



December 2015

FOUNDATION INVESTIGATION AND DESIGN REPORT

**Culvert Rehabilitation, Reynolds Creek
Site No. 19-305/C, Station 22+760, Highway 401
Contract 3 Structure Replacements and Rehabilitation
GWP 3045-11-00
Ministry of Transportation, West Region**

Submitted to:

Mr. Adam Barg, P.Eng., Transportation Engineer
Stantec Consulting Ltd.
200 - 835 Paramount Drive
Stoney Creek, Ontario
L8J 0B4

REPORT



Report Number: 12-1132-0163-3000-R01

Geocres No.: 40I15-42

Distribution:

8 Copies - Stantec Consulting Ltd.

1 Copy - Golder Associates Ltd.





Table of Contents

PART A - FOUNDATION INVESTIGATION REPORT

1.0 INTRODUCTION.....	1
2.0 SITE DESCRIPTION.....	2
2.1 Site Geology	2
3.0 INVESTIGATION PROCEDURES	3
4.0 SUBSURFACE CONDITIONS.....	4
4.1 Site Stratigraphy	4
4.2 Soil Conditions.....	4
4.2.1 Topsoil	4
4.2.2 Pavement Structure and Fill Materials	4
4.2.3 Sand to Silty Sand.....	5
4.2.4 Clayey Silt.....	5
4.2.5 Sand and Gravel	5
4.2.6 Sandy Silt Glacial Till	5
4.3 Groundwater Conditions	6
5.0 MISCELLANEOUS	7

PART B - FOUNDATION DESIGN REPORT

6.0 ENGINEERING RECOMMENDATIONS.....	8
6.1 General.....	8
6.1 Construction Considerations.....	8
6.2 Excavations and Groundwater Control	8
6.3 Shoring and Temporary Roadway Protection	9
7.0 MISCELLANEOUS	11

LIST OF ABBREVIATIONS

LIST OF SYMBOLS

RECORD OF BOREHOLE SHEETS

FIGURE 1 - Key Plan

DRAWING 1 - Borehole Locations and Soil Strata



FOUNDATION INVESTIGATION AND DESIGN REPORT
CULVERT REHABILITATION, REYNOLDS CREEK, SITE 19-305/C, HIGHWAY 401

APPENDICES

APPENDIX A

Laboratory Test Data

APPENDIX B

Site Photographs

APPENDIX C

Foundation Drawing and Records of Boreholes Previous Investigation (Geocres No. 40I15-027)



PART A

FOUNDATION INVESTIGATION REPORT

**CULVERT REHABILITATION, REYNOLDS CREEK
SITE NO. 19-305/C, STATION 22+760, HIGHWAY 401
CONTRACT 3 STRUCTURE REPLACEMENTS AND REHABILITATION
GWP 3045-11-00
MINISTRY OF TRANSPORTATION - WEST REGION**



1.0 INTRODUCTION

Golder Associates Ltd. (Golder Associates) has been retained by Stantec Consulting Ltd. (Stantec) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out foundation investigations as part of the detail design work for GWP 3045-11-00. The project involves the detail design of the replacement and rehabilitation of several structures along multiple highways in southern Ontario. This report addresses the proposed rehabilitation of the culvert at Reynolds Creek (Site 19-305/C) at Station 22+760 on Highway 401 in the Geographic Township of North Dorchester in Middlesex County.

The purpose of the foundation investigation is to explore the subsurface conditions at the culvert location by drilling boreholes and carrying out in situ testing and laboratory testing on selected samples. The terms of reference for the scope of work are outlined in the MTO's Request for Proposal and in Golder Associates' proposal P2-1132-0163 dated February 25, 2013. The work was carried out in accordance with our Quality Control Plan for Foundations Engineering dated March 26, 2013.



2.0 SITE DESCRIPTION

The subject culvert is situated at Station 22+760 on Highway 401, approximately 200 metres west of Putnam Road in the Township of North Dorchester in Middlesex County, Ontario. The Town of Ingersoll is approximately 7.0 kilometres east of the site. The location of the culvert is shown on the Key Plan, Figure 1.

This section of Highway 401 is currently a six lane divided highway with paved shoulders and is generally oriented east-west in the vicinity of the subject site. Reynolds Creek flows in the culvert from south to north beneath Highway 401. The existing culvert is a concrete arch structure constructed in 1955 which was extended in 1992. The existing culvert has the following characteristics:

Dimensions (m)	Obvert Elevation (m)		Construction
	Lt ¹	Rt ¹	
15.24 x 7.62 x 159.60	267.72	267.77	Concrete Arch

NOTE: 1. When facing the direction of increasing chainage, Lt and Rt are defined as Left and Right of centreline, respectively.

The banks of the Reynolds Creek channel immediately upstream and downstream of the culvert are grass covered with concrete retaining walls in each corner. Reynolds Creek flows through forested areas, agricultural lands and a golf course adjacent to Highway 401. Site photographs are provided in Appendix B.

The culvert is situated in a rural area with low relief. The ground surface elevation at the N/S-W and W-N/S Ramps in the vicinity of the culvert is about 269 metres and the off-platform elevation in the vicinity of the culvert varies from about 262 to 263 metres.

2.1 Site Geology

The project area is located within the Mount Elgin Ridges physiographic region. This region is characterized by morainic ridges composed of pale brown calcareous clay or silty clay.¹ The overburden in the area of the site generally consists of modern alluvium deposits of clay, silt, sand and muck with some areas of glaciofluvial outwash and deltaic deposits.²

The geological mapping indicates that the underlying bedrock consists of brown and tan microcrystalline and sublithographic limestone of the Anderdon Member of the Lucas Formation of the Detroit River Group of Middle Devonian age.³ The bedrock surface at the site is at about elevation 238 metres with the overburden thickness being about 25 metres.⁴

¹ Chapman, L.J., and Putnam, D.F., 1984: Physiography of Southern Ontario; Ontario Geological Survey, Special Volume 2, 270p. Accompanied by Map. P.2715 (coloured), scale 1:600,000.

² Barnett, P.J. et al. 1976: Quaternary Geology of the Tillsonburg Area. Southern Ontario; Ontario Division of Mines Prelim. Map P.1214, scale 1:50,000.

³ Sanford B.V., 1969: Geology Toronto-Windsor Area, Ontario; Ontario Geological Survey of Canada Map 1263A, Scale 1:250,000.

⁴ Barnett, P.J. and Starkoski, A.L. 1978: Bedrock Topography of the Tillsonburg Area, Southern Ontario. Ontario Geological Survey Prelim. Map.P.1567, Scale 1:50,000.



3.0 INVESTIGATION PROCEDURES

The field work for the investigation was carried out on July 6 and 7, 2015, during which time five boreholes were drilled at the approximate locations shown on the Borehole Location Plan, Drawing 1.

The boreholes were drilled to depths of 7.9 to 16.1 metres using track-mounted CME 75 drilling equipment supplied and operated by a specialist drilling contractor. Samples of the overburden were typically obtained at depth intervals of 0.75 metres using 50 millimetre outside diameter split spoon sampling equipment in accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586). In addition, field vane shear strength testing was carried out in accordance with ASTM D2573 to determine the undrained shear strength of softer cohesive soils encountered in the boreholes.

The recorded SPT N values are noted on the Record of Borehole sheets. The results of the SPT testing as presented on the Record of Borehole sheets, Drawing 1 and in Section 4.0 of this report are unmodified (not standardized for hammer efficiency, borehole diameter, rod length, etc.). The samplers used in the investigation limit the maximum particle size that can be sampled and tested to about 40 millimetres. Therefore, particles or objects that may exist within the soils that are larger than this dimension have not been sampled or represented in the grain size distributions. Larger particle sizes, including cobbles and boulders, are known to be present in the fill and glacial till as discussed in the text of this report.

Groundwater conditions in the boreholes were observed throughout the drilling operations and a standpipe was installed in borehole 101 as indicated on the corresponding Record of Borehole sheet. The boreholes were backfilled in accordance with current MTO procedures and Ontario Regulation 903 (as amended).

