
GWP No 5112-07-00

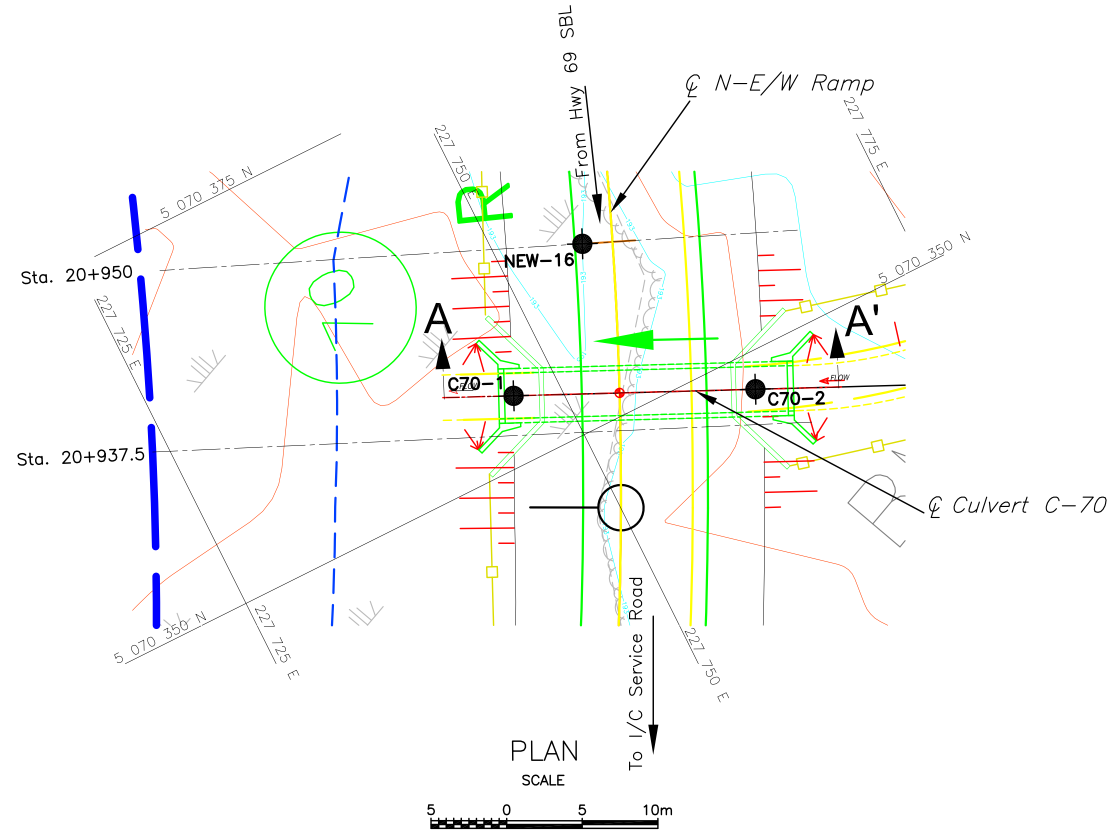
SHEET

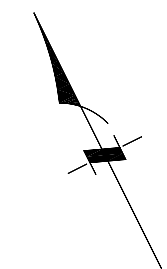
CULVERT C-70

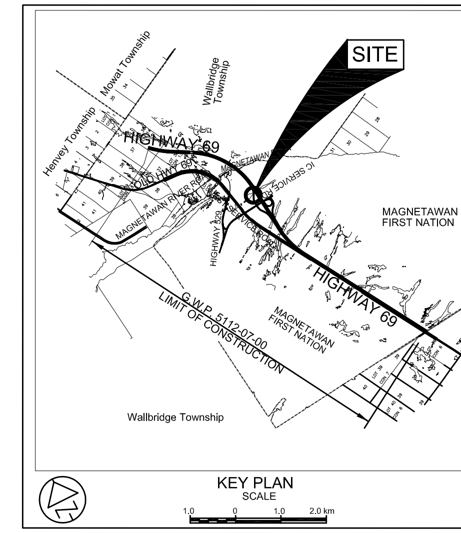
RAMP N-E/W HIGHWAY 69 FOUR-LANING

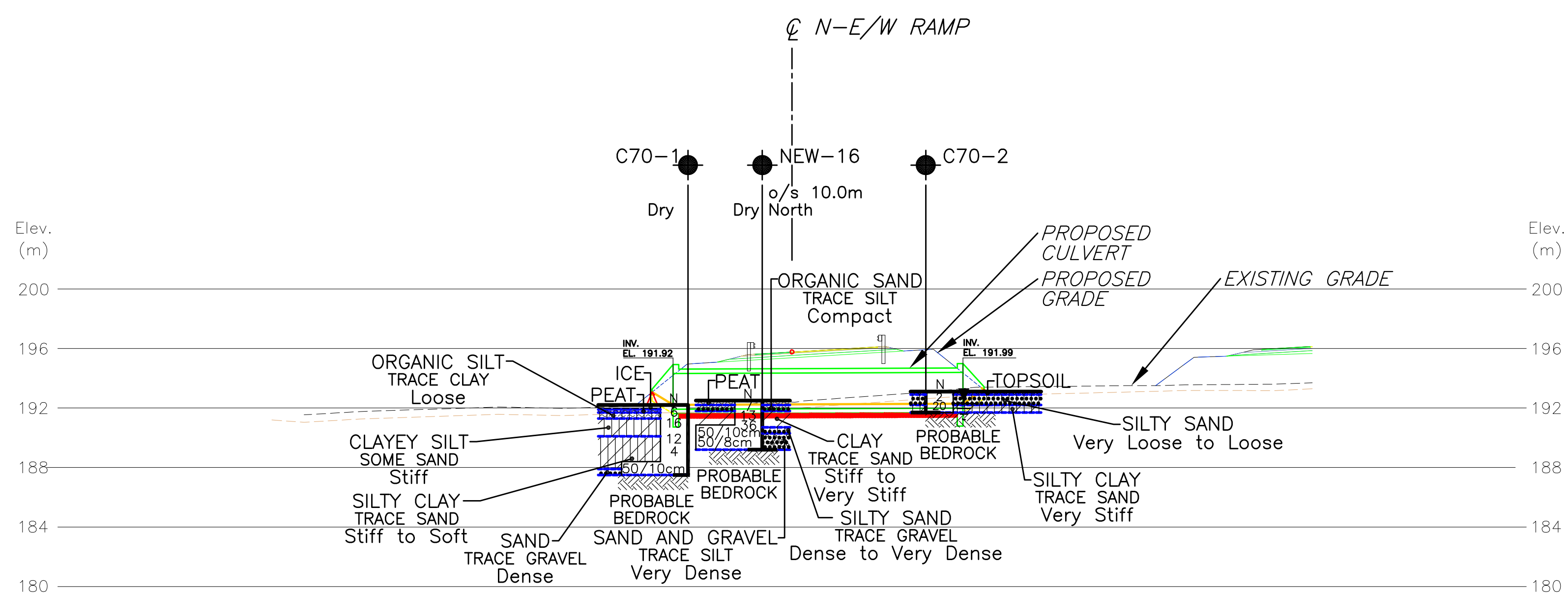
BOREHOLE LOCATIONS AND SOIL STRATA

Peto MacCallum Ltd. CONSULTING ENGINEERS









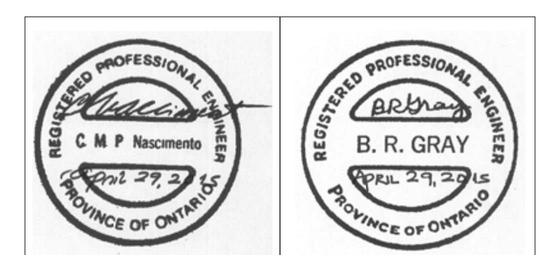
PROFILE A-A' ALONG CENTRELINE OF CULVERT C-70 AT STA. 20+940.0

SCALE
5 0 5 10m

LEGEND

- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & Cone
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60°Cone, 475 J/blow)
- WH Penetration due to weight of rods and hammer
- WL at time of investigation Feb., Oct. 2013 and Feb. 2014
- Water level not established
- Head
- ARTESIAN WATER Encountered
- PIEZOMETER

BH No	ELEVATION	COORDINATES NORTHINGS	COORDINATES EASTINGS
C70-1	192.2	5 070 354.4	227 747.0
C70-2	193.1	5 070 347.6	227 761.5
NEW-16	192.5	5 070 361.4	227 755.5



– NOTE –
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS DATE	BY	DESCRIPTION

Geocres No. 41H-147

HWY No 69			DIST 54
SUBM'D NA	CHECKED MK	DATE APR. 29, 2015	SITE C321
DRAWN NA	CHECKED GD	APPROVED BRG	DWG C70-1

Reference AECOM Drawing: 60143751-BOX CULVERT_ no.70_sta. 20+940.0_1_GA.dwg dated March 2015

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

MINISTRY OF TRANSPORTATION, ONTARIO PR-D-707 88-05

MODIFIED:

DRAWING NAME:
CREATED:

APPENDIX A

Site Photograph

Photograph 1: The location of borehole C21-1, facing north. (Sept. 30, 2013)

Photograph 2: Drilling at the location of borehole C21-2, facing north. (Oct. 1, 2013)

Photograph 3: The location of borehole C24-2, facing north from the east side of Highway 69. (Oct. 2, 2013)

Photograph 4: Drilling at the location of borehole C26-1, facing west. (Sept. 25, 2013)

Photograph 5: Drilling at the location of borehole C28-2, facing east. (Oct. 9, 2013)

Photograph 6: The location of borehole C42-1, facing west. (Oct. 10, 2013)

Photograph 7: The location of borehole C43-2, facing southeast. (Oct. 9, 2013)

Photograph 8: Drilling at the location of borehole C51-3, facing east. (Oct. 17, 2013)

FOUNDATION DESIGN REPORT
CULVERTS

for

HIGHWAY 69 FOUR-LANING
FROM 5.3 KM SOUTH OF HIGHWAY 529 (NORTH JUNCTION)
NORTHERLY TO 2.2 KM NORTH OF HIGHWAY 529, 7.5 KM
G.W.P. 5112-07-00
MAGNETAWAN FIRST NATION / WALLBRIDGE TOWNSHIP,
PARRY SOUND AREA, ONTARIO

PETO MacCALLUM LTD.
165 CARTWRIGHT AVENUE
TORONTO, ONTARIO
M6A 1V5
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PML Ref.: 09TF044-CV
Index No.: 395FDR
GEOCRES No.: 41H-147
April 29, 2015

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APPENDIX D – MTO Guideline for Rockfill Settlement and Rockfill Quantity Estimate

FOUNDATION DESIGN REPORT
CULVERTS
for
Highway 69 Four-Laning
From 5.3 km South of Highway 529 (North Junction) Northerly
to 2.2 km North of Highway 529 (North Junction), 7.5 km
G.W.P. 5112-07-00
Magnetawan First Nation / Wallbridge Township, Parry Sound Area, Ontario

1. INTRODUCTION

This report pertains to design and construction of the 32 identified culvert installations. These proposed culverts are required for the realignment and four-laning planned for an approximately 7.5 km long section of Highway 69 that extends from 5.3 km south of Highway 529 (north junction) to 2.2 km north of Highway 529 (north junction), some 90 km south of Sudbury. This report was prepared for AECOM Canada Ltd. (AECOM) on behalf of the Ministry of Transportation of Ontario (MTO).

The recommendations in this report will have to be reconciled with those in the Swamp and High Fill Crossings report for Highway 69 four-laning in this area (identified below):

FOUNDATION INVESTIGATION AND DESIGN REPORT

SWAMP AND HIGH FILL CROSSINGS

for

HIGHWAY 69 FOUR-LANING

FROM 5.3 KM SOUTH OF HIGHWAY 529 (NORTH JUNCTION) NORTHERLY TO 2.2 KM NORTH OF HIGHWAY 529, 7.5 KM

G.W.P. 5112-07-00

MAGNETAWAN FIRST NATION / WALLBRIDGE TOWNSHIP, ONTARIO

PML Reference # 09TF043

This reconciliation is necessary since the designs adopted for swamp and high fill crossings will have an influence on the designs adopted for culvert foundations where the culvert foundations will be within the zones of the swamp and high fill crossings.

1.1 Proposed Culvert Installations

This report provides foundation engineering recommendations for the proposed installation of thirty-two (32) culverts located between approximate Stations 16+028 and 23+644, Highway 69 alignment. The locations, types and sizes of the culverts, based on available information at the time of preparing this report, are listed below along with an identification of the proposed work at each culvert. Based on the TOR's, it has been assumed that concrete box culverts will be the preferred option, except in cases where the proximity of bedrock makes cast-in-place (CIP) open footing concrete culverts a viable option. Unless otherwise indicated in the site specific foundation recommendations, precast box culverts are the preferred option from a geotechnical perspective.

