



**FOUNDATION INVESTIGATION REPORT
for
CULVERT REPLACEMENTS
HIGHWAY 85
TOWNSHIPS OF WATERLOO AND WOOLWICH
KITCHENER / WATERLOO AREA, ONTARIO
G.W.P. 168-89-00**

CAT. 43.508805
LPMG - 80.546033

PETO MacCALLUM LTD.
165 CARTWRIGHT AVENUE
TORONTO, ONTARIO
M6A 1V5
Phone: (416) 785-5110
Fax: (416) 785-5120
Email: toronto@petomacallum.com

Distribution:

- 3 cc: McCormick Rankin Corporation (MRC) for
distribution to MTO Project Manager – West Region
(London) + 1 digital copy (pdf)
- 3 cc: Foundation Investigation Report only to MRC for
distribution to MTO Project Manager – West Region
(London) + 1 digital copy (pdf)
- 1 cc: MRC for distribution to MTO, Pavements and
Foundations Section + 1 digital copy (pdf) and
Drawing (AutoCAD)
- 1 cc: Foundation Investigation Report only to MRC
for distribution to MTO, Pavements and
Foundations Section + 1 digital copy (pdf) and
Drawing (AutoCAD)
- 2 cc: MRC +1 digital copy (pdf)
- 1 cc: PML Kitchener
- 1 cc: PML Toronto

PML Ref.: 10KF079B
Index No.: 137FIR
GEOCRES No.: 40P7-67
February 5, 2014



TABLE OF CONTENTS

FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION	1
2. SITE DESCRIPTION AND GEOLOGY	2
3. INVESTIGATION PROCEDURES	2
4. SUMMARIZED SUBSURFACE CONDITIONS.....	3
4.1 Culvert C1 – Sta. 26+020, Township of Waterloo.....	4
4.1.1 Fill / Topsoil.....	4
4.1.2 Silty Sand.....	4
4.1.3 Clayey Silt	5
4.1.4 Silty Clay	5
4.1.5 Bedrock.....	5
4.1.6 Groundwater	6
4.2 Culvert C2 – Sta. 28+087 (S-E Ramp Chainage) Township of Waterloo.....	6
4.2.1 Topsoil / Fill.....	6
4.2.2 Sand.....	7
4.2.3 Silt	7
4.2.4 Clayey Silt	7
4.2.5 Bedrock.....	8
4.2.6 Groundwater	8
4.3 Culvert C3 – Sta. 28+132 (Highway 85 Chainage), Township of Waterloo.....	8
4.3.1 Topsoil / Fill.....	8
4.3.2 Clayey Silt	9
4.3.3 Silt / Sand and Silt.....	9
4.3.4 Clayey Silt	10
4.3.5 Clayey Silt Till.....	10
4.3.6 Bedrock.....	10
4.3.7 Groundwater	11



4.4 Culvert C4 – Sta. 27+385 (W-S Ramp Chainage), Township of Waterloo	11
4.4.1 Topsoil / Fill	11
4.4.2 Clayey Silt Till.....	11
4.4.3 Sand / Silty Sand	12
4.4.4 Silt	12
4.4.5 Bedrock.....	13
4.4.6 Groundwater	13
4.5 Culvert C5 – Sta. 28+940 (N-E/W Ramp Chainage), Township of Waterloo	13
4.5.1 Topsoil / Fill	13
4.5.2 Silty Clay	14
4.5.3 Silt / Sandy Silt / Sand and Silt	14
4.5.4 Clayey Silt Till.....	14
4.5.5 Sand	15
4.5.6 Bedrock	15
4.5.7 Groundwater	15
4.6 Culvert C6 – Sta. 28+908 (Highway 85 Chainage), Township of Waterloo.....	16
4.6.1 Topsoil / Fill	16
4.6.2 Silt	16
4.6.3 Silty Sand	17
4.6.4 Sand and Silt.....	17
4.6.5 Sand	17
4.6.6 Sand and Gravel / Gravelly Sand	18
4.6.7 Silty Clay Till.....	18
4.6.8 Bedrock	18
4.6.9 Groundwater	19
4.7 Culvert C7 – Sta. 9+664 (N-E/W Ramp Chainage), Township of Woolwich	19
4.7.1 Topsoil / Fill	19
4.7.2 Sand and Gravel / Gravelly Sand	20
4.7.3 Silty Clay Till.....	20
4.7.4 Bedrock	20
4.7.5 Groundwater	21



4.8 Culvert C8 – Sta. 10+771 (Highway 85 Chainage), Township of Woolwich.....	21
4.8.1 Topsoil / Fill	21
4.8.2 Silt	22
4.8.3 Clayey Silt	22
4.8.4 Sandy Gravel / Gravelly Sand	22
4.8.5 Clayey Silt Till.....	22
4.8.6 Bedrock	23
4.8.7 Groundwater	23
5. MISCELLANEOUS	23
6. CLOSURE	24

Table A – List of Atterberg Limits Test Results

Explanation of Terms Used in Report

Culvert C1 – Sta. 26+020 (Highway 85 Chainage), Township of Waterloo
 Figures C1-PC-1 and C1-PC-2 – Result of Atterberg Limits Testing
 Figures C1-GS-1 and C1-GS-2 – Results of Grain Size Distribution Analyses
 Record of Borehole Sheets
 Drawing C1-1 – Borehole Locations and Soil Strata

Culvert C2 – Sta. 28+087 (S-E Ramp Chainage), Township of Waterloo
 Figure C2-PC-1 – Result of Atterberg Limits Testing
 Figures C2-GS-1 and C2-GS-2 – Results of Grain Size Distribution Analyses
 Record of Borehole Sheets
 Drawing C2-1 – Borehole Locations and Soil Strata

Culvert C3 – Sta. 28+132 (Highway 85 Chainage), Township of Waterloo
 Figures C3-PC-1 and C3-PC2 – Result of Atterberg Limits Testing
 Figures C3-GS-1 to C3-GS-5 – Results of Grain Size Distribution Analyses
 Record of Borehole Sheets
 Drawing C3-1 – Borehole Locations and Soil Strata

Culvert C4 – Sta. 27+385 (W-S Ramp Chainage), Township of Waterloo
 Figure C4-PC-1 – Result of Atterberg Limits Testing
 Figures C4-GS-1 to C4-GS-4 – Results of Grain Size Distribution Analyses
 Record of Borehole Sheets
 Drawing C4-1 – Borehole Locations and Soil Strata



Culvert C5 – Sta. 28+940 (N-E/W Ramp Chainage), Township of Waterloo

Figure C5-PC-1 – Result of Atterberg Limits Testing

Figures C5-GS-1 and C5-GS-4 – Results of Grain Size Distribution Analyses

Record of Borehole Sheets

Drawing C5-1 – Borehole Locations and Soil Strata

Culvert C6 – Sta. 28+908 (Highway 85 Chainage), Township of Waterloo

Figures C6-PC-1 and C6-PC-2 – Result of Atterberg Limits Testing

Figures C6-GS-1 and C6-GS-4 – Results of Grain Size Distribution Analyses

Record of Borehole Sheets

Drawing C6-1 – Borehole Locations and Soil Strata

Culvert C7 – Sta. 9+664 (N-E/W Ramp Chainage), Township of Woolwich

Figure C7-PC-1 – Result of Atterberg Limits Testing

Figures C7-GS-1 and C7-GS-2 – Results of Grain Size Distribution Analyses

Record of Borehole Sheets

Drawing C7-1 – Borehole Locations and Soil Strata

Culvert C8 – Sta. 10+771 (Highway 85 Chainage), Township of Woolwich

Figure C8-PC-1 – Result of Atterberg Limits Testing

Figures C8-GS-1 and C8-GS-2 – Results of Grain Size Distribution Analyses

Record of Borehole Sheets

Drawing C8-1 – Borehole Locations and Soil Strata

Peto MacCallum Ltd.

C O N S U L T I N G E N G I N E E R S

FOUNDATION INVESTIGATION REPORT

for
Culvert Replacements
Highway 85
Kitchener / Waterloo Area, Ontario
GWP 168-89-00

1. INTRODUCTION

This report summarizes the results of the foundation investigation carried out for the proposed culvert replacements as part of the pavement rehabilitation of Highway 85 from 0.1 km south of Lancaster Street northerly 8.1 km to 0.4 km north of Waterloo Regional Road 15. The study was carried out by Peto MacCallum Ltd. (PML) for the McCormick Rankin Corporation (MRC) on behalf of the Ministry of Transportation of Ontario (MTO).

A total of eight culverts were identified for foundation investigation within the project limit. The culverts that were selected for foundation design and their reference numbers and locations are given in the following table:

PML CULVERT DESIGNATION	LOCATION	APPROXIMATE STATION (Note 1)
Township of Waterloo		
C1	Highway 85 NBL and SBL and E-S Ramp at Highway 85 / University Avenue Interchange	26+020
C2	S-E Ramp at Highway 85 / King Street Interchange	28+087
C3	Highway 85 NBL and SBL	28+132
C4	W-S Ramp at Highway 85/King Street Interchange	27+385
C5	N-E/W Ramp at Highway 85 / King Street Interchange	28+940
C6	Highway 85 NBL and SBL	28+908
Township of Woolwich		
C7	N-E/W Ramp at Highway 85 / Waterloo Regional Road 15 Interchange	9+664
C8	Highway 85 SBL	10+771

Note 1: Culvert Stations are approximate.

The purpose of this report was to summarize the subsurface stratigraphy encountered during the foundation investigation carried out at the culvert sites.



2. SITE DESCRIPTION AND GEOLOGY

The Highway 85 pavement rehabilitation project is located within the cities of Kitchener and Waterloo. The study sites are within the Geographic Townships of Waterloo and Woolwich. Further site specific description are presented in respective culvert sections 4.1 to 4.8 of this report.

Land use in the vicinity of the site includes the existing Highway 85 transportation corridor including the University Avenue, King Road and Waterloo Regional Road 15 interchanges amidst residential and commercial areas.

The project site is situated within in the physiographic region known as the Waterloo Hills characterised by sandy hills, sandy till ridges, kames and kames moraines with outwash sandy soils occupying the intervening hollows. The principal surficial soil along the study corridor is fine sand at the hilly region to more uniform sandy and gravelly materials at the alluvial terraces of the Grand River spillway. Typically, the surficial soils overlay clayey soils/ clay tills.

3. INVESTIGATION PROCEDURES

The subsurface investigations were carried out during the period of April 13 to July 18, 2011. A total of twenty one (21) boreholes were carried out for this study.

The boreholes were advanced using continuous flight solid and hollow solid augers through the soil cover with a truck-mounted CME-55 drill rig or tripod set-up, supplied and operated by a specialist drilling contractor, working under the full-time supervision of a PML field supervisor.

Soil samples were recovered from the boreholes at regular 0.75 and 1.5 m depth intervals using the standard penetration test method. Standard penetration tests were conducted to assess the strength characteristics of the substrata. Penetrometer tests were also carried out on stiffer cohesive split spoon soil samples. Soils were identified in accordance with the MTO soil classification manual procedures.



The groundwater conditions in the boreholes were assessed during drilling by visual examination of the soil, the sampler and drill rods as the samples were retrieved and, where encountered, by measuring the groundwater level in the open holes.

The boreholes were backfilled with a bentonite/cement mixture where required in accordance with the MTO guideline and MOE Reg. 903 for borehole abandonment.

The locations of the boreholes were laid out by PML and surveyed by MMM Group Ltd. All elevations in this report are reported in metres.

The recovered soil samples were returned to our laboratory in Toronto for detailed visual examination, laboratory testing and classification. The laboratory testing program included the following tests:

- Natural moisture content determinations (171)
- Grain size distribution analyses (21)
- Atterberg limits tests (39)

The laboratory grain size distribution charts are presented in Figures C1-GS-1 to C8-GS-2. The Atterberg plasticity test results are shown on the Figures C1-PC-1 to C8-PC-1 and are listed on Table A. All of the test results are summarized on the Record of Borehole sheets.

4. SUMMARIZED SUBSURFACE CONDITIONS

Reference is made to the appended Record of Borehole and Cone Penetration Test Sheets for details of the subsurface conditions including soil classifications, inferred stratigraphy, standard penetration test results, penetrometer shear strength values and groundwater observations. The results of laboratory particle size distributions, Atterberg limits and moisture content determinations are also shown on the Record of Borehole Sheets.

The borehole locations, stratigraphic profile and cross-sections prepared from the borehole data are shown on Drawings C1-1 to C8-1. 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.

A summary of the findings is given below for each culvert.

4.1 Culvert C1 – Sta. 26+020, Township of Waterloo

Culvert C1 is located on the existing Highway 85 northbound and southbound lanes and E-S ramp approximately 300 m north of the University Avenue underpass.

Three boreholes were drilled for this culvert to depths ranging from 6.6 to 9.6 m. The subsurface stratigraphy revealed in the boreholes generally comprised a road embankment fill or surficial topsoil locally underlain by silty sand over cohesive clayey silt / silty clay. Groundwater was observed all of the boreholes.

4.1.1 Fill / Topsoil

A 1.4 m thick fill was encountered in boreholes C1-1 and C1-2 drilled on the existing embankment. The unit extended to 1.4 m (elevation 313.6 and 314.0). The fill layer includes topsoil over silty clay underlain by gravelly sand in borehole C1-1 and asphalt over sand and gravel containing clayey silt layers in borehole C1-2. N values varied from 6 to 19, locally 1 in borehole C1-1. The moisture content results were 5 and 10%, locally 30% due to organics.

A 200 mm thick topsoil was encountered in borehole C1-3 extending to 0.2 m (elevation 314.6).

4.1.2 Silty Sand

A cohesionless silty sand deposit was locally encountered below the fill at 1.4 m (elevation 313.6) in borehole C1-2. The unit was 0.7 m thick extending to 2.1 m (elevation 312.9). One N value of 28 was obtained indicating compact relative density. One moisture content result was about 19%.



4.1.3 Clayey Silt

A cohesive clayey silt layer was encountered below the silty sand at 2.1 m (elevation 312.9) in borehole C1-2 and below the topsoil at 0.2 m (elevation 314.6) in borehole C1-3. The layer was 0.9 and 1.2 m thick extending to 3.0 and 1.4 m (elevation 312.0 and 313.4) in boreholes C1-2 and C1-3, respectively. N values ranged from 11 to 31. One pocket penetrometer test result was 188 kPa. The layer was stiff to hard consistency.

The results of grain size distribution analysis for two clayey silt samples are included in Figure C1-GS-1. The plasticity chart is presented in Figure C1-PC-1. The liquid limits were 25 and 32 and the plastic limits 13 and 17 with plasticity index values of 12 and 15. The moisture content determinations varied from 13 to 26%.

4.1.4 Silty Clay

A cohesive silty clay stratum was encountered below the fill at 1.4 m (elevation 314.0) in borehole C1-1 and below the clayey silt at 3.0 and 1.4 m (elevation 312.0 and 313.4) in boreholes C1-2 and C1-3. The stratum was at least 5.2 to 6.6 m thick extending to borehole termination depths of 6.6 to 9.6 m (elevation 305.4 to 308.7). N values ranged from 10 to 52. One pocket penetrometer test result was 225 kPa. The stratum was stiff to hard consistency.

The results of grain size distribution analysis for silty clay samples are included in Figure C1-GS-2. The plasticity chart is presented in Figure C1-PC-2. The liquid and plastic limits varied from 37 to 45 and 18 to 21, respectively with plasticity index values of 19 to 24. The moisture content determinations varied from 15 to 24%.

4.1.5 Bedrock

No bedrock was encountered any of the boreholes. Boreholes were terminated within the silty clay stratum at 6.6 to 9.6 m (elevation 305.4 to 308.7).



4.1.6 Groundwater

Groundwater was encountered in all of the boreholes. During augering, groundwater was observed at 0.8 to 1.4 m (elevation 313.4 to 314.5). Upon completion of drilling, groundwater was measured at 5.2 m (elevation 310.2) in borehole C1-1. The groundwater level is subject to seasonal fluctuation and rainfall patterns.

4.2 Culvert C2 – Sta. 28+087 (S-E Ramp Chainage) Township of Waterloo

Culvert C2 is located on the existing S-E ramp approximately 300 m east of the King Street underpass.

Two boreholes were drilled along the alignment of this culvert and one common culvert borehole was utilized for this culvert. The boreholes were advanced to 4.4 and 9.8 m. The subsurface stratigraphy revealed in the boreholes generally comprised a road embankment fill or surficial topsoil locally underlain by sand over silt which in turn was underlain by cohesive clayey silt. Groundwater was observed in all of the boreholes.

4.2.1 Topsoil / Fill

A 300 mm thick topsoil layer was encountered surficially in boreholes C2-1 and C3-3 extending to 0.3 m (elevation 338.8 and 337.4).

A 3.7 m thick fill was encountered in borehole C2-2 drilled on existing embankment shoulder extending to 3.7 m (elevation 337.4). The fill layer includes sand and gravel to sand containing organic layers and organic silt inclusions. N values varied from 8 to 14. The moisture content results varied from 6 to 14%.



4.2.2 Sand

A cohesionless sand deposit was locally encountered in borehole C2-1 below the topsoil at 0.3 m (elevation 338.8). The layer was 1.1 m thick extending to underlying silt 1.4 m (elevation 337.7). N values were 2 and 7 indicating very loose to loose relative density. The moisture content results were 23 and 37% due to organics.

4.2.3 Silt

A cohesionless silt deposit was encountered below the sand at 1.4 m (elevation 337.7) in borehole C2-1 and below the fill at 3.7 m (elevation 337.4) in borehole C2-2 and below clayey silt at 0.8 m (elevation 336.9) in borehole C3-3. The deposit was 1.6 to 2.3 m thick extending to 2.4 to 5.8 m (elevation 335.3 to 335.4). N values ranged from 14 to 22 indicating compact relative density.

The results of grain size distribution analysis for a silt sample are included in Figure C2-GS-1. The moisture content determinations varied from 18 to 23%.

4.2.4 Clayey Silt

A cohesive clayey silt stratum was encountered below the topsoil at 0.3 m (elevation 337.4) in borehole C3-3 and below the silt at 3.7 and 5.8 m (elevation 335.4 and 335.3) in boreholes C2-1 and C2-2. In addition, this stratum was interbedded with cohesionless silt (1.6 m thick) at 0.8 m (elevation 336.9) in borehole C3-3. The layer was at least 0.5 to 4.0 m thick extending to borehole termination depths of 4.4 and 9.8 m (elevation 331.3 to 334.7). N values ranged from 11 to 21. Pocket penetrometer test results varied from 88 to 225 kPa. The stratum was stiff to hard consistency.

The results of grain size distribution analysis for clayey silt samples are included in Figure C2-GS-2. The plasticity chart is presented in Figure C2-PC-1. The liquid and plastic limits



varied from 18 to 23 and 12 to 16, respectively with plasticity index values of 6 and 7. The moisture content determinations varied from 16 to 23%.

4.2.5 Bedrock

No bedrock was encountered any of the boreholes. Boreholes were terminated within the clayey silt stratum at 4.4 and 9.8 m (elevation 331.3 to 334.7).

4.2.6 Groundwater

Groundwater was encountered in all of the boreholes. During augering, groundwater was observed at 0.3 to 3.7 m (elevation 337.4 to 338.8). Upon completion of drilling, groundwater was encountered at 0.9 and 5.2 m (elevation 335.9 to 337.0). The groundwater level is subject to seasonal fluctuation and rainfall patterns.

4.3 Culvert C3 – Sta. 28+132 (Highway 85 Chainage), Township of Waterloo

Culvert C3 is located on the existing Highway 85 northbound and southbound lanes approximately 500 m north of the King Street underpass.

Three boreholes were drilled along the alignment of this culvert to depths ranging from 4.4 to 11.3 m. The subsurface stratigraphy revealed in the boreholes generally comprised a road embankment fill or surficial topsoil underlain by cohesionless silt / sand and silt over cohesive clayey silt and clayey silt till. Groundwater was observed all of the boreholes.

4.3.1 Topsoil / Fill

A 300 mm thick topsoil layer was encountered surficially in borehole C3-3 and extending to 0.3 m (elevation 337.4).



A 1.4 and 4.7 m thick fill layer was present surficially in boreholes C3-1 and C3-2 drilled on the highway embankment toe of slope and shoulder. The unit extended to 1.4 and 4.7 m (elevation 335.9 and 337.7). The fill layer includes topsoil over silty clay in borehole C3-1 and sand and gravel to sandy silt containing organic inclusions in borehole C3-2. N values varied from 5 to 34 indicating very loose to dense relative density.

The results of grain size distribution analysis for a sand fill sample are included in Figure C3-GS-1. The moisture content results varied from 4 to 15%.

4.3.2 Clayey Silt

A cohesive clayey silt layer was encountered below the topsoil at 0.3 m (elevation 337.4) in borehole C3-3. The layer was 0.5 m thick extending to 0.8 m (elevation 336.9). One composite N value of 9 was obtained indicating stiff consistency. One moisture content result was 18%.

4.3.3 Silt / Sand and Silt

A cohesionless silt deposit was encountered below the fill at 1.4 m (elevation 335.9) in borehole C3-1 and below the clayey silt at 0.8 m (elevation 336.9) in boreholes C3-3. The deposit was 1.6 m thick extending to 3.0 and 2.4 m (elevation 334.3 to 335.3) in boreholes C3-1 and C3-3. N values ranged from 14 to 18 indicating compact relative density.

A cohesionless sand and silt layer was locally encountered below the fill at 4.7 m (elevation 337.7) in borehole C3-2. The layer was 1.3 m thick extending to 6.0 m (elevation 336.4). N values of 24 and 40 were obtained indicating compact to dense relative density.

The results of grain size distribution analysis for silt / sand and silt samples are included in Figures C3-GS-2 and C3-GS-3. The moisture content determinations varied from 14 to 21%.



4.3.4 Clayey Silt

A cohesive clayey silt stratum was encountered below the silt at 3.0 and 2.4 m (elevation 334.3 and 335.3) in boreholes C3-1 and C3-3 and below the sand and silt at 6.0 m (elevation 336.4) in borehole C3-2. The stratum was at least 1.4 to 2.4 m thick extending to underlying clayey silt till at 8.4 m (elevation 334.0) in borehole C3-2 and borehole termination depth of 4.4 m (elevation 332.9 and 333.3) in boreholes C3-1 and C3-3. N values ranged from 6 to 23. Pocket penetrometer test results varied from 38 to 175 kPa. The stratum was firm to very stiff consistency.

The results of grain size distribution analysis for three clayey silt samples are included in Figure C3-GS-4. The plasticity chart is presented in Figure C3-PC-1. The liquid limits were 17 and 20 and the plastic limits 14 and 16, respectively with plasticity index values of 3 to 6. The moisture content determinations varied from 13 to 23%.

4.3.5 Clayey Silt Till

A cohesive clayey silt till deposit was encountered below the clayey silt at 8.4 m (elevation 334.0) in borehole C3-2. The deposit was at least 3.9 m thick extending to borehole termination depth of 11.3 m (elevation 331.1). N values ranged from 8 to 13. Pocket penetrometer test results were 150 and 175 kPa. The deposit was firm to stiff consistency.

The results of grain size distribution analysis for clayey silt till sample are included in Figure C3-GS-5. The plasticity chart is presented in Figure C3-PC-2. The liquid and plastic limits were 29 and 15, respectively with the corresponding plasticity index value of 14. The moisture content determination varied from 16 to 18%.

4.3.6 Bedrock

No bedrock was encountered any of the boreholes. Boreholes were terminated within the clayey silt / clayey silt till layer at 4.4 and 11.3 m (elevation 331.1 to 333.3).



4.3.7 Groundwater

Groundwater was encountered in all of the boreholes. During augering, groundwater was observed at 0.8 to 5.5 m (elevation 335.7 and 336.9). Upon completion of drilling, groundwater was encountered at 0.9 and 2.1 m (elevation 335.2 and 336.8), locally at 9.9 m (elevation 332.5) in borehole C3-2. Cave-in was observed in boreholes C3-1 and C3-3 at 4.0 and 3.1 m, respectively. The groundwater level is subject to seasonal fluctuation and rainfall patterns.

4.4 Culvert C4 – Sta. 27+385 (W-S Ramp Chainage), Township of Waterloo

Culvert C4 is located on the existing W-S ramp and just east of the King Street. Three boreholes were drilled along the alignment of this culvert to depths of 4.3 and 6.4 m. The subsurface stratigraphy revealed in the boreholes generally comprised a road embankment fill or surficial topsoil underlain by cohesive clayey silt till over cohesionless sand/silty sand/silt. Groundwater was observed all of the boreholes.

4.4.1 Topsoil / Fill

A 300 mm thick topsoil layer was encountered surficially in borehole C4-3 and extending to 0.3 m (elevation 333.3).

A 0.8 and 1.4 m thick fill was encountered in boreholes C4-1 and C4-2 drilled on the existing embankment. The unit extended to 0.8 and 1.4 m (elevation 331.0 and 331.7). The fill layer includes topsoil over silty clay in borehole C4-1 and asphalt over sand and gravel to sand in borehole C4-2. N values were 4 and 11, locally 54 in borehole C4-2 indicating loose to very dense relative density. One moisture content result was about 4%.

4.4.2 Clayey Silt Till

A cohesive clayey silt till stratum was encountered below the topsoil at 0.3 m (elevation 333.3) and below the fill at 0.8 and 1.4 m (elevation 331.0 and 331.7) in boreholes C4-1 and C4-2. The



stratum extended to 1.2 to 2.2 m (elevation 329.7 to 332.4). In addition, 0.4 and 0.5 m thick clayey silt till layer was interbedded with sand at 3.0 and 3.2 m (elevation 328.8 and 329.9). N values ranged from 8 to 40. Pocket penetrometer test results varied from 88 to 188 kPa. The stratum was found to be firm to hard consistency.

The results of grain size distribution analysis for a clayey silt till sample are included in Figure C4-GS-1. The plasticity chart is presented in Figure C4-PC-1. The liquid and plastic limits were 18 and 12, respectively with the corresponding plasticity index value of 6. The moisture content determination varied from 9 to 20%.

4.4.3 Sand / Silty Sand

A cohesionless sand deposit was encountered below the clayey silt till at 2.1 and 2.2 m (elevation 329.7 and 330.9) in boreholes C4-1 and C4-2. In addition, sand deposit was interbedded with the clayey silt till stratum (0.4 and 0.5 m thick) at 3.0 and 3.2 m (elevation 328.8 and 329.9). The deposit was at least 0.9 to 2.7 m thick extending to borehole termination depths of 4.3 and 6.4 m (elevation 327.5 and 326.7). N values ranged from 34 to 41 and 50 for 15 cm sampler penetration indicating dense relative density.

A cohesionless silty sand layer was locally encountered below the clayey silt till at 1.2 m (elevation 332.4) in borehole C4-3. The layer was 2.5 m thick extending to 3.7 m (elevation 329.9). N values of 37 to 41 were obtained indicating dense relative density.

The results of grain size distribution analysis for sand and silty sand samples are included in Figures C4-GS-2 and C4-GS-3. The moisture content determinations varied from 4 to 21%.

4.4.4 Silt

Below the silty sand, a discontinuous cohesionless silt layer was encountered at 3.7 m (elevation 329.9) in borehole C4-3. The layer was at least 0.6 m thick extending to borehole



termination depth of 4.3 m (elevation 329.3). One N value of 31 was obtained indicating dense relative density.

The results of grain size distribution analysis on a silt sample are included in Figure C4-GS-4. One moisture content result was 20%.

4.4.5 Bedrock

No bedrock was encountered any of the boreholes. Boreholes were terminated within the cohesionless soil layer at 4.3 and 6.4 m (elevation 326.7 to 329.3).

4.4.6 Groundwater

Groundwater was encountered in all of the boreholes. During augering, groundwater was observed at 1.2 to 3.4 m (elevation 328.4 to 332.4). Upon completion of drilling, groundwater was encountered at 3.4 to 5.2 m (elevation 327.8 and 330.2). The groundwater level is subject to seasonal fluctuation and rainfall patterns.

4.5 Culvert C5 – Sta. 28+940 (N-E/W Ramp Chainage), Township of Waterloo

Culvert C5 is located on the existing N-E/W ramp approximately 300 m east of King Street. Three boreholes were drilled along the alignment of this culvert to depths of 4.3 and 9.4 m. The subsurface stratigraphy revealed in the boreholes generally comprised a road embankment fill or surficial topsoil locally underlain by silty clay over cohesionless soils. In addition, a cohesive clayey silt till stratum was interbedded with the cohesionless silt /sand. Groundwater was observed all of the boreholes.

4.5.1 Topsoil / Fill

A 200 and 300 mm thick topsoil layer was encountered surficially in boreholes C5-1 and C5-3 and extending to 0.2 and 0.3 m (elevation 332.7 and 336.5).



A 4.7 m thick fill layer was present in borehole C5-2 drilled on the highway embankment shoulder extending to 4.7 m (elevation 332.1). The fill layer includes 100 mm asphalt over sand and gravel to silty sand containing silty clay pockets and organics. N values varied from 15 to 45 indicating compact to dense relative density.

The results of grain size distribution analysis for a silty sand fill sample are included in Figure C5-GS-1. The moisture content results varied from 4 to 16%.

4.5.2 Silty Clay

A cohesive silty clay layer was locally encountered below the topsoil at 0.3 m (elevation 336.5) in borehole C5-1. The layer was 0.3 m thick extending to 0.6 m (elevation 336.2). One composite N value of 12 was obtained indicating stiff consistency. One moisture content result was 9%.

4.5.3 Silt / Sandy Silt / Sand and Silt

A cohesionless silt layer with varying sand portions was encountered below the silty clay at 0.6 m (elevation 336.2) in borehole C5-1 and below the fill at 4.7 m (elevation 332.1) in borehole C5-2 and below the topsoil at 0.2 m (elevation 332.7) in borehole C5-3. In addition, this deposit was interbedded with two sand layers (0.3 and 1.9 m thick) in borehole C5-3 at 0.8 and 2.2 m (elevation 332.1 and 330.7). The layer was at least 0.6 to 1.5 m thick extending to 2.1 to 5.6 m (elevation 330.7 to 334.7). N values ranged from 5 to 29 indicating loose to compact relative density.

The results of grain size distribution analysis for silt / sand and silt samples are included in Figures C5-GS-2 and C5-GS-3. The moisture content determinations varied from 4 to 17%.

4.5.4 Clayey Silt Till

A cohesive clayey silt till stratum was encountered below the silt at 2.1 and 5.6 m (elevation 334.7 and 331.2) in boreholes C5-1 and C5-2. In addition, the stratum was interbedded with a sand



layer (1.2 m thick) at 6.7 m (elevation 330.1). The stratum was 1.1 to 1.6 m thick extending to 3.7 m (elevation 333.1) in borehole C5-1 and to borehole termination depth of 9.4 m (elevation 327.4) in borehole C5-2. N values ranged from 17 to 27 and 50 for 10 cm sampler penetration. Pocket penetrometer test results varied from 75 to 150 kPa. The layer found to be very stiff consistency.

The results of grain size distribution analysis for clayey silt till samples are included in Figure C5-GS-4. The plasticity chart is presented in Figure C5-PC-1. The liquid limits were 16 and 18 and the plastic limit is 11 with plasticity index values of 5 and 7. The moisture content determinations varied from 10 to 18%.

4.5.5 Sand

A cohesionless sand deposit was encountered below the clayey silt till at 3.7 and 6.7 m (elevation 330.1 and 333.1) in boreholes C5-1 and C5-2 and below the sandy silt at 0.8 m (elevation 332.1) in borehole C5-3. In addition, the sand deposit was interbedded with the silt (1.1 m thick) at 1.1 m (elevation 331.8) in borehole C5-3. The layer was 0.3 to 1.9 m thick extending to 4.1 to 7.9 m (elevation 328.9 to 332.5). N values varied from 28 to 107 indicating compact to very dense relative density. The moisture content determinations varied from 4 to 20%.

4.5.6 Bedrock

No bedrock was encountered any of the boreholes. Boreholes were terminated at 4.3 and 9.4 m (elevation 327.4 to 332.5).

4.5.7 Groundwater

Groundwater was encountered in all of the boreholes. During augering, groundwater was observed at 1.5 to 7.5 m (elevation 329.3 to 335.3). The groundwater level is subject to seasonal fluctuation and rainfall patterns.



4.6 Culvert C6 – Sta. 28+908 (Highway 85 Chainage), Township of Waterloo

Culvert C6 is located on the existing Highway 85 northbound and southbound lanes approximately 400 m north of the King Street underpass.

Three boreholes were drilled along the alignment of this culvert to depths ranging from 4.6 to 10.8 m. The subsurface stratigraphy revealed in the boreholes generally comprised a road embankment fill or surficial topsoil over cohesionless soils which in turn were underlain by silty clay till in one borehole. Groundwater was observed all of the boreholes.

4.6.1 Topsoil / Fill

A 300 mm thick topsoil layer was encountered surficially in boreholes C6-1 and C6-3 and extending to 0.3 m (elevation 332.9 and 335.0).

A 3.0 m thick fill unit was present in borehole C6-2 drilled on the highway embankment shoulder extending to 3.0 m (elevation 331.8). The fill unit includes sand and gravel containing clayey silt pockets. N values varied from 6 to 17 indicating loose to compact relative density. The moisture content results varied from 5 to 13%.