The field work was monitored on a full-time basis by experienced members of our staff who located the boreholes in the field, monitored the drilling, sampling and in situ testing operations and logged the boreholes. The samples were identified in the field, placed in labelled containers and transported to our London laboratory for further examination and testing. Index and classification tests, consisting of water content determinations, Atterberg limits determinations and grain size distribution analyses, were carried out on selected samples. The results of the testing are shown on the Record of Borehole sheets and in Appendix A.

The as-drilled borehole locations and ground surface elevations are shown on the Record of Borehole sheets and on Drawing 1. The table below summarizes the coordinates, ground surface elevations and depths of the boreholes.

Borehole	Location (m)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
101	4 760 463	186 295	262.1	8.1
102	4 760 485	186 314	268.8	11.1
103	4 760 439	186 336	262.8	8.1
104	4 760 614	186 289	268.7	16.1
105	4 760 624	186 247	263.0	7.9



4.0 SUBSURFACE CONDITIONS

4.1 Site Stratigraphy

The detailed subsurface soil and groundwater conditions encountered in the boreholes, together with the results of the in situ testing and the laboratory testing carried out on selected samples, are given on the attached Record of Borehole sheets following the text of this report and in Appendix A. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous samples and observations of drilling resistance and, therefore, may represent transitions between soil types rather than exact planes of geological change. Further, the subsurface conditions will vary between and beyond the borehole locations.

The boreholes drilled at the site generally encountered the existing pavement structure or topsoil overlying variable embankment fill materials then, in sequence, native sand, silty sand, or sand and gravel which overlies a layer of clayey silt, which is in turn underlain by sand, sand and gravel, or sandy silt glacial till. The subsurface conditions were consistent with those reported in Record of Boreholes 2 and 6 of Geocres Report No. 40I15-027. The Foundation Drawing and Record of Boreholes advanced for the 1992 extension of the Reynolds Creek Culvert are presented in Appendix C. The locations and elevations of the boreholes, together with the interpreted stratigraphic profile, are shown on Drawing 1. A detailed description of the subsurface conditions encountered in the boreholes is provided on the Record of Borehole sheets and is summarized in the following sections.

4.2 Soil Conditions

4.2.1 Topsoil

Between 0.2 and 1.4 metres of topsoil was encountered at the ground surface in boreholes 101, 103 and 105. The topsoil in borehole 105 had an N value, as determined in the standard penetration testing, of 6 blows per 0.3 metres. A sample of the topsoil had a water content of 31 per cent.

Materials designated as topsoil in this report were classified solely based on visual and textural evidence. Testing of organic content or for other nutrients was not carried out. Therefore, the use of materials classified as topsoil cannot be relied upon for support and growth of landscaping vegetation.

4.2.2 Pavement Structure and Fill Materials

Boreholes 102 and 104 were advanced in the shoulders of the W-N/S and N/S-W ramps, respectively, and encountered 180 and 150 millimetres of asphalt at the shoulder surface.

The asphalt in boreholes 102 and 104 was underlain by 7.3 and 8.2 metres of granular fill materials to elevations 261.3 and 260.3 metres, respectively. The topsoil in boreholes 101 and 103 was underlain by 1.2 and 2.7 metres of granular fill materials, respectively. Cobbles were noted within the fill materials.

Standard penetration test N values in the very loose to very dense fill materials ranged from 2 to greater than 100 blows per 0.3 metres. Water contents of samples of the fill materials ranged from 3 to 68 per cent, but were typically less than about 15 per cent. Grain size distribution curves for samples of the fill materials are presented on Figure A-1 in Appendix A.



4.2.3 Sand to Silty Sand

Layers of loose to compact sand to silty sand, 0.8 and 2.1 metres thick, were encountered beneath the fill in borehole 102 and the topsoil in borehole 105, respectively, at elevations 261.3 and 261.7 metres. The sand to silty sand had N values of 5 to 18 blows per 0.3 metres. Samples of the sand to silty sand had water contents of 23 to 31 per cent. A grain size distribution curve for a sample of the sand is provided on Figure A-2.

4.2.4 Clayey Silt

Clayey silt was encountered beneath the fill materials in borehole 101 and 103, beneath layers of sand in boreholes 102 and 105, and beneath a layer of sand and gravel in borehole 104. The clayey silt layers were encountered between elevations 259.5 and 260.7 metres and were between 2.1 and 5.7 metres thick where fully penetrated. Boreholes 102 and 103 were terminated in the clayey silt after penetrating the layers for 2.9 and 5.2 metres, respectively. Silt and sandy silt seams were noted within the clayey silt layers.

The clayey silt had N values of 4 to 48 blows per 0.3 metres, indicating firm to hard consistency. Field vane shear strength testing carried out in the clayey silt indicated undrained shear strengths of 96 to greater than 144 kilopascals indicating stiff to very stiff consistency.

Samples of the clayey silt had water contents of 21 to 26 per cent. Seven Atterberg limits determinations carried out on samples of the clayey silt yielded liquid limits ranging from 23 to 28 per cent, plastic limits ranging from 15 to 17 per cent and plasticity indices ranging from 7 to 11 per cent, indicating low plasticity. The results of the Atterberg limits determinations are shown on Figure A-6. Grain size distribution curves for samples of the clayey silt are provided on Figure A-3.

4.2.5 Sand and Gravel

Layers of compact to dense sand and gravel were encountered beneath the clayey silt in borehole 101 and beneath the fill and the clayey silt in borehole 104 between elevations 255.0 and 260.3 metres. The sand and gravel layers in borehole 104 were 0.6 and 1.8 metres thick. Borehole 101 was terminated in the sand and gravel after penetrating the layer for 1.0 metre. Standard penetration test N values in the sand and gravel ranged from 14 to 50 blows per 0.3 metres. Water contents of samples of the sand and gravel ranged from 8 to 18 per cent. Grain size distribution curves for samples of sand and gravel are presented on Figure A-4.

Although not explicitly encountered in the boreholes, cobbles and boulders should be expected in the sand and gravel.

4.2.6 Sandy Silt Glacial Till

Compact to very dense sandy silt glacial till was encountered beneath the sand and gravel in borehole 104 and the clayey silt in borehole 105 at elevations 254.1 and 257.4 metres, respectively, to the termination depths of the boreholes. The layers were penetrated for 1.4 and 2.2 metres. The sandy silt till had N values ranging from 19 to greater than 100 blows per 0.3 metres. Samples of the sandy silt till had water contents of 9 to 19 per cent. Based on two grain size distribution analyses carried out on samples of the sandy silt till, the results of which are provided on Figure A-5, the sandy silt till ranged in gradation from sandy silt to sand and silt. Cobbles and boulders should be anticipated within the sandy silt glacial till deposit.



4.3 Groundwater Conditions

Groundwater conditions were observed during and on completion of drilling and sampling and a groundwater observation standpipe was installed in borehole 101. Installation details are provided on the corresponding Record of Borehole sheet following the text of this report. Groundwater was encountered in each of the boreholes during drilling between depths of 1.8 and 8.4 metres, or between elevations 258.3 and 264.4 metres. A summary of the encountered groundwater levels is provided in the table below.

Borehole	Ground Surface Elevation (m)	Encountered Groundwater Elevation (m)
101	262.1	258.3
102	268.8	264.4
103	262.8	260.5
104	268.7	260.3
105	263.0	261.2

The above-noted encountered water levels are not considered to be representative of the long-term, stabilized groundwater conditions.

Upon completion of drilling borehole 101 on July 6, 2015, artesian conditions were encountered at the termination depth of the borehole, elevation 254.0 metres. The water level was subsequently measured in the standpipe installed in borehole 101 between 0.9 and 1.2 metres above the ground surface, as summarized below.

Date	Measured Groundwater Level (m)	
	Elevation	Height Above Ground Surface
July 6, 2015	262.97	0.91
July 10, 2015	263.00	0.94
July 31, 2015	262.97	0.91
August 24, 2015	263.22	1.16

The corresponding water level in Reynolds Drain was measured at elevation 261.4 metres at the culvert inlet on July 6, 2015. The preliminary General Arrangement Drawing indicates a water level in the drain of elevation 260.99 metres in January 2015.