Culvert ID	Location (Highway 69 Centerline)	Type and Size	Proposed Work
C-2	Sta. 16+076.0 (SBL)	Concrete Box 3.0m×1.2m×4.0m	Extension of existing culvert
C-3	Sta. 16+086.2 (NBL)	Concrete Box 3.0m×1.2m×31.0m	New culvert installation
C-8	Sta. 16+531.9 (SBL)	Concrete Box 3.0m×2.3m×18.0m	Replacement culvert
C-9	Sta. 16+556.7 (NBL)	Concrete Box 3.0m×2.3m×28.0m	New culvert installation
C-16	Sta. 16+979.3 (NBL)	Concrete Box 1.2m×2.3m×33.0m	New culvert installation
C-17	Sta. 16+991.7 (SBL)	Concrete Box 1.2m×2.3m×25.0m	Replacement culvert
C-18	Sta. 17+108.3 (SBL)	Concrete Box 3.0m×2.3m×27.0m	Replacement culvert
C-19	Sta. 17+127.1 (NBL)	Concrete Box 3.0m×2.3m×30.0m	New culvert installation
C-20	Sta. 17+542.7 (NBL)	Concrete Box 3.0m×2.3m×17.0m	New culvert installation
C-21	Sta. 17+542.7 (SBL)	Concrete Box 3.0m×2.3m×17.0m	Replacement culvert
C-22	Sta. 17+822.8 (NBL)	Concrete Box 1.2m×1.2m×35.0m	New culvert installation
C-23	Sta. 17+864.5 (NBL)	Concrete Box 3.0m×2.3m×17.0m	New culvert installation
C-24	Sta. 17+864.5 (SBL)	Concrete Box 3.0m×2.3m×17.0m	Replacement culvert
C-25	Sta. 18+235.3 (NBL)	Concrete Box 3.0m×2.3m×18.0m	New culvert installation
C-26	Sta. 18+249.5 (SBL)	Concrete Box 3.0m×2.3m×18.0m	Replacement culvert
C-28	Sta. 18+585.0 (NBL)	Concrete Box 5.0m×5.3m×17.0m	New culvert installation
C-29	Sta. 18+585.0 (SBL)	Concrete Box 5.0m×5.3m×17.0m	New culvert installation
C-30	Sta. 18+612.9 (Median)	Concrete Box 2.4m×1.8m×87.0m	Replacement/New culvert installation
C-41	Sta. 19+385.3 (Median)	Concrete Box 2.4m×1.2m×85.0m	Replacement/New culvert installation

Culvert ID	Location (Highway 69 Centerline)	Type and Size	Proposed Work
C-42	Sta. 19+410.0 (NBL)	Concrete Box 5.0m×5.3m×17.0m	New culvert installation
C-43	Sta. 19+410.0 (SBL)	Concrete Box 5.0m×5.3m×17.0m	New culvert installation
C-46	Sta. 19+887.0 (SBL)	Concrete Box 3.0m×2.3m×20.0m	New culvert installation
C-47	Sta. 19+893.4 (NBL)	Concrete Box 3.0m×2.3m×17.0m	New culvert installation
C-48	Sta. 20+226.0 (SBL)	Concrete Box 3.0m×2.3m×25.0m	New culvert installation
C-49	Sta. 20+245.1 (NBL)	Concrete Box 3.0m×2.3m×33.0m	New culvert installation
C-51	Sta. 20+935.5 (NBL)	Concrete Box 3.0m×2.3m×20.0m	New culvert installation
C-52	Sta. 20+935.5 (SBL)	Concrete Box 3.0m×2.3m×17.0m	New culvert installation
C-53	Sta. 21+816.4 (SBL)	Concrete Box 3.0m×2.3m×18.0m	New culvert installation
C-54	Sta. 21+827.4 (NBL)	Concrete Box 3.0m×2.3m×18.0m	New culvert installation
C-65	Sta. 22+675.0 (NBL)	Concrete Box 3.0m×2.3m×17.0m	New culvert installation
C-66	Sta. 22+675.0 (SBL)	Concrete Box 3.0m×2.3m×17.0m	New culvert installation
C-70	Sta. 20+940.0 (N-E/W Ramp)	Concrete Box 3.0m×2.3m×13.0m	New culvert installation

The practical reach of the excavation equipment defines the limiting depth for subexcavation. Long reach excavators have reach lengths as high as 12 m, depending on the specific equipment. For the purposes of this report, it has been assumed that excavation equipment will have the capability to reach to bedrock or to 8 m depth, whichever is less.

1.2 Subexcavation to Bedrock Foundation Culverts

Twenty five (25) culverts are proposed to be constructed over areas where foundation preparation by subexcavation to bedrock. These culverts can be constructed using full subexcavation to bedrock. Permanent culverts can be installed prior to embankment preloading. Full subexcavation of compressible materials could be carried out locally at the culvert locations before constructing the culverts after which the construction of the embankments could proceed as recommended in the referenced Swamp and High Fills report.

A summary of fill heights and associated embankment report recommendations for these 25 culverts is provided below.

CULVERT No.	SECTION UNDER	SWAMP No.	RECOMMENDED TREATMENT AT CULVERT LOCATION	REQUIRED FILL HEIGHT (m)
C-2	SBL	-	Full subexcavation to bedrock	Up to 1.5
C-3	NBL	101	Full subexcavation to bedrock	1.5 to 2.0
C-8	SBL	-	Full subexcavation to bedrock	Up to 4.0
C-9	NBL	102	Full subexcavation to bedrock	2.5 to 3.5
C-16	NBL	105	Full subexcavation to bedrock	2.5 to 3.0
C-17	SBL	-	Full subexcavation to bedrock	2.0 to 2.5
C-18	SBL	-	Full subexcavation to bedrock	2.5 to 3.0
C-19	NBL	-	Full subexcavation to bedrock	2.5 to 3.0
C-20	NBL	106	Full subexcavation to bedrock	3.5 to 4.0
C-21	SBL	-	Full subexcavation to bedrock	3.0 to 3.5
C-23	NBL	107	Full subexcavation to bedrock	4.0
C-25	NBL	108	Full subexcavation to bedrock	3.0 to 5.5
C-26	SBL	-	Full subexcavation to bedrock	Up to 6.0
C-42	NBL	112	Full subexcavation to bedrock	4.0 to 6.0
C-43	SBL	-	Full subexcavation to bedrock	4.0
C-46	SBL	114	Full subexcavation to bedrock	2.5 to 4.0
C-47	NBL	114	Full subexcavation to bedrock	5.0 to 8.0
C-48	SBL	115	Full subexcavation to bedrock	4.0 to 5.0
C-51	NBL	116	Full subexcavation to bedrock	3.5
C-52	SBL	-	Full subexcavation to bedrock	2.5
C-53	SBL	-	Full subexcavation to bedrock	3.0 to 3.5
C-54	NBL	-	Full subexcavation to bedrock	3.5 to 4.0
C-65	NBL	119	Full subexcavation to bedrock	3.0
C-66	SBL	121	Full subexcavation to bedrock	3.5 to 4.5
C-70	N-E/W Ramp	Ramp N-E/W	Full subexcavation to bedrock	3.0 to 3.5

1.3 Partial Subexcavation/Preload Foundation Culverts

Seven (7) culverts are proposed to be constructed in soft ground areas where the depth of compressible materials is such full subexcavation to bedrock is not practical. For these culverts, it will be important to integrate the foundation designs for culverts with the treatments for the associated swamp crossings, which are documented in the referenced Swamp and High Fill Crossings report in order to minimize settlements in transition zones.

The partial subexcavation/preload strategy should be adopted where the depth to bedrock exceeds 8 m. This strategy would require subexcavating compressible materials to a depth of 8 m, backfilling to ground level, installing a temporary culvert and completing temporary embankment construction followed by a prescribed preload period. For this strategy, a surcharge equivalent to 20% of the design embankment height should be applied as part of the preload. At the completion of the preload period, the temporary embankment material would be excavated in order to replace the temporary culvert with the permanent culvert after which the embankment would be reconstructed to design grade. The temporary fill above ground level that would be required to be excavated for installation of the permanent culvert could be composed of either suitable fill or granular fill to facilitate its excavation or of rockfill. Permanent roadway fill can be composed of rockfill.

Where the partial subexcavation/preloading approach for culvert construction is adopted, temporary culverts would be required to be placed at water crossings prior to preloading/surcharging the embankment. These temporary culverts would have to be of sufficient size to perform their drainage function and would have to be removed and replaced with permanent culverts upon completion of the embankment preload.

A summary of fill heights and associated embankment report recommendations for the 7 culverts over swamps where foundation preparation requires more complex procedures such as partial subexcavation/preloading is provided in Appendix B Table 2.

The preload period for all partial subexcavation/preload culverts should be a minimum of 3 months. This preload duration should allow culvert construction to be completed within one construction season. The duration of this preload period has been predicted by practical modifications of the predicted settlement magnitudes and durations for the associated embankments over undistrurbed ground as recommended in the referenced embankment report. The determination of the required preload period at the culvert locations would depend on the degree that partial subexcavation/preloading eliminates compressible ground. This determination would impact the time at which permanent culvert construction could proceed. The prediction of the required duration of preload would be difficult to support with calculations due to uncertainties with the degree of elimination of compressible ground by the subexcavation/preloading operation.

As noted, the degree of consolidation under preload and the time duration required for preload could be conservatively estimated from comparison with the recommendations for duration of the embankment preloads considering the difference in that the embankment preload duration has been calculated assuming undisturbed foundation soil. The required preload period at the culvert foundations could be more accurately determined by the assessment of piezometer measurements during preloading. If piezometer installation and monitoring was the selected strategy to determine preload duration at the culvert foundations, piezometers would have to be installed at strategically selected locations and a monitoring program would have to be established to assess when consolidation settlements have been sufficiently realized to permit construction of culverts. The duration of the preload period could be reduced by the application of wick drains, but this option is not considered to be an economically viable one due to the relatively small size of the culvert sites. The design of settlement instrumentation and a monitoring program and the design of wick drains are beyond the scope of this assignment.

1.4 Culvert Type Selection Considerations

The selection of culvert type should be based on consideration of the ground conditions and the proposed culvert and highway embankment construction techniques.

The options for culvert construction consist of either construction in-the-dry or construction in-the-wet. Construction in-the-dry would permit both pre-cast and cast-in-place box culverts and open footing cast-in-place culverts whereas only box culverts would be suitable for construction-in-the-wet. Also, in-the-dry techniques would be required for cast-in-place culverts, which are an option for all culvert locations and especially those where the required culvert size may be impractical for precast concrete culverts.

In those areas where removal of bedrock would be required to found the culverts at an elevation to provide the prescribed invert elevation, open footing culverts would be an option. Open footing culverts, unless founded directly on bedrock, require frost protection and associated deeper excavations and more extensive dewatering. For open footings founded directly on bedrock, frost protection depth would not be required.

The amount of differential settlement that a culvert can tolerate depends on the properties of the connector gaskets between segments Precast box culverts are capable of withstanding more differential settlement than cast-in-place concrete culverts. Cast-in-place culverts should be designed with segment lengths and connecting gaskets that can tolerate the differential settlement associated with the recommended bearing resistance per the table in Section 2.1. Precast box culvert sections should be joined with sealing flexible joints capable of accommodating the specified differential settlements.

A critical consideration will be whether foundation conditions change along the culvert alignment to the extent that different culvert types and related foundation solutions are selected depending on depth to bedrock. That is, if a portion of the culvert is founded on unyielding foundations on bedrock while the remainder of that culvert is founded on yielding foundations that settle over time, the culvert must be designed to accommodate the differential movements between these two zones.

The precast concrete box culvert option should be less costly than the cast-in-place concrete box culvert or cast-in-place open footing culvert alternatives since construction of the culvert will be expedited without the forming and curing time needed for cast-in-place concrete construction and also because precast boxes can be installed without extensive dewatering provided that the residual depth of water is not excessive and an adequate leveling pad can be placed. If available precast culvert spans are smaller than required for the application, double barrel culverts could be considered if feasible.

If construction in-the-dry is used, cofferdams or well points may be required to facilitate dewatering. Refer to Appendix A for an NSSP for dewatering that should be included in contract documents. As noted elsewhere in this report, an alternate to constructing in-the-dry would be constructing in-the-wet if the conditions are favourable for placing adequate levelling pads without dewatering. Such levelling pads can be placed below water by using non-cohesive fill built up to approximately 0.5m above the water line to facilitate compaction and then subexcavated to the levelling pad level. Alternatively, specific granular leveling pad materials essentially compact upon end-dumping and spreading and would not require further compaction.

In any case, it would advantageous if construction was carried out during dry periods.

The following table compares the advantages, disadvantages, risks / consequences and relative costs of precast and cast-in-place (CIP) culverts from the foundation perspective:

Culvert Type	Advantages	Disadvantages	Risks/Consequences	Relative Costs
Precast Segmental Culvert	less time required for construction less complex dewatering more tolerant to settlement	precast concrete provides lower sliding resistance than CIP concrete	differential settlement	less cost due to shorter construction time
CIP Culvert	CIP concrete provides higher sliding resistance than precast concrete	more time required for construction more complex dewatering less tolerant to settlement	differential settlement increased risk of dewatering claims	more cost due to longer construction time

For those longer span culverts over deep compressible ground as identified in the site specific recommendations, other culvert configurations such as proprietary arch culverts could be considered. Foundation design requirements for such proprietary arch culverts would be similar to the scope for bridges and are considered to be beyond the scope of this report, which per the project TOR's assumes box section culverts. Proprietary arch culverts could require essentially unyielding foundations and hence deep foundations.

1.5 Contract Considerations

Consideration should be given to implementing contractual approaches to minimize the potential for contractor claims against differing site conditions. This consideration is important at sites such as these where depth to bedrock is variable and is not practical to define precisely because of limitations on the number of boreholes that can be advanced during design and the reality that the depth to bedrock is extremely variable in the Canadian Shield. One method to mitigate this risk would be to pay for excavation on a per cubic metre basis, in which case baseline quantities for both soil excavation and rock excavation should be specified in bid documents to prevent unbalanced bids.

2. GENERAL BOX CULVERT FOUNDATIONS RECOMMENDATIONS

Following are general recommendations applicable to all culvert sites. Refer to Sections 3 and 4 of this report for site specific recommendations for culvert foundations.

All elevations in the report are expressed in metres.

2.1 Culvert Foundation Type and Bearing Resistance

All culverts can be founded on spread footings.

The bearing resistances in the following table are recommended at the culvert/ground interface for various subgrade material categories. Refer to the site-specific recommendations in Sections 3 and 4 for identification of the subgrade material category for each site. At sites where there are mixed subgrade material categories for culvert foundations, the joints between culvert segments should be designed to accommodate the predicted differential settlements.