4.6.2 Silt

Below the fill layer, a 2.2 m thick cohesionless silt deposit was locally encountered in borehole C6-2 at 3.0 m (elevation 331.8). The layer extended to 5.2 m (elevation 329.6). N values obtained varied from 20 to 61 indicating compact to very dense relative density.

The results of grain size distribution analysis for a silt sample are presented in Figure C6-GS-1. Moisture content determinations were 16 and 19%.



4.6.3 Silty Sand

A cohesionless silty sand layer was encountered below the topsoil at 0.3 m (elevation 332.9 and 335.0) in boreholes C6-1 and C6-3 and below the silt at 5.2 m (elevation 329.6) in borehole C6-2. The layer was 0.8 to 2.4 m thick extending to 1.4 to 6.0 m (elevation 328.7 to 332.6). N values ranged from 11 to 37 indicating compact to dense relative density. The moisture content determinations varied from 4 to 20%.

4.6.4 Sand and Silt

Below the silty sand layer, a 3.1 m thick cohesionless sand and silt deposit was locally encountered in borehole C6-1 at 1.4 m (elevation 331.8). The layer extended to 4.5 m (elevation 328.7). N values obtained varied from 7 to 37 indicating loose to dense relative density.

The results of grain size distribution analysis for a sand and silt sample are presented in Figure C6-GS-2. The plasticity chart is presented in Figure C6-PC-1. The liquid limit and plastic limit were 14 and 12 with plasticity index value of 2. Moisture content determinations varied from 10 to 20%.

4.6.5 Sand

Below the sand and silt layer in borehole C6-1, a 2.5 m thick cohesionless sand stratum was locally encountered at 4.5 m (elevation 328.7). The layer extended to 7.0 m (elevation 326.2). N values obtained varied from 17 to 37 indicating compact to dense relative density.

The results of grain size distribution analysis for a sand sample are presented in Figure C6-GS-3. Moisture content determinations varied from 18 to 21%.



4.6.6 Sand and Gravel / Gravelly Sand

Cohesionless sand and gravel to gravelly sand deposits were encountered below the sand at 7.0 m (elevation 326.2) in borehole C6-1 and below the silty sand at 6.0 and 2.7 m (elevation 328.8 and 332.6) in boreholes C6-2 and C6-3, respectively. The deposit was at least 1.1 to 2.7 m thick extending to underlying silty clay till at 8.7 m (elevation 326.1) in borehole C6-2 and to borehole termination depths of 8.1 and 4.6 m (elevation 325.1 and 330.7) in boreholes C6-1 and C6-3. N values ranged from 33 to 70 and 50 for 15 cm sampler penetration indicating dense to very dense relative density.

The results of grain size distribution analysis for a sand and gravel sample are included in Figure C6-GS-4. The moisture content determinations varied from 6 to 20%.

4.6.7 Silty Clay Till

Below the sand and gravel layer in borehole C6-2, a cohesive silty clay till stratum was present at 8.7 m (elevation 326.1). The layer was at least 2.1 m thick extending to borehole termination depth of 10.8 m (elevation 324.0). N values were 24 and 50 for 15 cm sampler penetration indicating very stiff to hard consistency.

The plasticity chart is presented in Figure C6-PC-2. The liquid and plastic limits were 42 and 19, respectively with the corresponding plasticity index value of 23. One moisture content determination was 20%.

4.6.8 Bedrock

No bedrock was encountered any of the boreholes. Boreholes were terminated within the cohesionless deposit in boreholes C6-1 and C6-3 and within the cohesive silty clay till layer in borehole C6-2 at 4.6 to 10.8 m (elevation 324.0 to 330.7).



4.6.9 Groundwater

Groundwater was encountered in all of the boreholes. During augering, groundwater was observed at 2.3 to 5.3 m (elevation 329.5 and 333.0). Upon completion of drilling, groundwater was encountered at 2.4 to 5.5 m (elevation 327.7 to 332.9). Cave-in was observed at 5.5 and 5.2 m in boreholes C6-1 and C6-2, respectively. The groundwater level is subject to seasonal fluctuation and rainfall patterns.

4.7 Culvert C7 – Sta. 9+664 (N-E/W Ramp Chainage), Township of Woolwich

Culvert C7 is located on the existing N-E/W ramp and approximately 300 m north of Waterloo Regional Road 15.

Three boreholes were drilled along the alignment of this culvert to depths ranging from 3.7 to 5.2 m. The subsurface stratigraphy revealed in the boreholes generally comprised a road embankment fill or surficial topsoil over cohesionless sand and gravel / gravelly sand containing cobbles and boulders which in turn was underlain by silty clay till in two boreholes. Groundwater was observed all of the boreholes.

4.7.1 Topsoil / Fill

A 500 mm thick topsoil layer was encountered surficially in borehole C7-2 extending to 0.5 m (elevation 337.4).

A 600 mm and 2.2 m thick fill was present in boreholes C7-1 and C7-3 extending to 0.6 and 2.2 m (elevation 335.6 and 335.5). The fill unit includes silty sand containing some gravel and cobbles and asphalt over crushed gravelly sand to sand over clayey silt. N values varied from 9 to 34 indicating loose to dense relative density. The moisture content results varied from 3 to 8%.



4.7.2 Sand and Gravel / Gravelly Sand

A cohesionless sand and gravel to gravelly sand deposit was encountered below the fill at 0.6 and 2.2 m (elevation 335.6 and 335.5) in boreholes C7-1 and C7-3 and below the topsoil at 0.5 m (elevation 337.4) in borehole C7-2. The deposit contains sandy gravel and gravel layers and cobbles and boulders. The stratum was at least 1.5 to 2.9 m thick extending to underlying silty clay till at 3.4 m (elevation 332.8 and 334.5) in boreholes C7-1 and C7-2 and to the borehole termination depth of 3.7 m (elevation 334.0) in borehole C7-3. N values ranged from 19 to 40 and 20 for 18 cm sampler penetration indicating compact to dense relative density.

The results of grain size distribution analysis for sandy gravel and gravel samples are included in Figure C7-GS-1. The moisture content determinations varied from 5 to 10%.

4.7.3 Silty Clay Till

A cohesive silty clay till stratum was encountered at 3.4 m (elevation 332.8 and 334.5) below the sand and gravel in boreholes C7-1 and C7-2. The layer was at least 1.6 and 1.8 m thick extending to the borehole termination depths of 5.0 and 5.2 m (elevation 331.2 and 332.7). N values varied from 16 to 25 indicating very stiff consistency.

The results of grain size distribution analysis for two silty clay till samples are included in Figure C7-GS-2. The plasticity chart is presented in Figure C7-PC-1. The liquid limits were 39 and 42 and plastic limits were 17 and 19 with plasticity index values of 22 and 23. Moisture content determinations varied from 20 to 22%.

4.7.4 Bedrock

No bedrock was encountered any of the boreholes. Boreholes were terminated within the cohesionless deposit in borehole C7-3 and within the cohesive silty clay till layer in boreholes C7-1 and C7-2 at 3.7 to 5.2 m (elevation 331.2 to 334.0).



4.7.5 Groundwater

Groundwater was encountered in all of the boreholes. During augering, groundwater was observed at 0.5 and 0.6 m (elevation 337.4 and 335.6) in boreholes C7-1 and C7-2. Upon completion of drilling, groundwater was measured at 1.5 to 2.4 m (elevation 334.7 to 335.8) in all of the boreholes. Cave-in was observed at 1.8 m in borehole C7-1. The groundwater level is subject to seasonal fluctuation and rainfall patterns.

4.8 Culvert C8 – Sta. 10+771 (Highway 85 Chainage), Township of Woolwich

Culvert C8 is located on the existing Highway 85 southbound lanes and approximately 300 m north of Waterloo Regional Road 15.

One borehole was drilled along the alignment of this culvert and one common borehole from Culvert C7 reused. The boreholes were advanced to 3.7 and 5.3 m. The subsurface stratigraphy revealed in the boreholes generally comprised a road embankment fill or surficial topsoil over cohesionless silt / sand and gravel / gravelly sand which in turn was underlain by clayey silt till in one borehole. In addition, a cohesive clayey silt layer was locally encountered in one borehole. Groundwater was observed all of the boreholes.

4.8.1 Topsoil / Fill

A 200 mm thick topsoil layer was encountered surficially in borehole C8-1 extending to 0.2 m (elevation 336.7).

A 2.2 m thick fill unit was present in borehole C7-3 drilled on the existing embankment shoulder extending to 2.2 m (elevation 335.5). The fill unit includes asphalt over crushed gravelly sand to sand over clayey silt. N values were 29 and 34 indicating compact relative density. The moisture content results were 4 and 8%.



4.8.2 Silt

Below the topsoil layer, a 300 mm thick cohesionless silt deposit was locally encountered in borehole C8-1 at 0.2 m (elevation 336.7). The layer extended to 0.5 m (elevation 336.4). One composite N value of 20 obtained indicating compact relative density.

4.8.3 Clayey Silt

A 300 mm thick cohesive clayey silt stratum was locally encountered in borehole C8-1 at 0.5 m (elevation 336.4). The stratum extended to 0.8 m (elevation 336.1). One composite N value of 20 obtained indicating very stiff consistency.

4.8.4 Sandy Gravel / Gravelly Sand

Cohesionless sandy gravel to gravelly sand deposit was encountered and below the clayey silt at 0.8 m (elevation 336.1) in borehole C8-1 and below the fill at 2.2 m (elevation 335.5) in borehole C7-3. The unit was at least 1.5 and 2.9 m thick extending to underlying clayey silt till at 3.7 m (elevation 333.2) in borehole C8-1 and to the borehole termination depth of 3.7 m (elevation 334.0) in borehole C7-3. N values ranged from 25 to 40 indicating compact to dense relative density.

The results of grain size distribution analysis for a sandy gravel sample are included in Figure C8-GS-1. The moisture content determinations varied from 5 to 10%.

4.8.5 Clayey Silt Till

A cohesive clayey silt till stratum was encountered below the sandy gravel at 3.7 m (elevation 333.2) in borehole C8-1. The stratum was at least 1.6 m thick extending to the borehole termination depth of 5.3 m (elevation 331.6). N values were 20 and 31 indicating very stiff to hard consistency.



The results of grain size distribution analysis for a clayey silt till sample are included in Figure C8-GS-2. The plasticity chart is presented in Figure C8-PC-1. The liquid and plastic limits were 29 and 14, respectively with the corresponding plasticity index value of 15. One moisture content determination was 15%.

4.8.6 Bedrock

No bedrock was encountered any of the boreholes. Boreholes were terminated within the cohesionless deposit in borehole C7-3 and within the cohesive clayey silt till stratum in borehole C8-1 at 3.7 and 5.3 m (elevation 331.6 and 334.0).

4.8.7 Groundwater

Groundwater was encountered in both boreholes. During augering, groundwater was observed at 1.6 m (elevation 335.3) in borehole C8-1. Upon completion of drilling, groundwater was measured at 1.8 and 2.4 m (elevation 335.1 and 335.3) in boreholes C8-1 and C7-3. The groundwater level is subject to seasonal fluctuation and rainfall patterns.

5. MISCELLANEOUS

Mr. F. Portela carried out the field investigation for this study under the supervision of Mrs. N.S. Balakumaran, P. Eng., and Mr. C. M. P. Nascimento, P. Eng., Project Manager. London Soils and Sonic Drilling, supplied the drill rigs for the subsurface exploration. The laboratory testing of the selected samples was carried out in the PML laboratory in Toronto.



6. CLOSURE

This report was prepared by Mrs. N. S. Balakumaran, P. Eng., 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.



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



Brian R. Gray, MEng, P.Eng.
MTO Designated Principal Contact

CN/BRG:mi-nk



TABLE A
LIST OF ATTERBERG LIMITS RESULTS

CULVERT NO.	SOIL TYPE	BOREHOLE NO.	SAMPLE NO.	DEPTH / ELEVATION (m)	MOISTURE CONTENT (W) %	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)
C1	Clayey Silt	C1-2	4	2.6 / 312.4	25	32	17	15
		C1-3	2	1.1 / 313.7	13	25	13	12
	Silty Clay	C1-1	7	4.9 / 310.5	22	44	20	24
		C1-2	6	4.1 / 310.9	19	37	18	19
		C1-2	10	7.8 / 307.2	21	45	21	24
C2	Clayey Silt	C1-3	5	3.3 / 311.5	16	38	18	20
		C2-2	9	6.4 / 334.7	19	23	16	7
		C2-2	12	9.4 / 331.7	16	18	12	6
		C3-3	5	3.4 / 334.3	22	20	14	6
		C3-1	6	4.0 / 333.3	19	20	16	4
C3	Clayey Silt	C3-2	9	6.4 / 336.0	13	17	14	3
		C3-3	5	3.4 / 334.3	22	20	14	6
	Clayey Silt Till	C3-2	13	9.6 / 332.8	18	29	15	14



TABLE A
LIST OF ATTERBERG LIMITS RESULTS

CULVERT NO.	SOIL TYPE	BOREHOLE NO.	SAMPLE NO.	DEPTH / ELEVATION (m)	MOISTURE CONTENT (W) %	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)
C4	Clayey Silt Till	C4-1	3	1.7 / 330.1	11	18	12	6
C5	Clayey Silt	C5-1	4	2.5 / 334.3	11	16	11	5
		C5-2	9	6.3 / 330.5	10	18	11	7
C6	Sand and Silt	C6-1	3	1.8 / 331.4	12	14	12	2
	Silty Clay Till	C6-2	12	9.4 / 325.4	20	42	19	23
C7	Silty Clay Till	C7-1	6	4.0 / 332.3	22	42	19	23
		C7-2	6	4.2 / 333.7	20	39	17	22
C8	Clayey Silt Till	C8-1	7	5.0 / 331.9	15	29	14	15

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 31mm 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 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 1" 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 SILTY)

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/0.3m)	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 (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0-25	25-30	30-75	75-90	90-100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	30-300mm	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

SS SPLIT SPOON	TP THINWALL PISTON
WS WASH SAMPLE	OS OSTERBERG SAMPLE
ST SLOTTED TUBE SAMPLE	RC ROCK CORE
BS BLOCK SAMPLE	PH TW ADVANCED HYDRAULICALLY
CS CHUNK SAMPLE	PM TW ADVANCED MANUALLY
TW THINWALL OPEN	FS FOIL SAMPLE
FV FIELD VANE	

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
i		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		COEFFICIENT OF FRICTION

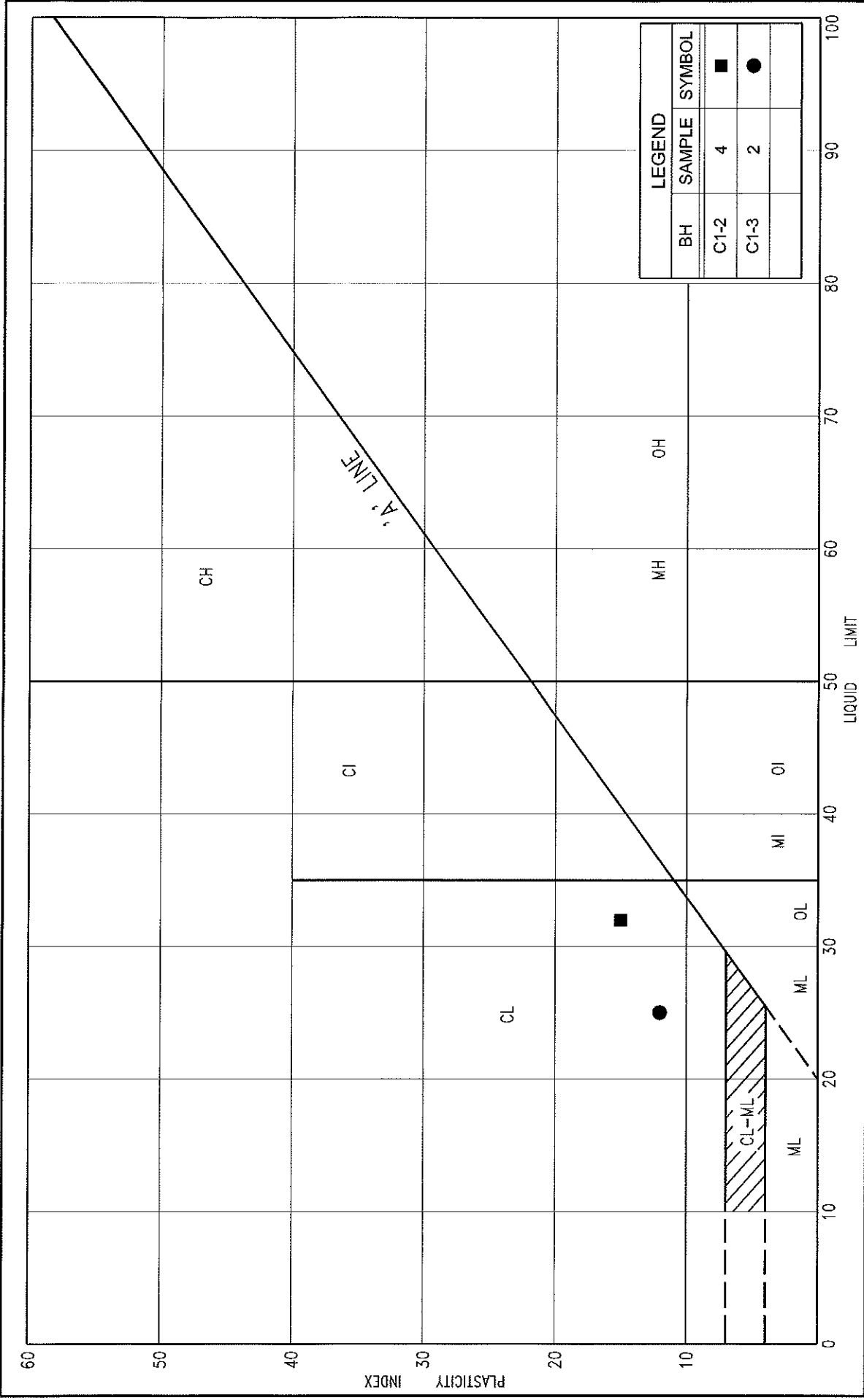
MECHANICAL PROPERTIES OF SOIL


m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c		COMPRESSION INDEX
C_s		SWELLING INDEX
C_α		RATE OF SECONDARY CONSOLIDATION
C_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v		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_i		SENSITIVITY = $\frac{c_u}{\tau_r}$

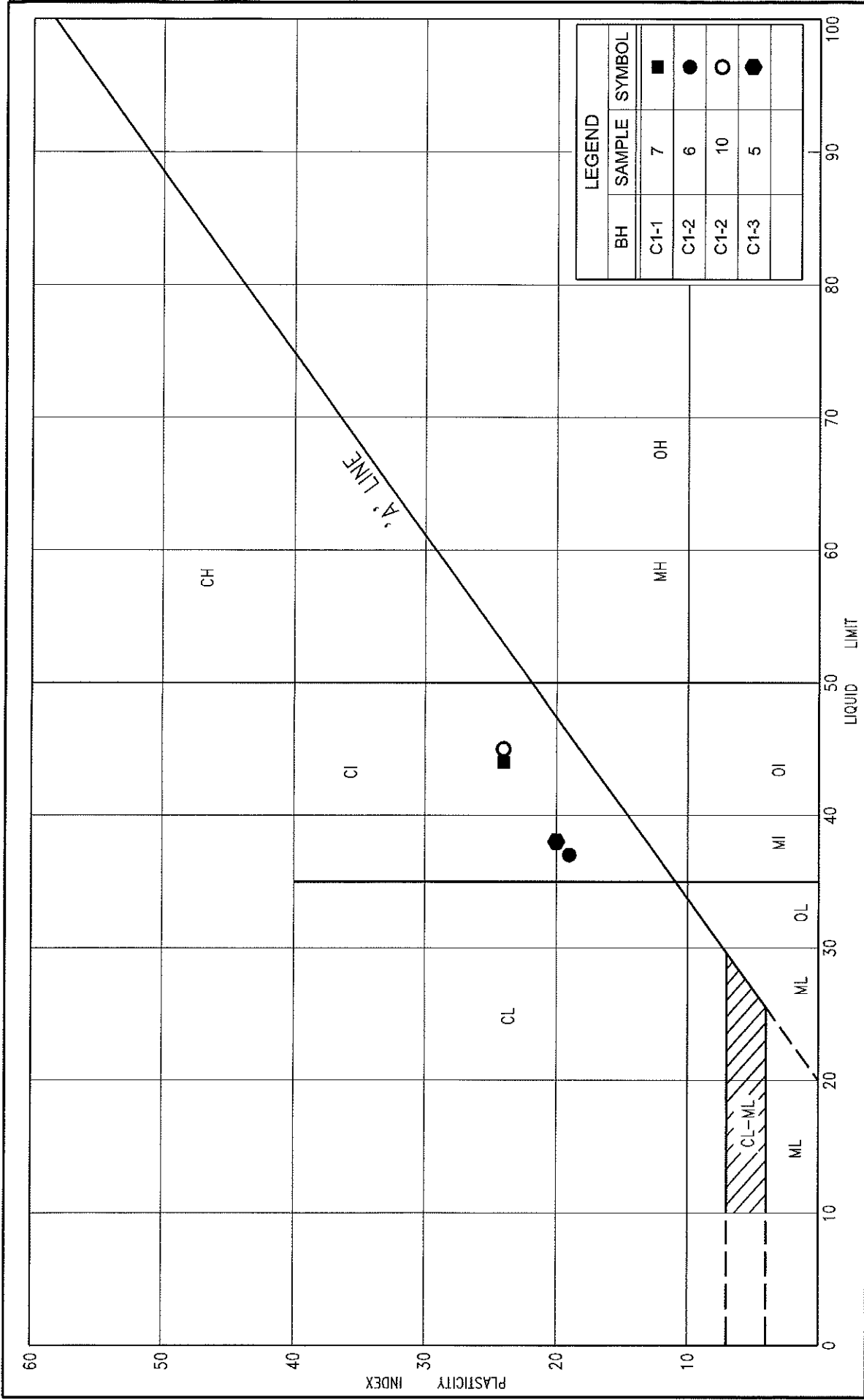
PHYSICAL PROPERTIES OF SOIL


ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	n	%	POROSITY	e_{max}	%	VOID RATIO IN LOOSEST STATE
γ_s	kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	w	%	WATER CONTENT	e_{min}	%	VOID RATIO IN DENSEST STATE
ρ_w	kg/m ³	DENSITY OF WATER	S_r	%	DEGREE OF SATURATION	I_D		DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
γ_w	kN/m ³	UNIT WEIGHT OF WATER	w_L	%	LIQUID LIMIT	D	mm	GRAIN DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_p	%	PLASTIC LIMIT	D_n	mm	n PERCENT - DIAMETER
γ	kN/m ³	UNIT WEIGHT OF SOIL	w_s	%	SHRINKAGE LIMIT	C_u		UNIFORMITY COEFFICIENT
ρ_d	kg/m ³	DENSITY OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	h	m	HYDRAULIC HEAD OR POTENTIAL
γ_d	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_L		LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	q	m ³ /s	RATE OF DISCHARGE
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_C		CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	v	m/s	DISCHARGE VELOCITY
γ_{sat}	kN/m ³	UNIT WEIGHT OF SATURATED SOIL	DTPL		DRIER THAN PLASTIC LIMIT	i		HYDRAULIC GRADIENT
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	APL		ABOUT PLASTIC LIMIT	k	m/s	HYDRAULIC CONDUCTIVITY
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL	WTPL		WETTER THAN PLASTIC LIMIT	j	kN/m ³	SEEPAGE FORCE
e	%	VOID RATIO						

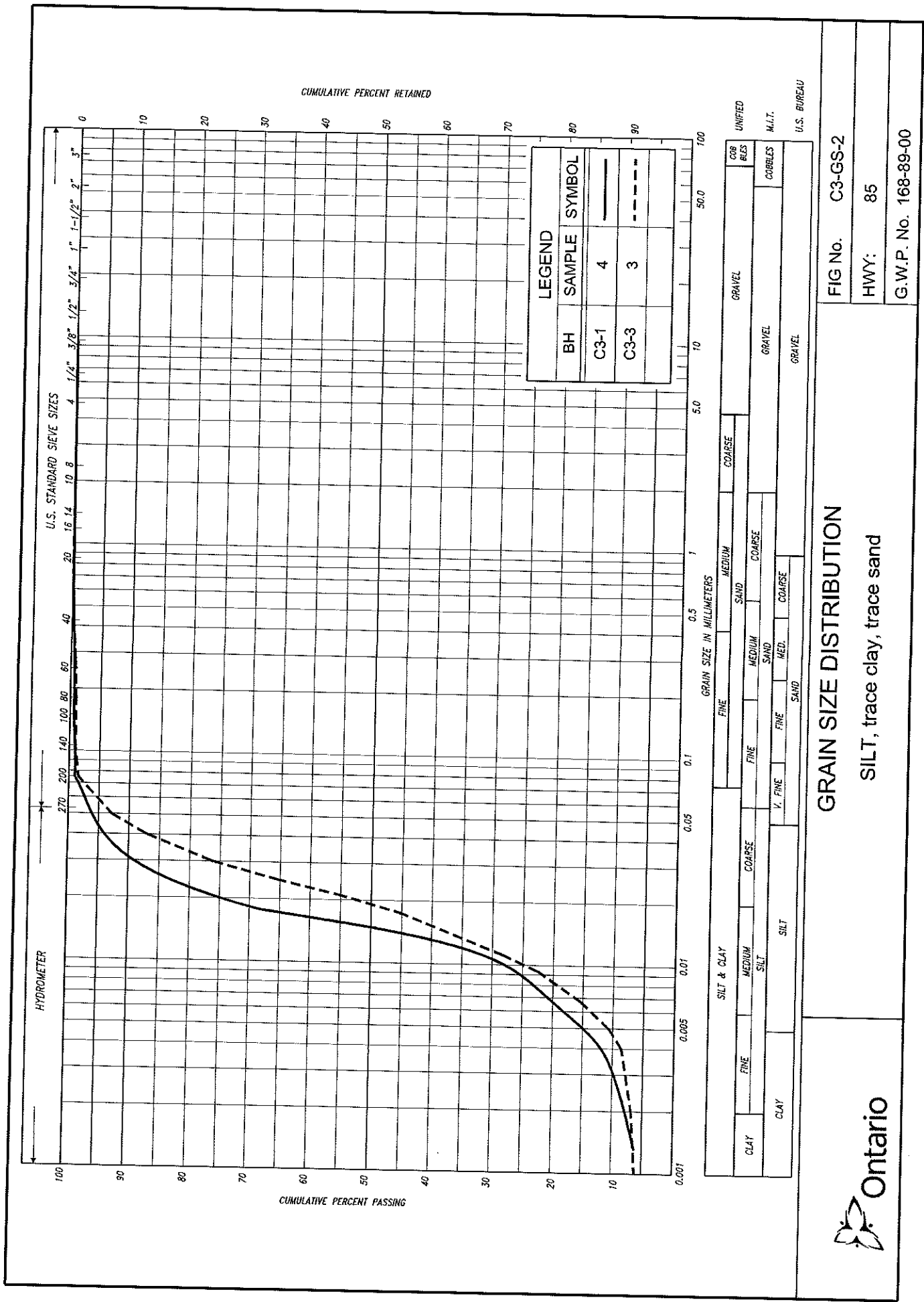
Culvert C1 – Sta. 26+020 (Highway 85 Chainage), Township of Waterloo
Figures C1-PC-1 and C1-PC-2 – Result of Atterberg Limits Testing
Figures C1-GS-1 and C1-GS-2 – Results of Grain Size Distribution Analyses
Record of Borehole Sheets
Drawing C1-1 – Borehole Locations and Soil Strata



	PLASTICITY CHART		FIG No. C1-PC-1
	CLAYEY SILT, trace to some sand		HWY: 85
			G.W.P. No. 168-89-00



	PLASTICITY CHART	
	FIG No.	C1-PC-2
	HWY:	85
SILTY CLAY, trace sand, trace gravel		
G.W.P. No. 168-89-00		



GRAIN SIZE DISTRIBUTION

SILT, trace clay, trace sand



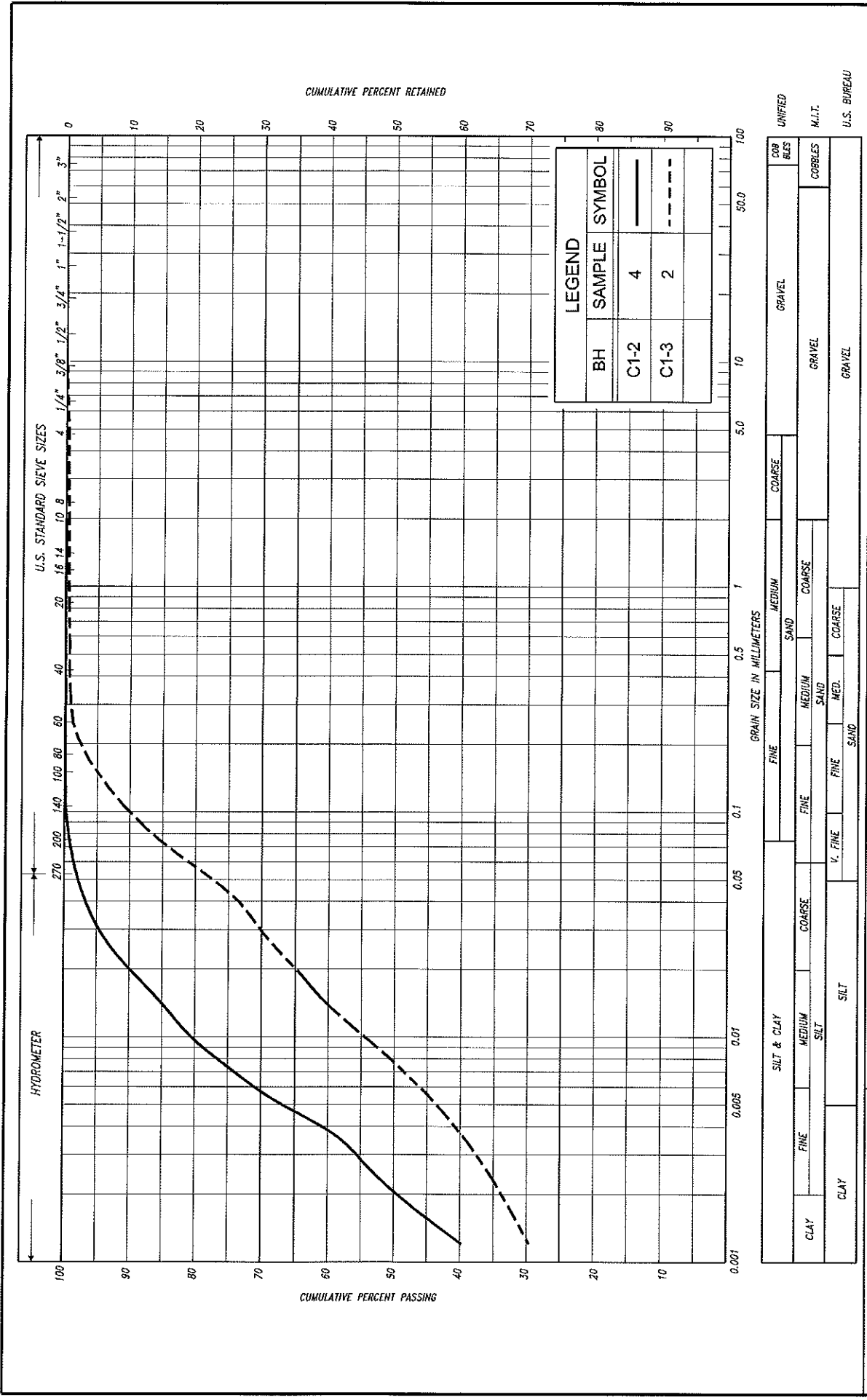


FIG No. C1-GS-1

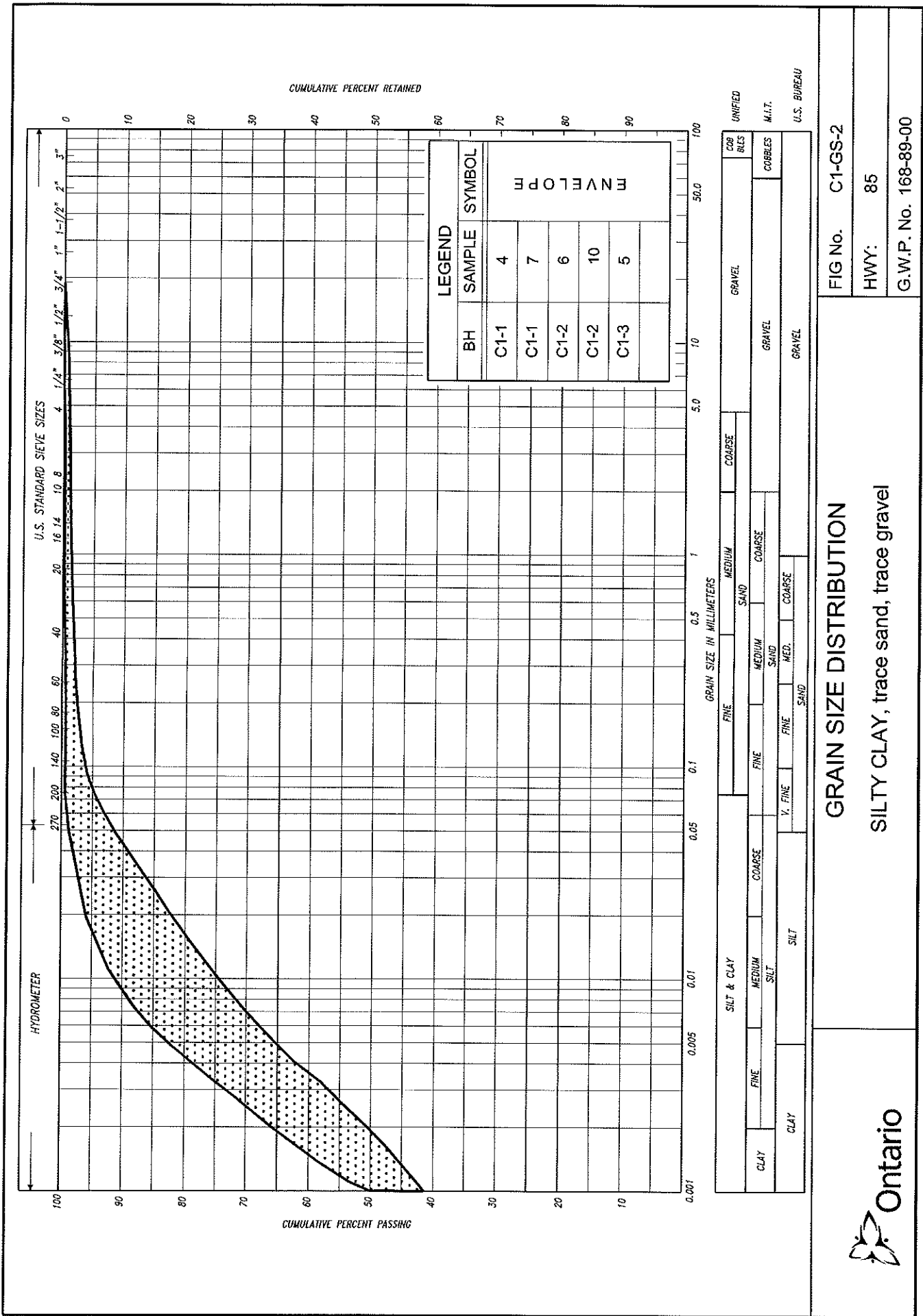
HWY: 85

G.W.P. No. 168-89-00

GRAIN SIZE DISTRIBUTION

CLAYEY SILT, trace to some sand

Ontario



RECORD OF BOREHOLE No C1-3

1 of 1

METRIC

G.W.P. 168-89-00 LOCATION Coords: 4 816 912.6 N; 223 720.0 E ORIGINATED BY F.P.
 DIST London HWY 85 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY N.S.B.
 DATUM Geodetic DATE May 11, 2011 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								20 40 60 80 100										20 40 60		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
314.8	Ground Surface																			
0.0	Topsoil		1	SS	11															
314.6	Clayey silt, some sand		2	SS	31															
0.2	Stiff to hard Brown/ grey Moist																			
313.4	Silty clay trace sand, trace gravel		3	SS	19															
1.4	Very stiff Grey Dry to moist		4	SS	34															
			5	SS	32															
			6	SS	40															
			7	SS	34															
			8	SS	52															
			9	SS	39															
308.2	End of borehole																			
6.6																				
									</											

* 2011 05 11

▽ Water level observed during drilling

■ Penetrometer test

RECORD OF BOREHOLE No C1-2

1 of 1

METRIC

G.W.P. 168-89-00

LOCATION Coords: 4 816 878.8N; 223 676.6 E

ORIGINATED BY F.P.