Based on the observed groundwater levels, the surrounding topography and water level in the drain, the groundwater level in the near surface granulars is inferred to typically be at about elevation 261.5 metres. Perched groundwater may be present in the granular fills above the clayey silt, as evidenced by the encountered water level in borehole 102. Flowing artesian conditions are present within the sand and gravel deposit below



elevation 255 metres. Groundwater levels should be expected to fluctuate seasonally and are expected to be higher during periods of sustained precipitation or during spring snow melt conditions.


5.0 MISCELLANEOUS



The investigation was carried out using equipment supplied and operated by London Soil Test Inc., an Ontario Ministry of Environment and Climate Change licensed well contractor. The field operations were supervised by Mr. Brett Thorner, E.I.T. under the direction of the Field Investigation Manager, Mr. David J. Mitchell. The laboratory testing was carried out at Golder Associates' London laboratory under the direction of Mr. Chris M. Sewell. The laboratory is an accredited participant in the MTO Soil and Aggregate Proficiency Program and is certified by the Canadian Council of Independent Laboratories for testing Types C and D aggregates. This report was prepared by Ms. Nicole A. Gould, P.Eng. under the direction of the Project Engineer, Ms. Dirka U. Prout, P.Eng. This report was reviewed by Mr. Michael E. Beadle, P.Eng., an Associate and Geotechnical Engineer with Golder Associates. Mr. Fintan J. Heffernan, P.Eng., the Designated MTO Contact and Quality Control Auditor for this assignment, conducted an independent quality review of the report.

GOLDER ASSOCIATES LTD.



Dirka U. Prout, P.Eng.
Project Engineer


Michael E. Beadle, P.Eng.
Associate



Fintan J. Heffernan, P.Eng.
MTO Designated Contact

NG/DUP/MEB/cr

Golder, Golder Associates and the GA globe design are trademarks of Golder Associates Corporation.

n:\active\2012\1132 - geo\1132-0100\12-1132-0163 stantec-fdns-mega culverts-3011-e-0041\ph 3000-gwp 3045-11-00\rpts\r01 - 19-305 (reynolds)\1211320163-3000-r01 dec 1 15 (final)
part a&b fdns rehab clvrt 19-305.docx



PART B

FOUNDATION DESIGN REPORT

**CULVERT REHABILITATION, REYNOLDS CREEK
SITE NO. 19-305/C, STATION 22+760, HIGHWAY 401
CONTRACT 3 STRUCTURE REPLACEMENTS AND REHABILITATION
GWP 3045-11-00
MINISTRY OF TRANSPORTATION - WEST REGION**



6.0 ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides recommendations on the geotechnical aspects of the design of the proposed rehabilitation of Culvert Site 19-305/C at Reynolds Creek at Station 22+760 on Highway 401 in the Township of North Dorchester in Middlesex County, Ontario.

The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the investigation at this site. The interpretation and recommendations are intended to provide the designers with sufficient information for design. As such, where comments are made on construction, they are provided only to highlight those aspects which could affect the design of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

The existing culvert is a 159.6 metre long concrete arch structure with a width of 15.2 metres and a 7.6 metre high opening. The culvert has invert elevations of 260.8 and 260.7 metres at the inlet and outlet, respectively. The existing culvert was constructed in 1955 and subsequently extended at both ends to its current length in 1992. Approximately 5.0 metre long concrete retaining walls are present at each corner. A visual assessment of the pavement and embankment side slopes above and adjacent to the culvert was carried out at the time of the field investigation. No evidence of foundation related distress or instability of the embankment side slopes was noted.

It is understood that the rehabilitation work will include repair of deteriorated concrete in the culvert barrel and injection of polyurethane grout into cracks and construction joints.

6.1 Construction Considerations

Sediment control, such as silt fences and erosion control blankets, may be required during construction. All retaining wall and culvert foundations must be protected against scour as noted in the Canadian Highway Bridge Design Code Section 1.9.5.

6.2 Excavations and Groundwater Control

Excavations to access the culvert exterior are expected to extend through the existing fill and may penetrate into the underlying native sands and silts. Excavations for the culvert repairs are not expected to extend below the inferred groundwater level of elevation 261.5 metres. Perched groundwater may be encountered within the granular embankment fills as noted in borehole 102 where the encountered groundwater level was approximately 3 metres above the inferred groundwater level. Some groundwater seepage from the native granulars and granular fill should be anticipated, particularly after major precipitation events. The excavations are not expected to extend to a sufficient depth to be affected by artesian conditions noted in borehole 101 some 7 metres below the culvert inlet. Water seepage into the excavations should be expected and will be more significant during periods of sustained precipitation. It is considered that any water accumulating in the excavations can be controlled by pumping from properly constructed and filtered sumps located in the base of the excavations. Depending on the timing of construction, seasonal variation potentially resulting in groundwater levels higher than those encountered during the investigation should be expected.



Surface water runoff should be directed away from the excavations at all times. The existing culvert flows may need to be diverted/piped during construction. The appropriate Non-Standard Special Provision (NSSP) should be included in the contract documents to alert the contractor about the need for adequate control of surface and groundwater flows and warn about the existence of artesian conditions.

Temporary open cut slopes within the fill materials should be maintained no steeper than 1 horizontal to 1 vertical. Localized sloughing and ground movements, however, should be expected and may necessitate flattening of the cut slopes. All excavations should be carried out in accordance with the latest edition of the Ontario Occupational Health and Safety Act and Regulations for Construction Projects. The native sands, silts and sand and gravel below the groundwater level and the fill materials would be classified as Type 3 soils. The native sands, silts and sand and gravel above the groundwater level or properly dewatered below the inferred groundwater level, the clayey silt and the glacial till would be classified as Type 2 soils.

6.3 Shoring and Temporary Roadway Protection

It is expected that excavations for the culvert repairs may require shoring to limit the extent of excavation. Temporary support systems could consist of cantilevered soldier piles and lagging or steel sheet piles. Cobbles were encountered within the fill materials at the site. The contractor should be prepared for the presence of cobbles and boulders within the fill materials, sand and gravel and glacial tills which may impede installation of the steel sheet piles. The appropriate NSSP should be included in the Contract Documents to alert the contractor about the presence of cobbles encountered within the fill materials and the potential for the presence of cobbles and boulders within the glacial tills at this site.

Excavation support systems should be designed and constructed in accordance with Ontario Provincial Standard Specification (OPSS) 539 and the design should limit the lateral movement of the temporary shoring system to meet Performance Level 2. The contractor is responsible for the complete detailed design of the protection system.

Where the support to the wall is provided by anchors or rakers, the wall design should be based on a triangular earth pressure distribution using the design parameters given below. The raker/anchor support must be designed to accommodate the loads applied from pressures and surcharge pressures from area, line or point loads as well as the impact of sloping ground behind the system. Passive toe restraint to the soldier piles may be determined using a triangular pressure distribution acting over an equivalent width equal to three times the pile socket diameter.

The unfactored triangular earth pressure distribution (p' in kN/m^2 ; increasing with depth) can be calculated as follows:

$$p' = K_a (H - h_w) \gamma + K_a (\gamma - \gamma_w) h_w + \gamma_w h_w + K_a q$$

where: H = the height of the excavation at any point in metres

K_a = active coefficient of earth pressure

γ = soil unit weight

γ_w = unit weight of water or 9.8 kN/m^3



q = surcharge for traffic and other loading

h_w = height of groundwater level above excavation base; water level to be taken as elevation 261.5 metres

Braced excavations with struts and walers will likely be required for temporary shoring excavations for repair of the culvert.

For braced excavations in granular fill and native materials, the unfactored rectangular earth pressure distribution (p in kN/m^2 ; constant with depth), can be calculated as follows:

$$p = 0.65 K_a (\gamma H + q)$$

where H = the height of the excavation at any point in metres

K_a = active coefficient of earth pressure

γ = soil unit weight

q = surcharge for traffic and other loading

The support systems may be designed using the parameters provided in the table below. These parameters are provided to assist with design for the unfactored ultimate resistance and loading conditions and may not result in a temporary support design that adequately controls ground and structure displacements. Achieving adequate displacement control in accordance with the MTO performance criteria may require designs that result in a system that is stiffer than might otherwise be required based on the soil parameters provided in the table below.