FOUNDATION TYPE	SUBGRADE MATERIAL CATEGORY	FACTORED GEOTECHNICAL RESISTANCE AT ULS (kPa)	GEOTECHNICAL REACTION AT SLS (kPa)
Box Culvert	bedrock	1000	500 (with <25mm settlement)
	rockfill on bedrock	500	350 (with <50mm settlement)
	rockfill on soil	375	250 (with <100mm settlement
	Granular A or Granular B Type II Bedding on bedrock *	750	350 (with <25mm settlement)
Open Footing Culvert	bedrock	>2,000	>2,000 with no settlement

** Note: Bearing resistance values apply where compaction in conformance to MTO standards is confirmed. This condition may not be feasible to achieve below the prevailing groundwater level.*

Watertight flexible joints to accommodate the indicated settlement for the identified subgrade material category in the above table should be provided between culvert segments. Where portions of culverts are founded on different subgrade materials, the flexible joints at the interface between segments founded on different subgrade materials should accommodate the differential settlement.

Site specific recommendations for culvert foundation type, subgrade material and bearing resistance at the culvert founding level are provided in Section 3 and Section 4. Customized connectors will be required to connect culverts with differing sizes.

Where the site specific recommendations indicate mixed subgrade materials for founding along or across the culvert alignment, culvert segments with flexible joints capable of accommodating the differential movements between culvert segments will be required.

2.2 Frost Protection

The foundation frost penetration depth at the site is 2.0 m according to OPSD 3090.101.

Frost protection is not required for box culverts.

2.3 Excavation

Excavation can be carried out in-the-wet or in-the-dry. Excavation of the soils should be feasible using conventional excavation equipment but will be constrained by the practical reach of the excavator. All excavations should be undertaken in accordance with OPSS 902. Where excavation of bedrock is required to establish the bedding elevation, rock excavation and blasting will be required. The selection of equipment and method for excavation in soil and rock will be the Contractor's responsibility.

Refer to OPSD 203.010 - Embankments Over Swamp, New Construction - for side slope excavations. Side slope below the prevailing groundwater level may be as steep as possible but are expected to be stable at 1H:1V or flatter.

The associated NSSP - Variable Mixed Fill and Rock Fill at Embankments provided in Appendix A should be included in the contract documents to advise the Contractor of potentially challenging conditions for excavation and for installation of shoring as cobbles, boulders and rockfill may be encountered within the ground.

Refer to Sections 3 and 4 for site specific recommendations for excavation. One of the following two strategies has recommended for excavation at culvert site depending on the depth from surface to bedrock:

1) Full subexcavation to bedrock (where bedrock is within 8m of the surface)
2) Partial subexcavation to 8m depth and preloading/displacement techniques (where bedrock is deeper than 8m from the surface)

In both cases, the soil under the plan limits of the culvert should be subexcavated to the specified elevation prior to backfilling to culvert bedding level. The minimum depth of excavation should allow for the backfill and cover requirements in accordance with OPSD 803.010. The depth of subexcavation should extend a minimum of 0.3 m below the culvert base level, which should be a equivalent to 0.5 m below the culvert invert to allow for the base thickness of the box culvert and for the granular bedding. A transition zone is required to provide smoother settlement transitions along the highway alignment and to mitigate excessive differential settlements between the culvert zones and the highway embankment. In order to provide these transitions zones, excavations should extend to specified depths under the plan limits of culverts and then with geometry of 2H:1V or flatter backslopes from the base of subexcavations to the ground surface.

For design and construction documentation purposes, the depth to bedrock at specific culverts is illustrated in the relevant boreholes and stratigraphical sections presented in the Foundation Investigation portion of this report. The depth to bedrock was determined only at borehole locations and will be variable along and across culvert alignments. For design purposes, refer also to Appendix C Table 3 for guideline values for depth of excavation at the locations specified in the table. Although the bedrock surface is expected to be variable along and across culvert alignments, the bedrock surface may be directly interpolated between the top of bedrock levels at the borehole locations unless other interpretations of the bedrock surface are recommended in the site specific recommendations in Sections 3 and 4 of this report.

If bedrock is encountered above the planned excavation elevation, removal of bedrock will be required to attain the subexcavation geometry and to provide base padding to improve the consistency of settlement performance with adjoining sections over more compressible ground. Although the selection of equipment and construction procedures should be the responsibility of the Contractor, rock excavation techniques such as blasting per OPSS 120 and possibly jack-hammering should be suitable. Near vertical sidewalls may be utilised for excavations in bedrock.

According to the Occupational Health and Safety Act (Ontario Regulation 213/91) criteria, native firm to stiff cohesive soils and loose to compact cohesionless soils are classified as Type 3 soils necessitating temporary cut slopes to be inclined at 1H:1V. The soft to very soft cohesive soils and very loose cohesionless soils are classified as Type 4 soils necessitating temporary cut slopes to be inclined at 3H:1V or flatter.

Temporary roadway protection is required at excavations in close proximity to existing highway embankments at which the excavation geometry would result in a slope steeper than 1H:1V from the base of the existing highway embankment to the base of excavation. Temporary roadway protection shall be designed in accordance with OPSS 539 providing a minimum performance level 2.

2.4 Groundwater Control

Groundwater is near the surface across most culvert sites.

For construction in-the-dry, it will be necessary to implement measures to control the surface water flow and the groundwater. Conventional procedures such as dam and pump and/or diversion of the stream may be sufficient to control surface water flow. However, cofferdams may be required to facilitate dewatering. Dewatering requirements would be minimized by scheduling affected construction activities during dry periods.

It is noted that the groundwater levels are subject to seasonal fluctuations and precipitation patterns. The contract documents should include an NSSP stating that the groundwater level should be lowered to a minimum 0.5 m below the proposed founding levels except in bedrock where it should be lowered to the surface of the bedrock. Refer to Appendix A for the draft NSSP - Surface Water Control and Dewatering.

In accordance with the Ontario Water Resources Act, the Water Taking and Transfer Regulation 387/04, a Permit to Take Water (PTTW) from the Ministry of Environment is required if the dewatering discharge is greater than 50,000 L/day. The expected daily flows at the culvert location should be assessed to determine if this permit will be necessary. It may be prudent to obtain the PTTW to avoid delays should the PTTW become necessary during construction.

2.5 Backfill and Embankment Fill

Backfill below ground level should be rock fill. For construction in-the-wet, rockfill should be end-dumped below the groundwater table without compaction.

Where excavation is to bedrock no preloading or surcharging is required. Where excavation terminates in soil, the installation of a temporary culvert followed by preloading and surcharging are required to partially displace and consolidate the underlying soil prior to construction of the permanent culvert.

In cases where excavation terminates in soil, the relevant recommendations in Section 1.3 and Section 4 (Site-Specific Culvert Foundations Recommendations - Partial Excavation/Preload Culverts) apply. A surcharge equivalent to 20% of the design embankment height should be applied to accelerate settlements. Excess rock fill can be graded over the sides of the road embankment or removed upon completion of the preload period.

Where bedrock is nearer the surface, mass concrete could be employed to level minor variations in the bedrock surface, if necessary.

Embankment fill may be suitable earth fill, granular fill or rockfill. All fill placed above the groundwater level should be compacted. This is particularly important above the water level within the zone of influence of the culvert, defined by an imaginary line inclined downwards at 2H:1V from the invert level of the culvert and extending to the highway grade.

The construction specifications for grading in SP 206S03 should be followed. The embankment fill above ground level should be placed and compacted in accordance with OPSS 501.

The rockfill embankment side slopes should be inclined no steeper than 1.25H:1V. If earth slope flattening is indicated, a vegetation cover over slope flattening material or other measures to control surface runoff and minimise erosion of the embankment slopes should be implemented.

2.6 Settlement within Embankment Rockfill

Design should be in accordance with the MTO memorandum in Appendix D entitled “Post Construction Rockfill Settlement and Guidelines for Estimating Rockfill Quantity” dated September 14, 2010, which provides direction for design and construction including magnitude of post-construction settlement of rockfill and bulking factor assumptions.

2.7 Culvert Subgrade Preparation

Preparation of the subgrade for construction of the culverts should be carried out in accordance with OPSS 902.

Subsurface soil conditions will vary between the boreholes drilled at the site and the thicknesses of overburden and the depths to bedrock should be expected to vary between the borehole locations. The soil and bedrock encountered should be excavated to the required bedding level prior to placement of the granular bedding for culverts. As noted previously, bedding can be placed below water level if sufficiently self-compacting or by overbuilding above the water level and then compacting and trimming to the bedding level. The excavated overburden including peat and soft ground and the rock should be replaced with appropriate rock fill, Granular A or Granular B Type II material.

Reference is made to OPSD 803.010, OPSS 422 and SP 422S01 for additional information on subgrade preparation, cover, backfill and frost treatment such as frost tapers.

2.8 Culvert Bedding

Box culverts should be placed on a minimum 300 mm thick layer of compacted granular bedding material. Open footing culverts may be founded directly on bedrock. To facilitate placement of bedding is placed on rock fill, the upper 0.5 m of the rock fill should consist of more uniform and smaller size rock not exceeding 150 mm in dimension. Further, the bedding should be separated from the rock fill with geotextile meeting the requirements specified in Section 2.9 of this report.

Bedding material should comprise Granular A or Granular B Type II compacted in conformance to OPSS 501.

2.9 Culvert Backfill

Backfill adjacent to the box culvert should be placed in accordance with OPSD 803.010, OPSS 422 and SP 422S01.

Backfill should be brought up simultaneously on each side of the box culvert. The operation of heavy equipment within a horizontal distance defined as 0.5 times the height of the culvert should be restricted to minimise the potential for movement and/or damage of the culvert due to the lateral earth pressure induced by compaction. Refer to OPSS 501 for additional requirements.

2.10 Geotextile Separator

For culverts placed on or within rockfill, the granular bedding material and rockfill material should be separated by a geosynthetic filter fabric to prevent loss of the granular materials into the voids of the rockfill. The rockfill surface should be chinked in accordance with the requirements of SP 206S03, prior to placing the geotextile. The filter fabric should conform to OPSS 1860 and comprise a Class II non-woven geotextile with a filtration opening size (FOS) of 105 to 210 μm. The filter fabric should be placed horizontally beneath the bedding and extend up on each side and to the top of the bedding and/or granular cover material.

2.11 Inlet Treatment Erosion Protection

Provisions are required to channel water through the culvert openings and to protect the embankment and culvert bedding and backfill from erosion. Where embankments are composed of rock fill, erosion protection of the rock fill is not required. However, bedding and backfill shall be designed per standard and require inlet sealing and erosion protection.

Where granular bedding and backfill is placed within rockfill, it should be wrapped in non-woven Class II geotextile with an FOS of 75-150 µm according to OPSS 1860 to minimise the potential for erosion.

Extended culverts to permit spill through embankments with horizontal cut-off aprons are preferred to avoid complex headwall and vertical cut-off wall construction that would require foundations with frost protection and associated dewatering. In this case, a minimum 0.6 m thickness of clay seal, or equivalent proprietary seal, covered by a minimum 0.6 m thickness of rock protection with minimum dimension of 0.3 m should be installed along the embankment and inlet channel.

- in the culvert longitudinal direction, from the high water level to a minimum dimension equivalent to 2 culvert heights upstream along the inlet channel

and

- in the culvert transverse direction, to cover the granular backfill and a minimum dimension equivalent to 1 culvert height on each side of the culvert along the embankment and the inlet channel.

Refer to OPSS 1205 for material specification for clay seal. Where appropriate, the erosion protection for the inlet watercourse should be determined by the Hydraulics Engineer and the above recommendations are presented as minimum requirements from a foundations engineering perspective.

Refer to OPSS 511 - Construction Specification for Rip-Rap, Rock Protection and Granular Sheeting, for design and installation requirements for these types of erosion control treatments.

Refer to OPSS.PROV 804 - Construction Specification for Seed and Cover, for design and installation requirement for Matrix Bonded Fabric (BMF) for erosion control.

Where embankments are composed of earth, they should be covered with topsoil or suitable excess earth material from swamps or muskeg areas and seeded in accordance with OPSS 802 and 804 as soon after grading as possible to prevent erosion. Slopes steeper than 2.5H:1V should be protected with erosion control blankets until vegetation is established.

No slope erosion protection is required for rock fill embankments.

2.12 Outlet Treatment and Erosion Protection

Provisions are required at the downstream embankment and outlet channel to prevent loss of embankment and culvert bedding materials and erosion of the outlet channel. Where embankments are composed of rock fill, erosion protection of the rock fill is not required.

A minimum 0.6 m thickness of Granular A covered by a minimum 0.6 m thickness of rock protection with minimum dimension of 0.3 m should be installed along the embankment in the culvert transverse direction, to cover the granular backfill and a minimum dimension equivalent to 1 culvert height on each side of the culvert.

In addition a minimum 0.6 m thickness of rock protection with minimum dimension of 0.3 m should be installed

- in the culvert longitudinal direction, a minimum dimension equivalent to 2 culvert heights downstream along the outlet channel

and

- in the culvert transverse direction, a minimum dimension equivalent to 1 culvert height on each side of the culvert along the outlet channel.

The above recommendations are minimum requirements from a foundations engineering perspective. Where appropriate, the erosion protection design for the outlet watercourse should be determined by the Hydraulics Engineer.

2.13 Camber

To mitigate the risk of ponding within culverts resulting from settlement, the invert geometry of culvert installations should be horizontal from the inlet to the mid-point of the culvert and then from that midpoint the invert should slope down to outlet elevation.

2.14 Headwalls and Wingwalls

Headwalls and wingwalls can be eliminated by extending culvert alignments so that the embankment fill can spill at natural slopes around the culverts. Where space constraints or other considerations dictate the need for headwalls and wingwalls, the following recommendations apply.

The previous recommendations and geotechnical parameters provided in this report for culvert foundations and backfill should be used for the design of any headwall and/or wingwall foundations in accordance with OPSD 3121.150. The wall founding levels should match those of the culvert where the walls are designed integral with the culvert structure. For walls designed separately from the culvert structure, the founding levels should be established a minimum 2.0 m below the culvert invert level to provide adequate frost protection for the foundations.