DIST London

HWY 85

BOREHOLE TYPE Continuous Flight Solid Stem Augers

COMPILED BY N. S. B.

DATUM Geodetic

DATE May 11, 2011

CHECKED BY C.N.

[illegible]

RECORD OF BOREHOLE No C1-3

1 of 1

METRIC

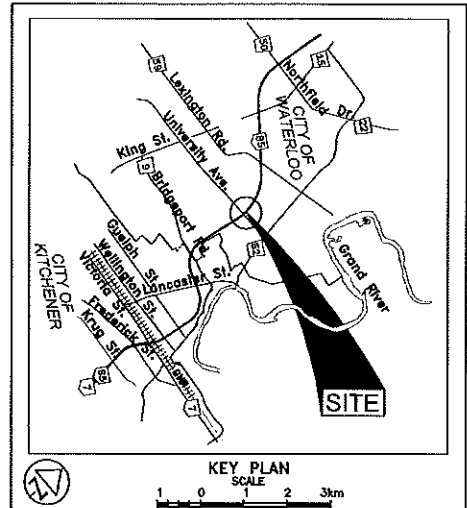
G.W.P. 168-89-00 LOCATION Coords: 4 816 912.6 N; 223 720.0 E ORIGINATED BY F.P.
DIST London HWY 85 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY N.S.B.
DATUM Geodetic DATE May 11, 2011 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)	
								○ UNCONFINED + FIELD VANE									—	
								● QUICK TRIAXIAL × LAB VANE										
314.8	Ground Surface						20	40	60	80	100	20	40	60				
0.0	Topsoil																	
314.6	Clayey silt, some sand		1	SS	11													
0.2	Stiff to hard Brown/ Moist grey		2	SS	31													
313.4	Silty clay trace sand, trace gravel		3	SS	19													
1.4	Very stiff Grey Dry to moist		4	SS	34													
			5	SS	32													
			6	SS	40													
			7	SS	34													
			8	SS	52													
			9	SS	39													
308.2	End of borehole																	
6.6																		
						</												

* 2011 05 11

▽ Water level observed during drilling

■ Penetrometer test



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)
- WL at time of investigation May 2011
- Head
- ARTESIAN WATER Encountered
- PIEZOMETER

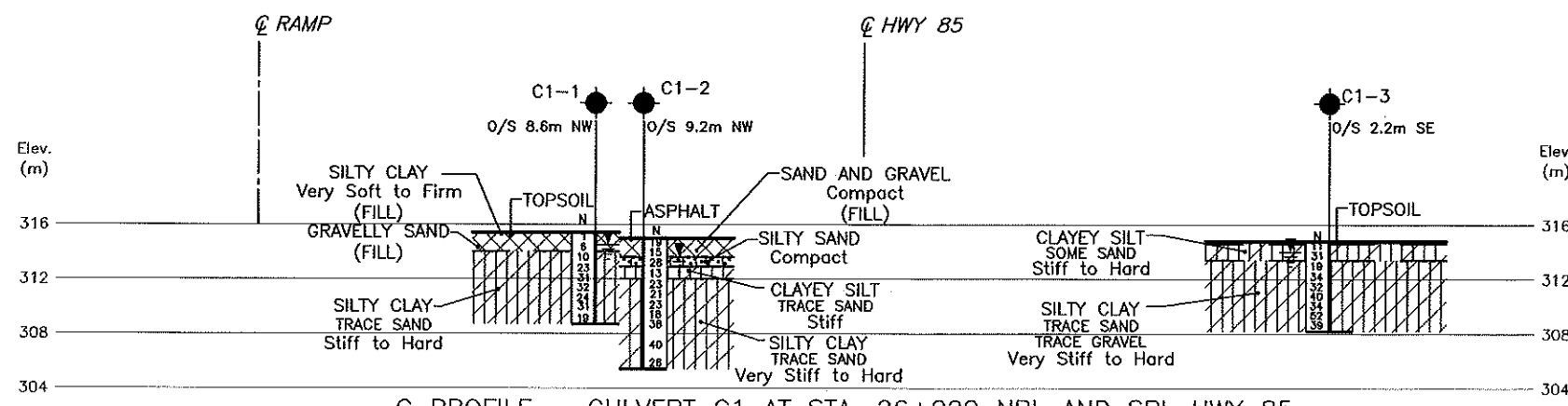
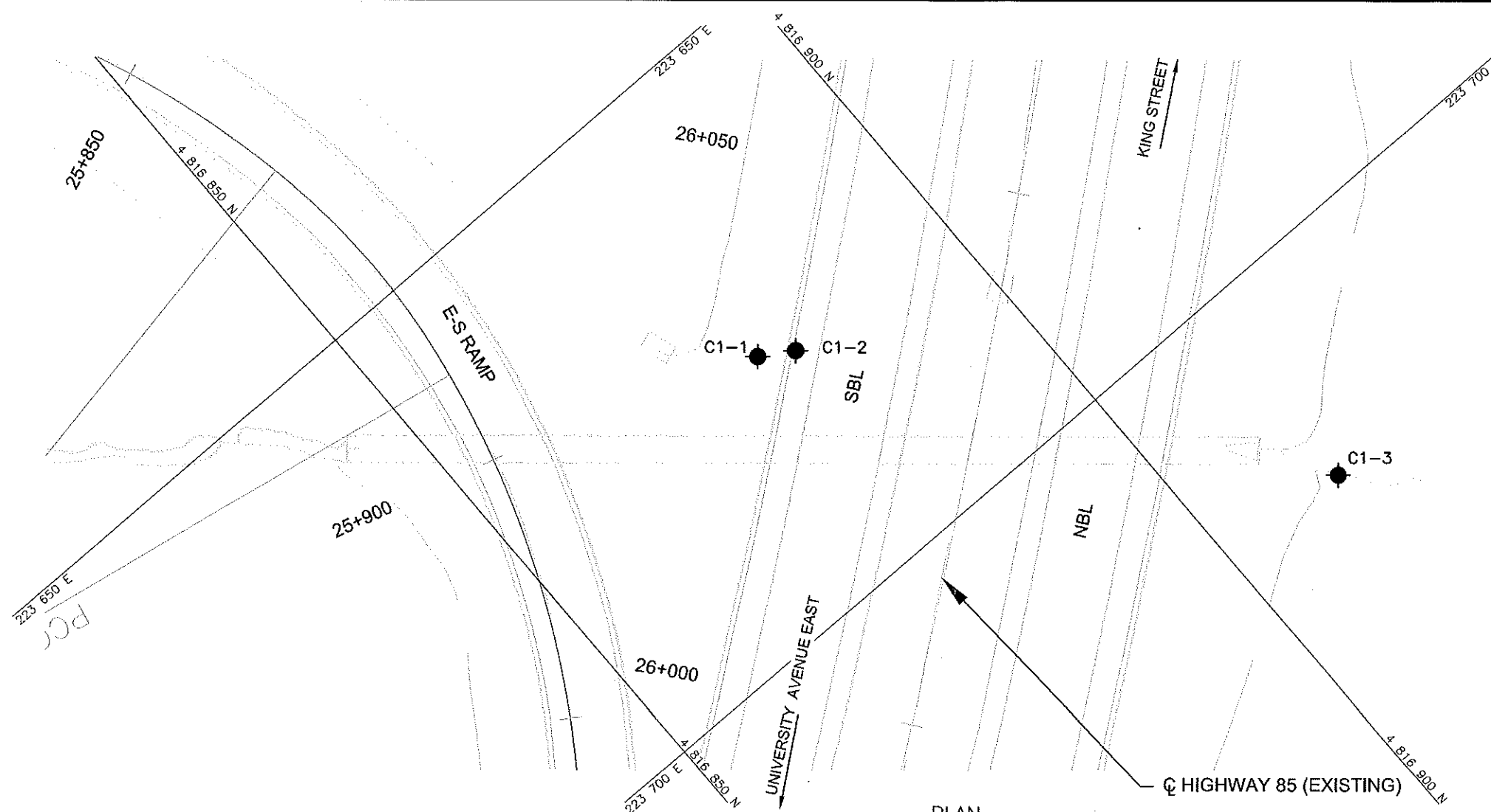
BH No	ELEVATION	NORTHINGS	EASTINGS
C1-1	315.4	4 816 881.8	223 678.5
C1-2	315.0	4 816 878.8	223 676.6
C1-3	314.8	4 816 912.6	223 720.0

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

DATE	BY	DESCRIPTION

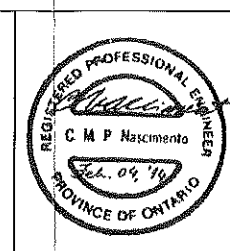
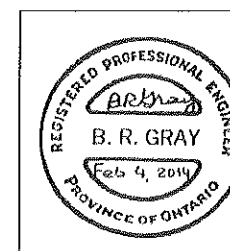
Geocres No. 40P7-67

HWY No	85	DIST	London
SUBM'D	NA	CHECKED	NSB
DRAWN	NA	CHECKED	CN
		APPROVED	BRG
			DWG C1-1



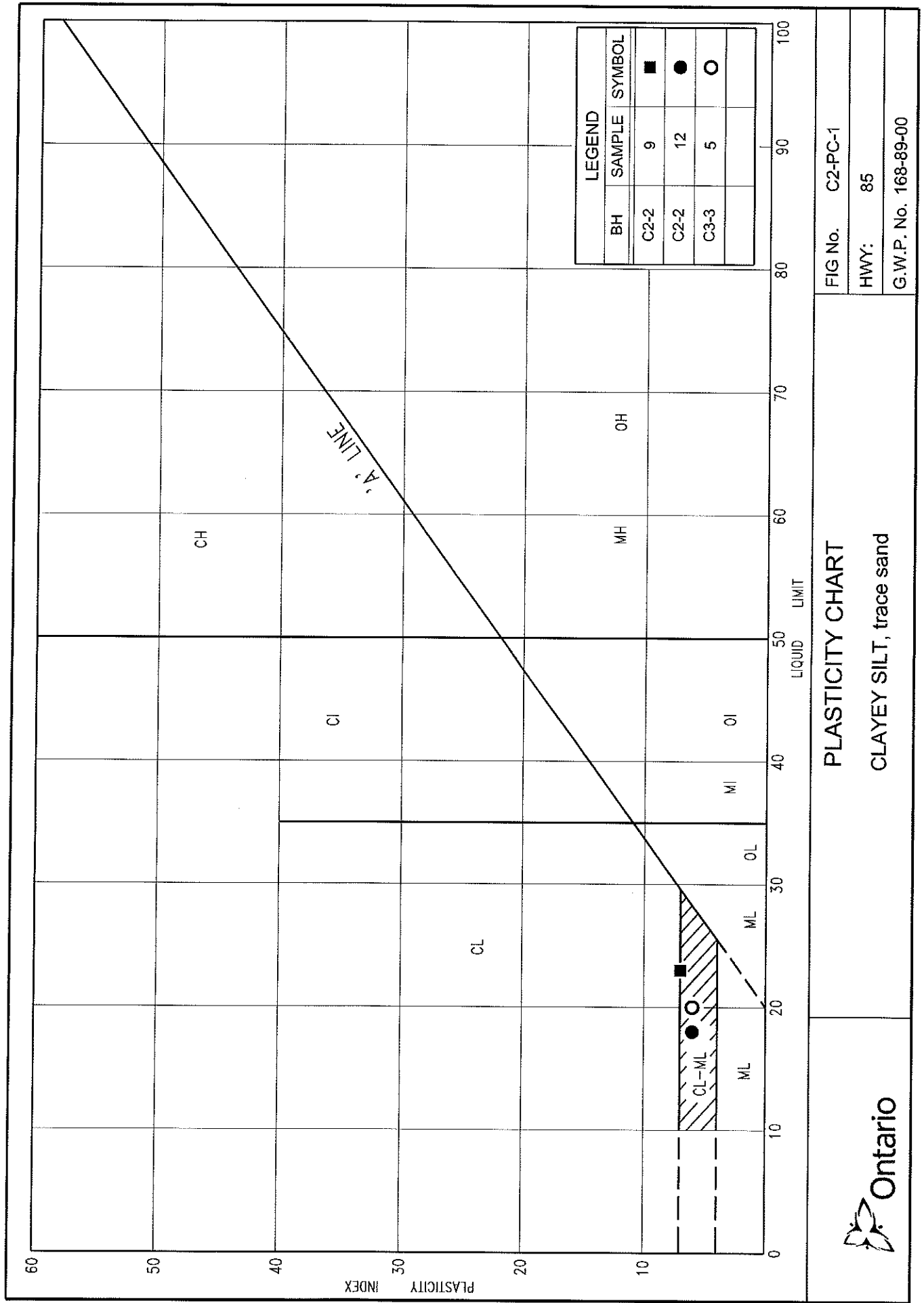
NOTES:

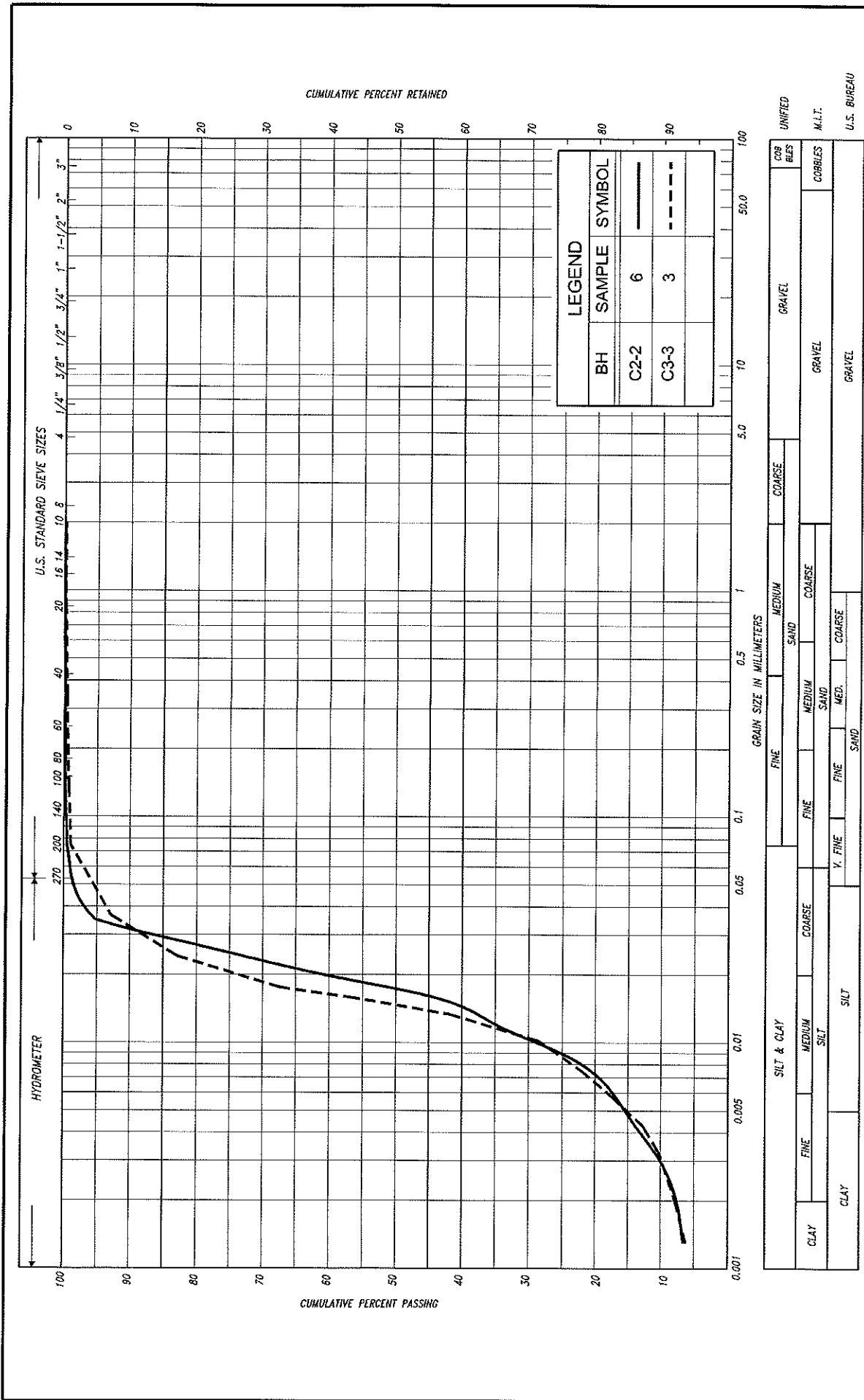
- DRAWING C1-1 SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND THE RECORD OF LOG OF BOREHOLES.
- THE CULVERT AT STA. 25+803 WAS DESIGNATED AS CULVERT C1 FOR THE INVESTIGATION PURPOSE.
- THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
- DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.



Ref. MRC Drawing: 2010362_Alignment.dwg;

Culvert C2 – Sta. 28+087 (S-E Ramp Chainage), Township of Waterloo
Figure C2-PC-1 – Result of Atterberg Limits Testing
Figures C2-GS-1 and C2-GS-2 – Results of Grain Size Distribution Analyses
Record of Borehole Sheets
Drawing C2-1 – Borehole Locations and Soil Strata





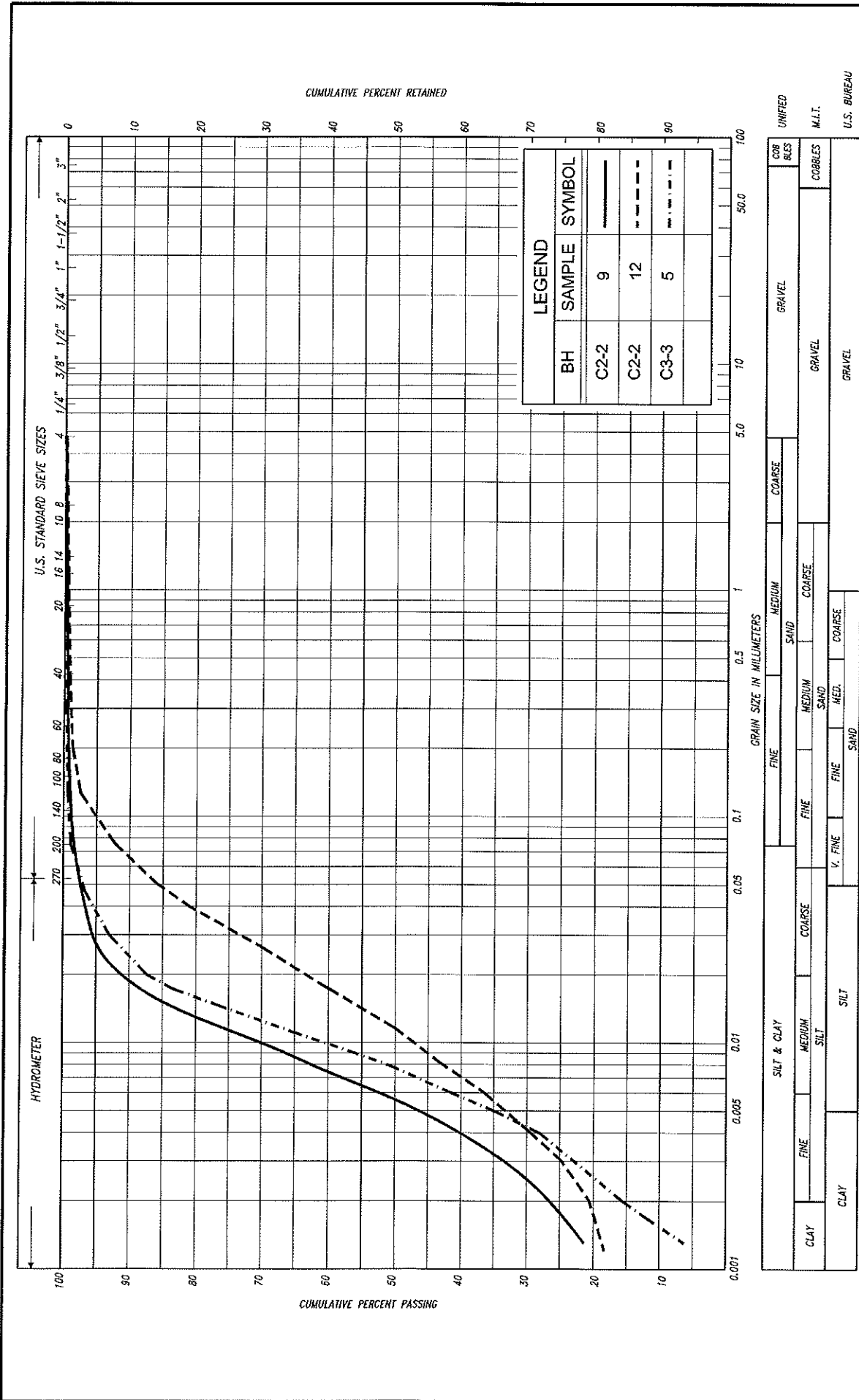
GRAIN SIZE DISTRIBUTION

SILT, trace clay, trace sand

FIG No. C2-GS-1

HWY: 85

G.W.P. No. 168-89-00



GRAIN SIZE DISTRIBUTION

FIG No. C2-GS-2

CLAYEY SILT, trace sand

HWY: 85

G.W.P. No. 168-89-00



RECORD OF BOREHOLE No C2-2

1 of 1

METRIC

G.W.P. 168-89-00

LOCATION Coords: 4 817 612.1 N; 221 805.9 E

ORIGINATED BY E. P.

DIST London

HWY 85

BOREHOLE TYPE Continuous Flight Solid Stem Augers

COMPILED BY N.S.I.

DATUM Geodetic

DATE May 12, 2011

CHECKED BY _____ C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		SHEAR STRENGTH kPa										WATER CONTENT (%)		
							20 40 60 80 100										20 40 60		
							○ UNCONFINED + FIELD VANE												
							● QUICK TRIAXIAL × LAB VANE												
ELEVATION SCALE							20 40 60 80 100			20 40 60									
341.1	Ground Surface					341													
0.0	Sand and gravel		1	SS	13														
	Compact Brown Moist																		
	sand, trace gravel		2	SS	14														
	clayey silt pockets																		
	organic layers		3	SS	14														
	organic silt inclusions		4	SS	8														
	Dark brown (FILL)		5	SS	12														
337.4																			
3.7	Silt		6	SS	17														
	trace clay, trace sand																		
	Compact Brown Wet		7	SS	22														
			8	SS	17														
335.3																			
5.8	Clayey silt, trace sand																		
	Very stiff Grey Moist		9	SS	21														
	to stiff																		
			10	SS	20														
			11	SS	17														
			12	SS	11														
331.3																			
9.8	End of borehole																		

RECORD OF BOREHOLE No C3-3

1 of 1

METRIC

G.W.P. 168-89-00 **LOCATION** Coords: 4 817 559.2 N; 221 750.3 E **ORIGINATED BY** F.P.
DIST London **HWY** 85 **BOREHOLE TYPE** Continuous Flight Solid Stem Augers **COMPILED BY** N.S.B.
DATUM Geodetic **DATE** May 16, 2011 **CHECKED BY** C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
337.7	Ground Surface						20	40	60	80	100	20	40	60	kN/m ³	GR SA SI CL				
0.0 337.4	Topsoil		1	SS	9							○								
0.3 336.9	Clayey silt trace sand, trace gravel					▽*														
0.8	Stiff Brown Moist		2	SS	14	▽						○								
	Silt trace clay, trace sand																			
	Compact Brown Wet		3	SS	15							○				0 2 91 7				
335.3																				
2.4	Clayey silt, trace sand		4	SS	6							○								
	Firm to Grey Wet																			
	stiff sand layers		5	SS	11							○				0 7 76 17				
			6	SS	15							○								
333.3																				
4.4	End of borehole																			

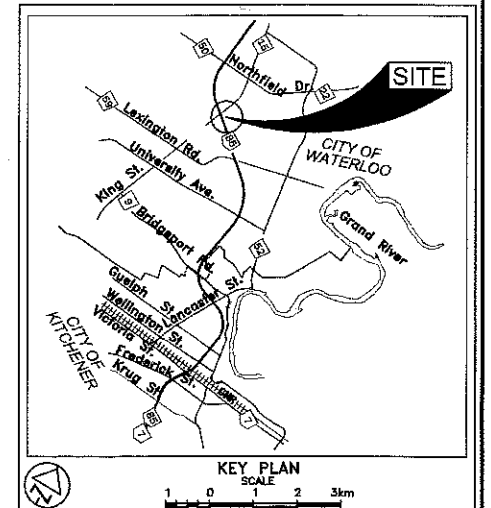
* 2011 05 16

▽ Water level observed
during drilling

▼ Water level measured
after drilling

■ Penetrometer test

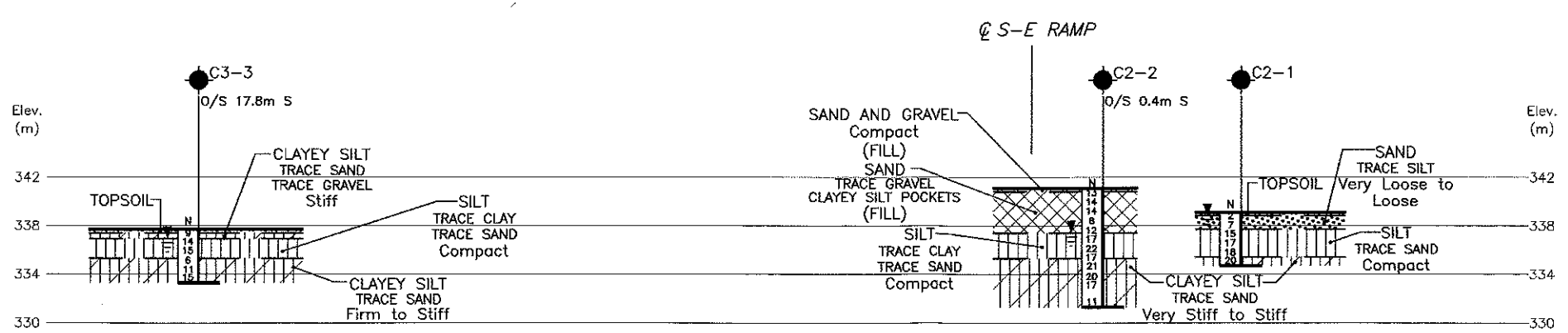
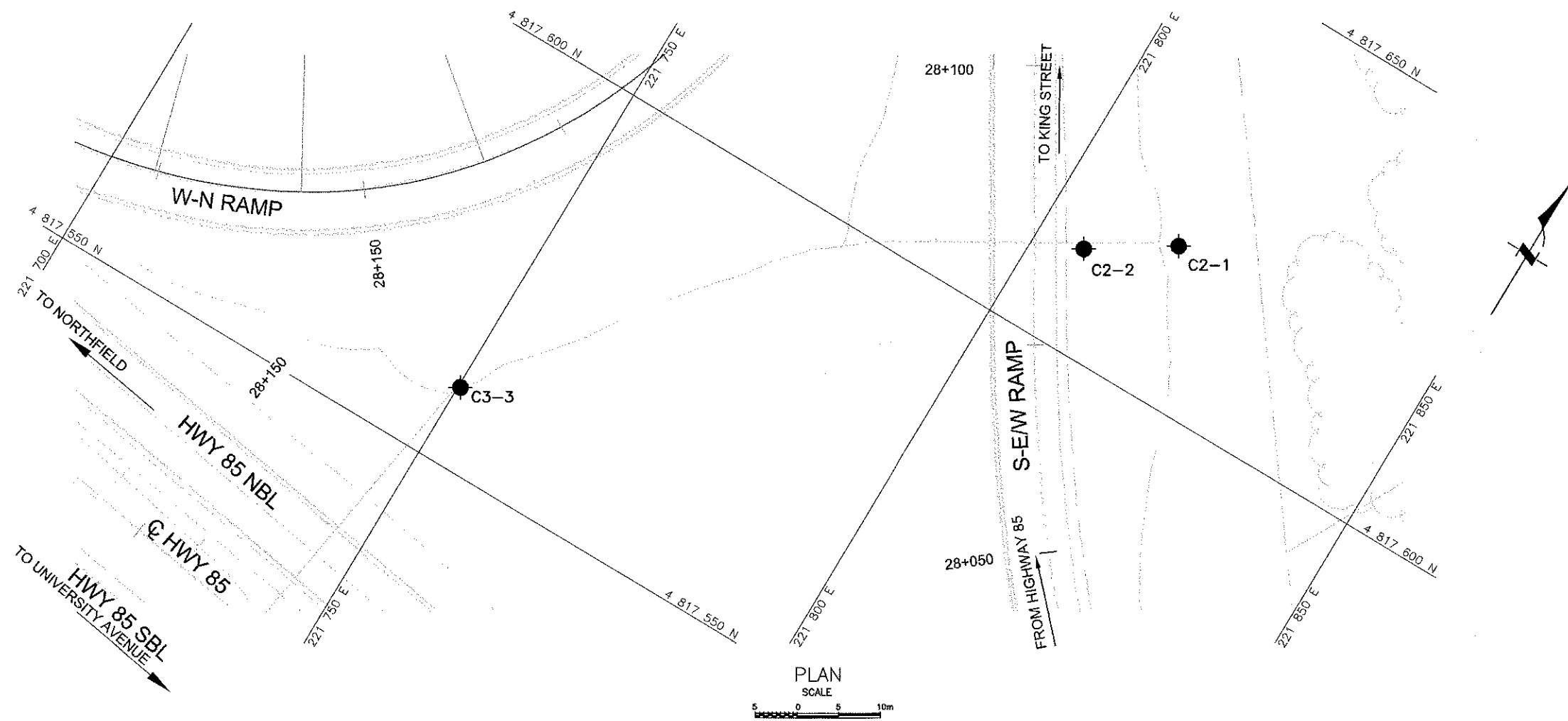
Note: Borehole cave-in at
3.1m



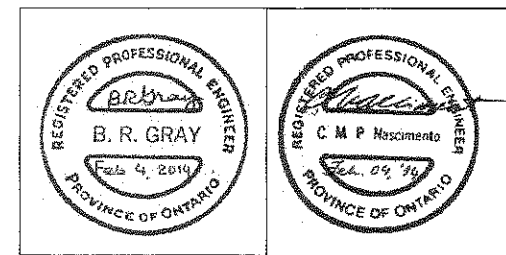
LEGEND

- 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)
- WL at time of investigation May 2011
- Head
- ARTESIAN WATER Encountered
- PIEZOMETER

BH No	ELEVATION	NORTHINGS	EASTINGS
C2-1	339.1	4 817 618.2	221 815.5
C2-2	341.1	4 817 612.1	221 805.9
C3-3	337.7	4 817 559.2	221 750.3



- NOTES:
- DRAWING C2-1 SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND THE RECORD OF LOG OF BOREHOLES.
 - THE CULVERT AT STA. 28+090 WAS DESIGNATED AS CULVERT C2 FOR THE INVESTIGATION PURPOSE.
 - THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
 - DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.
 - CULVERT STATION IS DEPICTED IN CONTRACT DRAWING 2012-3011.