Soil Type	Coefficient of Earth Pressure			Internal Angle of Friction (degrees)	Bulk Unit Weight $\square(\text{kN/m}^3)$	Effective Unit Weight $\square(\text{kN/m}^3)$
	Active, K_a	At Rest, K_o	Passive, K_p			
Fill	0.36	0.53	2.8	28	19	9.0
Clayey Silt	0.36	0.53	2.8	28	19	9.0
Sand to Silty Sand	0.33	0.50	3.0	30	19	9.0
Sand and Gravel	0.28	0.44	3.5	34	22	12.0
Sandy Silt Till	0.28	0.44	3.5	34	22	12.0

The earth pressure coefficients identified above may be applied assuming a horizontal ground surface behind the retaining structure. Where the ground surface behind the retaining structure is sloped, the earth pressure coefficients provided in the table above must be increased accordingly.



7.0 MISCELLANEOUS

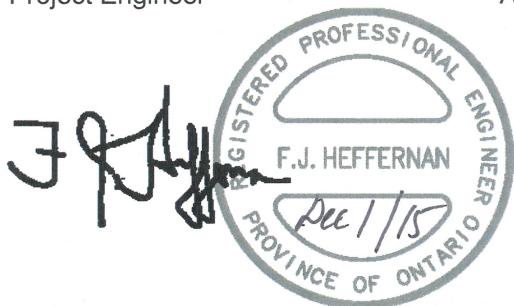
This section of the report was prepared by Ms. Nicole A. Gould, P.Eng. under the direction of the Project Engineer, Ms. Dirka U. Prout, P.Eng. The report was reviewed by Mr. Michael E. Beadle, P.Eng., an Associate and Geotechnical Engineer with Golder Associates. Mr. Fintan J. Heffernan, P.Eng., the Designated MTO Contact and Quality Control Auditor for this assignment, conducted an independent quality review of the report.

GOLDER ASSOCIATES LTD.



Dirka U. Prout, P.Eng.
Project Engineer

Michael E. Beadle, P.Eng.
Associate



Fintan J. Heffernan, P.Eng.
MTO Designated Contact

NG/DUP/MEB/cr

Golder, Golder Associates and the GA globe design are trademarks of Golder Associates Corporation.

n:\active\2012\1132 - geo\1132-0100\12-1132-0163 stantec-fdns-mega culverts-3011-e-0041\ph 3000-gwp 3045-11-00\vrpts\vr01 - 19-305 (reynolds)\1211320163-3000-r01 dec 1 15 (final)
part a&b fdns rehab clvrt 19-305.docx

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

III. SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	N Blows/300 mm or Blows/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split spoon sampler for a distance of 300 mm (12 in.)

(b) Cohesive Soils

Consistency

	c_u, s_u	c_u, s_u
	kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

Dynamic Cone Penetration Resistance; N_d :

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. General

π	3.1416
$\ln x$,	natural logarithm of x
\log_{10}	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
F	factor of safety
V	volume
W	weight

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ϵ	linear strain
ϵ_v	volumetric strain
η	coefficient of viscosity
ν	poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

(a) Index Properties (continued)

w	water content
w_l	liquid limit
w_p	plastic limit
I_p	plasticity index $= (w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index $= (w - w_p) / I_p$
I_C	consistency index $= (w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_a	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction $= \tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 + \sigma_3)/2$ or $(\sigma'_1 + \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 + \sigma_3)$
S_t	sensitivity

- Notes:**
- 1 $\tau = c' + \sigma' \tan \phi'$
 - 2 shear strength = (compressive strength)/2
 - * density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)

RECORD OF BOREHOLE No 101

1 OF 1

METRIC

PROJECT 12-1132-0163
W.P. 3045-11-00 LOCATION N 4760462.6 , E 186295.1 ORIGINATED BY BT
DIST HWY 401 BOREHOLE TYPE POWER AUGER, HOLLOW STEM COMPILED BY WDF
DATUM GEODETIC DATE July 6, 2015 CHECKED BY

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											
							20 40 60 80 100	20 40 60 80 100					10 20 30									
262.06	GROUND SURFACE																					
0.00	TOPSOIL, silty Brown																					
0.21	FILL, silty sand and gravel, with cobbles																					
261.30	Brown																					
0.76	FILL, sandy silt, some clay, trace gravel, trace topsoil		1	SS	6										68							
260.68	Loose Brown																					
1.38	CLAYEY SILT, trace to some sand, with sandy silt seams		2	SS	6											2 1 66 31						
	Firm Grey																					
			3	SS	5																	
			4	SS	5																	
			5	SS	6																	
			6	SS	6											0 11 69 20						
			7	SS	5																	
			8	SS	5																	
255.35	CLAYEY SILT, trace sand																					
6.71	Hard																					
254.96	Grey		9	SS	48											0 3 69 28						
7.10	SAND AND GRAVEL, trace to some silt																					
	Compact to Dense																					
	Grey		10	SS	23																	
253.98	END OF BOREHOLE																					
8.08	Groundwater encountered at about 258.3m during drilling on July 6, 2015. ARTESIAN conditions encountered at elev. 253.98m. Water level measured in piezometer at elev. 262.97m on July 6, 2015. Water level measured in piezometer at elev. 263.00m on July 10, 2015. Water level measured in piezometer at elev. 262.97m on July 31, 2015. Water level measured in piezometer at elev. 263.22m on August 24, 2015.																					

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


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

PROJECT <u>12-1132-0163</u>		RECORD OF BOREHOLE No 103		1 OF 1 METRIC	
W.P. <u>3045-11-00</u>		LOCATION <u>N 4760439.2 , E 186335.5</u>		ORIGINATED BY <u>BT</u>	
DIST <u> </u> HWY <u>401</u>		BOREHOLE TYPE <u>POWER AUGER, HOLLOW STEM</u>		COMPILED BY <u>WDF</u>	
DATUM <u>GEODETIC</u>		DATE <u>July 7, 2015</u>		CHECKED BY <u> </u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIMIT MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
262.80	GROUND SURFACE																			
0.00	TOPSOIL, silty Brown																			
0.24	FILL, silty sand, some gravel, some topsoil and roots Very Loose to Compact Brown		1	SS	2		262													
			2	SS	3		261													
			3	SS	10		260													
259.90							259													
2.90	CLAYEY SILT, trace to some sand, with silt seams Firm to Very Stiff Grey		4	SS	7		258													
			5	SS	5															
			6	SS	5															
							257													
			7	SS	4		256													
			8	SS	5															
255.33							255													
7.47	CLAYEY SILT, trace to some sand Firm Grey		9	SS	8															
254.72																				
8.08	END OF BOREHOLE																			
	Groundwater encountered at about 260.5m during drilling on July 7, 2015.																			