The design of the walls should be checked for sliding resistance using the geotechnical parameters provided in Section 2.16 for cast-in-place concrete foundations.

For headwalls and wing walls, a perforated subdrain should be installed to minimise the build-up of hydrostatic pressure behind the wall. The perforated subdrain should be surrounded by a properly designed granular filter or non-woven Class II geotextile (with an FOS of 75-150 µm according to OPSS 1860) placed to prevent migration of fines into the system. The wall drainage pipe should drain away from the wall and, where possible, to a frost free outlet.

2.15 Earth Pressure

The box culvert and headwalls should be designed to resist the unbalanced lateral earth pressure and compaction pressure exerted by the backfill adjacent to the culvert. Recommendations for headwalls and wingwalls are also provided in Section 2.15 of this report.

The lateral earth and water pressure, p (kPa), should be computed using the equivalent fluid pressures presented in Section 6.9 of the CHBDC or employing the following equation assuming a triangular pressure distribution:

$$P = K(\gamma h_1 + \gamma' h_2 + q) + \gamma_w h_2 + Cp + Cs$$

where K = lateral earth pressure coefficient
γ = unit weight of free draining granular material above the design water level (kN/m^3)
γ' = unit weight of backfill submerged below the design water level (kN/m^3)
h_1 = depth below final grade (m), above the design water level
h_2 = depth below the design water level (m)
q = any surcharge load (kN/m^2)
γ_w = unit weight of water equal to 9.8 kN/m^3
Cp = compaction pressure (refer to clause 6.9.3 of CHBDC)
Cs = earth pressure induced by seismic events, kPa (refer to clause 4.6.4 of CHBDC)
where Ø = angle of internal friction of retained soil (35º for Granular A)
δ = angle of friction between soil and wall (23.5º for Granular A)

The following parameters are recommended for design:

PARAMETER	GRANULAR A, GRANULAR B TYPE II	ROCKFILL
Angle of Internal Friction, degrees	35	42
Unit Weight, kN/m^3	22.8	18.0
Active Earth Pressure Coefficient (K_a)	0.27	0.20
At-Rest Earth Pressure Coefficient (K_o)	0.43	0.33
Passive Earth Pressure Coefficient (K_p)	3.69	5.04

The design should consider the stabilised groundwater level conditions and the maximum water level dictated by the design storm.

The coefficient of earth pressure at rest should be employed to design unyielding walls and the active earth pressure coefficient for unrestrained structures.

2.16 Modulus of Subgrade Reaction

The estimated values of the modulus of subgrade reaction for culverts constructed on various subgrade materials are as follows:

SOIL TYPE	MODULUS OF SUBGRADE REACTION MN/m^3
Firm to Very Stiff Clayey Silt/Silty Clay or Clay	5 - 30
Compact to Very Dense Silty Sand or Silt	35 - 60
Dense to Very Dense Sand	80
Granular A or B Type II	45
Rockfill	50

2.17 Sliding Resistance

The following parameters should be used for sliding resistance of cast-in-place concrete culvert foundations. The friction angle in the case of precast concrete should be reduced by a factor of 0.67.

SOIL TYPE	Friction Angle, (degrees)	Cohesion, (kPa)	Unit Weight, (kN/m^3)
Granular A or B Type II	35	0	22.8
Firm to Very Stiff Clayey Silt/Silty Clay or Clay	0	25-100	17-19
Compact to Very Dense Silty Sand or Silt	30	0	20-22
Dense to Very Dense Sand	30-32	0	21-22
Rockfill	42	0	18

If required to resist lateral forces, the lateral resistance of culvert bases founded on bedrock should be increased by means of a shear key and/or by installing dowels/anchors into the bedrock (SP 999S26). The increased lateral resistance will be provided by the shear strength of steel dowels if used, the horizontal resistance of the bedrock, the horizontal component of tensile forces developed in any inclined anchors and/or a greater frictional resistance between the footing and rock if the anchors are prestressed to increase the vertical pressure.

If anchors are installed, design, installation and testing of the anchors subjected to tensile stresses should be conducted in accordance with SP 999S26 and clause 6.10.4 of the Canadian Highway Bridge Design Code (CHBDC).

2.18 Seismic Site Coefficient

The site coefficient for the seismic conditions at the culvert sites is 1.0 – Type I soil profile as per clause 4.4.6 of the CHBDC. From a foundations engineering perspective, seismic conditions are not a consideration at these sites.

2.19 Contract Specifications

A list of standard specifications and draft NSSP's referenced in this report are compiled in Appendix A. The Granular A and B materials referenced in the report should conform to SP 110S13.

A critical contract issue will be designation and payment for excavation due to the varying depth to bedrock between borehole locations. In order to mitigate this risk, consideration should be given to implementing a process in the contract to account for this, such as the following;

- The measure for payment should be defined as cost per cubic metre of excavated material for both soil and bedrock/rockfill.
- The excavation geometry should be defined as to the specified depth beneath the plan limits of the culvert and from that depth at a backslope of 2H:1V or flatter to the ground surface.
- The Contractor should submit prices per cubic metre for excavation of soil and for excavation of bedrock/rockfill.
- Payment should be for actual volumes removed.
- In order to avoid unbalanced bids, the Contractor should be advised that for bid evaluation purposes a presumed total excavation quantity of say 50,000 cubic metres and a blended bid price of 20% weighting for rock/rock fill and 80% weighting for soil will be assumed.

2.20 Construction Considerations and Red-Flag Issues

The "red-flag" issues outlined in the preceding paragraphs and the recommended methods of overcoming these issues noted in the following sections of this report are intended to alert and aid the designer and where appropriate to alert the Contractor through subsequent contract specification. It is noted that no responsibility or liability is assumed by the MTO or its design consultants for alerting the contractor to all "red-flag" issues. The requirement to deliver acceptable construction quality remains the responsibility of the Contractor.

The red-flag issues for this project include complex dewatering challenges and the designation of ground and rock for contract purposes for subexcavation below ground surface.

All construction work should be carried out in accordance with the Occupational Health and Safety Act and with local/MTO regulations.

Refer to Appendix A, for Table 1 - Standard Specifications Referenced in Report for a list of relevant OPSS's and for draft NSSP's that should be included in the contract documents.

3. SITE-SPECIFIC CULVERT FOUNDATIONS RECOMMENDATIONS – EXCAVATION TO BEDROCK CULVERTS

Site-specific comments and recommendations are provided below for all 'excavation to bedrock' culverts. At these sites excavations will extend to bedrock and permanent culverts can be constructed in conjunction with permanent highway embankments without surcharging or preloading. Refer to the relevant recommendations in Sections 1 and 2 for recommendations for pertaining to 'excavation to bedrock' culverts. Refer to the table in Section 2.1 for bearing resistance recommendations and associated settlements for the foundation type/subgrade material category identified in the site specific recommendations for each culvert.

3.1 Culvert C-2 at Sta. 16+076.0 (SBL)

A 4.0 m long concrete box culvert extension is proposed at the southbound lanes of Highway 69, connecting to the existing 760 mm diameter and 27.5 m long CSP culvert. The invert levels of the proposed 1.2 m high and 3.0 m wide culvert extension are specified at approximate elevation 193.2 at the left (west) end and 193.5 at the right (east) end of the culvert extension. Consideration should be given to the consequences of the differing sizes of the existing culvert and the proposed extension. A specially designed connector will be required to transition from the existing CSP culvert to the new culvert.

Based upon the proposed road centreline grade elevation of 196.0 and the existing ground elevation of 194.6, the embankment fill at the culvert will be up to 1.4 m high. At borehole C2-1 at the proposed culvert extension, probable bedrock was contacted at elevation 194.1. However the depth to bedrock is expected to be variable across this site. Surface water was measured at the ground surface (elevation 194.6) in borehole C2-1 during drilling.

No embankment preloading is required and the permanent culvert extension can be constructed in conjunction with embankment construction.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations. The foundation type/subgrade material category at this site is

- a box culvert founded on rockfill on bedrock

or

- an open footing culvert founded on bedrock.

Due to the different subgrade conditions and loading history at the existing and new culvert extension, an appropriate connector to adapt to the different sizes of the existing and proposed culverts and incorporating an articulated joint capable of accommodating 50 mm differential settlement is recommended between the existing culvert and the culvert extension.

3.2 Culvert C-3 at Sta. 16+086.2 (NBL)

A new 31.0 m long concrete box culvert is proposed at the northbound lanes of Highway 69 in swamp 101. The invert levels of the proposed 1.2 m high and 3.0 m wide culvert are specified at approximate elevation 193.8 at the left (west) end and 193.9 at the right (east) end of the culvert.

Based upon the proposed road centreline grade elevation 196.1 and the existing ground elevations 194.2 to 194.8, the embankment fill at the culvert is assessed to be 1.5 to 2.0 m high.

In summary, the overburden consists of peat over stiff clayey silt and/or bedrock. Probable bedrock was contacted at depths of 0.1 to 2.0 m (elevation 192.2 to 194.7). However the depth to bedrock is expected to be variable across this site. Open water was present under 300 mm of snow at elevation 193.9 in boreholes C3-1 and C3-2.

No embankment preloading is required and the permanent culvert can be constructed in conjunction with embankment construction.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations. The foundation type/subgrade material category at this site is

- a box culvert founded on rockfill on bedrock

or

- an open footing culvert founded on bedrock.

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

3.3 Culvert C-8 at Sta. 16+531.9 (SBL)

The existing 910 mm CSP culvert under the southbound lanes of Highway 69 will be replaced with a new 18.0 m long concrete box culvert. The invert levels of the proposed 2.3 m high and 3.0 m wide culvert are specified at approximate elevation 192.7 at the left (west) end and 192.9 at the right (east) end of the culvert.

Based upon the proposed road centreline grade elevation 197.0 and the existing elevations 193.2 and 193.6, the embankment fill at the culvert is assessed to be up to 4.0 m high.

The overburden consists of sand, gravel, cobbles and boulders fill overlying bedrock. Bedrock was contacted at 1.3 and 4.1 m (elevation 191.9 and 189.5). However the depth to bedrock is expected to be variable across this site. No groundwater was established in boreholes C8-1 and C8-2 charged with drilling water for rock coring.

No embankment preloading is required and the permanent culvert can be constructed in conjunction with embankment construction.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations. The foundation type/subgrade material category at this site is

- a box culvert founded on rockfill on bedrock

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

3.4 Culvert C-9 at Sta. 16+556.7 (NBL)

The new 28.0 m long concrete box culvert is proposed at the northbound lanes of Highway 69 in swamp 102. The invert levels of the proposed 2.3 m high and 3.0 m wide culvert are specified at approximate elevation 193.0 at the left (west) end and 193.3 at the right (east) end of the culvert.

Based upon the proposed road centreline grade elevation 197.0 and the existing elevations 193.7 to 194.4, the embankment fill at the culvert is assessed to be 2.5 to 3.5 m high.

The soil revealed below the subgrade level at the left (west) end of the culvert comprised cohesive firm to soft clay deposit mantling probable bedrock at elevation 190.6. At the centre and right (east) end of the culvert, bedrock was encountered at elevation 194.1 and 193.2 respectively, some 1.4 and 0.4 m above the anticipated subgrade level. However the depth to bedrock is expected to be variable across this site.

Open water was present under 300 and 600 mm of snow/ice at elevation 193.4 and 193.8 in boreholes C9-1 and C9-2 respectively. No groundwater was observed in borehole 102-4 during and upon completion of drilling.

No embankment preloading is required and the permanent culvert can be constructed in conjunction with embankment construction.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations.

Refer to Table 3 in Appendix C for descriptions of foundation conditions at the west extent, the centre and the east extent of culverts. The subgrade material category at this culvert foundation is mixed. Culvert foundation types can be:

- a box culvert founded on rockfill on bedrock

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

3.5 Culvert C-16 at Sta. 16+979.3 (NBL)

A new 33.0 m long concrete box culvert is proposed under the northbound lanes of Highway 69 in swamp 105. The invert levels of the proposed 2.3 m high and 1.2 m wide culvert are specified to be at approximate elevation 195.7 at the left (west) end and 195.6 at the right (east) end of the culvert.

Based upon the proposed road centreline grade elevation 198.7 and the existing elevations 195.9 to 196.3, the embankment fill at the culvert is assessed to be 2.5 to 3.0 m high.

In summary, the soils revealed below the culvert subgrade levels consisted of peat over soft to firm cohesive soils (silty clay, clayey silt and clay) or bedrock. Probable bedrock was contacted at 0.2 to

3.2 m (elevation 192.8 to 196.1). However the depth to bedrock is expected to be variable across this site.

Upon completion of drilling, groundwater was observed at the ground surface and 0.3 m (elevation 195.9 and 195.8) in boreholes C16-1 and 105-7 respectively. No groundwater was observed in borehole 105-8 during and upon completion of drilling.

No embankment preloading is required and the permanent culvert can be constructed in conjunction with embankment construction.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations.

Refer to Table 3 in Appendix C for descriptions of foundation conditions at the west extent, the centre and the east extent of culverts. The subgrade material category at this culvert foundation is mixed. Culvert foundation types can be:

- a box culvert founded on rockfill on bedrock

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

3.6 Culvert C-17 at Sta. 16+991.7 (SBL)

Culvert C-17 is proposed under the southbound lanes of Highway 69 alignment. The existing 910 mm diameter CSP culvert at the location will be replaced with a new 25.0 m long, 2.3 m high and 1.2 m wide concrete box culvert. The invert levels are specified to be at approximate elevation 195.7 at both ends of the culvert.

Based upon the proposed road centreline grade elevation 198.5 and the existing elevations 196.3 and 196.7, the embankment fill at the culvert is assessed to be 2.0 to 2.5 m high.

The subgrade levels are in the bedrock at both ends of the culvert. Probable bedrock was contacted at 0.2 and 1.3 m (elevation 196.1 and 195.4). However the depth to bedrock is expected to be variable across this site.