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

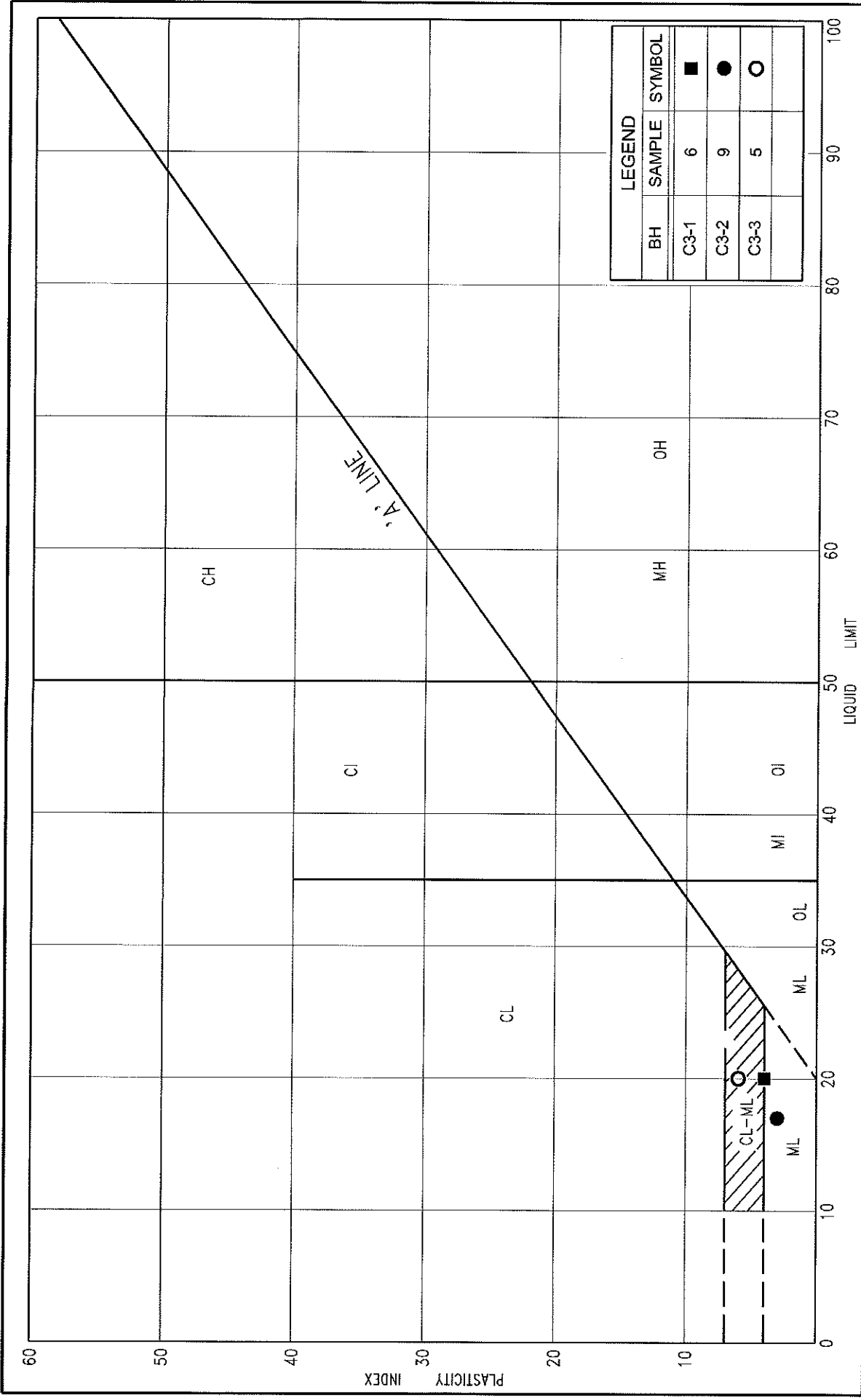
DATE	BY	DESCRIPTION

Geocres No. 40P7-67

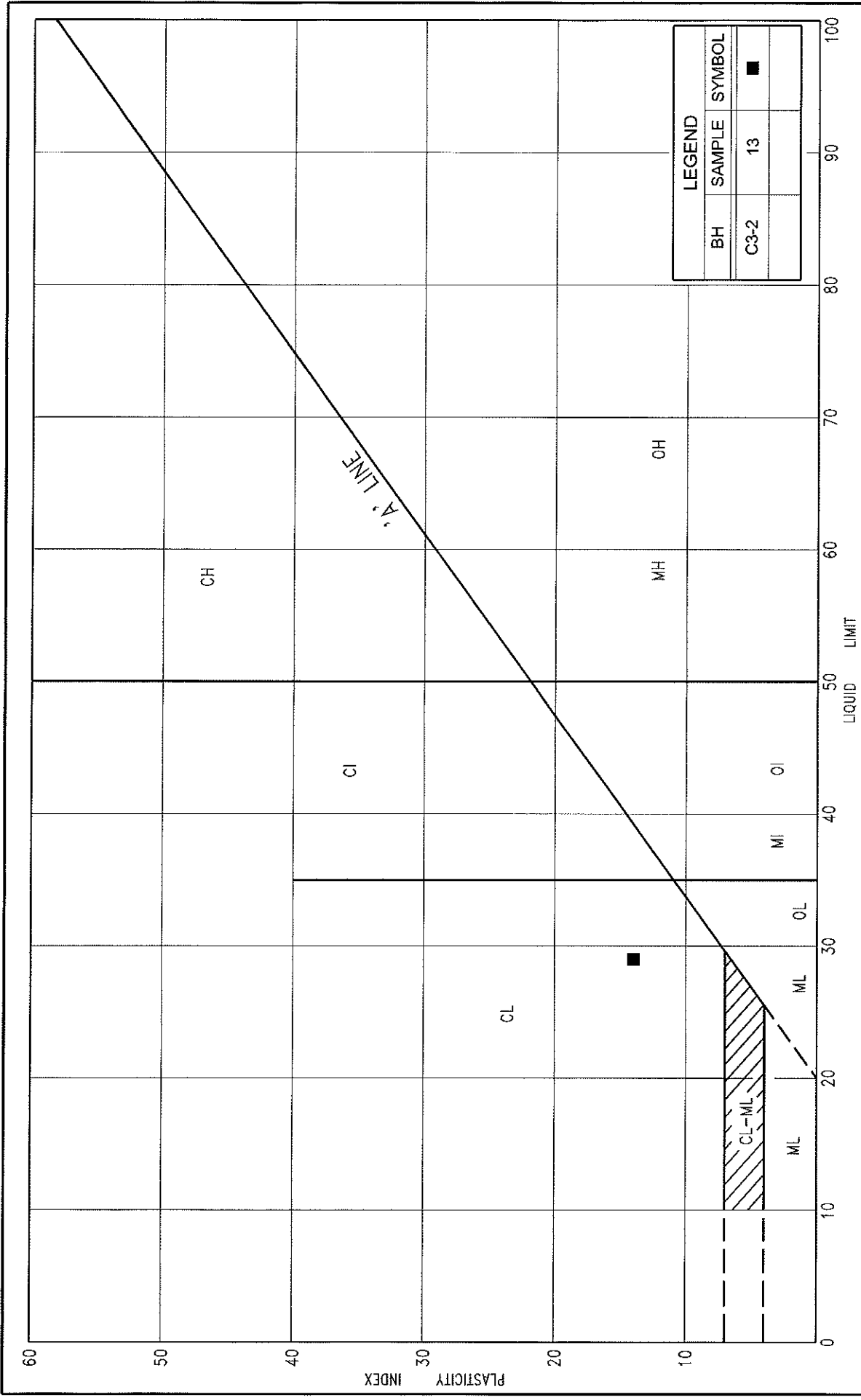
HWY No	85	DIST	London
SUBMIT	NA	CHECKED	NSB
DRAWN	NA	CHECKED	CN

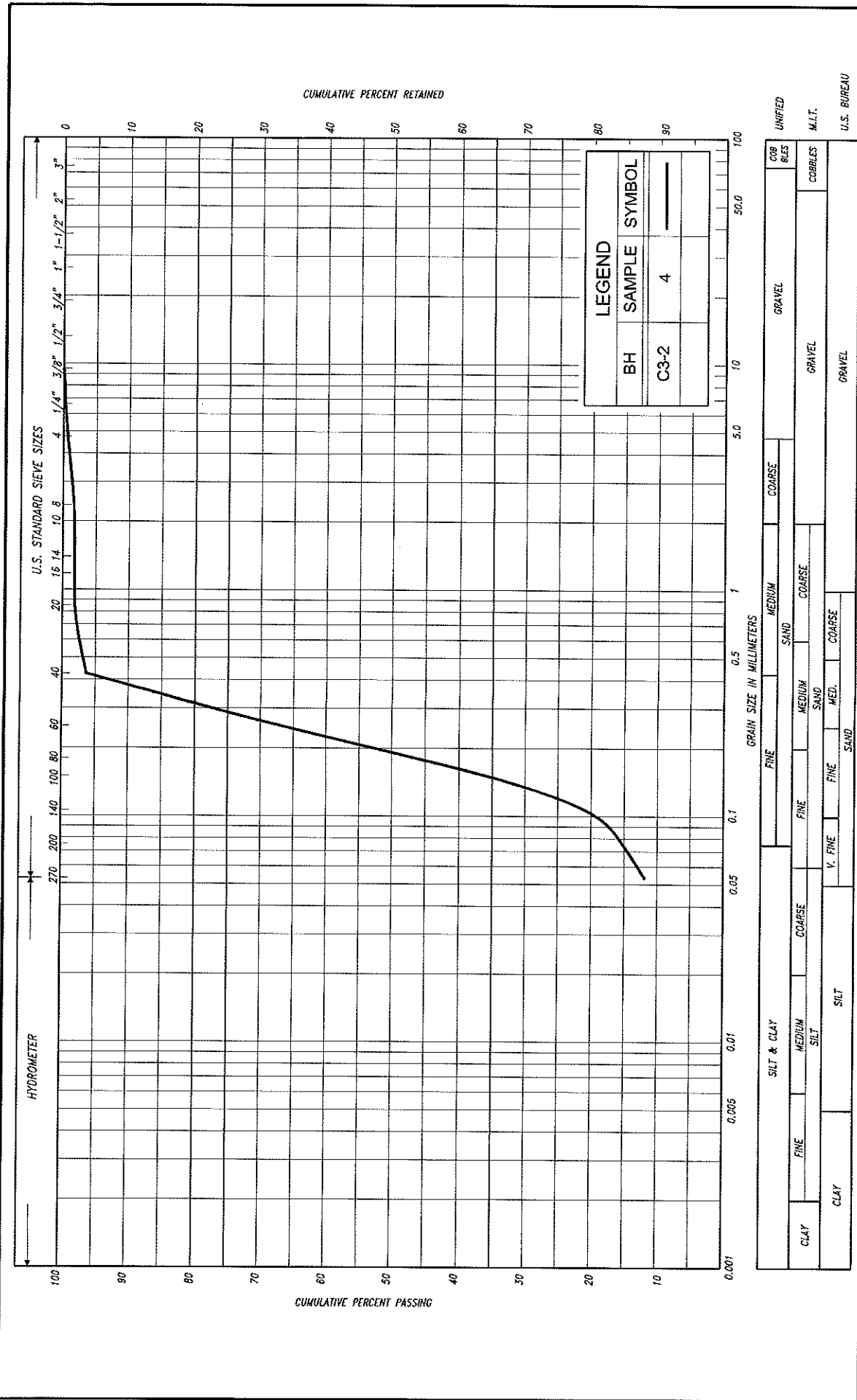
DATE FEB. 04, 2014
APPROVED BRG
DWG C2-1

Culvert C3 – Sta. 28+132 (Highway 85 Chainage), Township of Waterloo
Figures C3-PC-1 and C3-PC2 – Result of Atterberg Limits Testing
Figures C3-GS-1 to C3-GS-5 – Results of Grain Size Distribution Analyses
Record of Borehole Sheets
Drawing C3-1 – Borehole Locations and Soil Strata

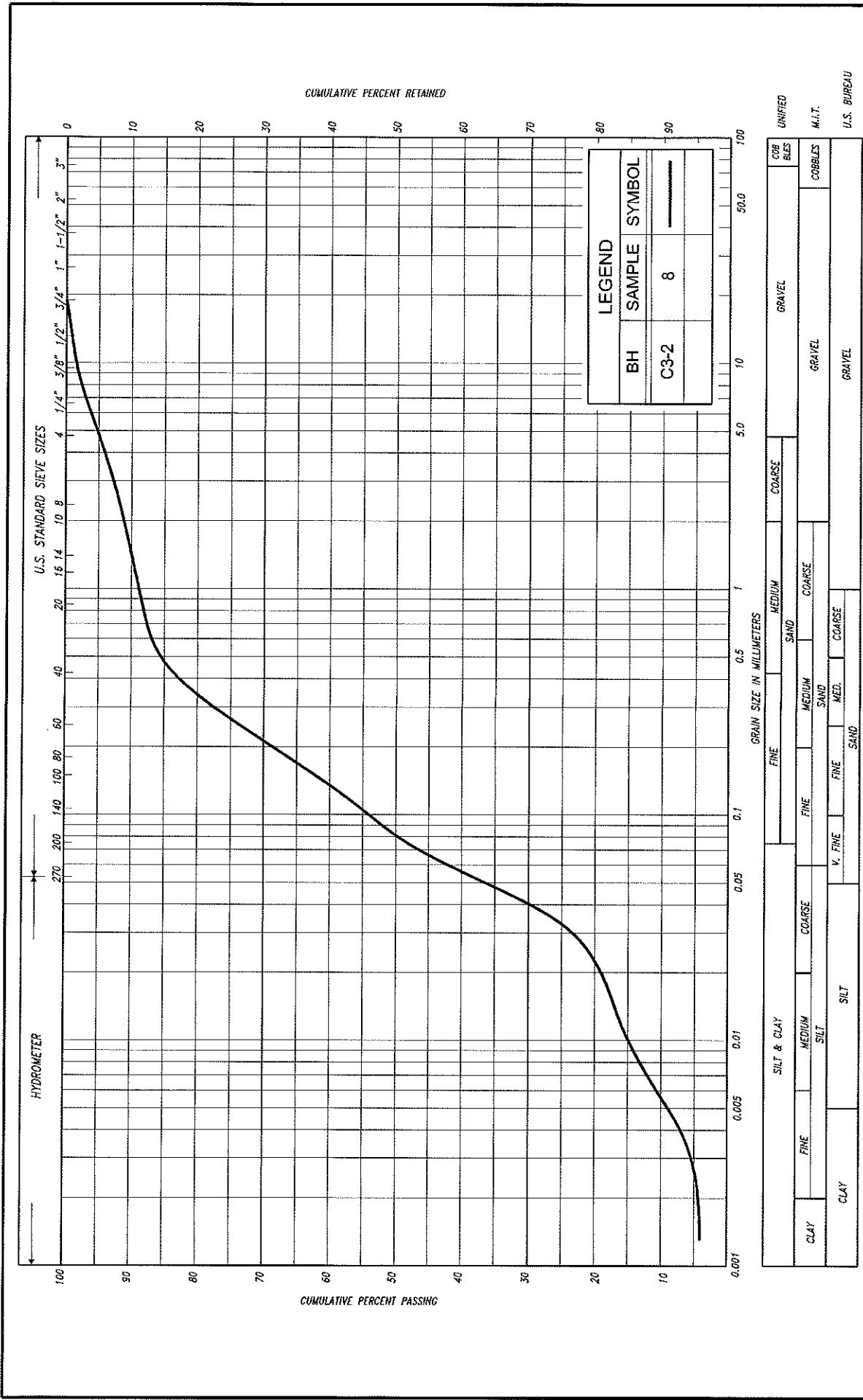


	PLASTICITY CHART CLAYEY SILT, trace to some sand, trace gravel	FIG No. C3-PC-1
		HWY: 85
		G.W.P. No. 168-89-00

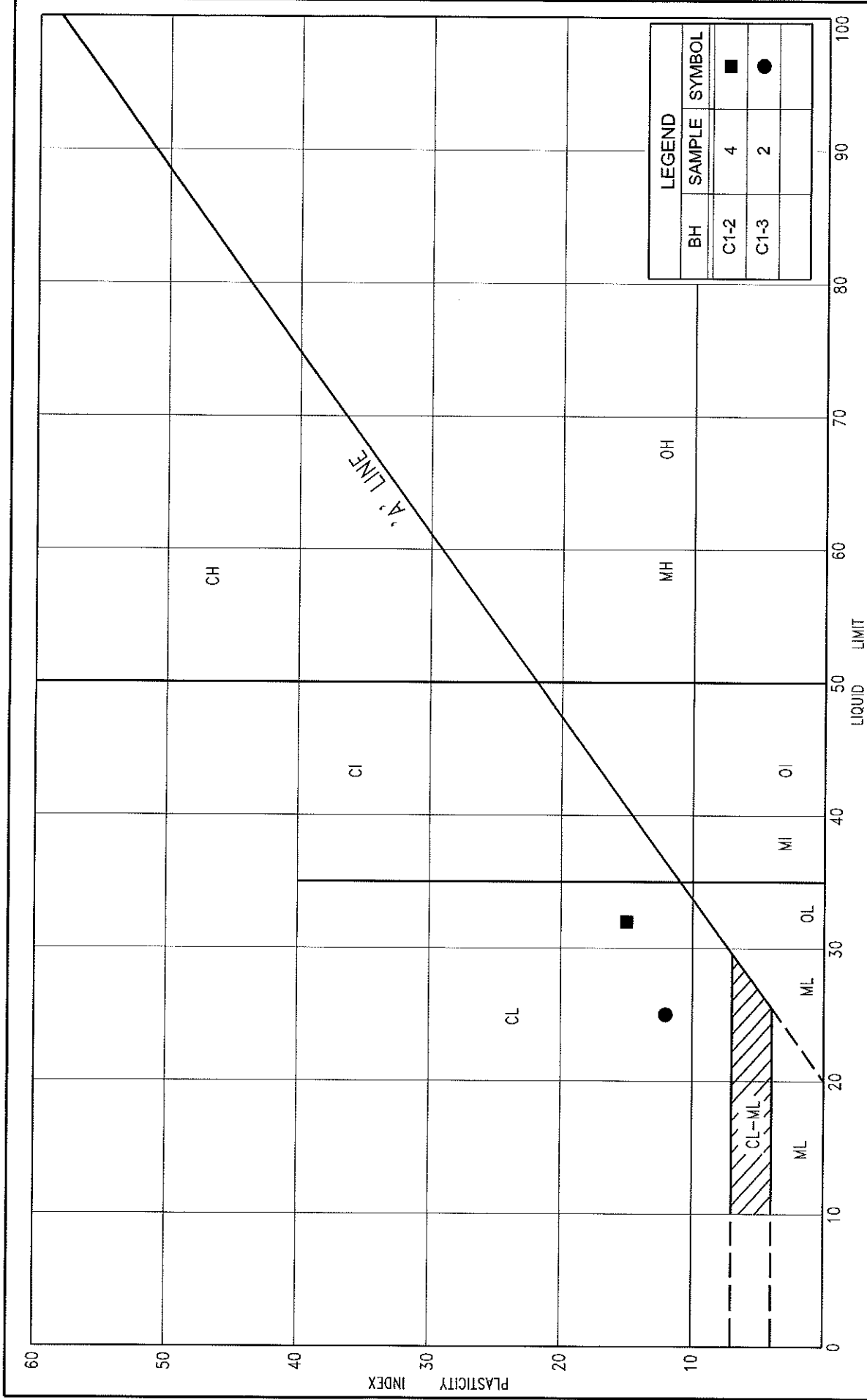




	GRAIN SIZE DISTRIBUTION SAND, some silt, trace gravel (FILL)		FIG No. C3-GS-1
	HWY: 85		U.S. BUREAU
	G.W.P. No. 168-89-00		COBLES M.I.T.



GRAIN SIZE DISTRIBUTION		FIG No. C3-GS-3
SAND and SILT, trace clay, trace gravel		HWY: 85
 Ontario		G.W.P. No. 168-89-00



LEGEND		
BH	SAMPLE	SYMBOL
C1-2	4	■
C1-3	2	●

PLASTICITY CHART

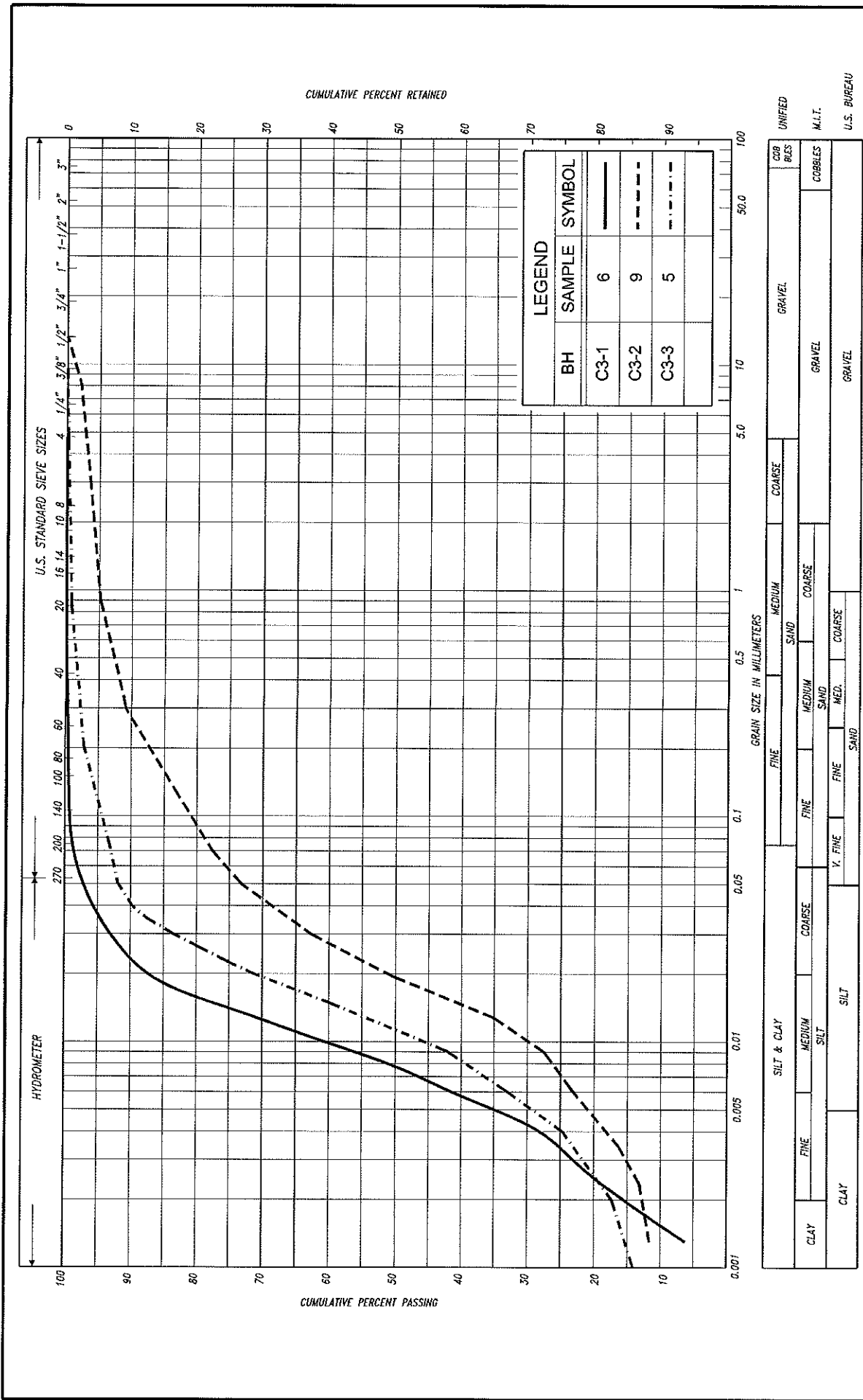
CLAYEY SILT, trace to some sand

FIG No. C1-PC-1

HWY: 85

G.W.P. No. 168-89-00





		GRAIN SIZE DISTRIBUTION CLAYEY SILT, trace to some sand, trace gravel		FIG No. C3-GS-4
				HWY: 85
				G.W.P. No. 168-89-00

RECORD OF BOREHOLE No C3-1

1 of 1

METRIC

G.W.P. 168-89-00 LOCATION Coords: 4 817 485.4 N; 221 740.4 E ORIGINATED BY F.P.
 DIST London HWY 85 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY N.S.B.
 DATUM Geodetic DATE May 12, 2011 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA S _i CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20 40 60 80 100					20 40 60				
337.3	Ground Surface															
0.0	Topsoil		1	SS	6											
	Silty clay, trace sand															
	Firm Brown Moist		2	SS	5											
	(FILL)															
335.9	Silt															
1.4	trace clay, trace sand		3	SS	15											
	Compact Brown Wet															
			4	SS	18											
334.3	Clayey silt, trace sand															
3.0	Very stiff Grey Moist		5	SS	17											
			6	SS	23											
332.9	End of borehole															
4.4																

* 2011 05 12

▽ Water level observed during drilling

▼ Water level measured after drilling

■ Penetrometer test

Note: Borehole cave-in at 4.0m

RECORD OF BOREHOLE No C3-2

1 of 1

METRIC

G.W.P. 168-89-00 LOCATION Coords: 4 817 542.2 N; 221 752.0 E ORIGINATED BY F.P.
DIST London HWY 85 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY N.S.B.
DATUM Geodetic DATE May 12, 2011 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kn/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)				
								○ UNCONFINED		+ FIELD VANE		○ QUICK TRIAXIAL						× LAB VANE				
								20	40	60	80	100						20	40	60		
342.4	Ground Surface																					
0.0	Sand and gravel		1	SS	14		342															
	Compact to dense sand, trace gravel		2	SS	18																	
	with clay, trace silt silty clay pockets		3	SS	34		341															
			4	SS	34		340									1 84 (15)						
	silty sand, organics		5	SS	26		339															
	Compact Dark brown sandy silt organic inclusions		6	SS	7		338															
	Loose																					
337.7	(FILL)		7	SS	40																	
4.7	Sand and silt trace clay, trace gravel		8	SS	24		337									5 47 44 4						
	Dense to Grey Wet compact silty sand layers		9	SS	16		336									3 19 65 13						
336.4			10	SS	7		335															
6.0	Clayey silt some sand, trace gravel		11	SS	8																	
	Very stiff Brown Moist to firm																					
	silt layers																					
	Wet																					
334.0	silty clay layers		12	SS	8		334															
8.4	Clayey silt trace sand, trace gravel		13	SS	12		333									2 9 48 41						
	Firm to Grey Moist stiff (TILL)																					
			14	SS	13																	
331.1																						
11.3	End of borehole																					
												</										

* 2011 05 12

▽ Water level observed during drilling

▼ Water level measured after drilling

■ Penetrometer test

RECORD OF BOREHOLE No C3-3

1 of 1

METRIC

G.W.P. 168-89-00 LOCATION Coords: 4 817 559.2 N; 221 750.3 E ORIGINATED BY F.P.
 DIST London HWY 85 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY N.S.B.
 DATUM Geodetic DATE May 16, 2011 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
337.7	Ground Surface							20	40	60	80	100						
0.0	Topsoil		1	SS	9													
337.4	Clayey silt																	
0.3	trace sand, trace gravel																	
336.9	Stiff Brown Moist		2	SS	14													
0.8	Silt																	
	trace clay, trace sand																	
	Compact Brown Wet		3	SS	15													
335.3	Clayey silt, trace sand		4	SS	6													
2.4	Firm to Grey Wet																	
	stiff																	
	sand layers		5	SS	11													
			6	SS	15													
333.3	End of borehole																	
4.4																		
		</																

* 2011 05 16

▽* Water level observed during drilling

▽ Water level measured after drilling

■ Penetrometer test

Note: Borehole cave-in at 3.1m

RECORD OF BOREHOLE No C3-3

1 of 1

METRIC

G.W.P. 168-89-00

LOCATION Coords: 4 817 559.2 N; 221 750.3 E

ORIGINATED BY F.P.

DIST London HWY 85 BOREHOLE TYPE Continuous Flight Solid Stem Augers

COMPILED BY N.S.B

DATUM Geodetic DATE May 16, 2011

CHECKED BY C.N.