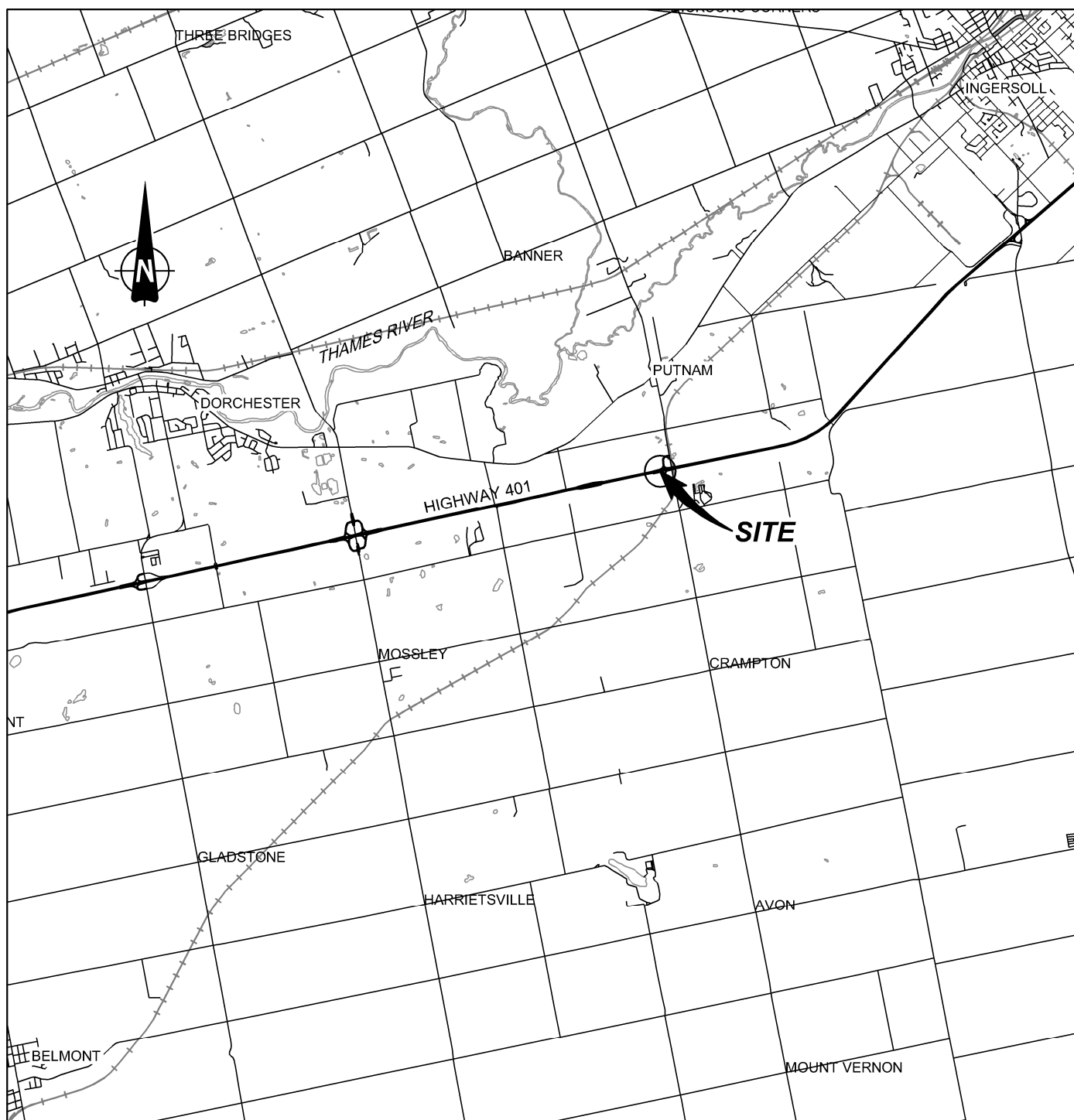
LDN_MTO_06 1211320163-3000.GPJ LDN_MTO.GDT 01/10/15

PROJECT <u>12-1132-0163</u>		RECORD OF BOREHOLE No 104		2 OF 2	METRIC
W.P. <u>3045-11-00</u>		LOCATION <u>N 4760614.1, E 186289.1</u>		ORIGINATED BY <u>BT</u>	
DIST <u> </u> HWY <u>401</u>		BOREHOLE TYPE <u>POWER AUGER, HOLLOW STEM</u>		COMPILED BY <u>WDF</u>	
DATUM <u>GEODETIC</u>		DATE <u>July 7, 2015</u>		CHECKED BY <u> </u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
								20	40	60	80	100	W _p	W	W _L					
		SANDY SILT TILL, trace to some gravel, some clay Very Dense Grey																		
252.63				17	SS	122														
16.06		END OF BOREHOLE		18	SS	105/ 200mm														
		Groundwater encountered at about 260.3m during drilling on July 7, 2015.																		

PROJECT <u>12-1132-0163</u>		RECORD OF BOREHOLE No 105		1 OF 1 METRIC	
W.P. <u>3045-11-00</u>		LOCATION <u>N 4760624.2 , E 186247.1</u>		ORIGINATED BY <u>BT</u>	
DIST <u> </u> HWY <u>401</u>		BOREHOLE TYPE <u>POWER AUGER, HOLLOW STEM</u>		COMPILED BY <u>WDF</u>	
DATUM <u>GEODETIC</u>		DATE <u>July 7, 2015</u>		CHECKED BY <u> </u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			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 (%)							
								20	40	60	80	100	W _p	W	W _L					
263.02	GROUND SURFACE					▽	263													
0.00	TOPSOIL, sandy silt, with roots Loose Brown		1	SS	6		262													
261.65	SILTY SAND, trace gravel Loose Brown		2	SS	5		261													
260.89	SAND, fine to medium, some silt, trace gravel Loose Brown		3	SS	8		260													
259.51	CLAYEY SILT, trace sand Firm to Very Stiff Grey		4	SS	9		259													
3.51			5	SS	8		258													
			6	SS	8		257													
257.38	SANDY SILT TILL, trace to some gravel, some clay Compact to Very Dense Grey		7	SS	19		256													
5.64			8	SS	34															
			9	SS	100/ 275mm															
255.15	END OF BOREHOLE		10	SS	100/ 250mm															
7.87																				
	Groundwater encountered at about 261.2m during drilling on July 7, 2015.																			



REFERENCE

PLAN BASED ON CANMAP STREETFILES V.2008.5.

NOTE

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.

PROJECT

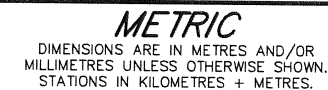
SITE 19-305/C
HIGHWAY 401 - CULVERT REPLACEMENT
GWP 3045-11-00

TITLE

KEY PLAN



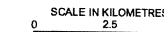
PROJECT No.	12-1132-0163	FILE No.	1211320163-3000-F01001
CADD	WDF/DCH	Sept 14/15	SCALE AS SHOWN REV. 0
CHECK			
FIGURE 1			








SHEET



KEY PLAN



LEGEND

- | | |
|---|--|
|  | Borehole - Current Investigation |
|  | Seal |
|  | Standpipe |
| N | Standard Penetration Test Value |
| 16 | Blows/0.3m unless otherwise stated
(Std. Pen. Test, 475 j/blow) |
|  | WL measured on August 24, 2015 |
|  | WL encountered during drilling |
| DRY | Water level not established |

No.	ELEVATION	CO-ORDINATES (MTM NAD83 ZONE 10)	
		NORTHING	EASTING
101	262.06	4 760 462.6	186 295.1
102	268.77	4 760 485.1	186 314.2
103	262.80	4 760 439.2	186 335.5
104	268.69	4 760 614.1	186 289.1
105	263.02	4 760 624.2	186 247.1

NOTES

This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

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

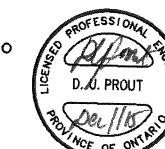
REFERENCE

Base plans provided by Stantec.