In the process of augering, water was detected at 0.2 m (elevation 196.5) in borehole C17-1. Groundwater was not established in the borehole upon completion of drilling. No groundwater was observed in borehole 105-8 during and upon completion of drilling.

No embankment preloading is required and the permanent culvert can be constructed in conjunction with embankment construction.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations. The foundation type/subgrade material category at this site is

- a box culvert founded on rockfill on bedrock

or

- an open footing culvert founded on bedrock.

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

3.7 Culvert C-18 at Sta. 17+108.3 (SBL)

Culvert C-18 is proposed under the southbound lanes of Highway 69 alignment. The existing 760 mm diameter CSP culvert will be replaced with a new 27.0 m long, 2.3 m high and 3.0 m wide concrete box culvert. The invert levels are specified to be at approximate elevation 196.3 at the left (west) end and 196.4 at the right (east) end of the culvert.

Based upon the proposed road centreline grade elevation 199.9 and the existing elevations 197.2 and 197.5, the embankment fill at the culvert is assessed to be 2.5 to 3.0 m high.

The subgrade levels are in the bedrock at both ends of the culvert. Bedrock / probable bedrock was contacted at 0.6 and 1.2 m (elevation 196.9 and 196.0). However the depth to bedrock is expected to be variable across this site.

No groundwater was established in boreholes C18-1 and C18-2 upon completion of drilling. Borehole C18-1 was charged with water during rock coring.

No embankment preloading is required and the permanent culvert can be constructed in conjunction with embankment construction.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations. The foundation type/subgrade material category at this site is

- a box culvert founded on rockfill on bedrock

or

- an open footing culvert founded on bedrock.

Construction joint articulation would be required to accommodate 25 mm of differential settlement to account for possible variations in depth to bedrock and associated backfill to culvert foundation level.

3.8 Culvert C-19 at Sta. 17+127.1 (NBL)

A new 30.0 m long concrete box culvert is proposed under the northbound lanes of Highway 69. The invert levels of the proposed 2.3 m high and 3.0 m wide culvert are specified to be at approximate elevation 196.7 at the left (west) end and 197.1 at the right (east) end of the culvert.

Based upon the proposed road centreline grade elevation 200.0 and the existing elevations 197.0 and 197.4, the embankment fill at the culvert is assessed to be 2.5 to 3.0 m high.

At the left end of the culvert, probable bedrock was contacted at 0.9 m (elevation 196.1), some 0.1 m below the anticipated subgrade level. At the right end, probable bedrock was contacted at 0.4 m (elevation 197.0), some 0.4 m above the subgrade level. However the depth to bedrock is expected to be variable across this site.

Upon completion of drilling, groundwater was at 0.0 and 0.2 m (elevation 197.0 and 197.2) in boreholes C19-1 and C19-2 respectively.

No embankment preloading is required and the permanent culvert can be constructed in conjunction with embankment construction.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations.

Refer to Table 3 in Appendix C for descriptions of foundation conditions at the west extent, the centre and the east extent of culverts. The subgrade material category at this culvert foundation is mixed. Culvert foundation types can be:

- a box culvert founded on rockfill on bedrock

or

- an open footing culvert founded on bedrock.

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

3.9 Culvert C-20 at Sta. 17+542.7 (NBL)

A new 17.0 m long concrete box culvert is proposed under the northbound lanes of Highway 69 in swamp 106. The invert levels of the proposed 2.3 m high and 3.0 m wide culvert are specified to be at approximate elevation 196.8 at both ends of the culvert.

Based upon the proposed road centreline grade elevation 201.0 and the existing elevations 197.3 to 197.7, the embankment fill at the culvert is assessed to be 3.5 to 4.0 m high.

In summary, the soils revealed below the culvert subgrade levels included cohesionless loose to compact soils (organic sand, sand and silty sand) and cohesive firm to very stiff silty clay. Probable bedrock was contacted at 3.0 to 4.0 m (elevation 193.3 to 194.7). However the depth to bedrock is expected to be variable across this site.

Open water was present under 200 to 300 mm of snow and ice (elevation 197.0 to 197.5) in boreholes C20-1 to C20-3.

No embankment preloading is required and the permanent culvert can be constructed in conjunction with embankment construction.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations. The foundation type/subgrade material category at this site is

- a box culvert founded on rockfill on bedrock

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

3.10 Culvert C-21 at Sta. 17+542.7 (SBL)

A 17.0 m long concrete box culvert is proposed at the southbound lanes of Highway 69, replacing the existing 910 mm diameter CSP culvert. The invert levels of the proposed 2.3 m high and 3.0 m wide culvert are specified to be at approximate elevation 196.8 at both ends of the culvert.

Based upon the proposed road centreline grade elevation 201.0 and the existing elevations 197.7 and 198.2, the embankment fill at the culvert is assessed to be 3.0 to 3.5 m high.

In summary, the soils revealed below the subgrade levels comprised loose sandy silt or firm clayey silt, overlying stiff to very stiff silty clay and loose to dense silty/sandy deposits. Bedrock was contacted at 3.3 and 4.3 m (elevation 194.4 and 193.9). However the depth to bedrock is expected to be variable across this site.

In the process of augering, groundwater was present at the surface (elevation 197.7) in borehole C21-2 and detected at 0.8 m (elevation 197.4) in borehole C21-1. No groundwater was established in either borehole upon completion of drilling.

No embankment preloading is required and the permanent culvert can be constructed in conjunction with embankment construction.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations. The foundation type/subgrade material category at this site is

- a box culvert founded on rockfill on bedrock

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

3.11 Culvert C-23 at Sta. 17+864.5 (NBL)

A new 17.0 m long concrete box culvert is proposed under the northbound lanes of Highway 69 in swamp 107. The invert levels of the proposed 2.3 m high and 3.0 m wide culvert are specified to be at approximate elevation 197.1 at the left (west) end and 197.5 at the right (east) end of the culvert.

Based upon the proposed road centreline grade elevation 201.5 and the existing elevations 197.7 to 197.8, the embankment fill at the culvert is assessed to be about 4.0 m high.

In summary, the soils revealed below the subgrade levels comprised peat and soft to firm silty clay. Probable bedrock was inferred at 0.7 to 2.6 m (elevation 195.2 to 197.0). However the depth to bedrock is expected to be variable across this site.

In the process of augering, water was detected at the ground surface (elevation 197.7) in boreholes C23-1 and 107-27 and at 0.4 m (elevation 197.4) in borehole C23-2. Upon completion of drilling, water was at the ground surface (elevation 197.7 to 197.8) in all the boreholes.

No embankment preloading is required and the permanent culvert can be constructed in conjunction with embankment construction.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations.

Refer to Table 3 in Appendix C for descriptions of foundation conditions at the west extent, the centre and the east extent of culverts. The subgrade material category at this culvert foundation is mixed. Culvert foundation types can be:

- a box culvert founded on rockfill on bedrock

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

3.12 Culvert C-25 at Sta. 18+235.3 (NBL)

A new 18.0 m long concrete box culvert is proposed under the northbound lanes of Highway 69 in swamp 108. The invert levels of the proposed 2.3 m high and 3.0 m wide culvert are specified to be at approximate elevation 194.6 at the left (west) end and 194.7 at the right (east) end of the culvert.

Based upon the proposed road centreline grade elevation 200.2 and the existing elevations 195.0 to 197.1, the embankment fill at the culvert is assessed to be 3 to 5.5 m high.

In summary, the soils revealed below the subgrade levels comprised firm to stiff clay. Bedrock was contacted / inferred at 0.2 to 2.1 m (elevation 193.1 to 196.8). However the depth to bedrock is expected to be variable across this site.

In the process of augering, water was detected at the ground surface (elevation 195.2) in borehole C25-2. No groundwater was observed in any of the boreholes upon completion of drilling.

No embankment preloading is required and the permanent culvert can be constructed in conjunction with embankment construction.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations.

Refer to Table 3 in Appendix C for descriptions of foundation conditions at the west extent, the centre and the east extent of culverts. The subgrade material category at this culvert foundation is mixed. Culvert foundation types can be:

- a box culvert founded on rockfill on bedrock

or

- an open footing culvert founded on bedrock.

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

3.13 Culvert C-26 at Sta. 18+249.5 (SBL)

The existing 1220 mm diameter CSP culvert under the southbound lanes of Highway 69 will be replaced with a new 18.0 m long concrete box culvert. The invert levels of the proposed 2.3 m high and 3.0 m wide culvert are specified to be at approximate elevation 194.4 at the left (west) end and 194.5 at the right (east) end of the culvert.

Based upon the proposed road centreline grade elevation 201.8 and the existing elevations 195.7 to 196.0, the embankment fill at the culvert is assessed to be about 6 m high.

The subgrade levels are in the bedrock at both ends of the culvert. Bedrock was contacted at 1.7 and 1.3 m (elevation 194.0 and 194.7), some 0.1 and 0.7 m above the anticipated subgrade levels (elevation 193.9 and 194.0). However the depth to bedrock is expected to be variable across this site.

In the process of augering, water was detected at 1.5 m (elevation 194.2) in borehole C26-1. No groundwater was established in either borehole upon completion of drilling.

No embankment preloading is required and the permanent culvert can be constructed in conjunction with embankment construction.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations. The foundation type/subgrade material category at this site is

- a box culvert founded on rockfill on bedrock

or

- an open footing culvert founded on bedrock.

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

3.14 Culvert C-42 at Sta. 19+410.0 (NBL)

A new 17.0 m long concrete box culvert is proposed under the northbound lanes of Highway 69 in swamp 112. The invert levels of the proposed 5.3 m high and 5.0 m wide culvert are specified to be at approximate elevation 191.2 at the left (west) end and 191.0 at the right (east) end of the culvert.

Based upon the proposed road centreline grade elevation 197.8 and the existing elevations 191.1 to 193.7, the embankment fill at the culvert is assessed to be about 4 to 6 m high. The bedrock / probable bedrock surface was contacted at 0.0 to 2.1 m (elevation 189.0 to 193.7) at the culvert. However the depth to bedrock is expected to be variable across this site.

Water was present at the surface (elevation 191.1) in one borehole.

No embankment preloading is required and the permanent culvert can be constructed in conjunction with embankment construction.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations.

Refer to Table 3 in Appendix C for descriptions of foundation conditions at the west extent, the centre and the east extent of culverts. The subgrade material category at this culvert foundation is mixed. Culvert foundation types can be:

- a box culvert founded on rockfill on bedrock

or

- an open footing culvert founded on bedrock.

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

3.15 Culvert C-43 at Sta. 19+410.0 (SBL)

A new 17.0 m long concrete box culvert is proposed under the southbound lanes of Highway 69. The invert levels of the proposed 5.3 m high and 5.0 m wide culvert are specified to be at approximate elevation 191.6 at the left (west) end and 191.3 at the right (east) end of the culvert.

Based upon the proposed road centreline grade elevation 198.0 and the existing ground surface elevations, the embankment fill at the culvert is assessed to be 4.0 m high.

Probable rockfill was encountered at 0.8 m (elevation 197.4), some 6.3 m above the design subgrade level, at the left end of the culvert. Bedrock was contacted at the ground surface (elevation 194.3), some 3.5 m above the anticipated subgrade level, at the right end of the culvert. However the depth to bedrock is expected to be variable across this site.

The boreholes were dry on completion of drilling. Borehole C43-2 was charged with water during rock coring.

No embankment preloading is required and the permanent culvert can be constructed in conjunction with embankment construction.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations.

Refer to Table 3 in Appendix C for descriptions of foundation conditions at the west extent, the centre and the east extent of culverts. The subgrade material category at this culvert foundation is mixed. Culvert foundation types can be:

- a box culvert founded on rockfill on bedrock

or

- an open footing culvert founded on bedrock.

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

3.16 Culvert C-46 at Sta. 19+887.0 (SBL)

A new 20.0 m long concrete box culvert is proposed under the southbound lanes of Highway 69 in swamp 114. The invert levels of the proposed 2.3 m high and 3.0 m wide culvert are specified to be at approximate elevation 193.2 at the left (west) end and 193.5 at the right (east) end of the culvert.

Based upon the proposed road centreline grade elevation 197.8 and the existing elevations 193.6 to 195.3, the embankment fill at the culvert is assessed to be 2.5 to 4.0 m high.

Bedrock was exposed at the ground surface (elevation 193.6 to 195.3) at the west end and centre of the culvert and contacted below the boulders at 0.5 m (elevation 193.9) at the east end. However the depth to bedrock is expected to be variable across this site.

No groundwater was established in any of the boreholes during or upon completion of drilling. Boreholes C46-1 and C46-2 were charged with water during rock coring.

No embankment preloading is required and the permanent culvert can be constructed in conjunction with embankment construction.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations. The foundation type/subgrade material category at this site is

- a box culvert founded on rockfill on bedrock

or

- an open footing culvert founded on bedrock.

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

3.17 <u>Culvert C-47 at Sta. 19+893.4 (NBL)</u>

A new 17.0 m long concrete box culvert is proposed under the northbound lanes of Highway 69 in swamp 114. The invert levels of the proposed 2.3 m high and 3.0 m wide culvert are specified to be at approximate elevation 193.7 at the left (west) end and 194.0 at the right (east) end of the culvert.

Based upon the proposed road centreline grade elevation 198.5 and the existing ground surface elevations, the embankment fill at the culvert is assessed to be 5.0 to 8.0 m high.

The only native soil revealed below the subgrade level at the centre of the culvert included loose silty sand. Probable bedrock was contacted at elevation 190.2 to 193.2. However the depth to bedrock is expected to be variable across this site.

Open water was present under 300 to 500 mm of ice at elevation 193.8 to 195.0 in all the boreholes.