[illegible]

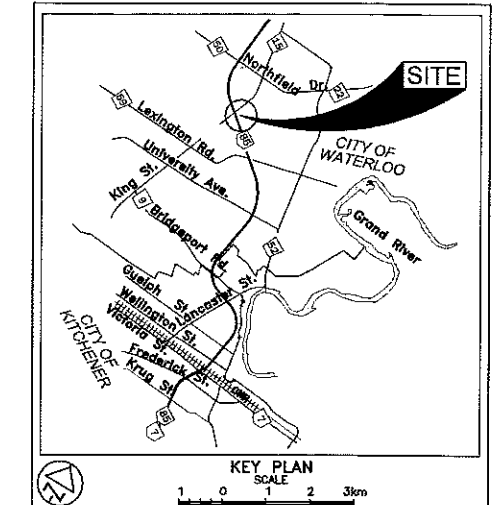
CONT No
GWP No 168-89-00



CULVERT AT STA. 28+132
(SBL AND NBL) (C3)
HIGHWAY 85 WATERLOO TWP
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

PMI Peto MacCallum Ltd.
CONSULTING ENGINEERS



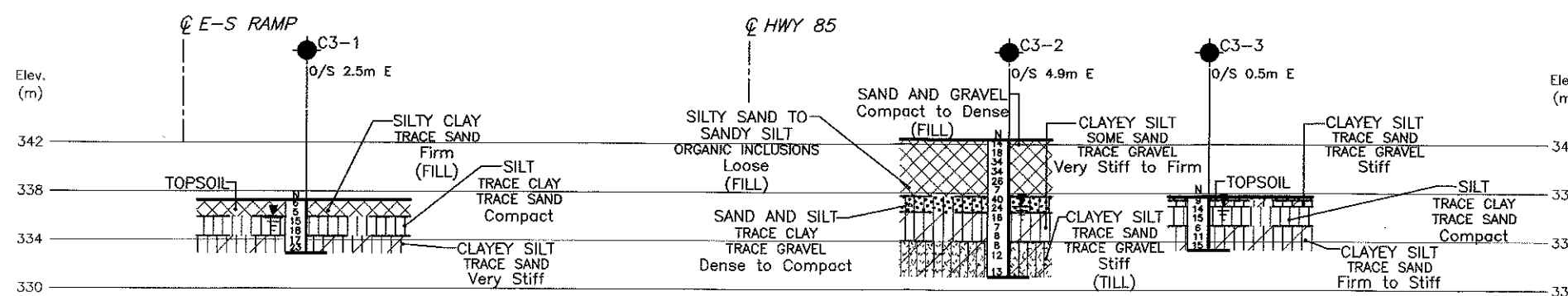
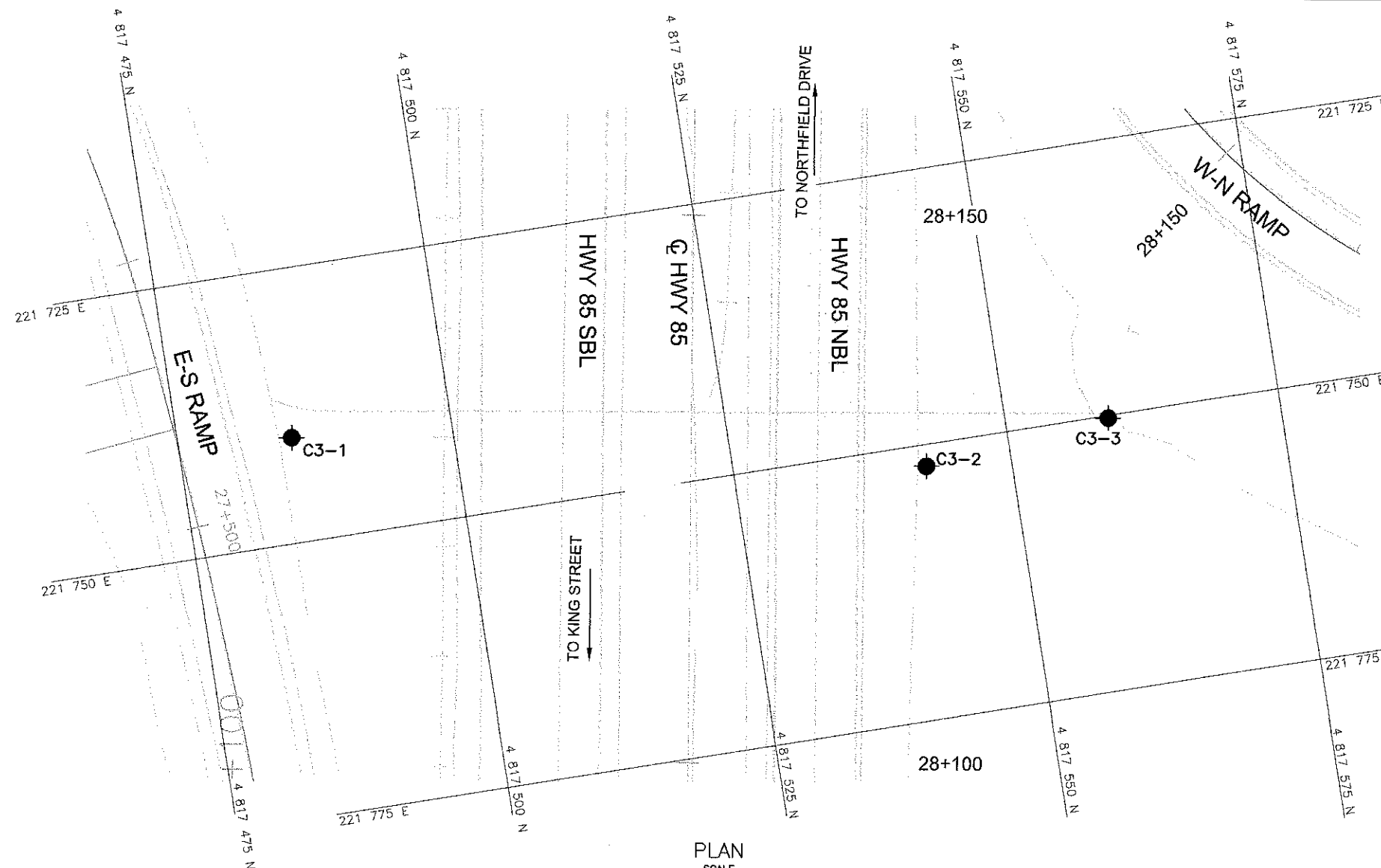
LEGEND			
	Borehole		
	Dynamic Cone Penetration Test (Cone)		
	Borehole & Cone		
N	Blows/0.3m (Std. Pen Test, 475 J/blow)		
CONE	Blows/0.3m (60° Cone, 475 J/blow)		
	WL at time of investigation May 2011		
	Head		
	ARTESIAN WATER		
	Encountered		
	PIEZOMETER		

BH No	ELEVATION	NORTHINGS	EASTINGS
C3-1	337.3	4 817 485.4	221 740.4
C3-2	342.4	4 817 542.2	221 752.0
C3-3	337.7	4 817 559.2	221 750.3

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

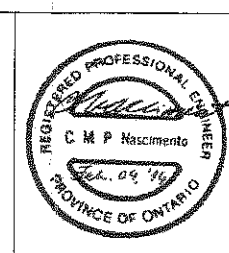
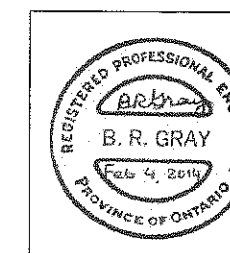
REVISIONS	DATE	BY	DESCRIPTION

Geocres No. 40P7-67
HWY No 85
SUB'D NA
DRAWN NA
CHECKED NSB
DATE FEB. 04, 2014
SITE
APPROVED BRG
DWG C3-1



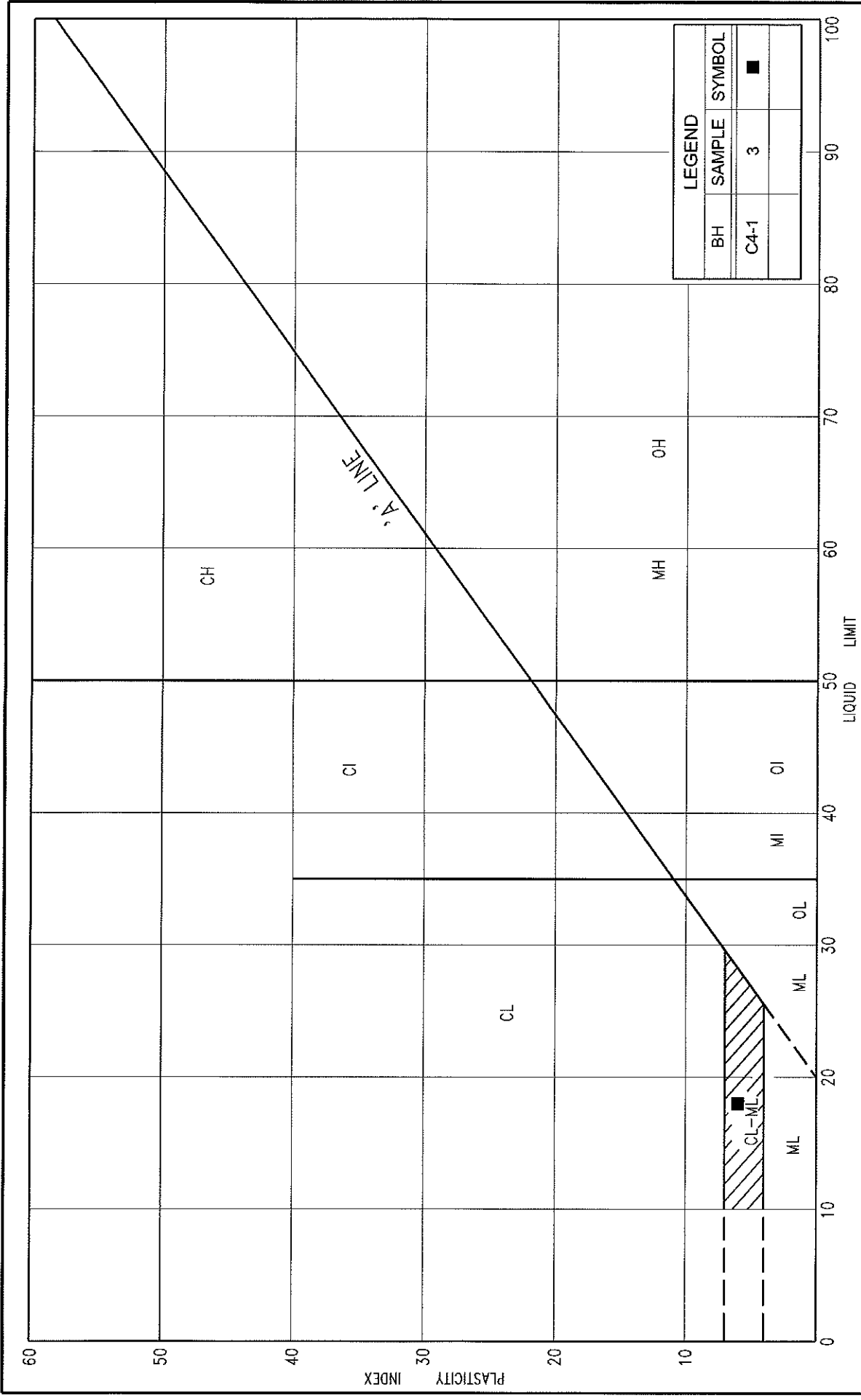
NOTES:

- DRAWING C3-1 SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND THE RECORD OF LOG OF BOREHOLES.
- THE CULVERT AT STA. 28+129 WAS DESIGNATED AS CULVERT C3 FOR THE INVESTIGATION PURPOSE.
- THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
- DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.
- CULVERT STATION IS DEPICTED IN CONTRACT DRAWING 2012-3011.



Ref. MRC Drawing: 2010362_Alignment.dwg;

Culvert C4 – Sta. 27+385 (W-S Ramp Chainage), Township of Waterloo
Figure C4-PC-1 – Result of Atterberg Limits Testing
Figures C4-GS-1 to C4-GS-4 – Results of Grain Size Distribution Analyses
Record of Borehole Sheets
Drawing C4-1 – Borehole Locations and Soil Strata



LEGEND		
BH	SAMPLE	SYMBOL
C4-1	3	■

PLASTICITY CHART

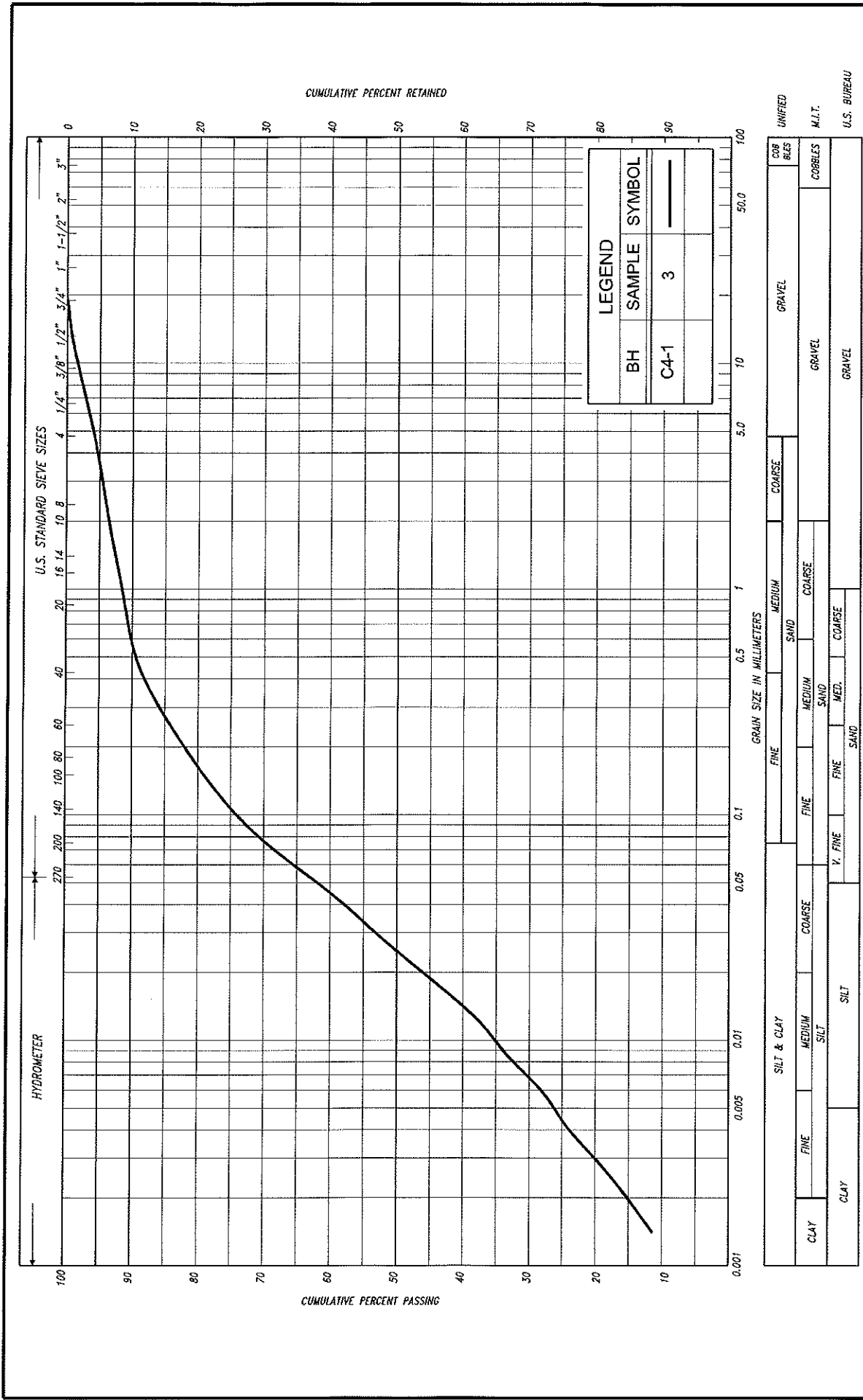
FIG No. C4-PC-1

HWY: 85

G.W.P. No. 168-89-00



CLAYEY SILT, with sand, trace gravel



	GRAIN SIZE DISTRIBUTION		FIG No. C4-GS-1
	CLAYEY SILT, with sand, trace gravel		HWY: 85
	G.W.P. No. 168-89-00		U.S. BUREAU

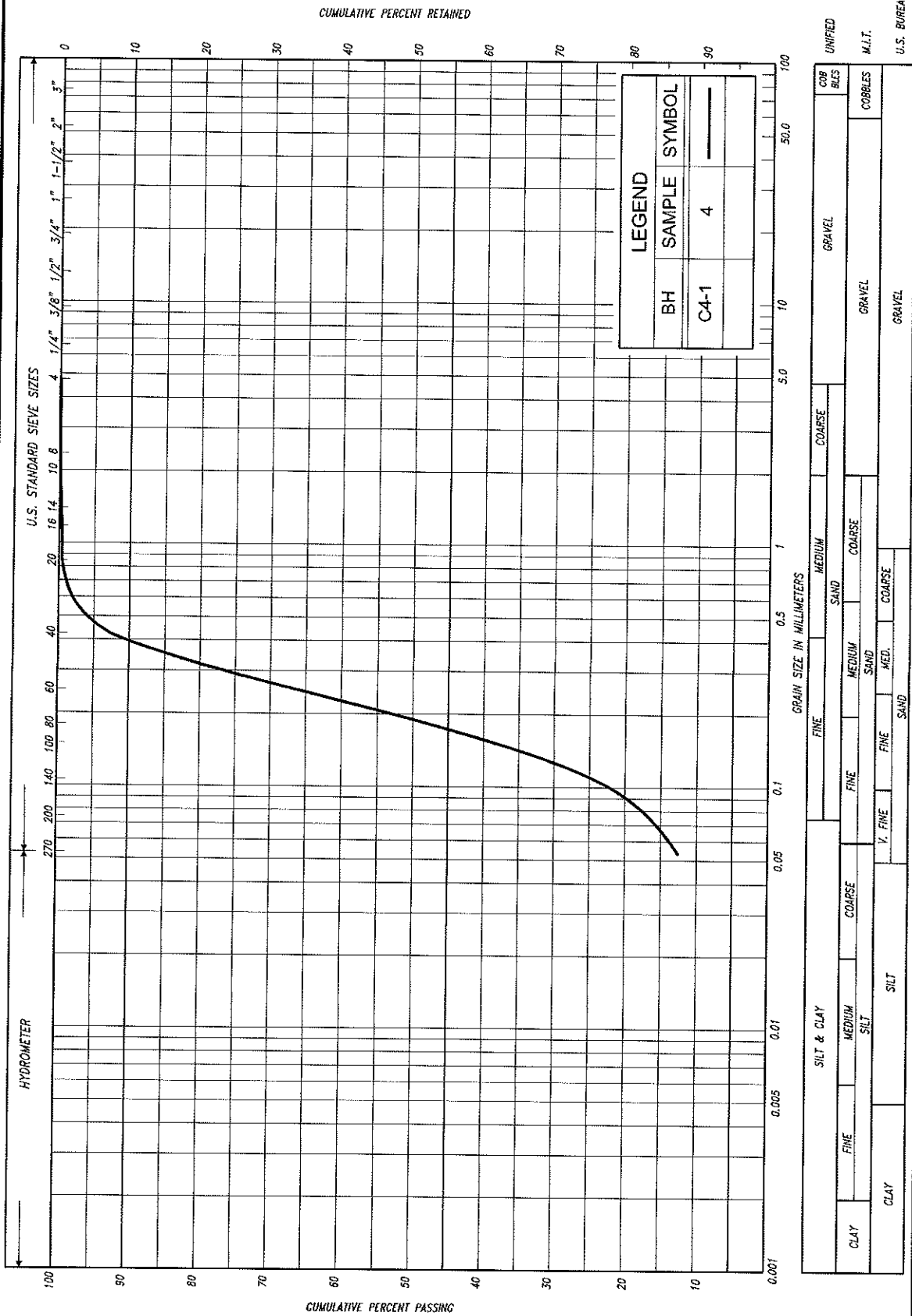


FIG No. C4-GS-2

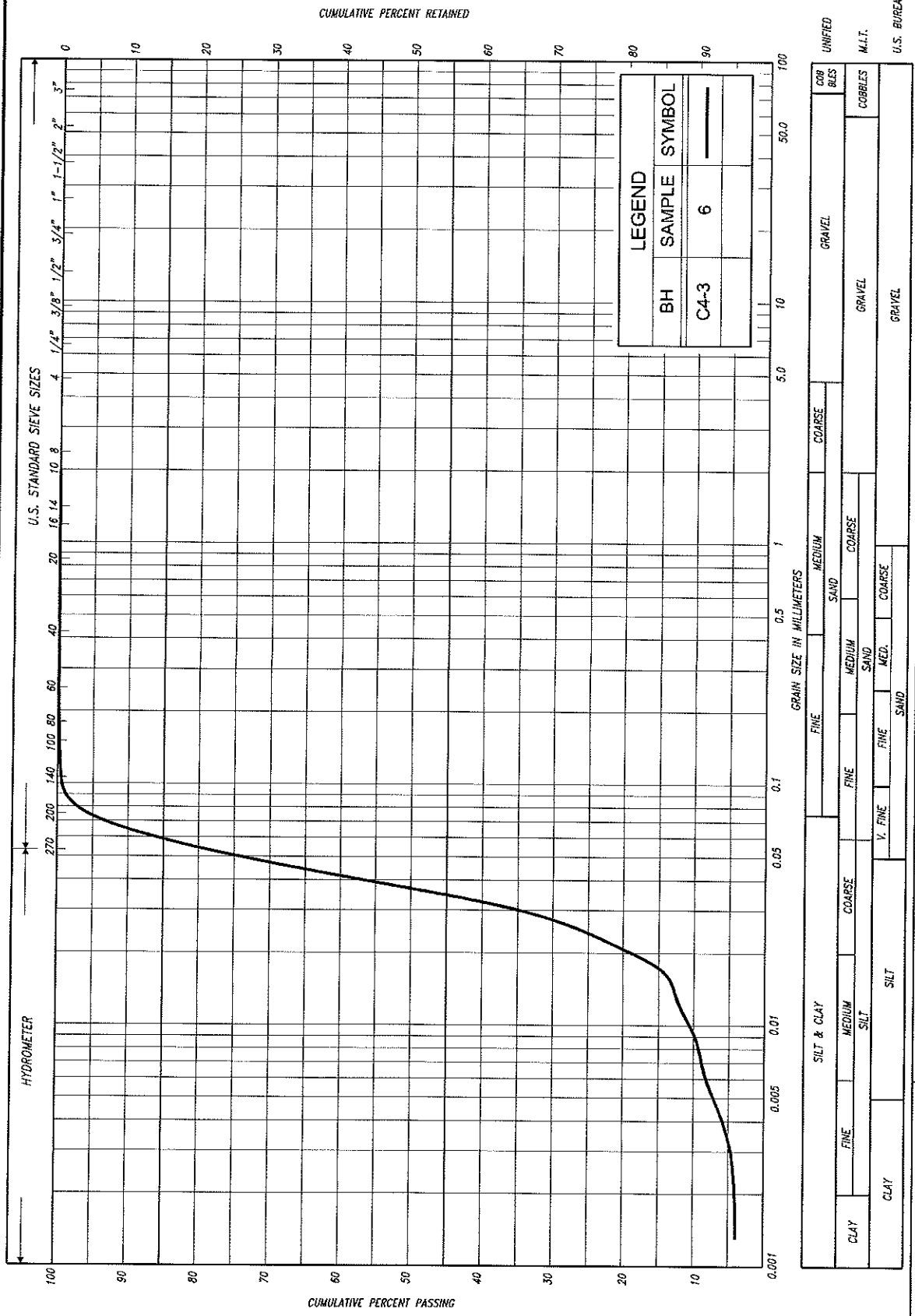
HWY: 85

G.W.P. No. 168-89-00

GRAIN SIZE DISTRIBUTION

SAND, some silt





GRAIN SIZE DISTRIBUTION
 SILT, trace clay, trace sand

FIG No. C4-GS-4
 HWY: 85
 G.W.P. No. 168-89-00



RECORD OF BOREHOLE No C4-1

1 of 1

METRIC

G.W.P. 168-89-00 LOCATION Coords: 4 817 422.6 N; 221 659.3 E ORIGINATED BY F.P.
DIST London HWY 85 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY N.S.B.
DATUM Geodetic DATE May 16, 2011 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)	
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL							× LAB VANE
331.8 0.0	Ground Surface						20	40	60	80	100						
	Topsoil		1	SS	11												
331.0 0.8	Silty clay with sand and gravel topsoil inclusions																
	Stiff Brown Moist (FILL)		2	SS	8												
	Clayey silt with sand, trace gravel																
	Firm Brown Moist to hard (FILL)		3	SS	33												
329.7 2.1	Sand, some silt																
	Dense Brown Wet		4	SS	36												
328.8 3.0	Clayey silt																
328.4 3.4	trace sand, trace gravel		5	SS	22												
	Very stiff Brown Moist (FILL)																
	Sand, trace silt																
327.5 4.3	Dense Brown Wet		6	SS	41												
	End of borehole																
<div>* 2011 05 16</div> <div>▽ Water level observed during drilling</div> <div>▼ Water level measured after drilling</div> <div>■ Penetrometer test</div>																	

* 2011 05 16

▽ Water level observed during drilling

▼ Water level measured after drilling

■ Penetrometer test

METRIC

ORIGINATED BY F. P.

COMPILED BY N.S.B.

CHECKED BY C.N.

Numbers refer to Sensitivity

RECORD OF BOREHOLE No C4-3

1 of 1

METRIC

G.W.P. 168-89-00 LOCATION Coords: 4 817 428.1 N; 221 646.6 E ORIGINATED BY F.P.
DIST London HWY 85 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY N.S.B.
DATUM Geodetic DATE May 16, 2011 CHECKED BY C.N.

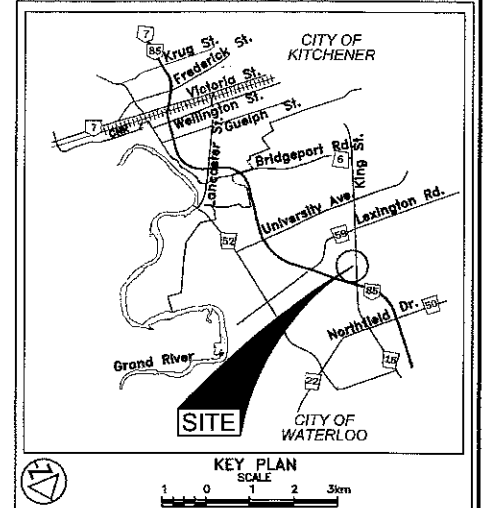
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kn/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									W _p	W	W _L
								20 40 60 80 100											
333.6	Ground Surface																		
0.0	Topsoil		1	SS	15		333												
333.3	Clayey silt with sand, trace gravel																		
0.3	Very stiff Brown Moist to hard (TILL)		2	SS	40														
332.4	Silty sand, trace clay																		
1.2	Dense Brown Moist to wet		3	SS	41		332												
			4	SS	40		331												
			5	SS	37														
329.9	Silt trace sand, trace clay						330												
3.7	Dense Brown Wet		6	SS	31														
329.3	End of borehole																		
4.3																			
* 2011 05 16																			
∇ Water level observed during drilling																			
\blacktriangledown Water level measured after drilling																			
Note: Borehole cave-in at 4.0m																			

* 2011 05 16

▽ Water level observed
during drilling

▼ Water level measured
after drilling

Note: Borehole cave-in at
4.0m



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 hammer and rods

▽

 WL at time of investigation May 2011

▽

 Head

▽

 ARTESIAN WATER Encountered

—

 PIEZOMETER

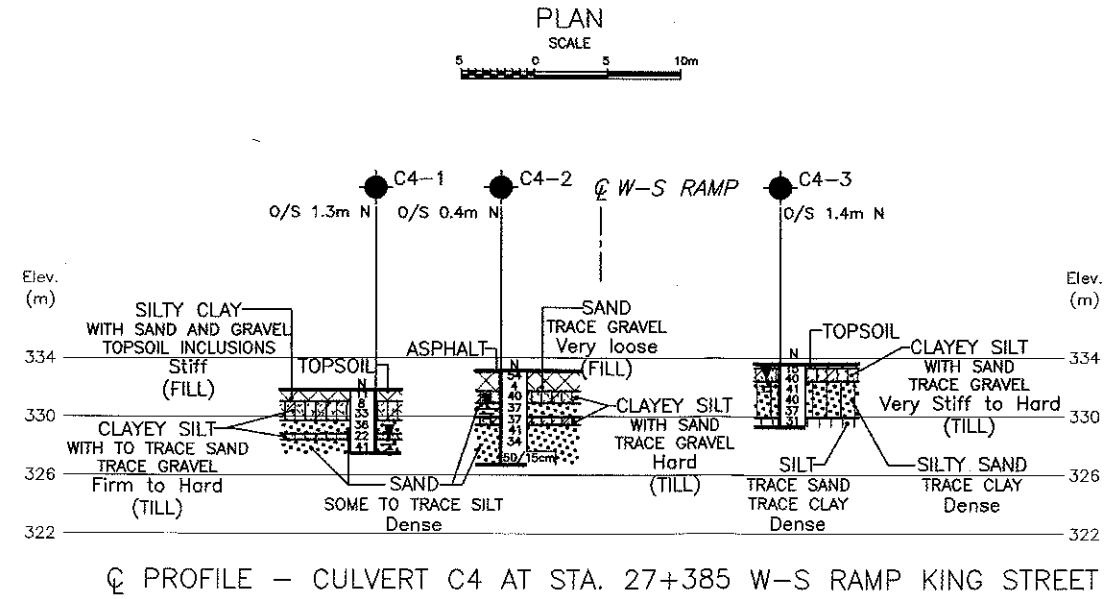
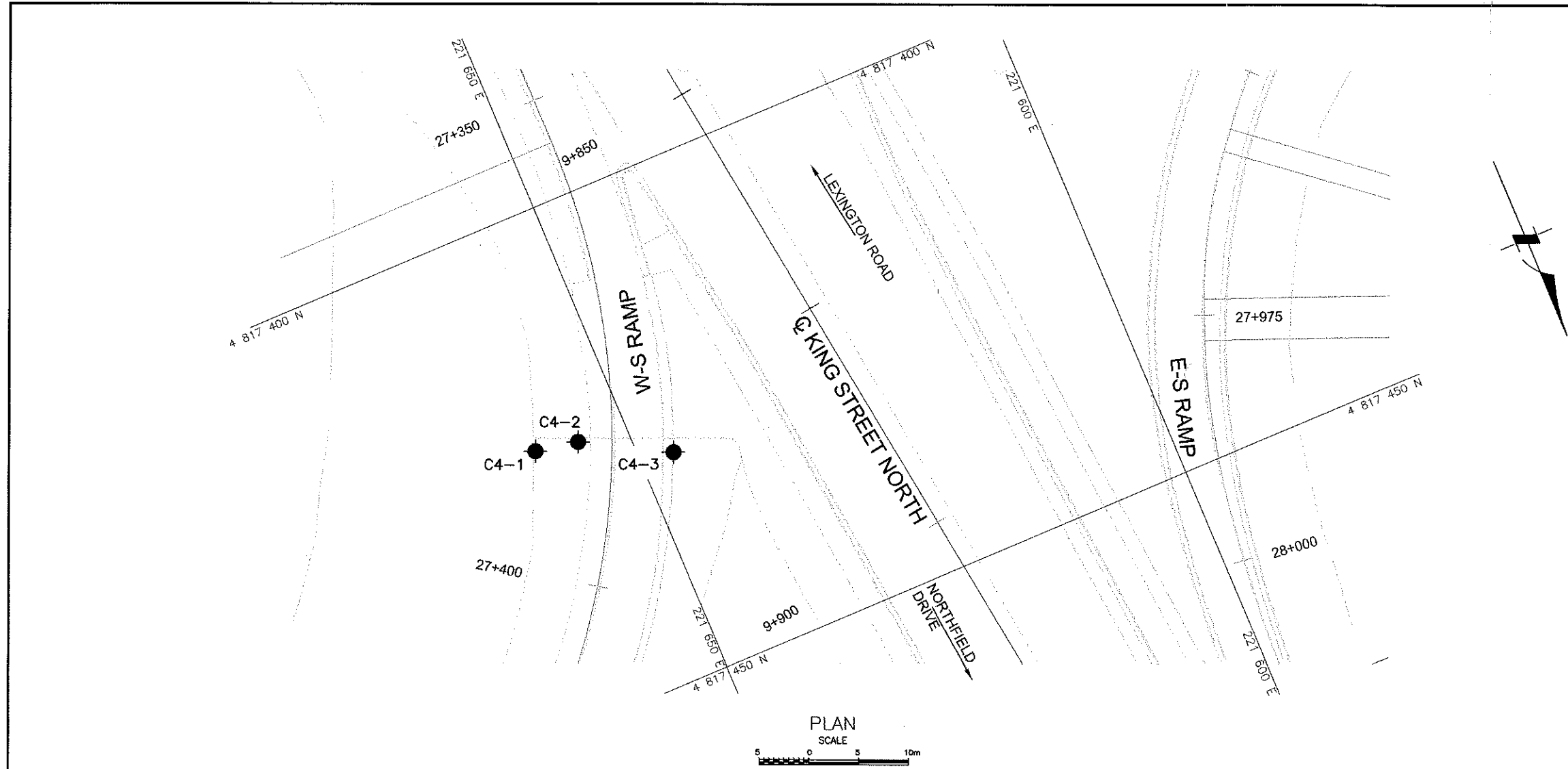
BH No	ELEVATION	NORTHINGS	EASTINGS
C4-1	331.8	4 817 422.6	221 659.3
C4-2	333.1	4 817 423.4	221 655.0
C4-3	333.6	4 817 426.1	221 646.6

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. 40P7-67

HWY No 85	CHECKED NSB	DATE FEB. 04, 2014	DIST London
SUBM'D NA	CHECKED CN	APPROVED BRG	DWG C4-1




- NOTES:
1. DRAWING C4-1 SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND THE RECORD OF LOG OF BOREHOLES.

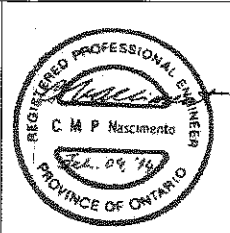
2. THE CULVERT AT STA. 28+200 WAS DESIGNATED AS CULVERT C4 FOR THE INVESTIGATION PURPOSE.

3. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.

4. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

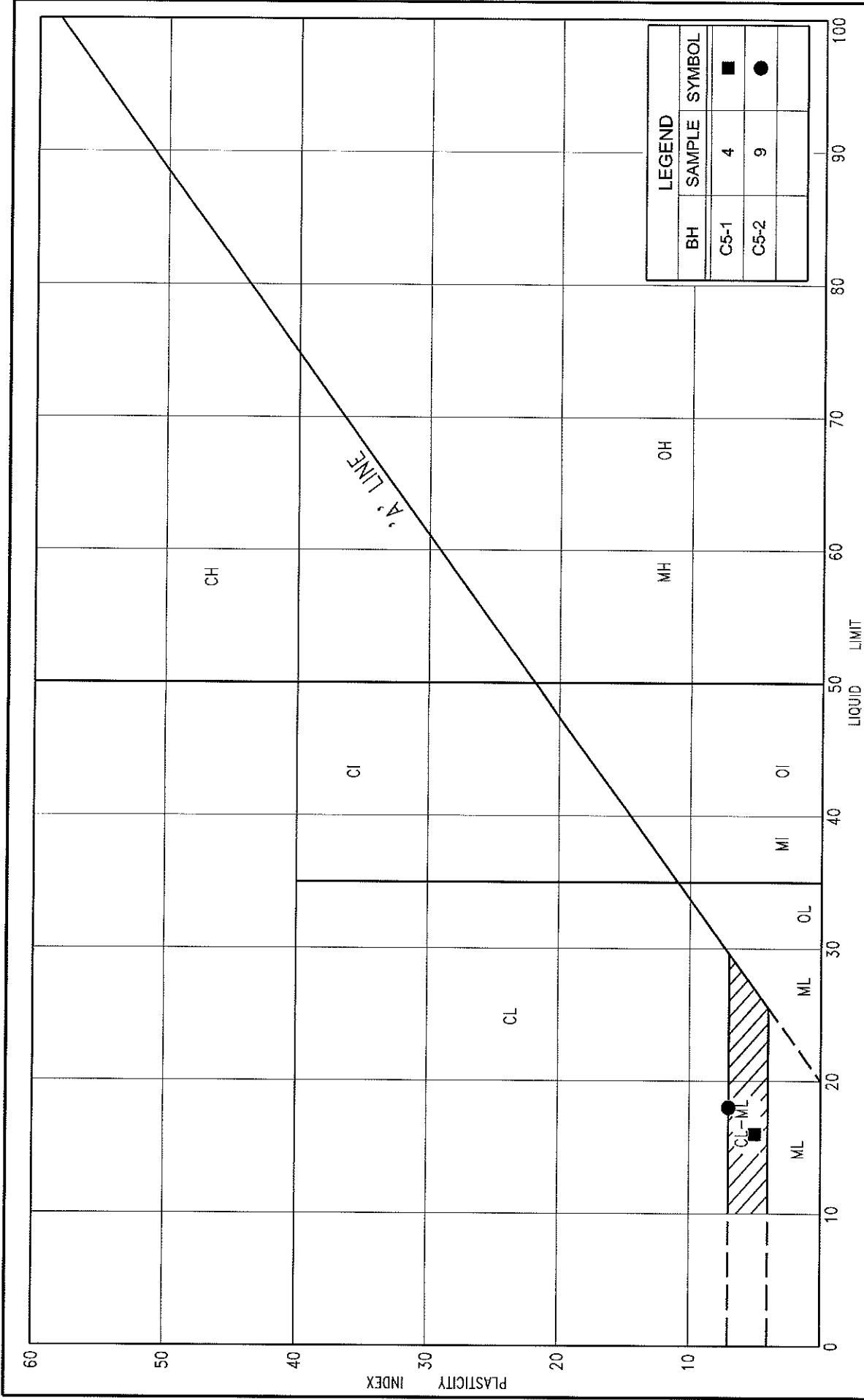
5. CULVERT STATION IS DEPICTED IN CONTRACT DRAWING 2012-3011.