HORIZONTAL SCALE
8 0 8 m

VERTICAL SCALE
3 0 3 m

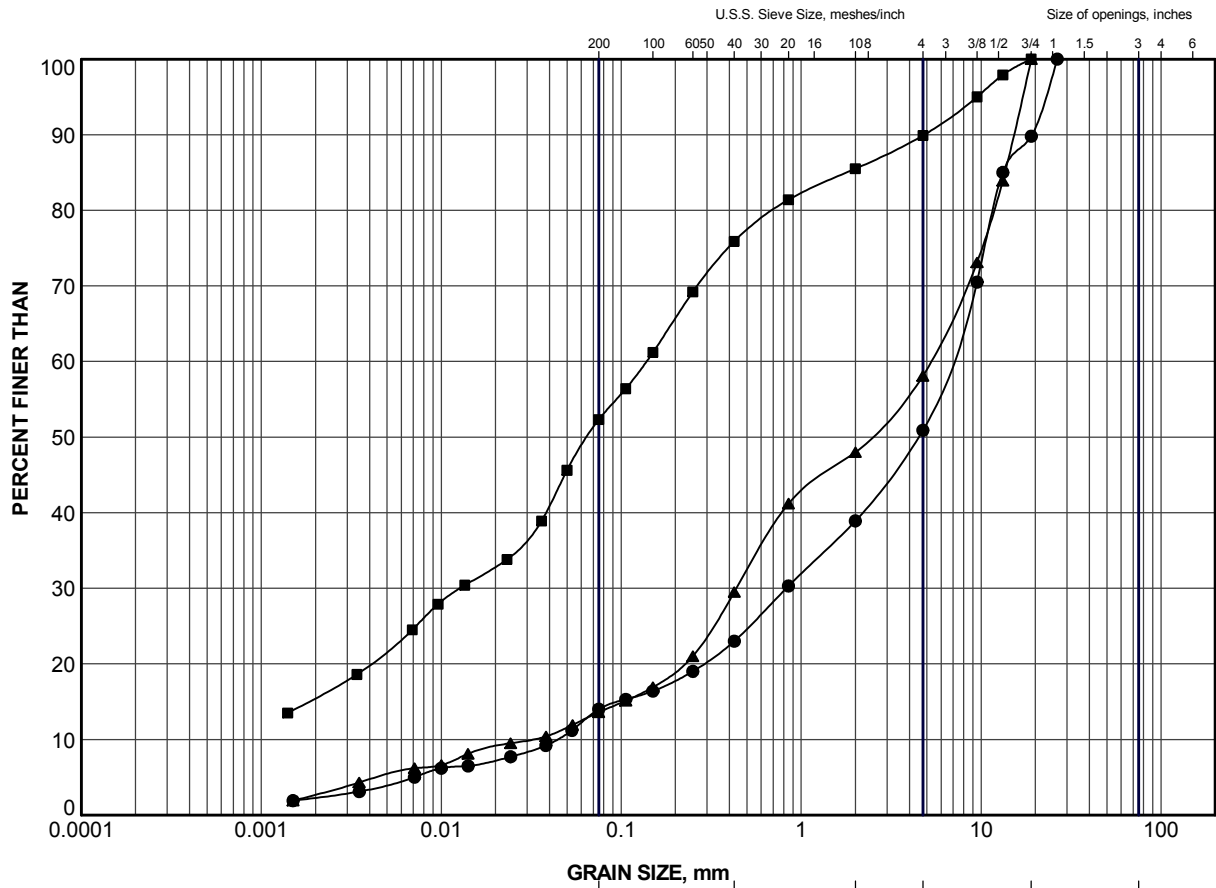


NO.		DATE		BY		REVISION	
40115-42							
HWY. 401		PROJECT NO. 12-1132-0163				DIST.	
SUBM'D. BT		CHKD. NAG		DATE: Nov. 13/15		SITE: 19-305	
DRAWN: WDF/DCH		CHKD. MEB		APPD. FJH		DWG. 1	




APPENDIX A

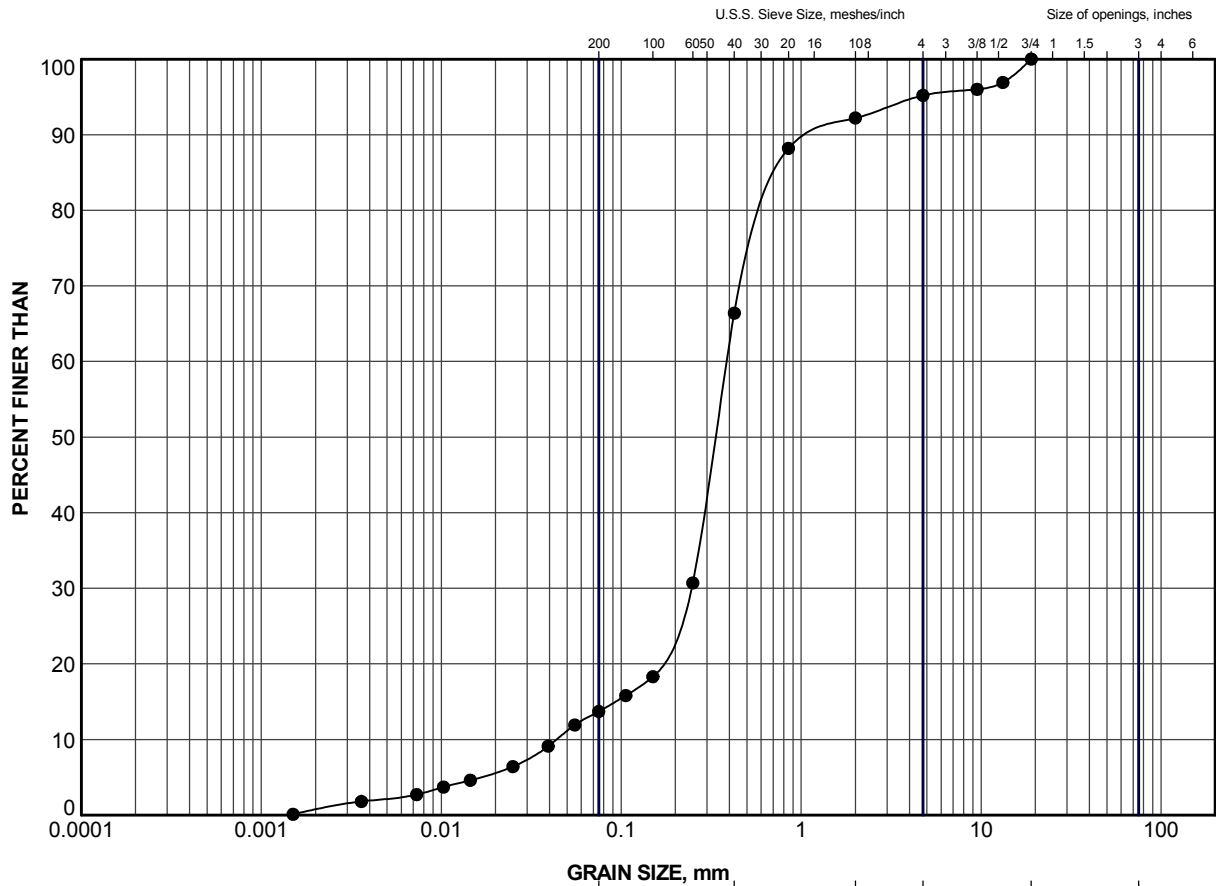
Laboratory Test Data



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	102	6	264.0
■	102	9	261.7
▲	104	6	263.9

PROJECT		SITE 19-305/C HIGHWAY 401 - CULVERT REPLACEMENT GWP 3045-11-00	
TITLE		GRAIN SIZE DISTRIBUTION FILL	
PROJECT No. 12-1132-0163		FILE No. 1211320163-3000-F010A1	
DRAWN WDF/DCH		Sept 14/15	
CHECK			
		FIGURE A-1	