No embankment preloading is required and the permanent culvert can be constructed in conjunction with embankment construction.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations. The foundation type/subgrade material category at this site is

- a box culvert founded on rockfill on bedrock

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

3.18 Culvert C-48 at Sta. 20+226.0 (SBL)

A new 25.0 m long concrete box culvert is proposed under the southbound lanes of Highway 69 in swamp 115. The invert levels of the proposed 2.3 m high and 3.0 m wide culvert are specified to be at approximate elevation 194.5 at both ends of the culvert.

Based upon the proposed road centreline grade elevation 199.5 and the existing elevations 194.8 to 195.3, the embankment fill at the culvert is assessed to be about 4 to 5 m high.

In summary, the soils revealed below the subgrade levels included typically firm clay / silty clay overlying loose to compact sand or bedrock. Bedrock / probable bedrock was contacted at 0.6 to 3.2 m (elevation 191.7 to 194.2). However the depth to bedrock is expected to be variable across this site.

Open water was present under 300 mm of ice at elevation 195.0 in borehole 115-10. No groundwater was present in boreholes C48-1 and C48-2 during or upon completion of drilling.

No embankment preloading is required and the permanent culvert can be constructed in conjunction with embankment construction.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations.

Refer to Table 3 in Appendix C for descriptions of foundation conditions at the west extent, the centre and the east extent of culverts. The subgrade material category at this culvert foundation is mixed. Culvert foundation types can be:

- a box culvert founded on rockfill on bedrock

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

3.19 Culvert C-51 at Sta. 20+935.5 (NBL)

A new 20.0 m long concrete box culvert is proposed under the northbound lanes of Highway 69 in swamp 116. The invert levels of the proposed 2.3 m high and 3.0 m wide culvert are specified to be at approximate elevation 192.3 at the left (west) end and 192.4 at the right (east) end of the culvert.

Based upon the proposed road centreline grade elevation 196.5 and the existing elevations 192.9 to 193.2, the embankment fill at the culvert is assessed to be about 3.5 m high.

The soils revealed below the subgrade level consisted of firm to stiff silty clay / clayey silt or bedrock. Bedrock / probable bedrock was contacted at 1.2 to 2.1 m (elevation 190.8 to 192.0). However the depth to bedrock is expected to be variable across this site.

Groundwater was at the ground surface (elevation 193.1) in borehole C51-2 upon completion of drilling. No groundwater was established in boreholes 51-1 and 51-3. Borehole 51-3 was charged with water during rock coring.

No embankment preloading is required and the permanent culvert can be constructed in conjunction with embankment construction.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations.

Refer to Table 3 in Appendix C for descriptions of foundation conditions at the west extent, the centre and the east extent of culverts. The subgrade material category at this culvert foundation is mixed. Culvert foundation types can be:

- a box culvert founded on rockfill on bedrock

or

- an open footing culvert founded on bedrock.

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

3.20 Culvert C-52 at Sta. 20+935.5 (SBL)

A new 17.0 m long concrete box culvert is proposed under the southbound lanes of Highway 69. The invert levels of the proposed 2.3 m high and 3.0 m wide culvert are specified to be at approximate elevation 192.1 at the left (west) end and 192.2 at the right (east) end of the culvert.

Based upon the proposed road centreline grade elevation 196.0 and the existing elevations 193.6 to 193.7, the embankment fill at the culvert is assessed to be about 2.5 m high.

Bedrock / probable bedrock was contacted at 0.4 m (elevation 193.2 and 193.3) at both ends of the culvert. However the depth to bedrock is expected to be variable across this site.

No groundwater was established in boreholes C52-1 and C52-2 during or upon completion of drilling. Borehole C52-1 was charged with water during rock coring.

No embankment preloading is required and the permanent culvert can be constructed in conjunction with embankment construction.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations. The foundation type/subgrade material category at this site is

- a box culvert founded on rockfill on bedrock

or

- an open footing culvert founded on bedrock.

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

3.21 Culvert C-53 at Sta. 21+816.4 (SBL)

A new 18.0 m long concrete box culvert is proposed under the southbound lanes of Highway 69. The invert levels of the proposed 2.3 m high and 3.0 m wide culvert are specified to be at approximate elevation 192.8 at the left (west) end and 193.1 at the right (east) end of the culvert.

Based upon the proposed road centreline grade elevation 197.5 and the existing elevations 194.0 to 194.6, the embankment fill at the culvert is assessed to be 3 to 3.5 m high.

Bedrock was contacted at 0.1 and 0.6 m (elevation 193.9 and 194.0) at the west and east ends of the culvert. However the depth to bedrock is expected to be variable across this site.

Open water was present under 100 mm of ice in borehole C53-2. No groundwater was established in borehole C53-1 charged with drilling water for rock coring.

No embankment preloading is required and the permanent culvert can be constructed in conjunction with embankment construction.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations. The foundation type/subgrade material category at this site is

- a box culvert founded on rockfill on bedrock

or

- an open footing culvert founded on bedrock.

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

3.22 Culvert C-54 at Sta. 21+827.4 (NBL)

A new 18.0 m long concrete box culvert is proposed under the northbound lanes of Highway 69. The invert levels of the proposed 2.3 m high and 3.0 m wide culvert are specified to be at approximate elevation 193.4 at the left (west) end and 193.8 at the right (east) end of the culvert.

Based upon the proposed road centreline grade elevation 197.9 and the existing elevations 193.7 to 194.6, the embankment fill at the culvert is assessed to be 3.5 to 4.0 m high.

In summary, the soils revealed below the subgrade levels comprised peat, organic sand and very stiff clayey silt overlying dense sand. Probable bedrock was contacted at 1.1 to 1.9 m (elevation 192.6 to 192.7) at the west and east end of the culvert. However the depth to bedrock is expected to be variable across this site.

Open water was present under 200 mm of ice at elevation 193.5 and 193.8 in boreholes C54-1 and C54-2. No groundwater was established in the borehole C54-3 during or upon completion of drilling.

No embankment preloading is required and the permanent culvert can be constructed in conjunction with embankment construction.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations. The foundation type/subgrade material category at this site is

- a box culvert founded on rockfill on bedrock

or

- an open footing culvert founded on bedrock.

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

3.23 Culvert C-65 at Sta. 22+675.0 (NBL)

A new 17.0 m long concrete box culvert is proposed under the northbound lanes of Highway 69 in swamp 119. The invert levels of the proposed 2.3 m high and 3.0 m wide culvert are specified to be at approximate elevation 196.2 at the left (west) end and 196.5 at the right (east) end of the culvert.

Based upon the proposed road centreline grade elevation 199.9 and the existing elevations 196.7 to 196.8, the embankment fill at the culvert is assessed to be about 3 m high.

In summary, the soils revealed below the subgrade levels included peat and probable clayey silt / silty sand. Probable bedrock was contacted at 1.2 and 2.0 m (elevation 195.6 and 194.7). However the depth to bedrock is expected to be variable across this site.

Groundwater was measured in borehole C65-2 to be at 0.4 m (elevation 196.4) upon completion of drilling.

No embankment preloading is required and the permanent culvert can be constructed in conjunction with embankment construction.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations. The foundation type/subgrade material category at this site is

- a box culvert founded on rockfill on bedrock

or

- an open footing culvert founded on bedrock.

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

3.24 Culvert C-66 at Sta. 22+675.0 (SBL)

A new 17.0 m long concrete box culvert is proposed under the southbound lanes of Highway 69 in swamp 121. The invert levels of the proposed 2.3 m high and 3.0 m wide culvert are specified to be at approximate elevation 195.5 at the left (west) end and 195.7 at the right (east) end of the culvert.

Based upon the proposed road centreline grade elevation 199.8 and the existing elevations 195.3 to 196.5, the embankment fill at the culvert is assessed to be 3.0 to 4.5 m high.

In summary, the soils revealed below the subgrade levels comprised peat overlying firm to very stiff clayey silt and dense to very dense sand or bedrock. Probable bedrock was contacted at 1.0 to 2.1 m (elevation 193.2 to 195.5). However the depth to bedrock is expected to be variable across this site.

Water was present under 100 to 600 mm of snow / ice at elevation 194.7 to 196.3 in all the boreholes. Groundwater was established at 0.8 m (elevation 195.7) in borehole C66-2 upon completion of drilling.

No embankment preloading is required and the permanent culvert can be constructed in conjunction with embankment construction.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations.

Refer to Table 3 in Appendix C for descriptions of foundation conditions at the west extent, the centre and the east extent of culverts. The subgrade material category at this culvert foundation is mixed. Culvert foundation types can be:

- a box culvert founded on rockfill on bedrock

or

- an open footing culvert founded on bedrock.

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

3.25 Culvert C-70 at Sta. 20+940.0 (N-E/W Ramp)

A new 13.0 m long concrete box culvert is proposed under the N-E/W ramp of Highway 69. The invert levels of the proposed 2.3 m high and 3.0 m wide culvert are specified to be at approximate elevation 191.9 at the left (west) end and 192.0 at the right (east) end of the culvert.

Based upon the proposed road centreline grade elevation 195.8 and the existing elevations 192.2 to 193.1, the embankment fill at the culvert is assessed to be about 3.0 to 3.5 m high.

In summary, the soils encountered below the subgrade levels consisted of loose organic silt over soft to stiff cohesive soils or bedrock. Probable bedrock was inferred at 1.4 to 4.7 m (elevation 187.5 to 191.7). However the depth to bedrock is expected to be variable across this site.

In the process of augering, water was detected at 0.8 m (elevation 192.3) in borehole C70-2. No groundwater was established in any of the boreholes upon completion of drilling.

No embankment preloading is required and the permanent culvert can be constructed in conjunction with embankment construction.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations.

Refer to Table 3 in Appendix C for descriptions of foundation conditions at the west extent, the centre and the east extent of culverts. The subgrade material category at this culvert foundation is mixed. Culvert foundation types can be:

- a box culvert founded on rockfill on bedrock

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

4. SITE-SPECIFIC CULVERT FOUNDATIONS RECOMMENDATIONS - PARTIAL EXCAVATION/PRELOAD CULVERTS

Site-specific comments and recommendations are provided below for all partial excavation/preload culverts. At these sites, excavations will terminate in soil and temporary culverts and preloading/surcharging will be required. Refer to the relevant recommendations in

Sections 1 and 2 for recommendations for 'partial subexcavation/preload' culverts. Refer to the table in Section 2.1 for bearing resistance recommendations and associated settlements for the foundation type/subgrade material category identified in the site specific recommendations for each culvert.

4.1 Culvert C-22 at Sta. 17+822.8 (NBL)

A new 35.0 m long concrete box culvert is proposed under the northbound lanes of Highway 69 in swamp 107. The invert levels of the proposed 1.2 m high and 1.2 m wide culvert are specified to be at approximate elevation 197.3 at the left (west) end and 197.8 at the right (east) end of the culvert.

Based upon the proposed road centreline grade elevation 201.0 and the existing elevations 197.6 to 198.0, the embankment fill at the culvert is assessed to be 3.0 to 3.5 m high. At the proposed culvert location, the existing grade will be cut up to 1.5 m to achieve the anticipated culvert subgrade level.

In summary, the soils revealed below the subgrade levels included peat and very loose sand / sandy silt overlying soft to firm cohesive silty clay. The silty clay deposit was underlain by very dense gravelly sand at the centre of the culvert. Probable bedrock was inferred at 11.5 m (elevation 186.5) at the left (west) end and at 1.0 m (elevation 196.6) at the right (east) end of the culvert. Water was at 0.0 to 0.8 m (elevation 197.2 to 197.6). However the depth to bedrock is expected to be variable across this site.

Considering the soft and compressible soil conditions at the west end and centre of the culvert, it is recommended that the ground should be excavated to bedrock or to a maximum depth of 8 m, whichever is less, and then backfilled/preloaded with rockfill in accordance with the recommendations of Sections 1.3 and 2.1. It is estimated that at the east end of the culvert the probable bedrock is at approximately elevation 196.6.

Following excavation and backfilling with rockfill to ground level, a temporary culvert should be installed and the embankment should be constructed to the surcharge height and preloaded for a minimum period of 3 months. After completion of the preload, the temporary culvert should be replaced with the permanent culvert.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations.

Refer to Table 3 in Appendix C for descriptions of foundation conditions at the west extent, the centre and the east extent of culverts. The subgrade material category at this culvert foundation is mixed. Culvert foundation types can be:

- a box culvert founded rockfill on soil.

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

4.2 Culvert C-24 at Sta. 17+864.5 (SBL)

Culvert C-24 is proposed under the southbound lanes of Highway 69 alignment. The existing 1060 mm diameter CSP culvert at the location will be replaced with a new 17.0 m long, 2.3 m high and 3.0 m wide concrete box culvert. The invert levels are specified to be at approximate elevation 197.1 at the left (west) end and 197.2 at the right (east) end of the culvert.

Based upon the proposed road centreline grade elevation 201.0 and the existing elevations 197.6 to 197.9, the embankment fill at the culvert is assessed to be up to 3.5 m high. At the proposed culvert location, the existing grade will be cut about 1.0 to 1.5 m to achieve the anticipated culvert subgrade level.

In summary, the soils revealed below the subgrade levels included surficial peat / fill overlying very loose sandy silt and very soft to soft silty clay. Bedrock / probable bedrock was contacted at 1.6 and 8.1 m (elevation 196.0 and 189.8). However the depth to bedrock is expected to be variable across this site.

Water was at the ground surface (elevation 197.9) in borehole C24-1. No groundwater was established in borehole C24-2 charged with drilling water for rock coring.

Considering the soil conditions at the west and east ends of the culvert, it is recommended that the ground should be excavated to bedrock or to a maximum depth of 8 m, whichever is less, and then backfilled/preloaded with rockfill in accordance with the recommendations of Section 1.3 and

Section 2.1. It is estimated that at the east end of the culvert the probable bedrock is at approximately elevation 196.0.

Following excavation and backfilling with rockfill to ground level, a temporary culvert should be installed and the embankment should be constructed to the surcharge height and preloaded for a minimum period of 3 months. After completion of the preload, the temporary culvert should be replaced with the permanent culvert.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations.