Ref. MRC Drawing: 2010362_Alignment.dwg;

Culvert C5 – Sta. 28+940 (N-E/W Ramp Chainage), Township of Waterloo
Figure C5-PC-1 – Result of Atterberg Limits Testing
Figures C5-GS-1 and C5-GS-4 – Results of Grain Size Distribution Analyses
Record of Borehole Sheets
Drawing C5-1 – Borehole Locations and Soil Strata



LEGEND		
BH	SAMPLE	SYMBOL
C5-1	4	■
C5-2	9	●

PLASTICITY CHART

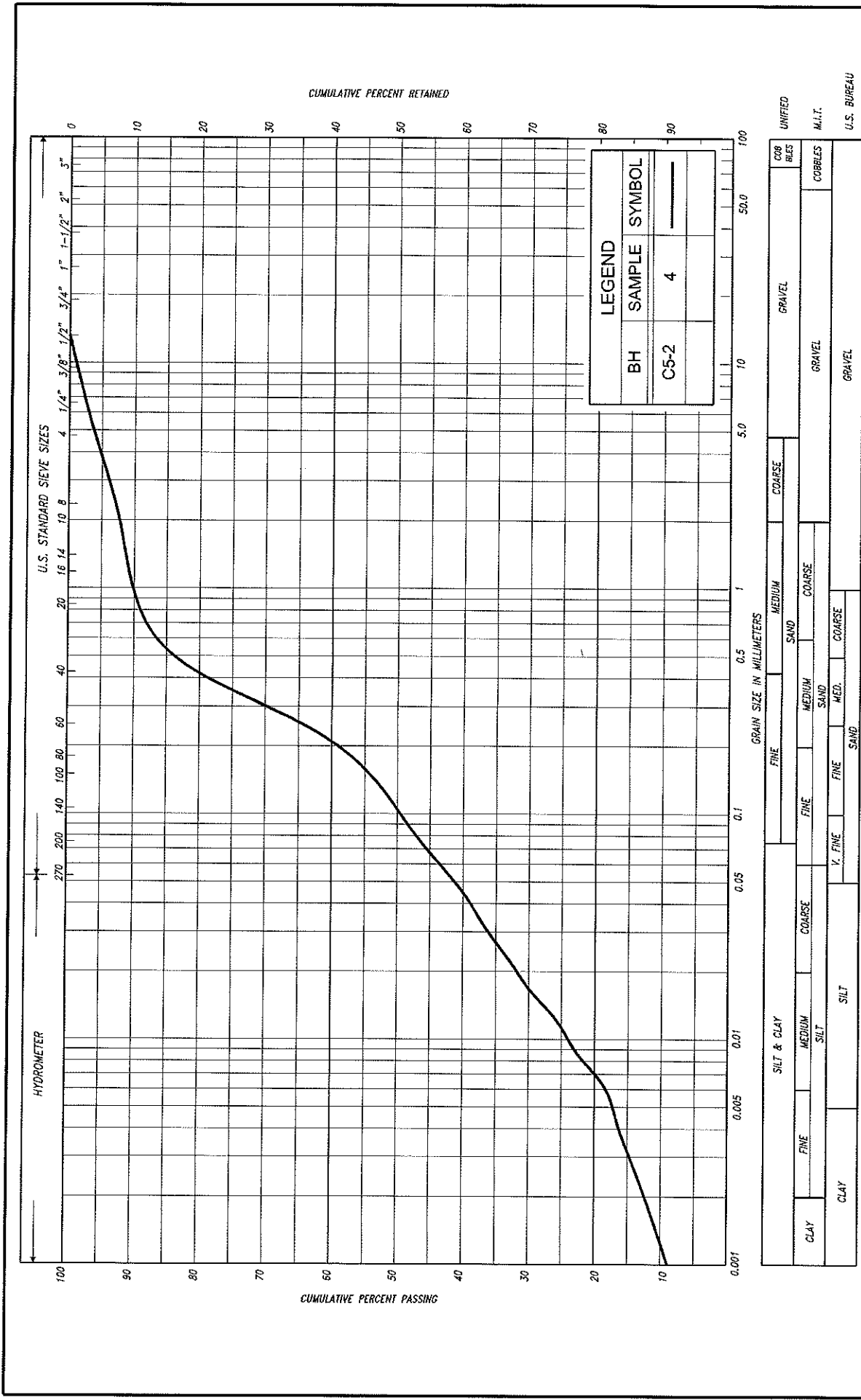
CLAYEY SILT, sandy, trace gravel
(TILL)

FIG No. C5-PC-1

HWY: 85

G.W.P. No. 168-89-00





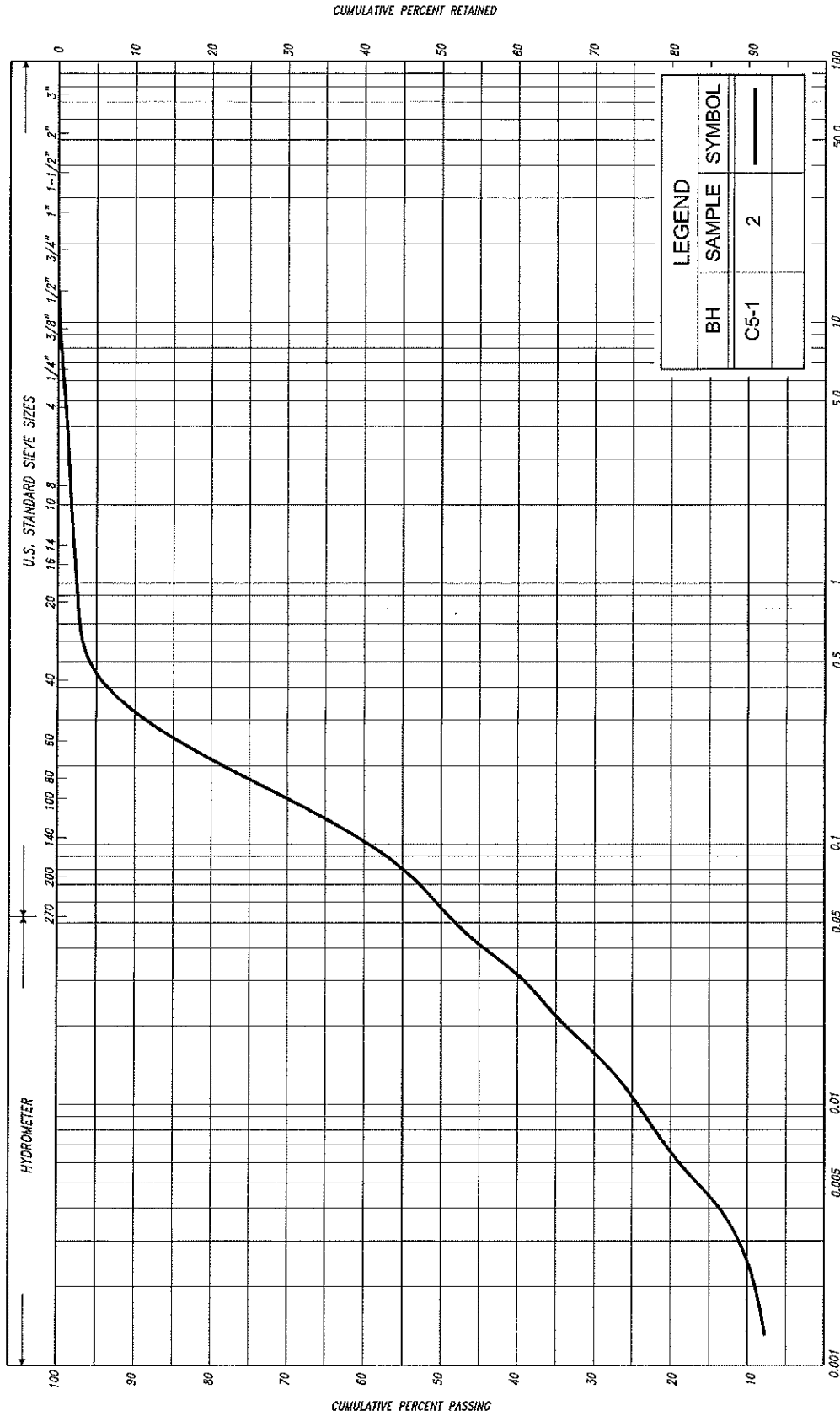
GRAIN SIZE DISTRIBUTION

SILTY SAND, some clay, trace gravel (FILL)

FIG No. C5-GS-1

HWY: 85

G.W.P. No. 168-89-00



GRAIN SIZE IN MILLIMETERS													COBBLES		UNIFIED			
SILT & CLAY															GRAVEL		COBBLES	UNIFIED
CLAY		FINE	MEDIUM SILT		COARSE		FINE		MEDIUM SAND		COARSE		GRAVEL					
CLAY		FINE	MEDIUM SILT		COARSE		FINE		MEDIUM SAND		COARSE		GRAVEL	COBBLES	M.I.T.	U.S. BUREAU		
CLAY		V. FINE		FINE	MED.		COARSE		GRAVEL							COBBLES	M.I.T.	U.S. BUREAU

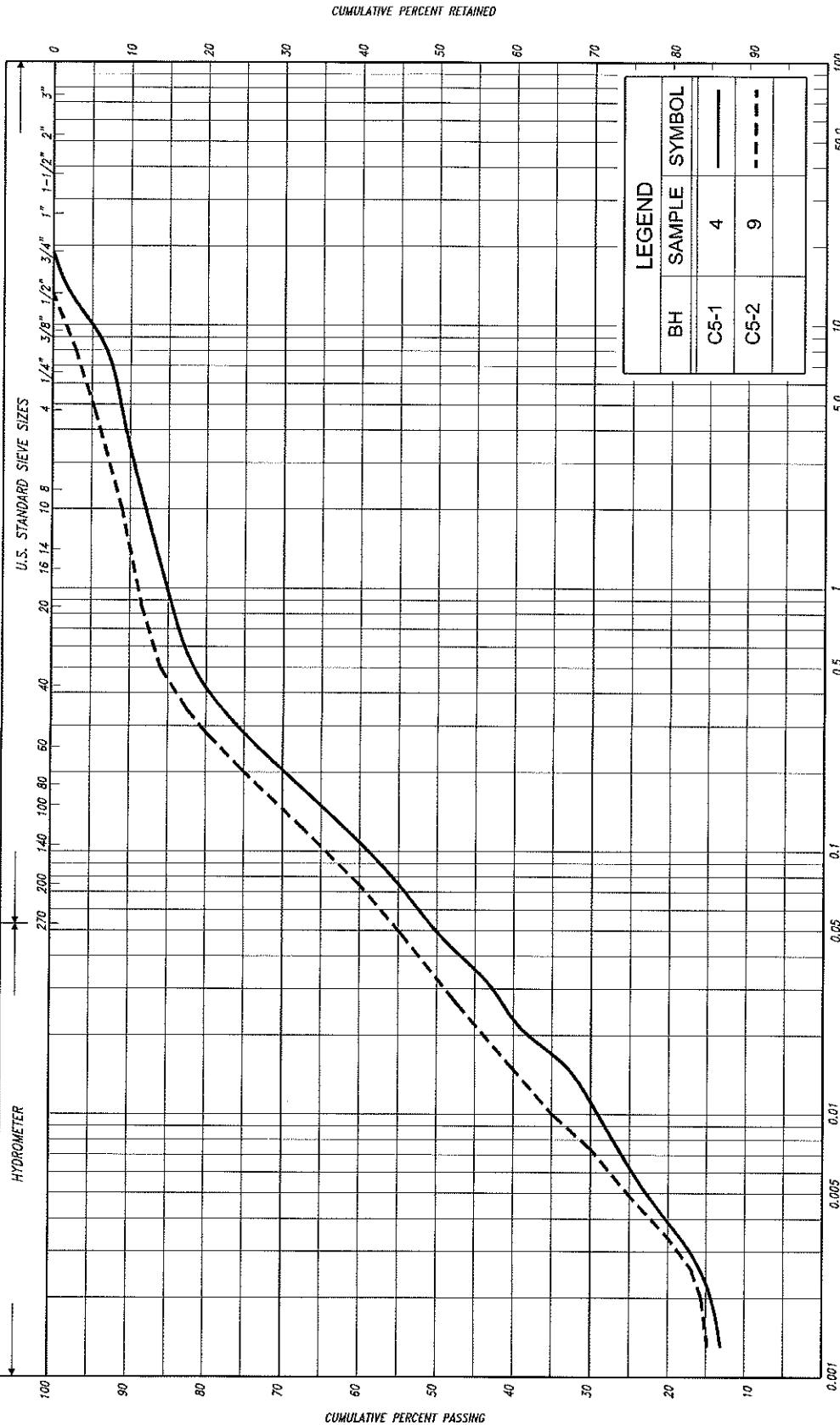


FIG No. C5-GS-4

GRAIN SIZE DISTRIBUTION

CLAYEY SILT, sandy, trace gravel
(TILL)

HWY: 85

G.W.P. No. 168-89-00



RECORD OF BOREHOLE No C5-1

1 of 1

METRIC

G.W.P. 168-89-00 LOCATION Coords: 4 817 447.3 N; 221 445.7 E ORIGINATED BY F.P.
 DIST London HWY 85 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY N.S.B
 DATUM Geodetic DATE May 16, 2011 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)	
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE						W _p	W _L
336.8	Ground Surface						20	40	60	80	100							
0.0	Topsoil		1	SS	12							○						
336.5	Silty clay																	
0.3	Stiff Brown Moist																	
336.2	Sand and silt trace clay, trace gravel		2	SS	5							○				1 45 45 9		
0.6	Loose Brown Wet																	
335.4	Silt some clay, trace sand		3	SS	7							○						
1.4	Loose Brown Wet																	
334.7	Clayey silt sandy, trace gravel																	
2.1	Very stiff Brown Moist (TILL)		4	SS	17							41				9 36 41 14		
			5	SS	24													
333.1	Sand, trace silt											125	○					
3.7	Very dense Brown Moist		6	SS	68							○						
332.5	End of borehole																	
4.3																		

* 2011 05 16

▽ Water level observed
during drilling

■ Penetrometer test

RECORD OF BOREHOLE No C5-2

1 of 1

METRIC

G.W.P. 168-89-00

LOCATION _____

Coords: 4 817 441.5 N; 221 437.0 E

ORIGINATED BY E. P.

DIST London

HWY_____

HWY 85 BOREHOLE TYPE Continuous Flight Hollow Stem Augers

COMPILED BY N.S.B

DATUM Geodetic

DATE _____

May 16, 2011

CHECKED BY C.N.

[illegible]

RECORD OF BOREHOLE No C5-3

1 of 1

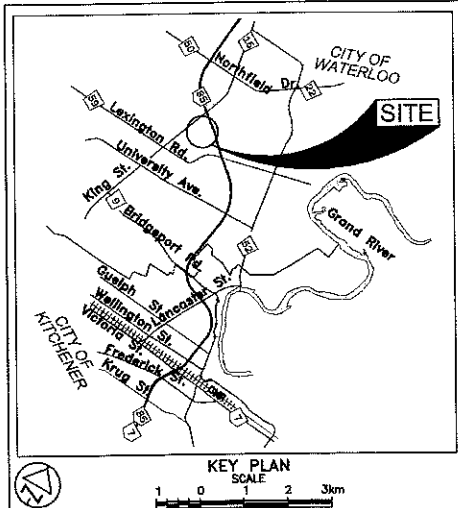
METRIC

G.W.P. 168-89-00 LOCATION Coords: 4 817 435.1 N; 221 427.6 E ORIGINATED BY F.P.
DIST London HWY 85 BOREHOLE TYPE Portable Wash Boring COMPILED BY N.S.B
DATUM Geodetic DATE July 19, 2011 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20 40 60 80 100									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
332.9	Ground Surface																
0.0	Topsoil																
332.7	Sandy silt, trace clay		1	SS	29												
0.2	clayey silt seams																
332.1	Compact Brown Damp																
0.8	Sand		2	SS	24		332										
331.8	Compact Brown Moist																
1.1	Silt some clay, trace sand																
	Compact Brown Moist to wet		3	SS	24		331										
330.7	Sand, trace silt																
2.2	Very dense Brown Moist		4	SS	66												
			5	SS	107		330										
328.8			6	SS	91		329										
4.1	Silt																
328.6	some clay, trace sand																
4.3	Very dense Brown Moist																
	End of borehole																
* 2011 07 19																	
▽ Water level observed during drilling																	

* 2011 07 19

▽ Water level observed during drilling



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 hammer and rods
 WL at time of investigation May to July 2011
 Head
 ARTESIAN WATER Encountered
 PIEZOMETER

BH No	ELEVATION	NORTHINGS	EASTINGS
C5-1	336.8	4 817 447.3	221 445.7
C5-2	336.8	4 817 441.5	221 437.0
C5-3	332.9	4 817 435.1	221 427.6

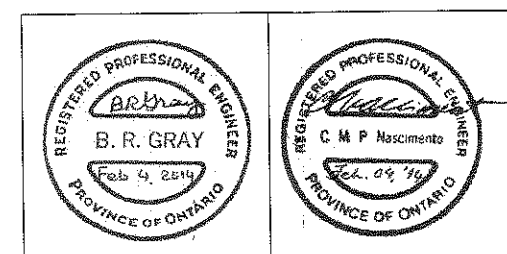
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS

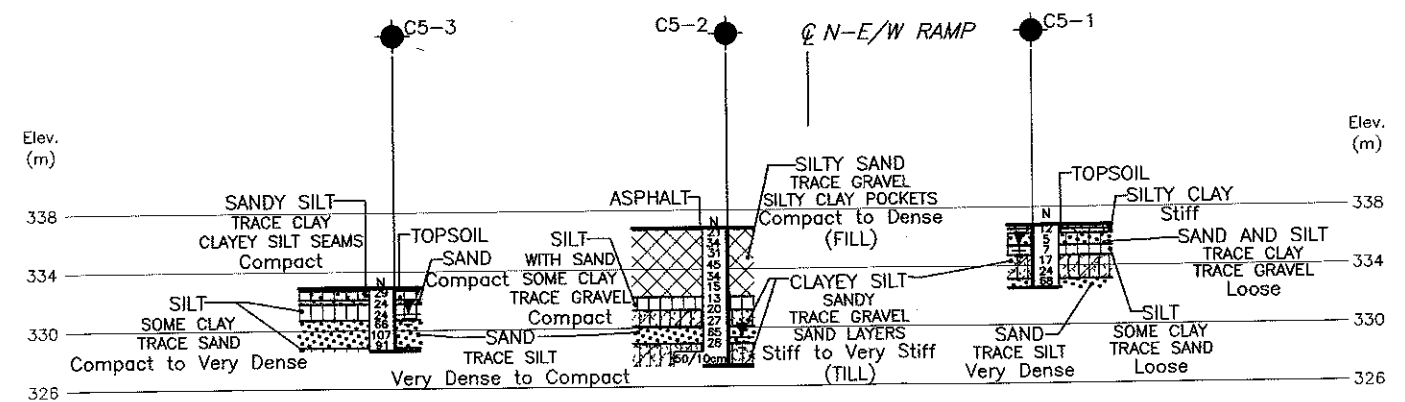
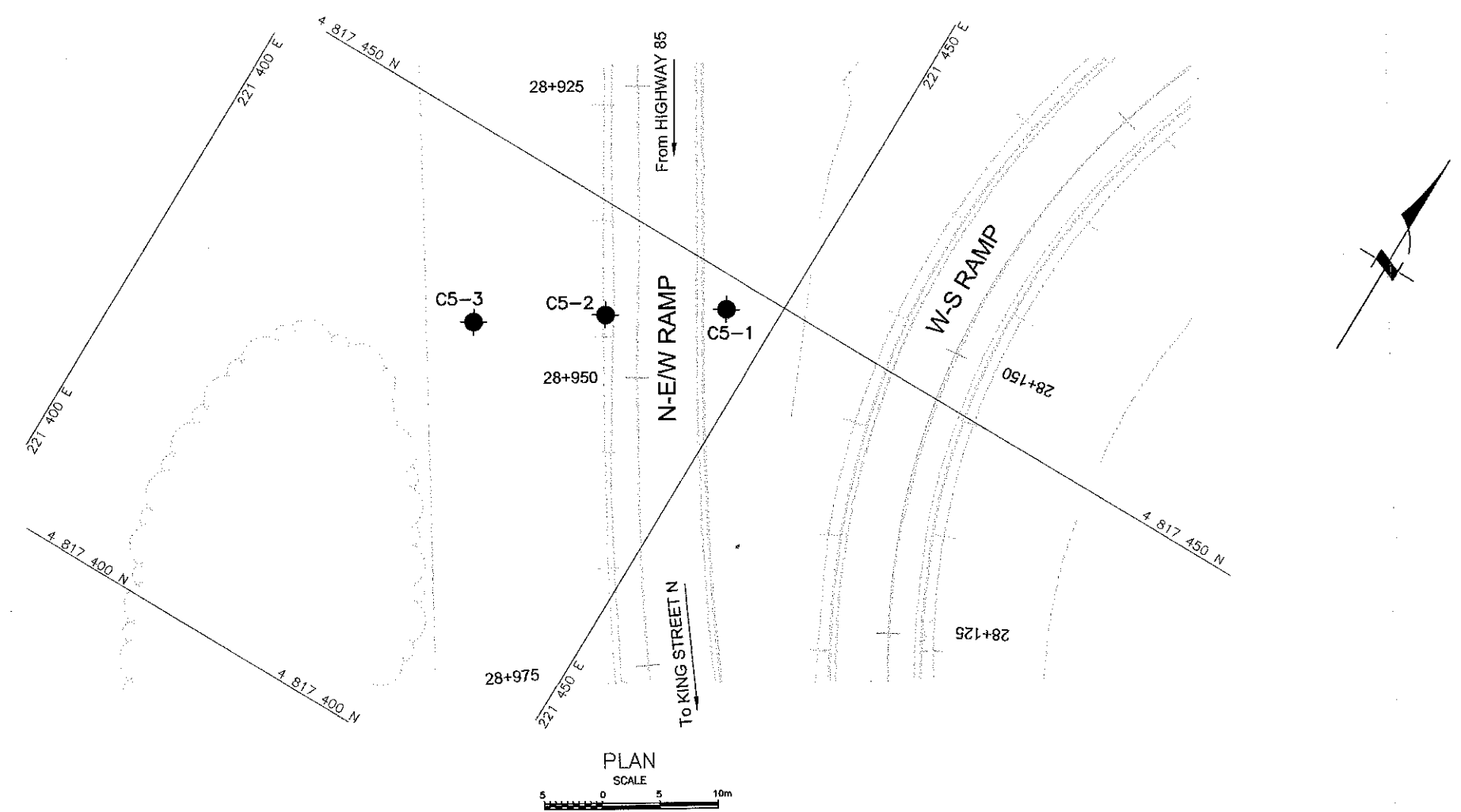
DATE	BY	DESCRIPTION

Geocres No. 40P7-67

HWY No	85	DIST	London
SUB'D	NA	CHECKED	NSB
DATE	FEB. 04, 2014	SITE	
DRAWN	NA	CHECKED	CN
APPROVED	BRG	DWG	C5-1

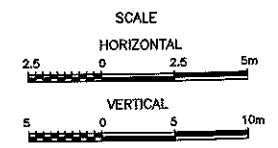


Ref. MRC Drawing: 2010362_Alignment.dwg;

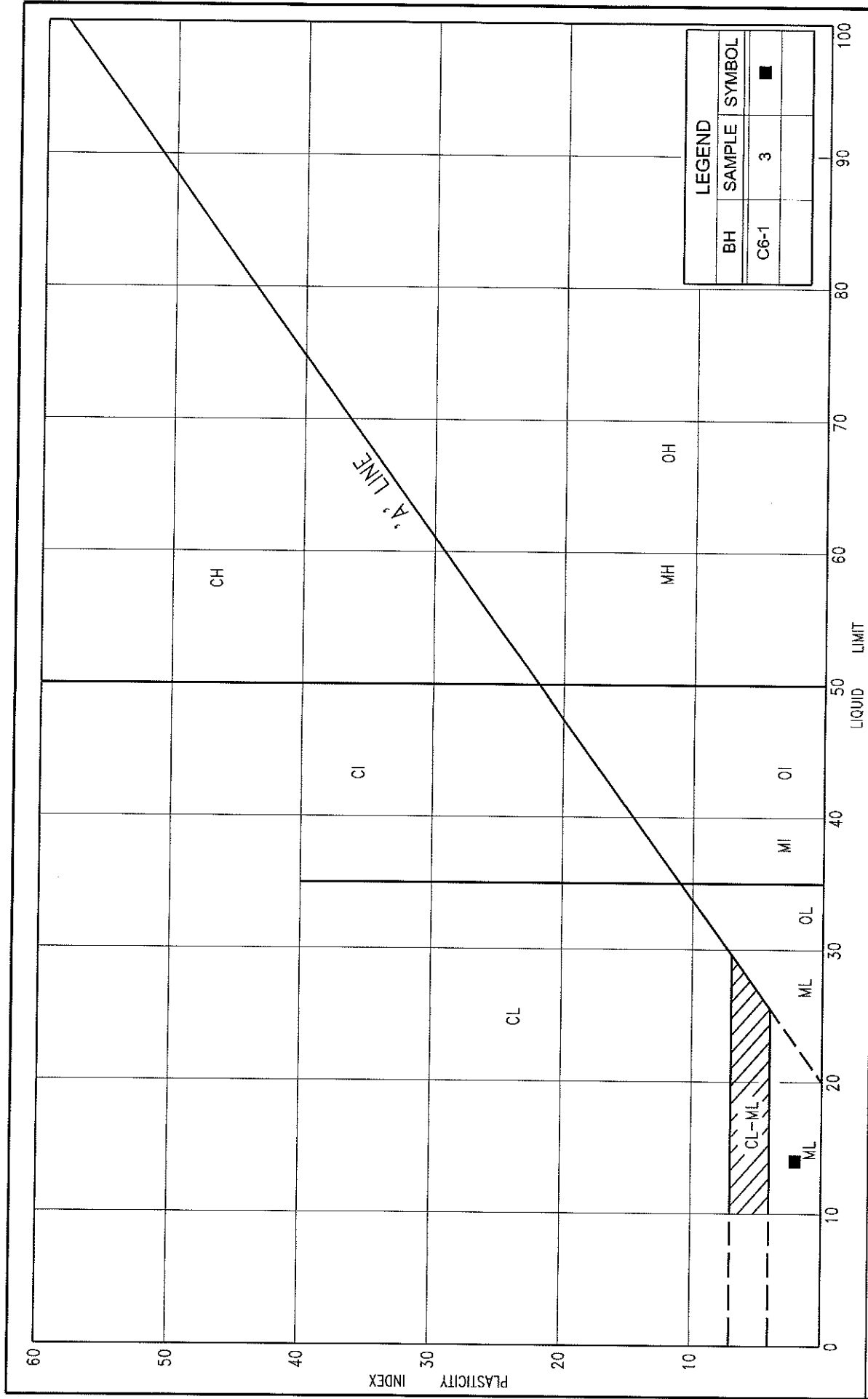



C PROFILE - CULVERT C5 AT STA. 28+940 N-E/W RAMP KING STREET

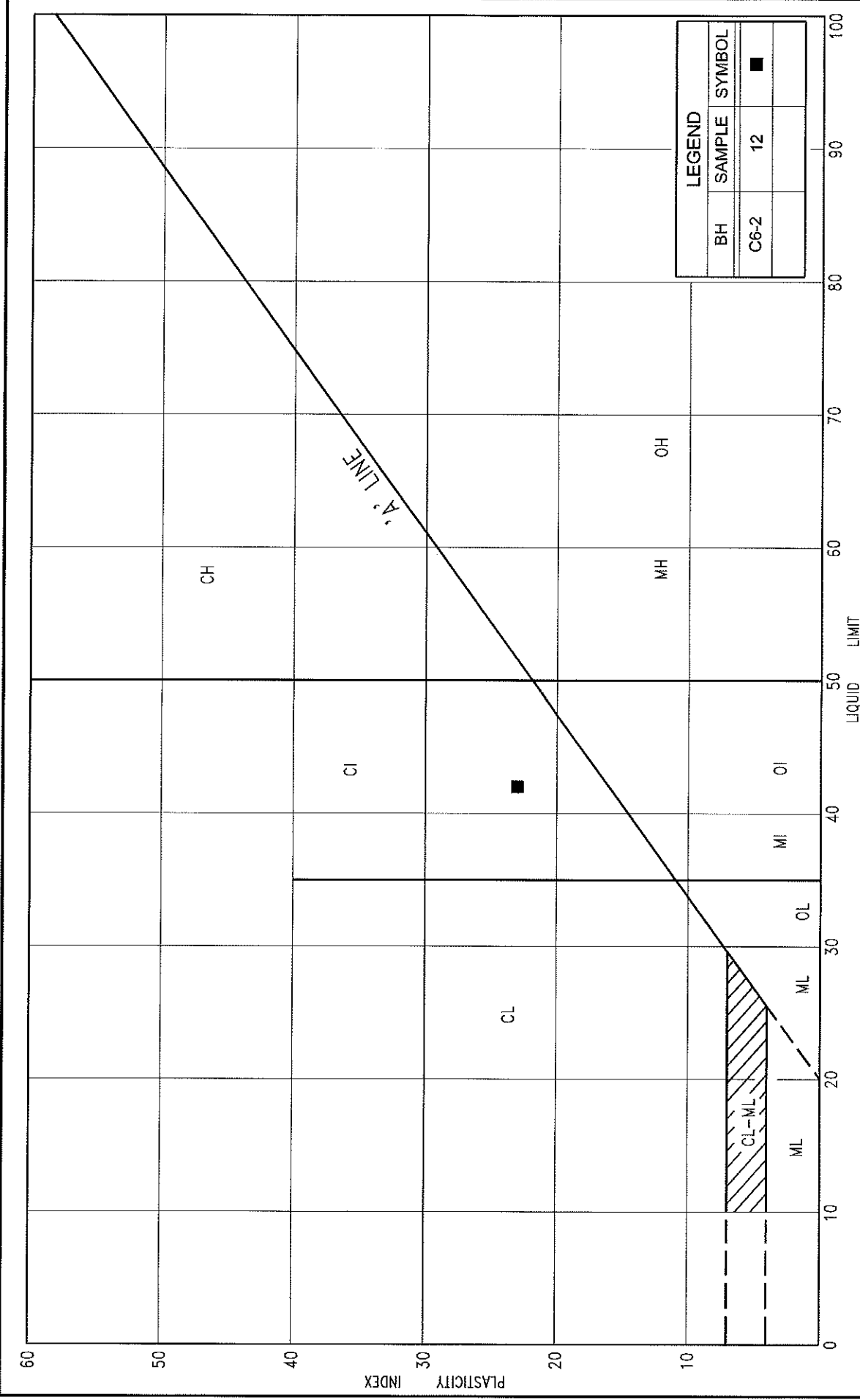
- NOTES:
- DRAWING C5-1 SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND THE RECORD OF LOG OF BOREHOLES.
 - THE CULVERT AT STA. 28+455 WAS DESIGNATED AS CULVERT C5 FOR THE INVESTIGATION PURPOSE.
 - THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
 - DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.
 - CULVERT STATION IS DEPICTED IN CONTRACT DRAWING 2012-3011.