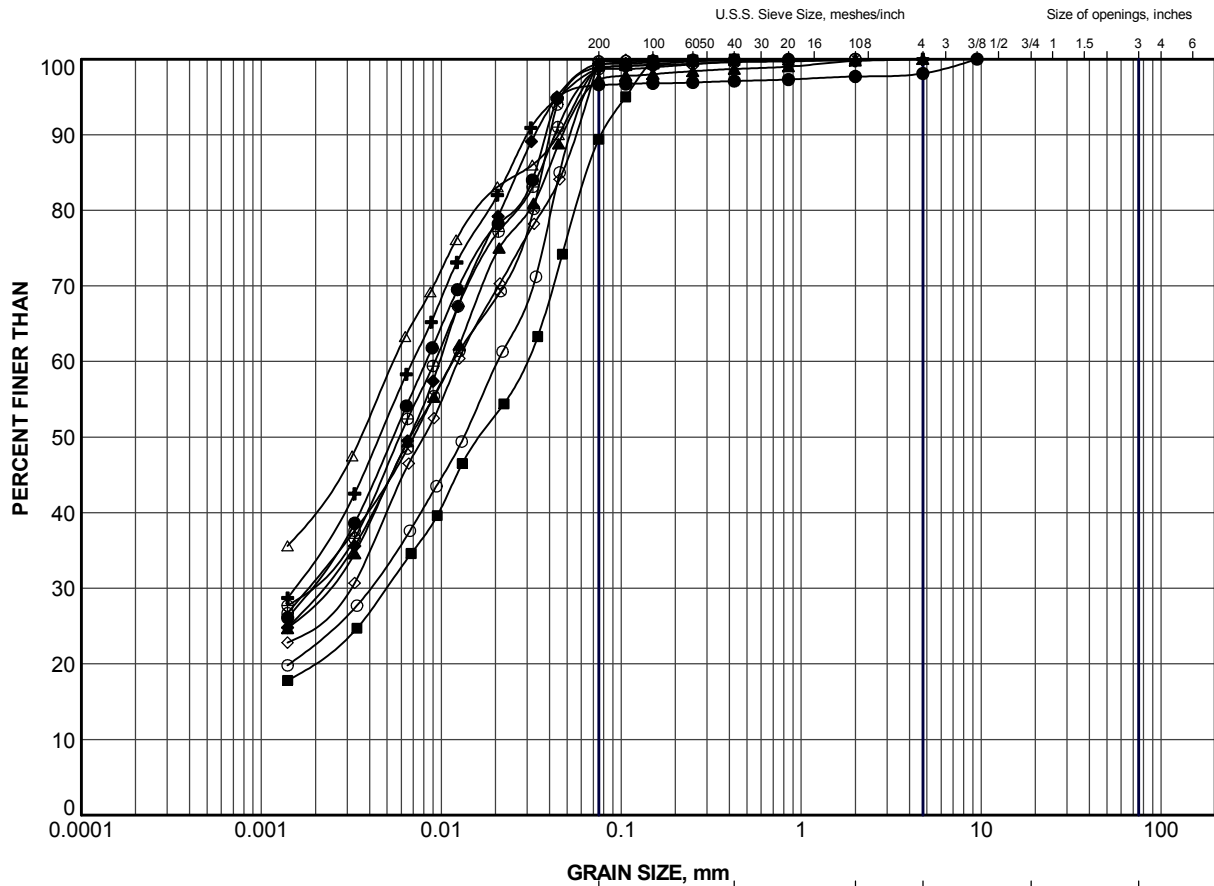
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	105	3	260.5

PROJECT	SITE 19-305/C HIGHWAY 401 - CULVERT REPLACEMENT GWP 3045-11-00		
TITLE	GRAIN SIZE DISTRIBUTION SAND		
	PROJECT No.	12-1132-0163	FILE No. 1211320163-3000-F010A2
	DRAWN	WDF/DCH	Sept 14/15
	CHECK		
	SCALE	N/A	REV.
			FIGURE A-2

LDN_MTO_GSD_GLDR_LDN.GDT 11/08/15



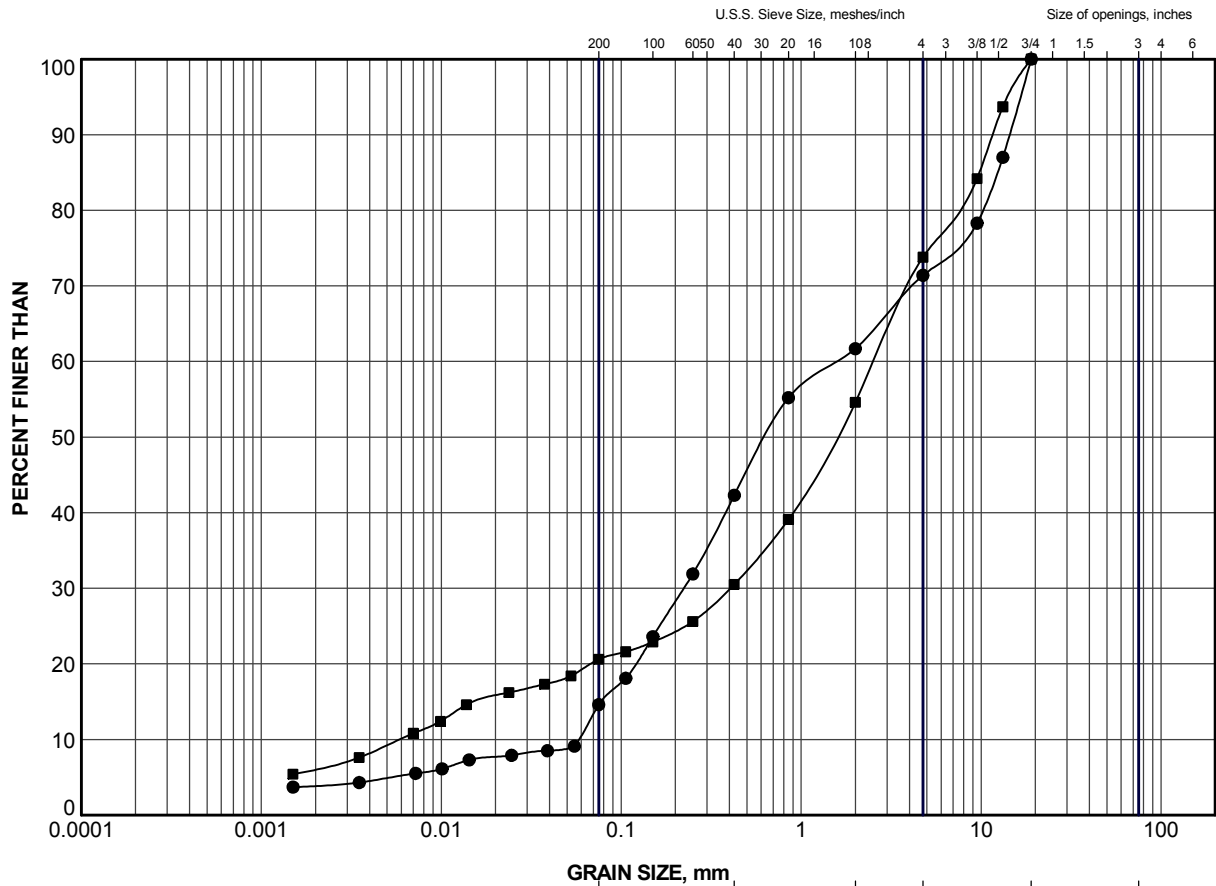
CLAY AND SILT						Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	101	2	259.5
■	101	6	257.3
▲	101	9	255.0
+	102	11	260.2
◆	102	12	259.4
◇	103	5	258.8
○	103	7	256.5
△	103	9	254.9
⊗	104	12	259.3
⊕	105	6	258.2

PROJECT		SITE 19-305/C HIGHWAY 401 - CULVERT REPLACEMENT GWP 3045-11-00	
TITLE		GRAIN SIZE DISTRIBUTION CLAYEY SILT	
PROJECT No. 12-1132-0163		FILE No. 1211320163-3000-F010A3	
DRAWN	LMK	Oct 01/15	SCALE N/A REV.
CHECK			FIGURE A-3