Refer to Table 3 in Appendix C for descriptions of foundation conditions at the west extent, the centre and the east extent of culverts. The subgrade material category at this culvert foundation is mixed. Culvert foundation types can be:

- a box culvert founded rockfill on soil.

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

4.3 Culvert C-28 at Sta. 18+585.0 (NBL)

A new 17.0 m long concrete box culvert is proposed under the northbound lanes of Highway 69 in swamp 109. The invert levels of the proposed 5.3 m high and 5.0 m wide culvert are specified to be at approximate elevation 190.3 at the left (west) end and 190.6 at the right (east) end of the culvert.

Based upon the proposed road centreline grade elevation 197.1 and the existing elevations 189.0 to 193.2, the embankment fill at the culvert is assessed to be 4.0 to 8.0 m high. At the left (west) end of the proposed culvert location, the existing ground surface should be raised about 1.5 m to achieve the anticipated culvert subgrade level. The existing ground surface at the right (east) end and centre of the culvert will be cut about 3 m to achieve the anticipated culvert subgrade level.

In summary, the soils revealed below the subgrade levels consist of bedrock at the east end of the culvert and extensive depths, up to 13 m, of very soft and compressible soil over under remainder of the culvert alignment.

The bedrock / probable bedrock surface was contacted at 0.0 to 15.1 m (elevation 173.9 to 193.2). However the depth to bedrock is expected to be variable across this site.

Open water was under 200 mm of ice at elevation 188.8 in borehole C28-1. Borehole C28-2 at the right end of the culvert was charged with water during rock coring.

Considering the soft and compressible soil conditions at the west end and centre of the culvert, it is recommended that the ground should be excavated to bedrock or to a maximum depth of 8 m, whichever is less, and then backfilled/preloaded with rockfill in accordance with the recommendations of Sections 1.3 and 2.1.

Following excavation and backfilling with rockfill to ground level, a temporary culvert should be installed and the embankment should be constructed to the surcharge height and preloaded for a minimum period of 3 months. After completion of the preload, the temporary culvert should be replaced with the permanent culvert.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations.

Refer to Table 3 in Appendix C for descriptions of foundation conditions at the west extent, the centre and the east extent of culverts. The subgrade material category at this culvert foundation is mixed. Culvert foundation types can be:

- a box culvert founded rockfill on soil.

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

4.4 Culvert C-29 at Sta. 18+585.0 (SBL)

A new 17.0 m long concrete box culvert is proposed under the southbound lanes of Highway 69. The invert levels of the proposed 5.3 m high and 5.0 m wide culvert are specified to be at approximate elevation 189.5 at the left (west) end and 189.8 at the right (east) end of the culvert.

Based upon the proposed road centreline grade elevation 197.5 and the existing elevations 189.7 to 191.5, the embankment fill at the culvert is assessed to be 6.0 to 8.0 m high. At the proposed culvert location, the existing grade will be cut 0.5 to 2.5 m to achieve the anticipated culvert subgrade level.

In summary, the soil revealed below the subgrade level at the west end of the culvert included typically firm silty clay / clay mantling bedrock contacted at 9.1 m (elevation 182.4). However the depth to bedrock is expected to be variable across this site. Rockfill was encountered at the surface (elevation 189.7) at the east end of the culvert.

Upon completion of drilling, water was present at the ground surface (elevation 191.5) in borehole C29-1. No groundwater was established in borehole C29-2 during or upon completion of drilling.

Considering the soft and compressible soil conditions at the west end and centre of the culvert, it is recommended that the ground should be excavated to bedrock or to a maximum depth of 8 m, whichever is less, and then backfilled/preloaded with rockfill in accordance with the recommendations of Sections 1.3 and 2.1.

Following excavation and backfilling with rockfill to ground level, a temporary culvert should be installed and the embankment should be constructed to the surcharge height and preloaded for a minimum period of 3 months. After completion of the preload, the temporary culvert should be replaced with the permanent culvert.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations.

Refer to Table 3 in Appendix C for descriptions of foundation conditions at the west extent, the centre and the east extent of culverts. The subgrade material category at this culvert foundation is mixed. Culvert foundation types can be:

- a box culvert founded rockfill on soil.

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

4.5 Culvert C-30 at Sta. 18+612.9 (Median)

The existing 910 mm diameter CSP culvert under the southbound lanes of Highway 69 will be replaced with a new 87.0 m long concrete box culvert, proposed under the south and north bound lanes of the highway. The right end of the proposed culvert under the northbound lanes is in swamp 109. The invert levels of the proposed 1.8 m high and 2.4 m wide culvert are specified to be at approximate elevation 187.2 at the left (west) end and 187.6 at the right (east) end of the culvert.

The proposed southbound road centreline grade is near elevation 197.2 and the existing elevation is 188.4 to 189.3. The embankment fill is assessed to be 8.0 to 9.0 m high. At the proposed culvert location, the existing grade will be cut up to 1.7 m to achieve the anticipated culvert subgrade level.

In summary, the soils revealed below the subgrade levels included stiff to firm cohesive soils (clayey silt, silty clay and clay), becoming soft to very soft at the east end of the culvert.

Bedrock was contacted at 4.4 and 6.1 m (elevation 184.9 and 182.3) at the centre and left (west) end of the culvert, respectively. Bedrock surface was not encountered at the right (east) end of the culvert at 9.8 m. However the depth to bedrock is expected to be variable across this site.

Open water was at 0.3 to 0.5 m (elevation 188.0 to 189.0).

Considering the soft and compressible soil conditions at the west end and centre of the culvert, it is recommended that the ground should be excavated to bedrock or to a maximum depth of 8 m, whichever is less, and then backfilled/preloaded with rockfill in accordance with the recommendations of Sections 1.3 and 2.1.

Following excavation and backfilling with rockfill to ground level, a temporary culvert should be installed and the embankment should be constructed to the surcharge height and preloaded for a minimum period of 3 months. After completion of the preload, the temporary culvert should be replaced with the permanent culvert.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations.

Refer to Table 3 in Appendix C for descriptions of foundation conditions at the west extent, the centre and the east extent of culverts. The subgrade material category at this culvert foundation is mixed. Culvert foundation types can be:

- a box culvert founded rockfill on soil.

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

4.6 Culvert C-41 at Sta. 19+385.3 (Median)

The existing 1080 mm diameter CSP culvert under the southbound lanes of Highway 69 will be replaced with a new 85.0 m long concrete box culvert, proposed under the south and north bound lanes of the highway. The right (east) end of the proposed culvert under the northbound lanes is in swamp 112. The invert levels of the proposed 1.2 m high and 2.4 m wide culvert are specified to be at approximate elevation 188.5 at both ends of the culvert.

The proposed southbound road centreline grade is near elevation 198.0 and the existing ground surface is at elevation 193.0. The embankment fill at the left (west) end of the culvert is assessed to be 5.0 m high. At the proposed culvert location, the existing grade will be cut some 5.0 m to achieve the anticipated culvert subgrade level.

At the northbound lanes, the proposed road centreline grade is near elevation 197.9, about 9.0 m higher than the existing elevation 188.8. The existing grade will be cut about 0.8 m to achieve the anticipated culvert subgrade level.

In summary, the soils revealed below the subgrade levels included peat or very loose organic silt overlying soft to firm cohesive clayey soils (clayey silt, silty clay and clay). Bedrock was inferred at 3.8 to 11.1 m (elevation 177.7 to 189.2). However the depth to bedrock is expected to be variable across this site. Groundwater was at 0.3 and 0.6 m (elevation 188.5 and 188.1) in two boreholes.

Considering the soft and compressible soil conditions at the west end and centre of the culvert, it is recommended that the ground should be excavated to bedrock or to a maximum depth of 8 m, whichever is less, and then backfilled/preloaded with rockfill in accordance with the recommendations of Sections 1.3 and 2.1.

Following excavation and backfilling with rockfill to ground level, a temporary culvert should be installed and the embankment should be constructed to the surcharge height and preloaded for a minimum period of 3 months. After completion of the preload, the temporary culvert should be replaced with the permanent culvert.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations.

Refer to Table 3 in Appendix C for descriptions of foundation conditions at the west extent, the centre and the east extent of culverts. The subgrade material category at this culvert foundation is mixed. Culvert foundation types can be:

- a box culvert founded rockfill on soil.

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

4.7 Culvert C-49 at Sta. 20+245.1 (NBL)

A new 33.0 m long concrete box culvert is proposed under the northbound lanes of Highway 69 in swamp 115. The invert levels of the proposed 2.3 m high and 3.0 m wide culvert are specified to be at approximate elevation 194.3 at both ends of the culvert.

Based upon the proposed road centreline grade elevation 200.2 and the existing elevations 194.6 to 194.7, the embankment fill at the culvert is assessed to be about 5.5 m high. At the proposed culvert location, the existing grade will be cut about 1.0 m to achieve the anticipated culvert subgrade level.

In summary, the soil revealed below the subgrade level included organic soils or loose silty sand overlying typically stiff to firm cohesive soils (clayey silt, silty clay and clay). Probable bedrock was inferred at 5.1 to 8.8 m (elevation 185.9 to 189.5). However the depth to bedrock is expected to be variable across this site.

Open water was present under 300 mm of ice at elevation 194.4 in borehole 115-16. No groundwater was present in boreholes C49-1 and C49-2 during or upon completion of drilling.

The anticipated geotechnical treatment for swamp 115 includes preloading for 12 months. The treatment for the culvert foundations will have to be compatible with the recommended treatment for embankments. In this case the preload period for the culvert is of shorter duration, which will not interfere with the embankment construction.

Considering the soft and compressible soil conditions at the west end and centre of the culvert, it is recommended that the ground should be excavated to bedrock or to a maximum depth of 8 m, whichever is less, and then backfilled/preloaded with rockfill in accordance with the recommendations of Sections 1.3 and 2.1.

Following excavation and backfilling with rockfill to ground level, a temporary culvert should be installed and the embankment should be constructed to the surcharge height and preloaded for a minimum period of 3 months. After completion of the preload, the temporary culvert should be replaced with the permanent culvert.

Refer to the table in Section 2.1 for bearing resistance and associated settlement recommendations.

Refer to Table 3 in Appendix C for descriptions of foundation conditions at the west extent, the centre and the east extent of culverts. The subgrade material category at this culvert foundation is mixed. Culvert foundation types can be:

- a box culvert founded rockfill on soil.

Construction joint articulation would be required to accommodate the differential settlement associated with the foundation type/subgrade material as specified in the table in Section 2.1.

5. CLOSURE

This report was prepared by Ms. Marzieh Kamranzadeh, MSc, Project Supervisor (EIT) and reviewed by Mr. D. Dundas, P. Eng., Senior Engineer and Mr. B.R. Gray, MEng, P.Eng., MTO Designated Principal Contact. Mr. C.M.P. Nascimento, P.Eng., Project Manager conducted an independent review of the report.

Yours very truly,

Peto MacCallum Ltd.

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APPENDIX A

List of Standard Specifications Referenced in Report
And Non-Standard Special Provision (NSPP)

TABLE 1

LIST OF STANDARD SPECIFICATIONS REFERENCED IN REPORT

DOCUMENT	TITLE
OPSS 120	General Specification for Use of Explosives
OPSS 422	Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut
OPSS 501	Construction Specification for Compacting
OPSS 511	Construction Specification for Rip-Rap, Rock Protection and Granular Sheeting
OPSS 539	Construction Specification for Temporary Protection Systems
OPSS 802	Construction Specification for Topsoil
OPSS 804	Construction Specification for Seed and Cover
OPSS 902	Excavation and Backfilling of Structures
OPSS.PROV 1004	Material Specification for Aggregates – Miscellaneous
OPSS 1205	Material Specification for Clay Seal
OPSS 1860	Material Specification for Geotextiles
SP 110S13	Material Specification for Aggregates, Base, Subbase, Select Subgrade and Backfill Material
SP 206S03	Construction Specification for Grading
SP 422S01	Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers
SP 999S26	Requirements for Design, Installation and Testing of Temporary and Permanent Pre-Stressed Anchors in Soil and Rock
OPSD 203.010	Embankments Over Swamp, New Construction
OPSD 803.010	Backfill and Cover for Concrete Culverts
OPSD 3090.101	Foundation Frost Depth for Southern Ontario
OPSD 3121.150	Minimum Granular Backfill Requirements – Retaining Walls

NON-STANDARD SPECIAL PROVISIONS (NSSP)

NSSP – Variation in Depth to Bedrock between Boreholes (Addition to OPSS 902)

The Contractor is advised that the depth to bedrock between boreholes will vary significantly along and across the culvert alignment.

NSSP - Variable Mixed Fill and Rock Fill at Embankments (Addition to OPSS 902 and OPSS539)

The Contractor shall be advised that the existing highway embankments and the ground in the vicinity of the embankments contain variable components of mixed fill and rock fill and that the Contractor shall use methods and equipment that are appropriate for the work.

NSSP – Surface Water Control and Dewatering (Addition to OPSS 902)

The Contractor shall be advised that the groundwater is at or near the natural ground surface and that the ground is susceptible to disturbance under conditions of unbalanced hydrostatic head. Although the Contractor shall be responsible for designing and implementing measures for surface water control and dewatering, the Contractor is advised that conventional sump pumping may not be effective and that consideration could be given to utilizing cofferdams or well point dewatering schemes as appropriate. The Contractor shall take measures for necessary surface water diversions and drainage and to lower the prevailing groundwater level a minimum of 0.5 m below the base of excavations for work in-the-dry in overburden and to the bedrock surface for work in-the-dry in bedrock.

NSSP – Installation of Shoring (Addition to OPSS 539)

The Contractor shall be advised that cobbles, boulders and rockfill may be encountered during the excavation and that the Contractor shall use appropriate methods for shoring installation.