Culvert C6 – Sta. 28+908 (Highway 85 Chainage), Township of Waterloo
Figures C6-PC-1 and C6-PC-2 – Result of Atterberg Limits Testing
Figures C6-GS-1 and C6-GS-4 – Results of Grain Size Distribution Analyses
Record of Borehole Sheets
Drawing C6-1 – Borehole Locations and Soil Strata



	PLASTICITY CHART SAND and SILT, some clay, trace gravel		FIG No. C6-PC-1
			HWY: 85
			G.W.P. No. 168-89-00



LEGEND		
BH	SAMPLE	SYMBOL
C6-2	12	■

PLASTICITY CHART

SILTY CLAY, trace sand

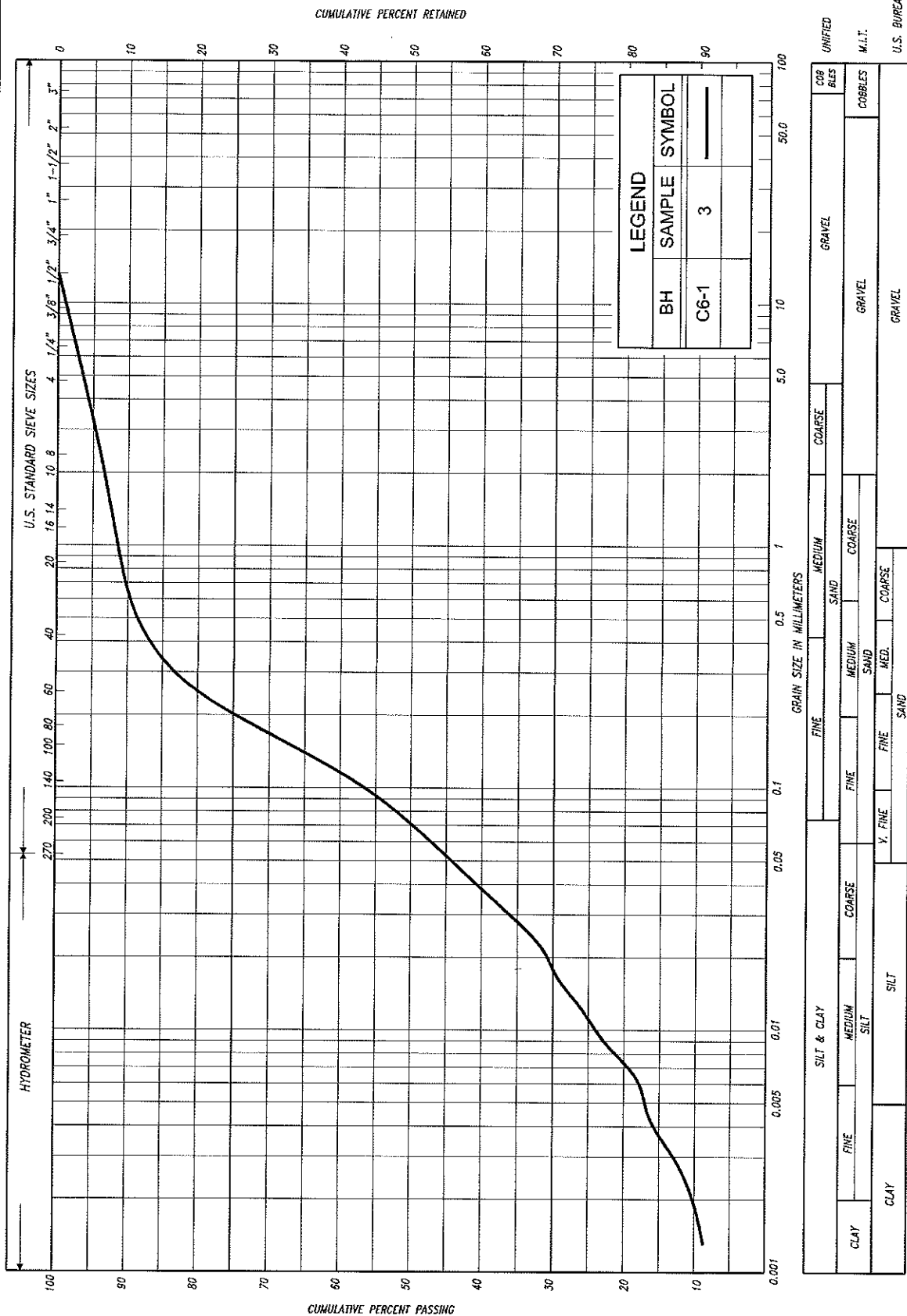
(TILL)

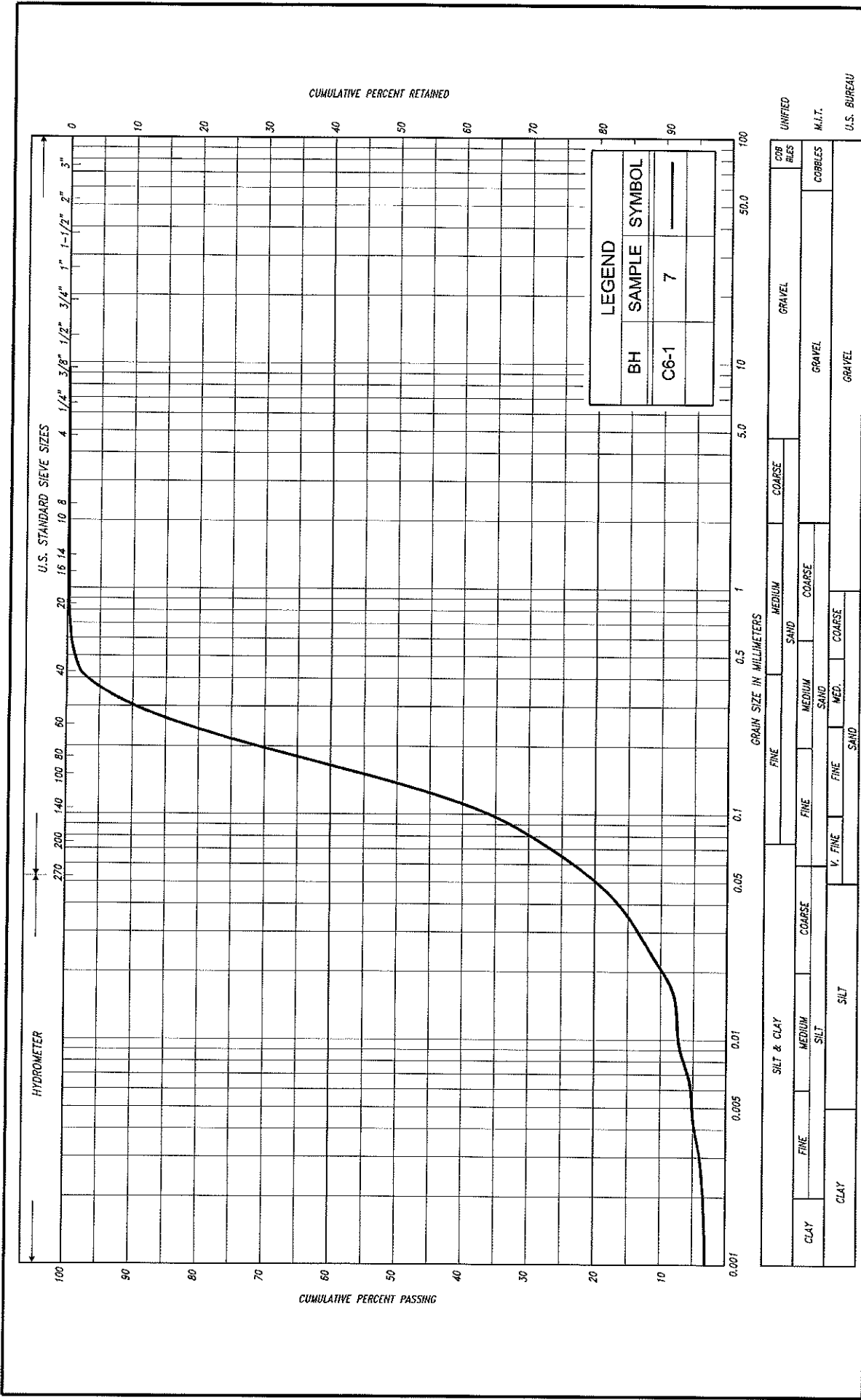
FIG No. C6-PC-2


HWY: 85

G.W.P. No. 168-89-00







**Ontario**

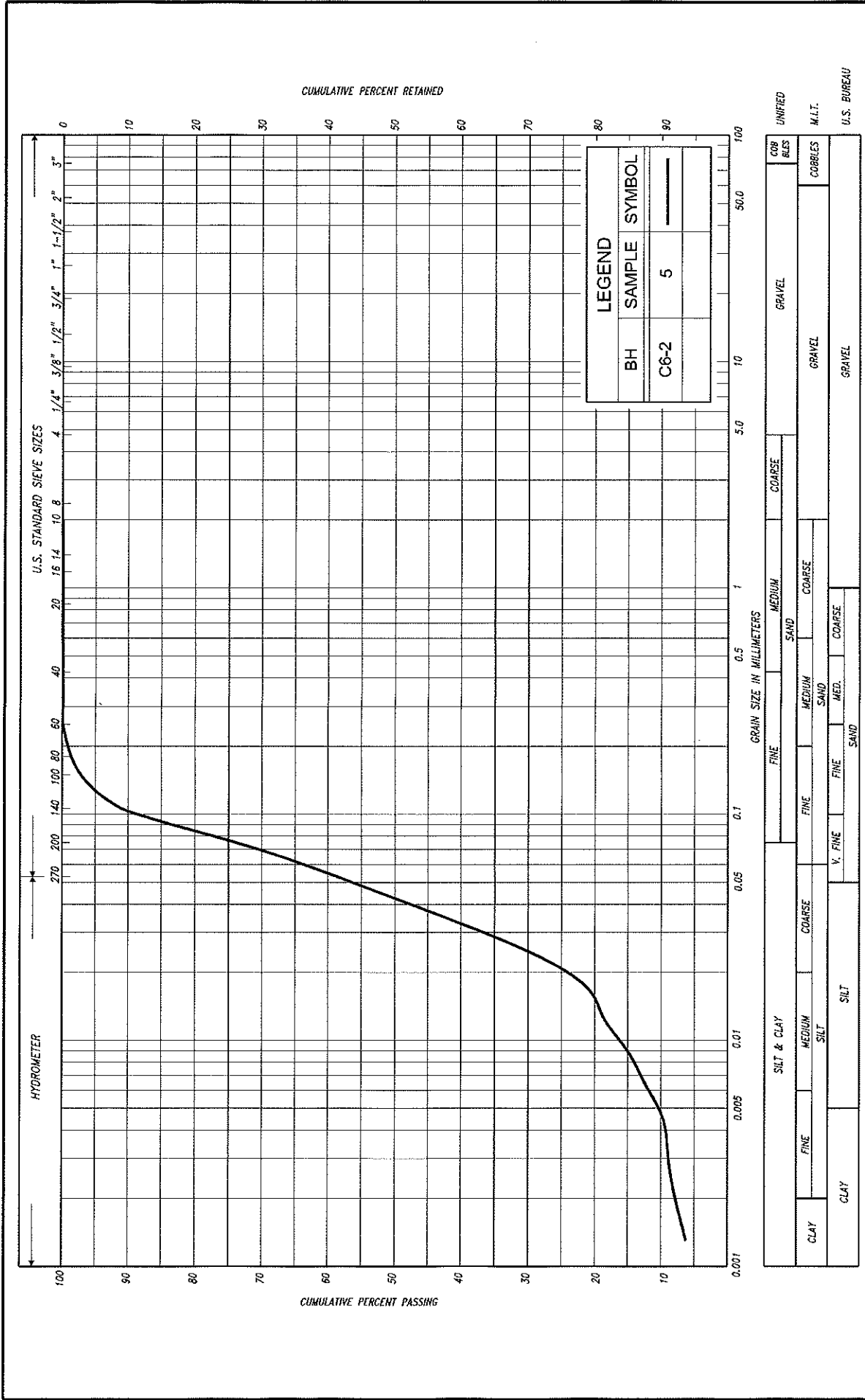
GRAIN SIZE DISTRIBUTION

FIG No. C6-GS-3

SAND, with silt, trace clay

HWY: 85

G.W.P. No. 168-89-00



GRAIN SIZE DISTRIBUTION

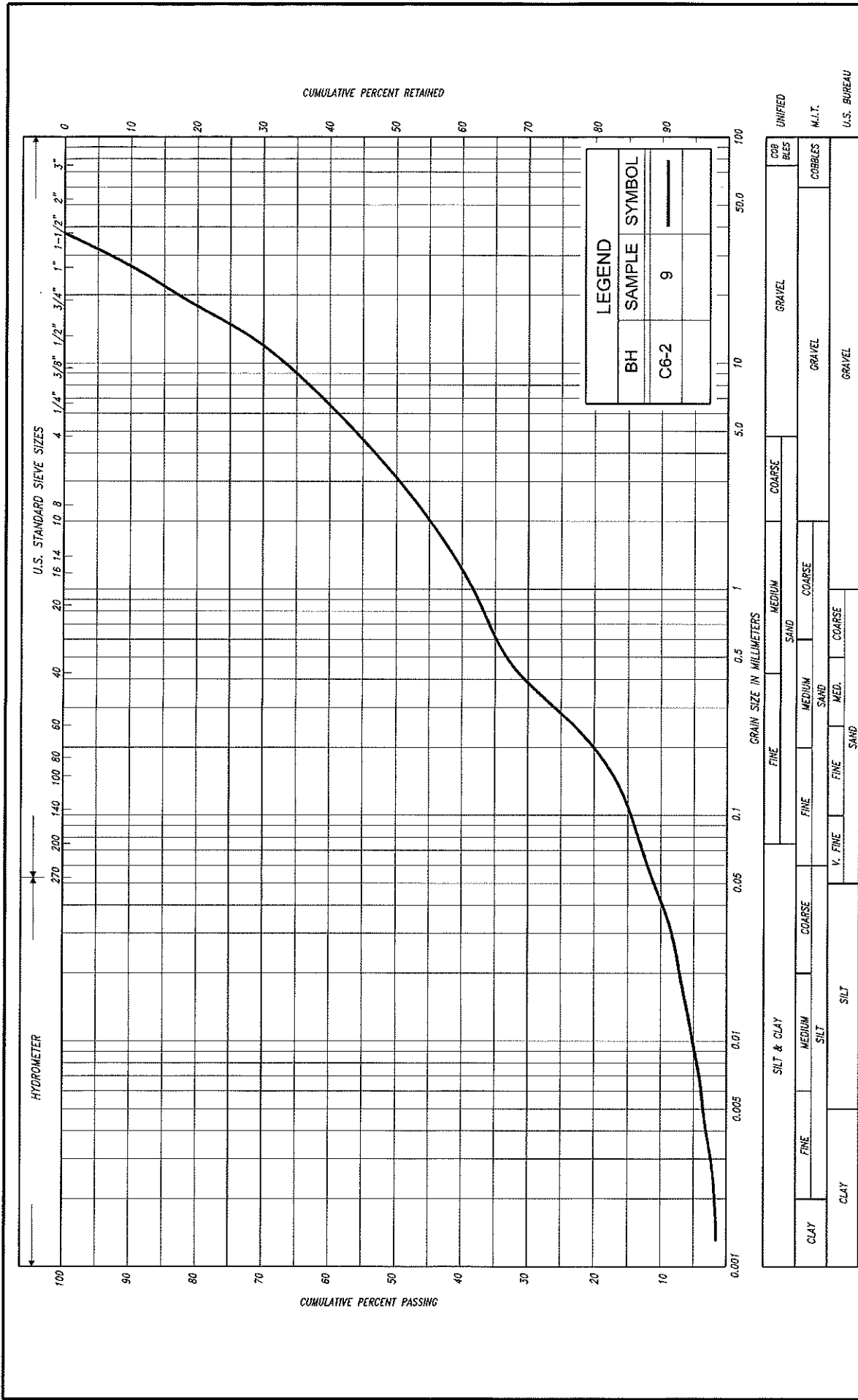
FIG No. C6-GS-1

SILT, with sand, trace clay

HWY: 85

G.W.P. No. 168-89-00





GRAIN SIZE DISTRIBUTION

SAND and GRAVEL, some silt, trace clay

FIG No. C6-GS-4

HWY: 85

G.W.P. No. 168-89-00



RECORD OF BOREHOLE No C6-1

1 of 1

METRIC

G.W.P. 168-89-00 LOCATION Coords: 4 817 694.6 N; 220 986.8 E ORIGINATED BY F.P.
DIST London HWY 85 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY N.S.B.
DATUM Geodetic DATE May 13, 2011 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60						80	100	SHEAR STRENGTH kPa			WATER CONTENT (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	</

* 2011 05 13

▽ Water level observed during drilling

▽ Water level measured after drilling

■ Penetrometer test






Note: Borehole cave-in at 5.5m

RECORD OF BOREHOLE No C6-2

1 of 1

METRIC

G.W.P. 168-89-00 LOCATION Coords: 4 817 742.9 N; 221 017.7 E ORIGINATED BY F.P.
DIST London HWY 85 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY N.S.B.
DATUM Geodetic DATE May 13, 2011 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w_p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w_L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE							
334.8 0.0	Ground Surface Sand and gravel Compact Brown Moist to loose some sand clayey silt pockets (FILL)		1	SS	17											
			2	SS	9											
			3	SS	6											
			4	SS	8											
331.8 3.0	Silt with sand, trace clay Very dense Brown Wet to compact		5	SS	61											
			6	SS	51											
			7	SS	20											
329.6 5.2	Silty sand, trace gravel Dense Brown Wet		8	SS	37											
328.8 6.0	Sand and gravel some silt, trace clay cobbles Very dense Brown Wet		9	SS	55											
			10	SS	50/15cm											
			11	SS	33											
326.1 8.7	Silty clay, trace sand Very stiff Brown Moist to hard (TILL)		12	SS	24											
324.0 10.8	End of borehole Samples 10 and 13: Sampler bouncing * 2011 05 13 ▽ Water level observed during drilling ▼ Water level measured after drilling Note: Borehole cave-in at 5.2m		13	SS	50/15cm											

METRIC

CHECKED BY C.N.

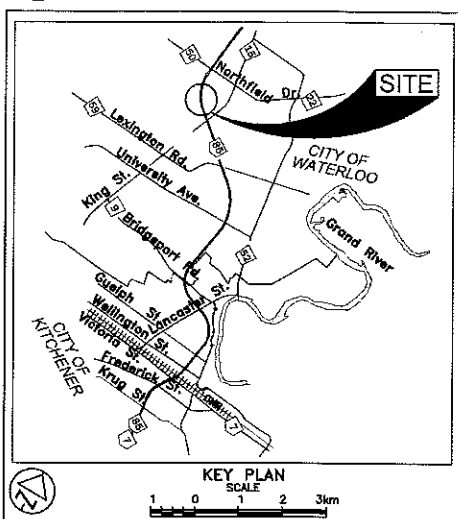
(%) STRAIN AT FAILURE

CONT No
GWP No 168-89-00



CULVERT AT STA. 28+908
(SBL AND NBL) (C6)
HIGHWAY 85 WATERLOO TWP
BOREHOLE LOCATIONS AND SOIL STRATA

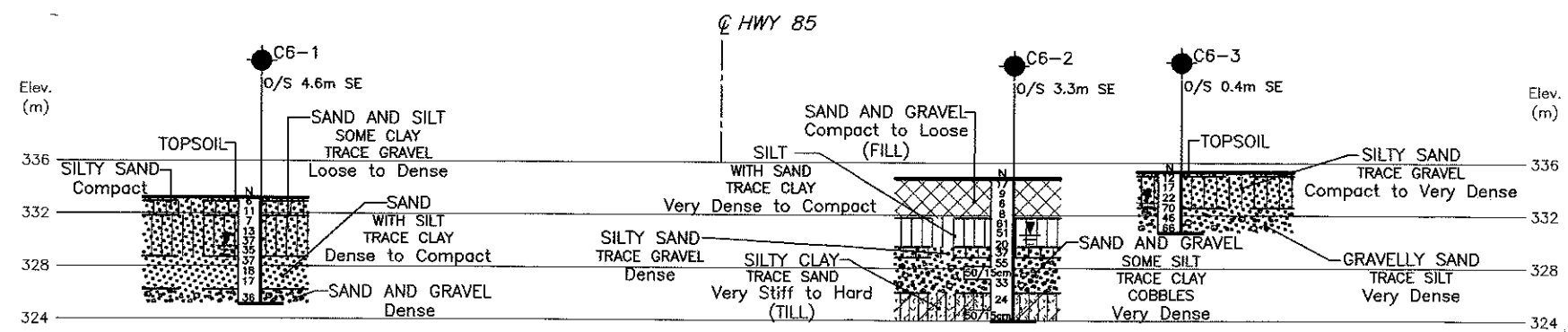
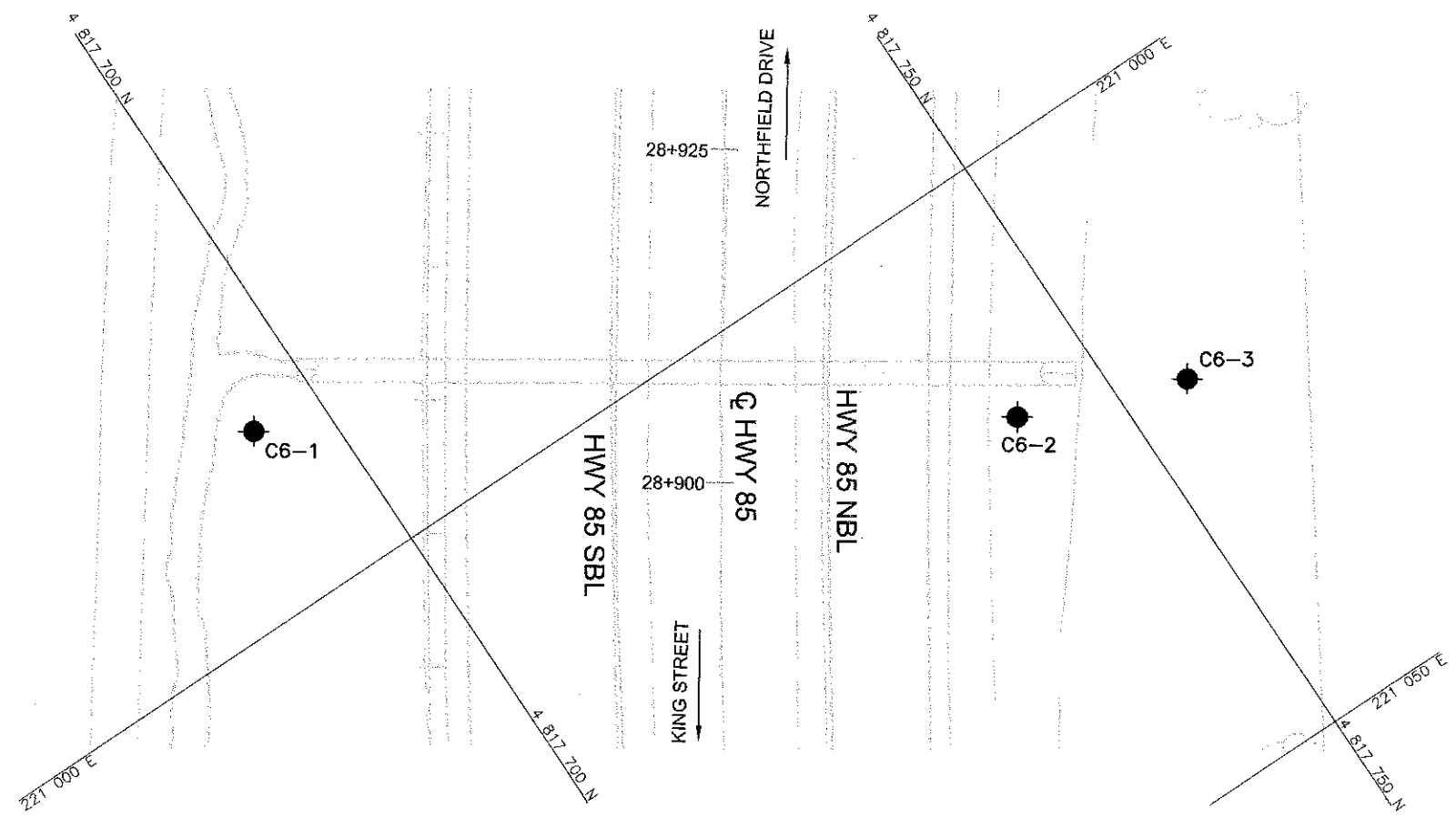
SHEET



LEGEND

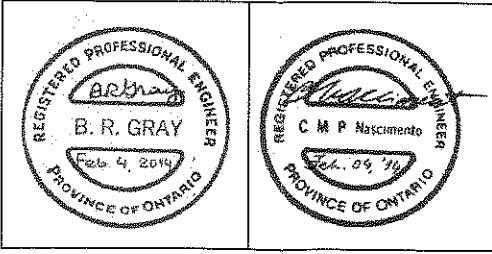
	Borehole
	Dynamic Cone Penetration Test (Cone)
	Borehole & Cone
N	Blows/0.3m (Std. Pen Test, 475 J/blow)
CONE	Blows/0.3m (60° Cone, 475 J/blow)
	WL at time of investigation May and July 2011
	Head
	ARTESIAN WATER Encountered
	PIEZOMETER

BH No	ELEVATION	NORTHINGS	EASTINGS
C6-1	333.2	4 817 694.6	220 986.8
C6-2	334.8	4 817 742.9	221 017.7
C6-3	335.3	4 817 755.1	221 022.4



Q PROFILE - CULVERT C6 AT STA. 28+908 NBL AND SBL HWY 85

- NOTES:
- DRAWING C6-1 SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND THE RECORD OF LOG OF BOREHOLES.
 - THE CULVERT AT STA. 28+908 WAS DESIGNATED AS CULVERT C6 FOR THE INVESTIGATION PURPOSE.
 - THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
 - DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.
 - CULVERT STATION IS DEPICTED IN CONTRACT DRAWING 2012-3011.



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

REVISIONS

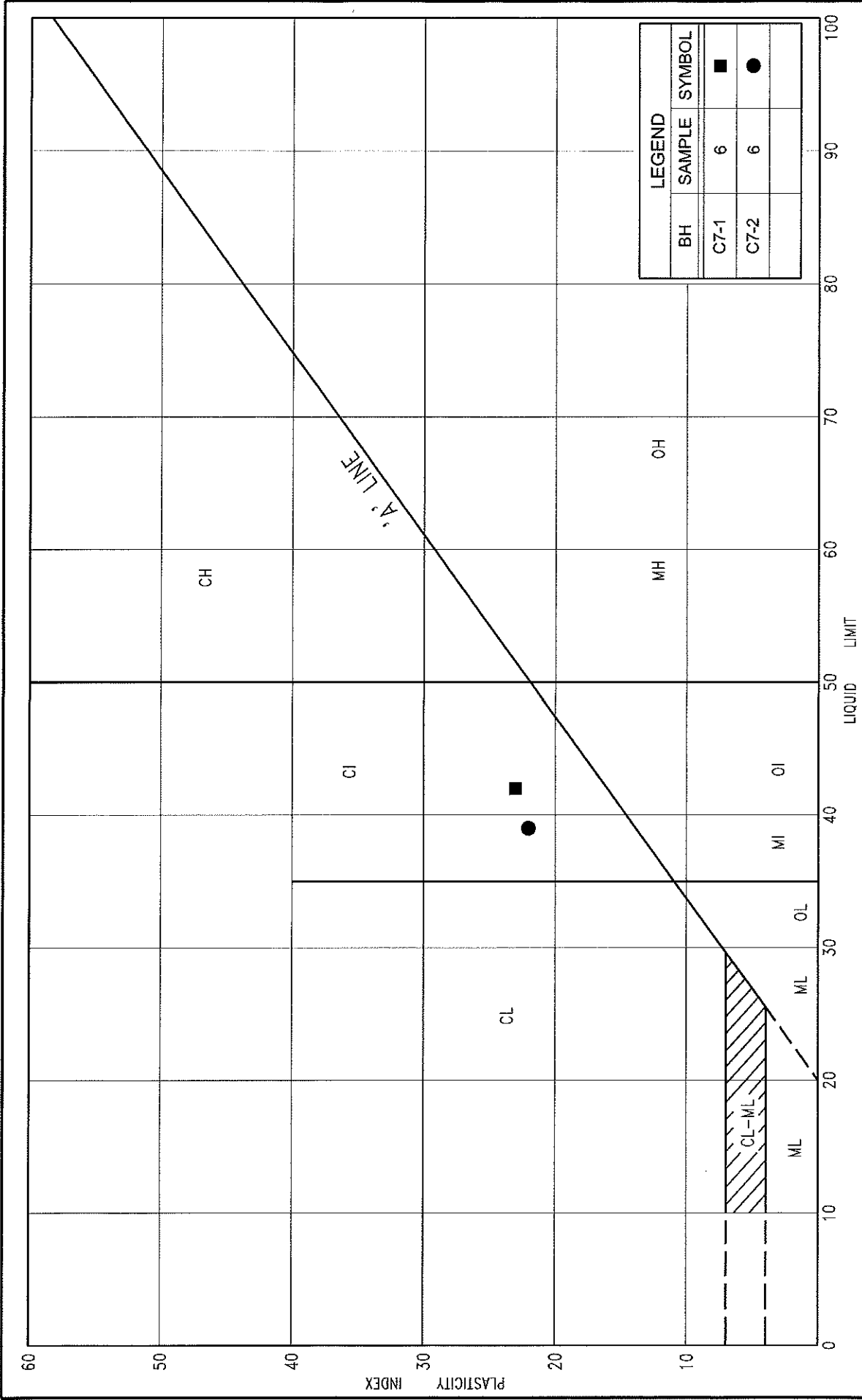
DATE	BY	DESCRIPTION


Geocres No. 40P7-67

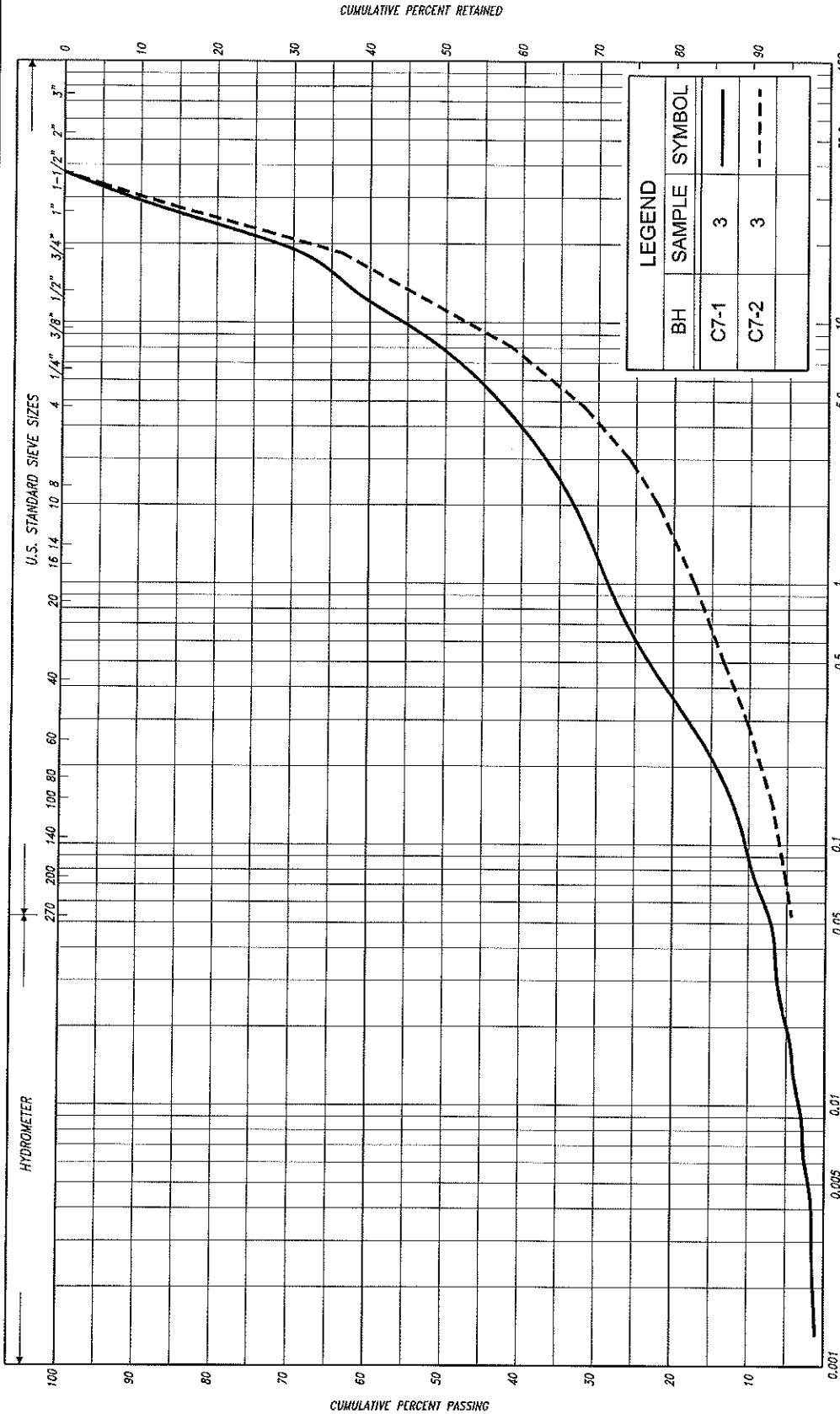
HWY No	85	CHECKED NSB	DATE FEB. 04, 2014	SITE	London
SUBM'D	NA	CHECKED CN	APPROVED BRG	DWG	C6-1

Ref. MRC Drawing: 2010362_Alignment.dwg

Culvert C7 – Sta. 9+664 (N-E/W Ramp Chainage), Township of Woolwich
Figure C7-PC-1 – Result of Atterberg Limits Testing
Figures C7-GS-1 and C7-GS-2 – Results of Grain Size Distribution Analyses
Record of Borehole Sheets
Drawing C7-1 – Borehole Locations and Soil Strata



	PLASTICITY CHART	
	SILTY CLAY, trace sand, trace gravel (TILL)	
	FIG No.	C7-PC-1
HWY: 85		
G.W.P. No. 168-89-00		



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

GRAIN SIZE DISTRIBUTION

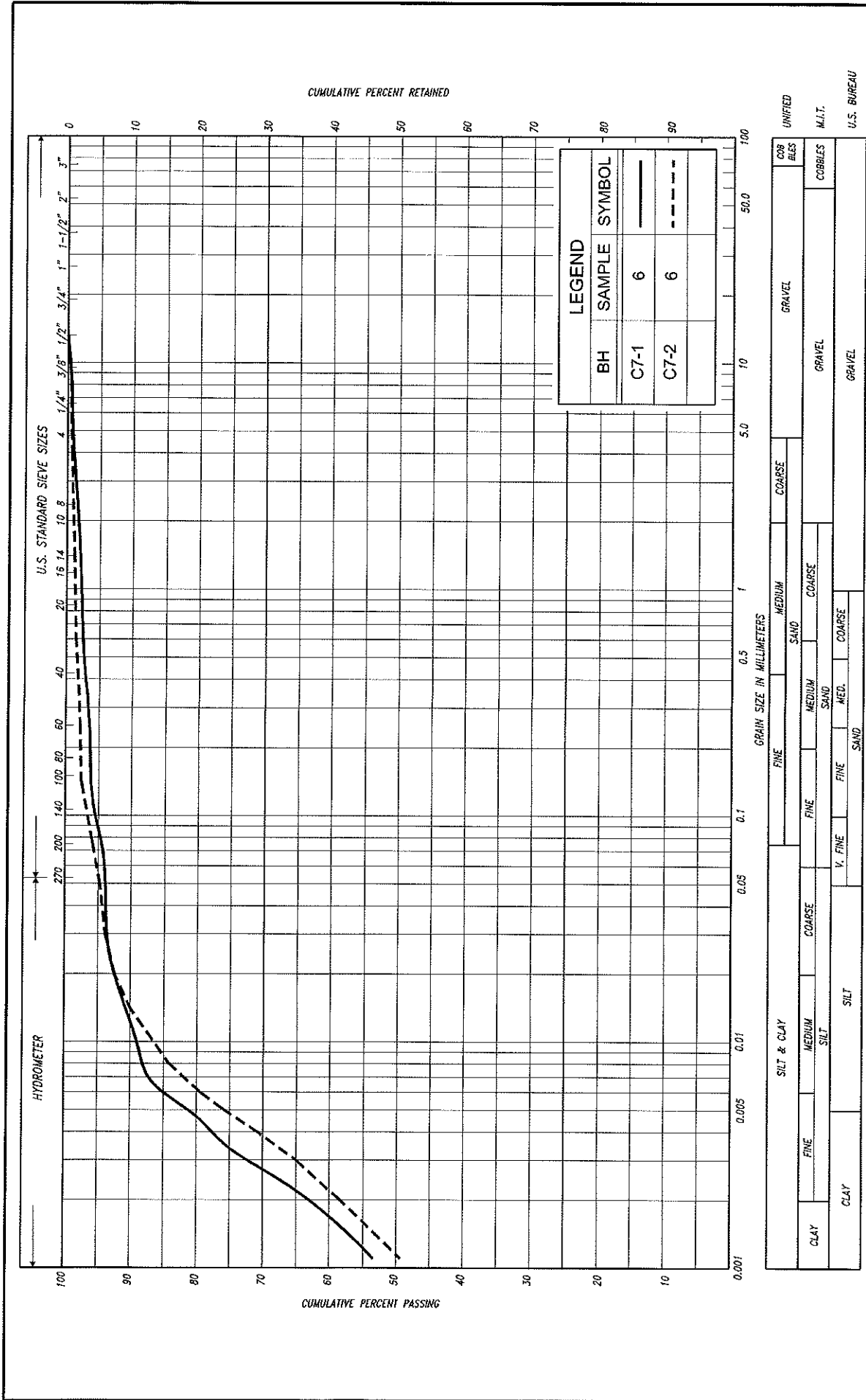
SANDY GRAVEL to GRAVEL, trace silt, trace clay

FIG No. C7-GS-1

HWY: 85

G.W.P. No. 168-89-00





GRAIN SIZE DISTRIBUTION

SILTY CLAY, trace sand, trace gravel

(TILL)

FIG No. C7-GS-2

HWY: 85

G.W.P. No. 168-89-00



RECORD OF BOREHOLE No C7-1

1 of 1

METRIC

G.W.P. 168-89-00

LOCATION Coords: 4 819 925.8 N; 220 172.2 E

ORIGINATED BY F.P.