APPENDIX B

Summary of Recommended Swamp Treatment Near Culvert Location

TABLE 2

SUMMARY OF RECOMMENDED SWAMP TREATMENT NEAR CULVERT LOCATION

(Note 1)

CULVERT No.	SECTION UNDER	SWAMP No.	SWAMP TREATMENT NEAR CULVERT LOCATION	REQUIRED FILL HEIGHT (m)
C-22	NBL	107	Preloading for 12 months without removal of compressible soils	3.0 to 3.5
C-24	SBL	-	-	Up to 3.5
C-28	NBL	109	Partial excavation to 7 m depth and surcharging for 14 months	4.0 to 8.0
C-29	SBL	-	-	6.0 to 8.0
C-30	Median	109	Preloading for a minimum period of 9 months without removal of compressible soils	8.0 to 9.0
C-41	Median	112	Preloading for 12 months without removal of compressible soils	5.0
C-49	NBL	115	Preloading for 12 months without removal of compressible soils	5.5

Note 1: The recommended treatments are from Associated Swamp and High Fill Crossings Report.

APPENDIX C

Approximate Extent of Excavation at Proposed Culvert Locations

TABLE 3: APPROXIMATE EXTENT OF EXCAVATION AT PROPOSED CULVERT LOCATIONS

CULVERT No.	SECTION UNDER	AASOCIATED SWAMP No.	RECOMMENDED TREATMENT AT CULVERT LOCATION			APPROXIMATE DEPTH OF EXCAVATION (m)
			West	**Centre**	**East**	
C-2	SBL	-	1.4 m bedrock excavation (Elev. 192.7)	n/a – extension to west only	n/a – extension to west only	2.0
C-3	NBL	101	Full excavation to bedrock (Elev. 193.3)	Full excavation to bedrock (Elev. 192.2)	Full excavation to bedrock (Elev. 192.4)	2.0
C-8	SBL	-	Full excavation to bedrock (Elev. 191.9)	no borehole	Full excavation to bedrock (Elev. 189.5)	1.5 to 4.0
C-9	NBL	102	Full excavation to bedrock (Elev. 190.6)	1.4 m bedrock excavation (Elev. 192.7)	0.4 m bedrock excavation (Elev. 192.8)	0.5 to 3.5
C-16	NBL	105	1.0 m bedrock excavation (Elev. 195.2)	Full excavation to bedrock (Elev. 192.9)	Full excavation to bedrock (Elev. 192.8)	1.0 to 3.0
C-17	SBL	-	0.2 m bedrock excavation (Elev. 195.2)	no borehole	1.0 m bedrock excavation (Elev. 195.2)	1.0 to 1.5
C-18	SBL	-	0.2 m bedrock excavation (Elev. 195.8)	no borehole	1.0 m bedrock excavation (Elev. 195.9)	1.5
C-19	NBL	-	Full excavation to bedrock (Elev. 196.1)	no borehole	0.4 m bedrock excavation (Elev. 196.6)	1.0
C-20	NBL	-	Full excavation to bedrock (Elev. 194.7)	Full excavation to bedrock (Elev. 193.9)	Full excavation to bedrock (Elev. 193.3)	3.0 to 4.0
C-21	SBL	-	Full excavation to bedrock (Elev. 193.9)	No borehole	Full excavation to bedrock (Elev. 194.4)	3.5 to 4.5

TABLE 3: APPROXIMATE EXTENT OF EXCAVATION AT PROPOSED CULVERT LOCATIONS

CULVERT No.	SECTION UNDER	AASOCIATED SWAMP No.	RECOMMENDED TREATMENT AT CULVERT LOCATION			APPROXIMATE DEPTH OF EXCAVATION (m)
			West	**Centre**	**East**	
C-22	NBL	107	Soil excavation to 8.0 m deep (Elev. 190.0)	Soil excavation to 8.0 m deep (Elev. 189.6)	Full excavation to bedrock (Elev. 196.6)	1.0 to 8.0
C-23	NBL	107	0.4 m bedrock excavation (Elev. 196.6)	Full excavation to bedrock (Elev. 196.8)	Full excavation to bedrock (Elev. 195.2)	1.0 to 3.0
C-24	SBL	-	Soil excavation to 8.0 m deep (Elev. 189.9)	no borehole	Full excavation to bedrock (Elev. 196.0)	2.0 to 8.0
C-25	NBL	108	0.7 m bedrock excavation (Elev. 194.1)	2.5 m bedrock excavation (Elev. 194.2)	Full excavation to bedrock (Elev. 193.1)	1.0 to 3.0
C-26	SBL	-	0.1 m bedrock excavation (Elev. 193.9)	no borehole	0.7 m bedrock excavation (Elev. 194.0)	2.0
C-28	NBL	109	Soil excavation to 8.0 m deep (Elev. 181.0)	3.0 m bedrock excavation (Elev. 190.0)	3.1 m bedrock excavation (Elev. 190.1)	3.0 to 8.0
C-29	SBL	-	Soil excavation to 8.0 m deep (Elev. 183.5)	no borehole	no borehole - rockfill at surface - soil excavation to bedrock or maximum 8.0 m	0.5 to 8.0
C-30	Median	109	Full excavation to bedrock (Elev. 182.3)	Full excavation to bedrock (Elev. 184.9)	Soil excavation to 8.0 m deep (Elev. 180.5)	4.5 to 8.0
C-41	Median	112	1.2 m bedrock excavation (Elev. 188.0)	Full excavation to bedrock (Elev. 183.4)	Soil excavation to 8.0 m deep (Elev. 180.8)	5.0 to 8.0

TABLE 3: APPROXIMATE EXTENT OF EXCAVATION AT PROPOSED CULVERT LOCATIONS

CULVERT No.	SECTION UNDER	AASOCIATED SWAMP No.	RECOMMENDED TREATMENT AT CULVERT LOCATION			APPROXIMATE DEPTH OF EXCAVATION (m)
			West	Centre	East	
C-42	NBL	112	3.0 m bedrock excavation (Elev. 190.7)	Full excavation to bedrock (Elev. 189.0)	1.7 m bedrock excavation (Elev. 190.5)	1.5 to 3.0
C-43	SBL	-	6.3 m excavation required to culvert invert - soil excavation to bedrock or maximum 8.0 m - fill at surface	no borehole	3.5 m bedrock excavation (Elev. 190.8)	3.5 to 7.0
C-46	SBL	114	1.7 m bedrock excavation (Elev. 192.7)	0.7 m bedrock excavation (Elev. 192.9)	1.4 m bedrock excavation (Elev. 193.0)	1.0 to 2.0
C-47	NBL	-	Full excavation to bedrock (Elev. 193.2)	Full excavation to bedrock (Elev. 190.2)	Full excavation to bedrock (Elev. 191.4)	2.0 to 5.0
C-48	SBL	115	0.2 m bedrock excavation (Elev. 194.0)	Full excavation to bedrock (Elev. 193.3)	Full excavation to bedrock (Elev. 191.7)	1.0 to 3.5
C-49	NBL	115	Full excavation to bedrock (Elev. 187.4)	Soil excavation to 8.0 m deep (Elev. 186.7)	Full excavation to bedrock (Elev. 189.5)	5.0 to 8.0
C-51	NBL	116	0.2 m bedrock excavation (Elev. 191.8)	Full excavation to bedrock (Elev. 191.6)	Full excavation to bedrock (Elev. 190.8)	1.5 to 2.0
C-52	SBL	-	1.6 m bedrock excavation (Elev. 191.6)	no borehole	1.6 m bedrock excavation (Elev. 191.7)	2.0

TABLE 3: APPROXIMATE EXTENT OF EXCAVATION AT PROPOSED CULVERT LOCATIONS

CULVERT No.	SECTION UNDER	AASOCIATED SWAMP No.	RECOMMENDED TREATMENT AT CULVERT LOCATION			APPROXIMATE DEPTH OF EXCAVATION (m)
			West	Centre	East	
C-53	SBL	-	1.6 m bedrock excavation (Elev. 192.3)	no borehole	1.4 m bedrock excavation (Elev. 192.6)	1.5 to 2.0
C-54	NBL	-	Full excavation to bedrock (Elev. 192.6)	no borehole	Full excavation to bedrock (Elev. 192.7)	1.0 to 2.0
C-65	NBL	119	Full excavation to bedrock (Elev. 194.7)	no borehole	Full excavation to bedrock (Elev. 195.6)	1.5 to 2.0
C-66	SBL	121	Full excavation to bedrock (Elev. 193.2)	0.1 m bedrock excavation (Elev. 195.1)	0.3 m bedrock excavation (Elev. 195.2)	1.5 to 2.5
C-70	N-E/W Ramp	N-E/W Ramp	Full excavation to bedrock (Elev. 187.5)	Full excavation to bedrock (Elev. 189.2)	0.2 m bedrock excavation (Elev. 191.5)	2.0 to 5.0

APPENDIX D

MTO Guideline for Rockfill Settlement and Rockfill Quantity Estimate

MTO Guideline for Rock Fill Settlement and Rock Fill Quantity Estimates

September 14, 2010

SUBJECT: **ROCKFILL SETTLEMENT AND ROCK FILL QUANTITY ESTIMATES**

PURPOSE: To provide direction for estimating settlements and quantity of rock fill used for the construction of new embankments. The criteria are to provide guidance for estimating settlement within rock fill (within the embankment proper exclusive of the settlement of the native subsoil) of new embankments; and outlining the information that should be provided for use in the estimation of the quantity of rock fill that may be required for construction. The criteria apply to strong, granitic-type rock fills (placed above and below original ground surface) that are up to 15 m in total thickness. The criteria should be reviewed and the designs modified for thicker/higher rock fill embankments and/or for weaker types of rock fill on a project specific basis.

BACKGROUND: If rock fill is used for the construction of embankments, there will be settlement due to compression of the rock fill. In highway embankments, settlement of rock fill during and after construction occurs as a result of re-arrangement of rock particles under load and as a result of crushing of rock particles at point contacts.

The magnitude of settlement of the rock fill depends on the following factors:

- type of rock/strength of particles;
- size and shape of rock particles;
- gradation of rock fill;
- total height/thickness of rock fill (stress level); and,
- method of construction and sequence of placement (including, lift thickness, compactive effort, and state of packing).

The magnitude of the short-term settlement (i.e. within about 1 year following completion of construction to full height) and long-term settlement (i.e. after 1 year, over the life of the embankment) of rock fill depends on amongst other variables the method of placement (compacted versus dumped) as discussed below.

Compacted Rock Fill

Where possible, rock fill should be placed in a controlled manner (i.e. not end dumped) in accordance with Special Provision 206S03. Blading, dozing and 'chinking' the rock to form a dense, compact mass will be required to minimize voids and bridging and should be used to construct rock fill embankments above the existing groundwater table. Rock size shall be controlled in accordance with SP206S03.

Dumped Rock Fill

If rock fill embankments are constructed by end dumping rock fill (for cases where Special Provision 206S03 cannot be applied) or when backfilling sub-excavated areas below the groundwater table by end dumping rock fill with little or no control on the lift thickness and compactive effort, the settlement of rock fill placed in this uncontrolled manner will be greater than that of compacted rock fill.

POLICY:

Section 1: Performance - Recommendation for Design

For rock fill embankments, both the short-term and long-term settlement of the fill should be considered in the design. Further, both the compacted and un-compacted portions of rock fill in the embankment should be considered when estimating the magnitude of settlement. In all cases, the total height of the rock fill embankment will be measured from the base of the rock fill.

1.1 Short-Term Rock Fill Settlement

For rock fill embankments constructed over a non-compressible subgrade, the percentages in Table 1.1 should be used for estimating the short-term settlement of the embankment.

Table 1.1: Short-Term Rock Fill Settlement

Height of Rock Fill, H (m)	Short-Term Settlement (m)	
	Compacted Rock Fill	Dumped Rock Fill
Up to 5	0.5%·H	1.0%·H
>5 to 10	0.75%·H	1.5%·H
>10 to 15	1.0%·H	2.0%·H

Short-term is defined as 1 year after the rock fill embankment is constructed to full height. Approximately 90% of the short-term settlement may be expected to be complete within 6 months following construction to full height (including surcharge, if applicable).

1.2 Long-Term Rock Fill Settlement

For rock fill embankments constructed over a non-compressible subgrade, the percentages in Table 1.2 should be used for estimating the long-term settlement of the embankment.

Table 1.2: Long-Term Rock Fill Settlement

Height of Rock Fill, H (m)	Long-Term Settlement (m)	
	Compacted Rock Fill	Dumped Rock Fill
Up to 15	0.1%·H	0.2%·H

Long-term is defined as being after 1 year following construction to full height, over the life of the embankment.

1.3 Rock Fill Embankments over a Compressible Subgrade

For rock fill embankments constructed over a compressible subgrade, the estimated settlement of the embankment must include the compression of the rock fill (short-term and long-term, as described in Section 1.1 and 1.2) plus the settlement of the compressible foundation soils.

Section 2: Guidelines for Estimating Rock Fill Quantities for Construction

Each fill material has its own unique quantity requirements that are dependent upon the type of material used. For the appropriate embankment fill item, the designer determines the quantity of material for backfill and embankment construction by considering the following:

- neat lines of the embankment;
- embedment of fill material into the founding stratum;
- settlement during construction of the underlying founding stratum;
- settlement during construction of the un-compacted fill material;
- settlement during construction of the compacted fill material; and,
- construction loss of material below the water line.

For each swamp crossing and high fill area, the Foundation Investigation and Design Report should include the following estimates:

- estimated max. embedment of fill into the founding stratum (m);
- estimated max. settlement of the founding stratum during construction (m); and
- estimated max. settlement within the fill itself (both compacted and un-compacted) (m)

The estimates of maximum embedment and foundation soil settlement during construction are to be considered by the designer when estimating the quantity of fill required for construction. To account for the settlement of rock fill during construction, the rock fill quantity should be estimated using the standard bulking factor(s) currently recommended by MTO.