DIST London HWY 85 BOREHOLE TYPE Continuous Flight Solid Stem Augers

COMPILED BY N.S.B.

DATUM Geodetic DATE May 13, 2011

CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa									
								20 40 60 80 100									
336.2	Ground Surface																
0.0	Silty sand, some gravel cobbles		1	SS	9	▽*	336										
335.6	Loose Brown Moist (FILL)		2	SS	20/18cm												
0.6	Sand and gravel cobbles and boulders					▼*	335										
	Compact Brown Wet to dense		3	SS	35											57 34 7 2	
	trace silt, trace clay sandy gravel layers		4	SS	34		334										
332.8	Silty clay trace sand, trace gravel		5	SS	23		333										
3.4	Very stiff Brown/ Moist grey (TILL)		6	SS	18		332									1 5 31 63	
331.2	End of borehole		7	SS	25												
5.0	Sample 2: Sampler bouncing																
	Samples 2, 3 & 4 combined for Grain size analysis																
	* 2011 05 13																
	▽ Water level observed during drilling																
	▼ Water level measured after drilling																
	■ Penetrometer test																
	Note: Borehole cave-in at 1.8m																

RECORD OF BOREHOLE No C7-2

1 of 1

METRIC

G.W.P. 168-89-00 LOCATION Coords: 4 819 919.2 N; 220 185.1 E ORIGINATED BY F.P.
DIST London HWY 85 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY N.S.B
DATUM Geodetic DATE May 13, 2011 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
337.9	Ground Surface							20	40	60	80	100								
0.0	Topsoil		1	SS	8															
337.4	Sand and gravel, trace silt cobbles and boulders		2	SS	28															
0.5	Compact Brown Wet to dense																			
	gravel layers		3	SS	38															
			4	SS	19															
334.5	Silty clay trace sand, trace gravel		5	SS	32															
3.4	Very stiff Brown/ Moist grey (TILL)		6	SS	16															
			7	SS	16															
332.7	End of borehole																			
5.2	Samples 3 & 4 combined for Grain size analysis																			

RECORD OF BOREHOLE No C7-3

1 of 1

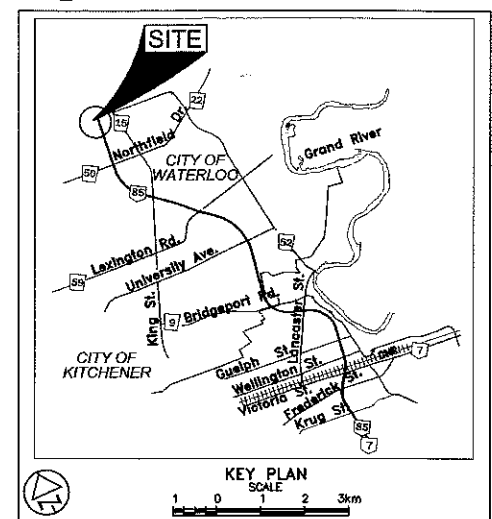
METRIC

G.W.P. 168-89-00 LOCATION Coords: 4 819 923.7 N; 220 199.5 E ORIGINATED BY R.B.
DIST London HWY 85 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY N.S.B.
DATUM Geodetic DATE April 13, 2011 CHECKED BY C.N.









SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								20 40 60 80 100										20 40 60		
337.7	Ground Surface																			
0.0	140mm asphalt over Crushed gravelly sand, trace silt		1	AS	-															
	Compact Brown Moist to dense																			
	Sand with gravel cobbles		2	SS	29															
	Clayey silt trace sand, trace gravel (FILL)		3	SS	34															
335.5																				
2.2	Gravelly sand, some silt																			
	Dense Brown Wet		4	SS	33															
			5	SS	40															
334.0																				
3.7	End of borehole																			

* 2011 04 13

Water level measured
after drilling



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)
 WL at time of investigation April and May 2011
 Head
 ARTESIAN WATER
 Encountered
 PIEZOMETER

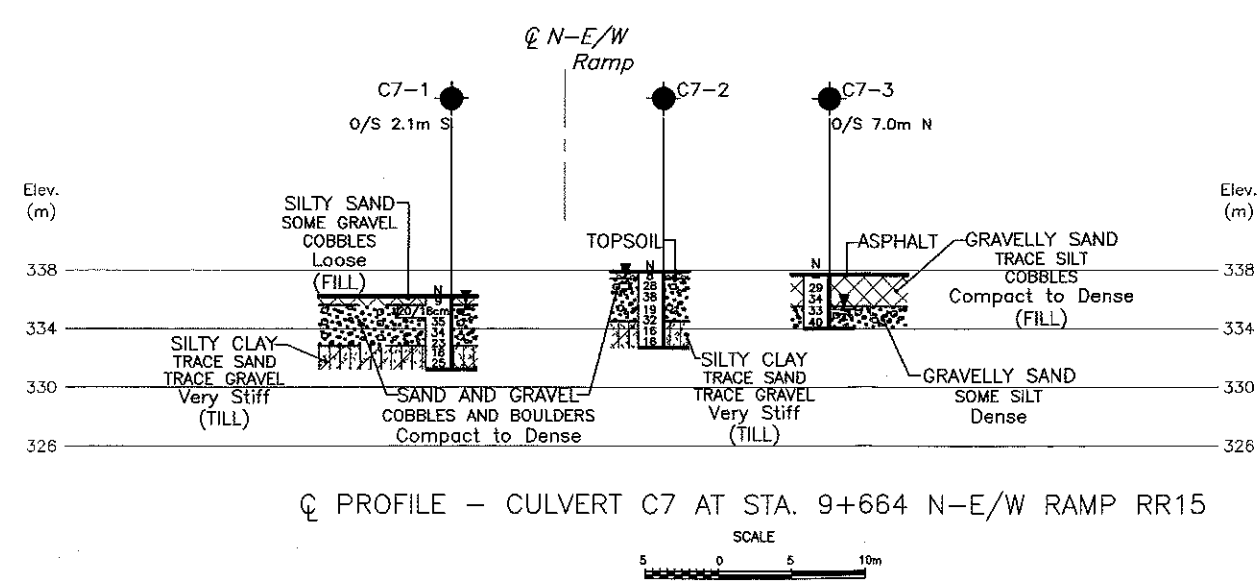
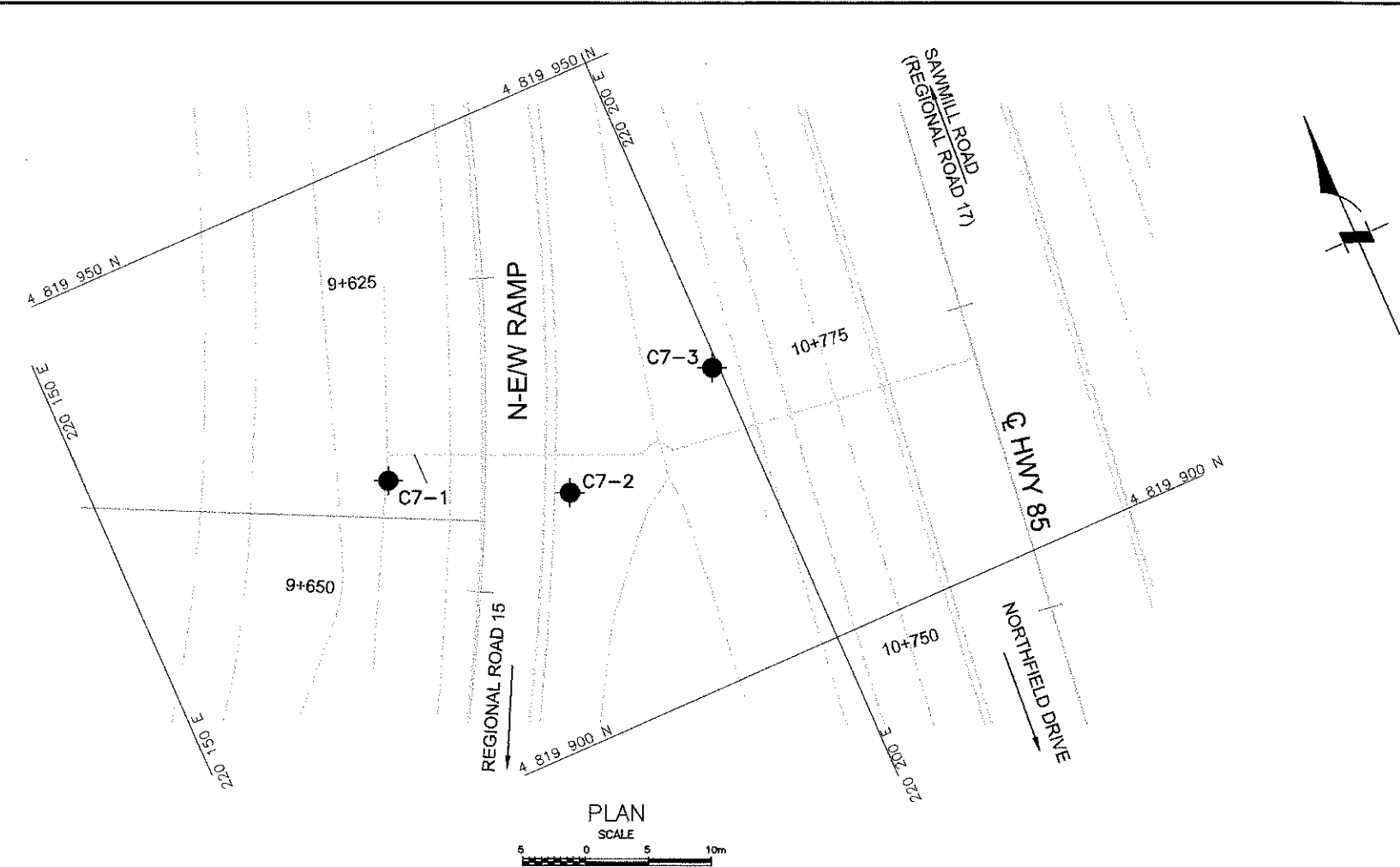
BH No	ELEVATION	NORTHINGS	EASTINGS
C7-1	336.2	4 819 925.8	220 172.2
C7-2	337.9	4 819 919.2	220 185.1
C7-3	337.7	4 819 923.7	220 199.5

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


REVISIONS

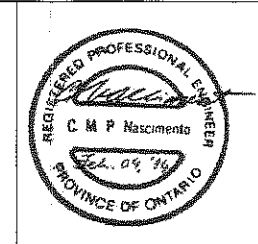
DATE	BY	DESCRIPTION

Geocres No. 40P7-67
HWY No 85
SUBMIT NA CHECKED NSB DATE FEB. 04, 2014 DIST London
DRAWN NA CHECKED CN APPROVED BRG SITE
DWG C7-1



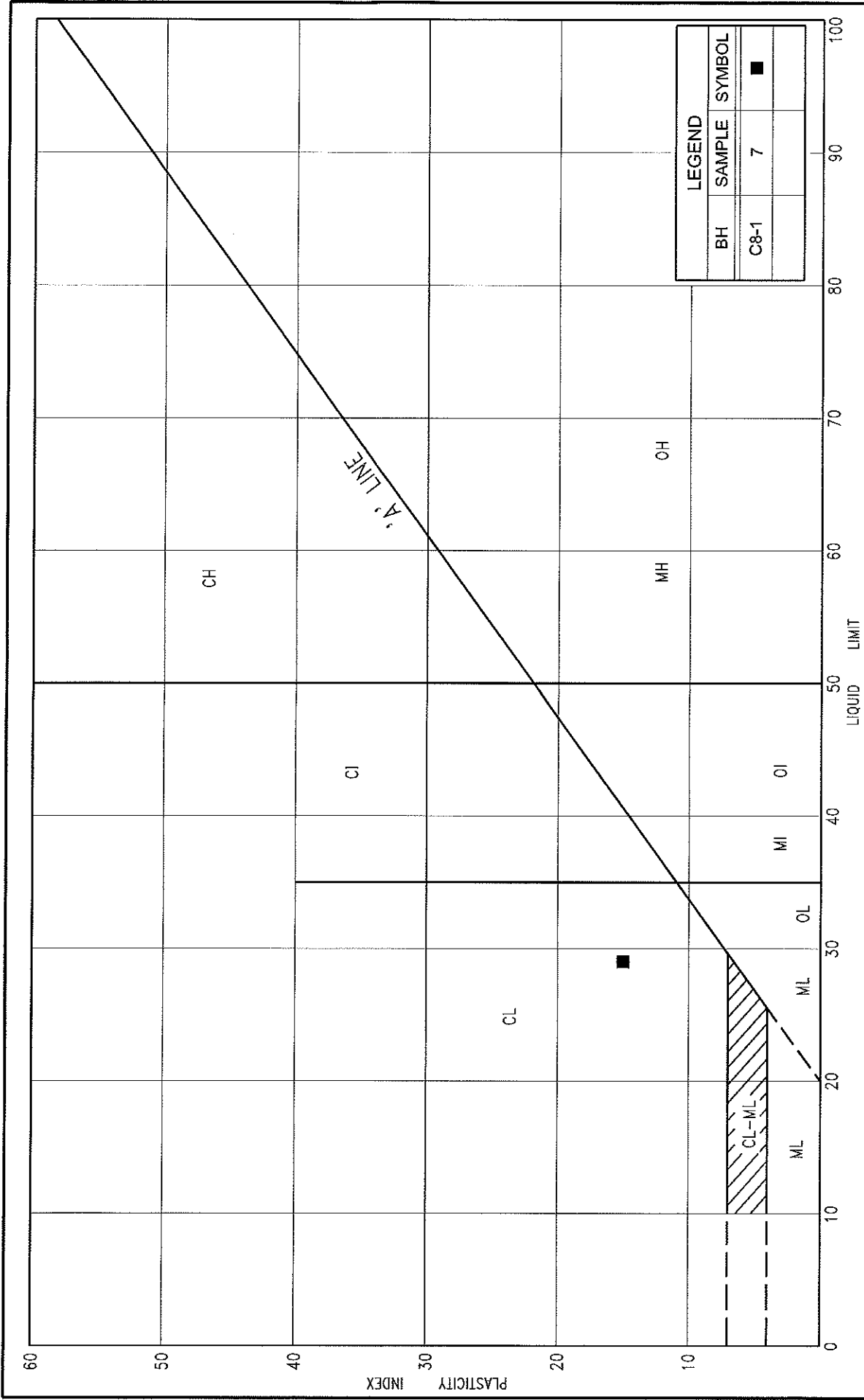
- NOTES:
- DRAWING C7-1 SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND THE RECORD OF LOG OF BOREHOLES.
 - THE CULVERT AT STA. 9+664 WAS DESIGNATED AS CULVERT C7 FOR THE INVESTIGATION PURPOSE.
 - THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
 - DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.
 - CULVERT STATION IS DEPICTED IN CONTRACT DRAWING 2012-3011.




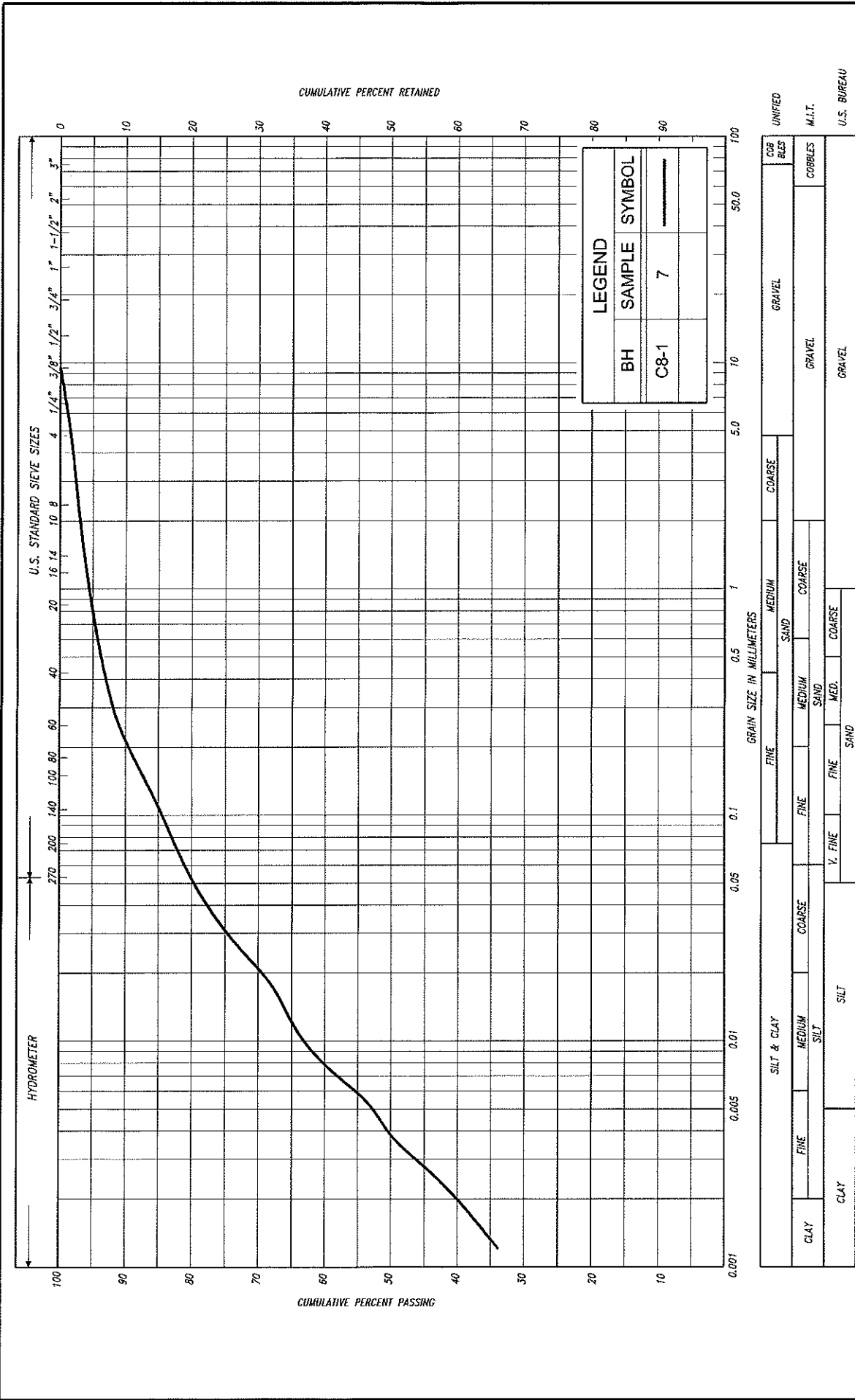


Ref. MRC Drawing: 2010362_Alignment.dwg;

Culvert C8 – Sta. 10+771 (Highway 85 Chainage), Township of Woolwich
Figure C8-PC-1 – Result of Atterberg Limits Testing
Figures C8-GS-1 and C8-GS-2 – Results of Grain Size Distribution Analyses
Record of Borehole Sheets
Drawing C8-1 – Borehole Locations and Soil Strata



	PLASTICITY CHART CLAYEY SILT, some sand, trace gravel (TILL)	FIG No. C8-PC-1
		HWY: 85
		G.W.P. No. 168-89-00



**Ontario**

GRAIN SIZE DISTRIBUTION

CLAYEY SILT, some sand, trace gravel
(TILL)

FIG No. C8-GS-2

HWY: 85

G.W.P. No. 168-89-00

RECORD OF BOREHOLE No C8-1

1 of 1

METRIC

G.W.P. 168-89-00

LOCATION Coords: 4 819 919.9 N; 220 219.7 E

ORIGINATED BY F.P.

DIST London

HWY 85

BOREHOLE TYPE Dynamic Ram Sounder

COMPILED BY N.S.B

DATUM Geodetic

DATE July 18, 2011

CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)		
								○ UNCONFINED		+ FIELD VANE							● QUICK TRIAXIAL × LAB VANE		
336.9	Ground Surface						20	40	60	80	100	20	40	60	kN/m ³	GR SA SI CL			
336.7	Topsoil																		
0.2	Silt, trace sand		1	SS	20														
336.4	trace clay, trace gravel																		
0.5	Compact Brown Moist																		
336.1	Clayey silt		2	SS	37														
0.8	trace sand, trace gravel																		
	Very stiff Brown Moist																		
	Sandy gravel, trace silt		3	SS	38														
	Dense Brown Moist to wet																		
	limestone pockets		4	SS	25											64 34 (4)			
	Compact to dense																		
333.2			5	SS	32														
3.7	Clayey silt																		
	some sand, trace gravel		6	SS	31														
	Hard Brown Moist																		
	Very stiff Grey		7	SS	20											2 15 43 40			
331.6	(TILL)																		
5.3	End of borehole																		
<div>* 2011 07 18</div> <div>▽ Water level observed during drilling</div> <div>▼ Water level measured after drilling</div>																			

* 2011 07 18

▽ Water level observed during drilling

▼ Water level measured after drilling

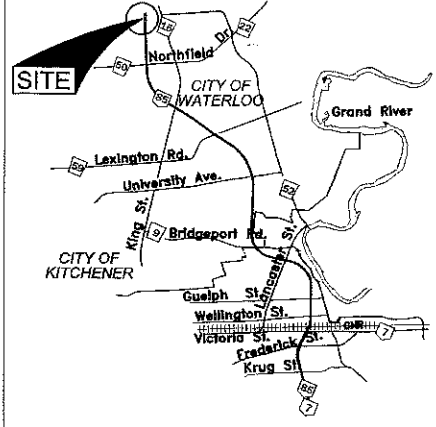
CONT No
GWP No 168-89-00



CULVERT AT STA. 10+771
(SBL HWY 85) (C8)
HIGHWAY 85 WOOLWICH TWP
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

PML Peto MacCallum Ltd
CONSULTING ENGINEERS



KEY PLAN
SCALE
1 0 1 2 3km

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)
- WL at time of investigation April and July 2011
- Head
- ARTESIAN WATER
- Encountered
- PIEZOMETER

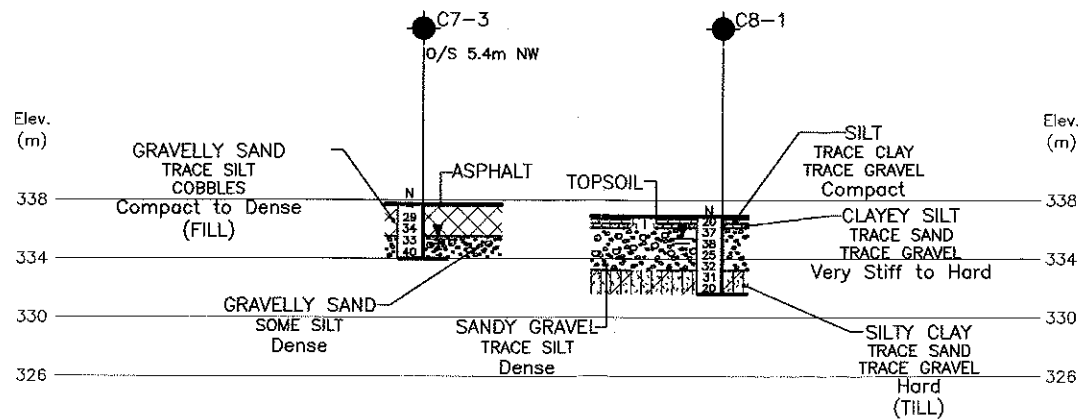
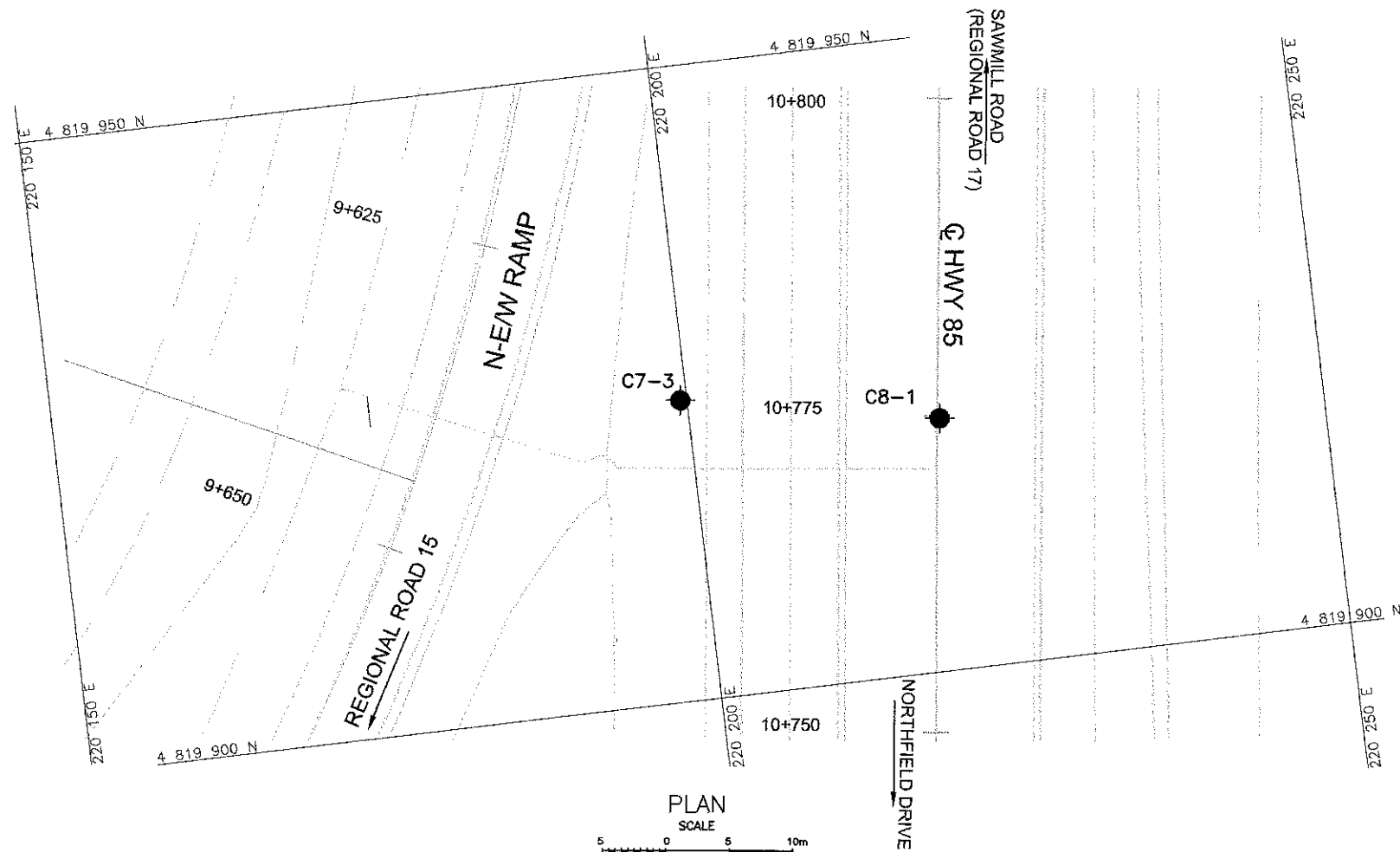
BH No	ELEVATION	NORTHINGS	EASTINGS
C7-3	337.7	4 819 923.7	220 199.5
C8-1	336.9	4 819 919.9	220 219.7

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

DATE	BY	DESCRIPTION

Geocres No. 40P7-67

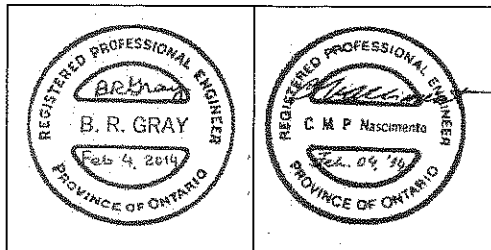
HWY No. 85	CHECKED NSB	DATE FEB. 04, 2014	SITE
SUBM'D NA	CHECKED CN	APPROVED BRG	DWG C8-1



CULVERT C8 AT STA. 10+771 SBL HWY 85

NOTES:

- DRAWING C8-1 SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND THE RECORD OF LOG OF BOREHOLES.
- THE CULVERT AT STA. 10+771 WAS DESIGNATED AS CULVERT C8 FOR THE INVESTIGATION PURPOSE.
- THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY, SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
- DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.
- CULVERT STATION IS DEPICTED IN CONTRACT DRAWING 2012-3011.



REF MRC Drawing: 2010362_Alignment.dwg;