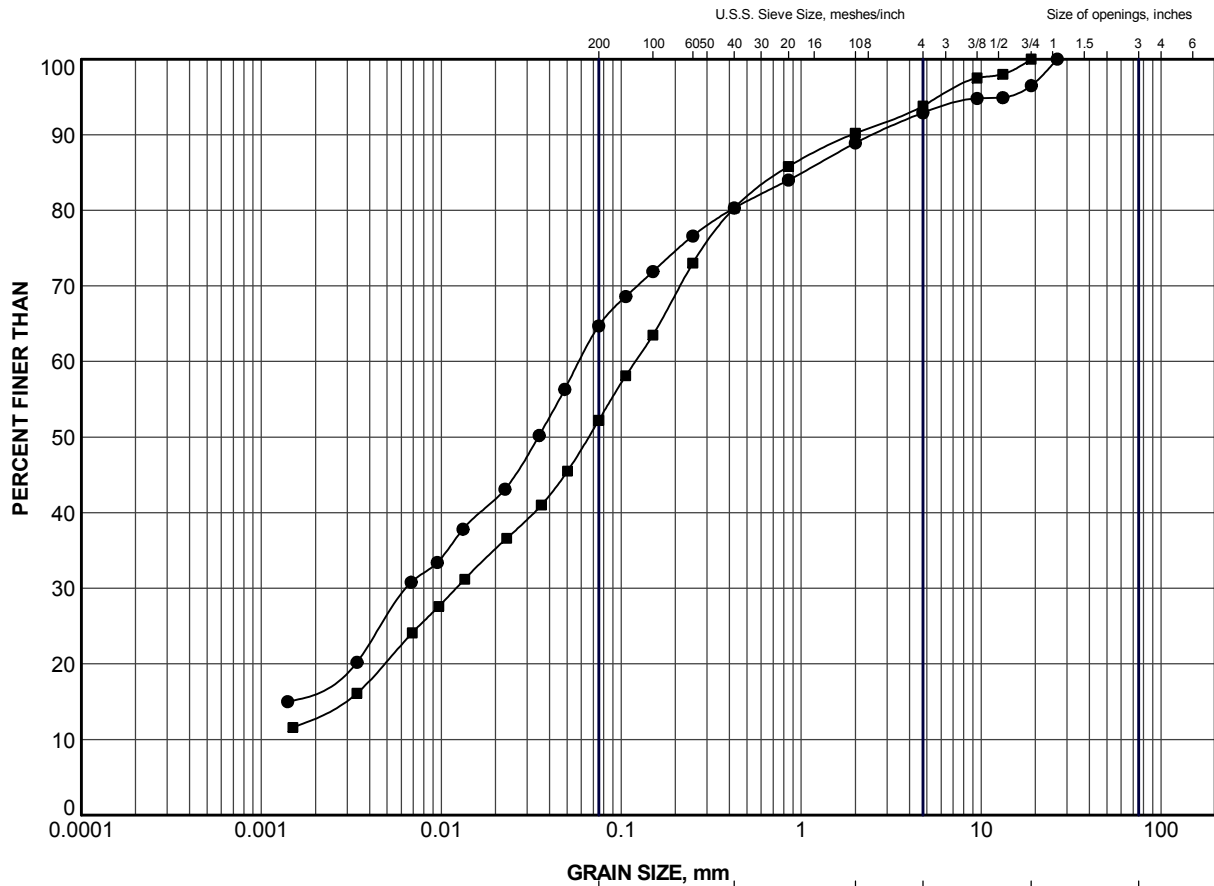
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	104	11	260.1
■	104	16	254.7

PROJECT				SITE 19-305/C HIGHWAY 401 - CULVERT REPLACEMENT GWP 3045-11-00			
TITLE				GRAIN SIZE DISTRIBUTION SAND AND GRAVEL			
PROJECT No.		12-1132-0163		FILE No. 1211320163-3000-F010A4			
DRAWN		WDF/DCH		Sept 14/15		SCALE N/A REV.	
CHECK						FIGURE A-4	




LDN_MTO_GSD_GLDR_LDN.GDT 11/08/15

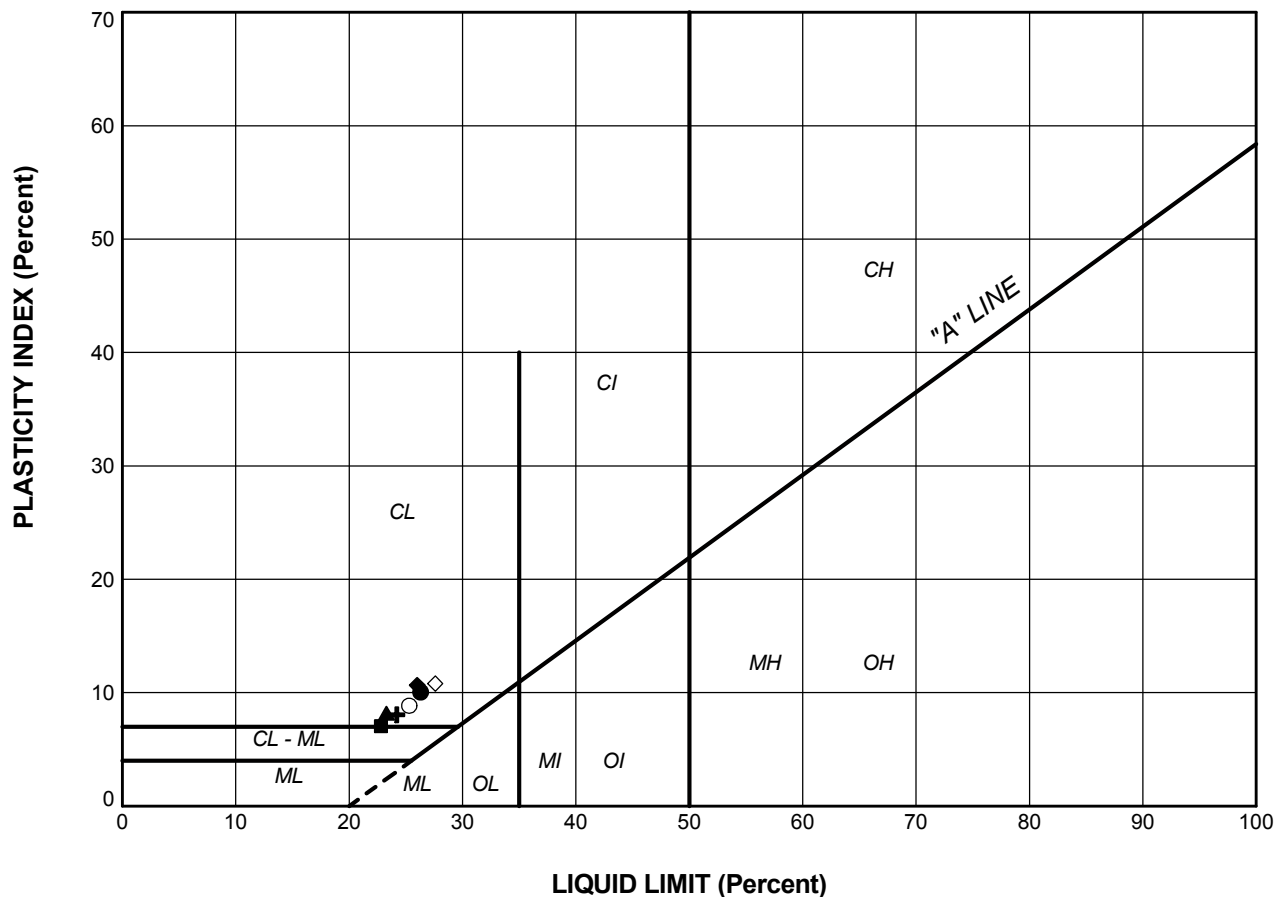


CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	104	17	253.2
■	105	9	255.9

PROJECT		SITE 19-305/C HIGHWAY 401 - CULVERT REPLACEMENT GWP 3045-11-00	
TITLE		GRAIN SIZE DISTRIBUTION SANDY SILT TILL	
PROJECT No. 12-1132-0163		FILE No. 1211320163-3000-R010A5	
DRAWN WDF/DCH		Sept 14/15	
CHECK			
		FIGURE A-5	




SOIL TYPE
 C = Clay
 M = Silt
 O = Organic

PLASTICITY
 L = Low
 I = Intermediate
 H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	101	3	26.3	16.3	10.1
■	101	6	22.8	15.8	7.1
▲	102	11	23.3	15.1	8.2
+	103	5	24.2	16.2	8.1
◆	103	9	26.0	15.4	10.7
◇	104	12	27.6	16.8	10.8
○	105	6	25.3	16.5	8.9

PROJECT		SITE 19-305/C HIGHWAY 401 - CULVERT REPLACEMENT GWP 3045-11-00	
TITLE		PLASTICITY CHART	
PROJECT No. 12-1132-0163		FILE No. 1211320163-3000-R010A6	
DRAWN	WDF/DCH	Sept 14/15	SCALE N/A REV.
CHECK			
 Golder Associates		FIGURE A-6	



APPENDIX B

Site Photographs



APPENDIX B PHOTOGRAPHS



Photograph 1: South elevation (inlet) of Culvert Site 19-305/C. (Courtesy MTO)



Photograph 2: North elevation (outlet). (Courtesy MTO)



APPENDIX B PHOTOGRAPHS



Photograph 3: N/S-W On Ramp of Highway 401 looking south from Culvert Site 19-305/C.
(Courtesy MTO)

n:\active\2012\1132 - geo\1132-0100\12-1132-0163 stantec-fdns-mega culverts-3011-e-0041\ph 3000-gwp 3045-11-00\rvpts\rv01 - 19-305 (reynolds)\1211320163-3000-r01 dec 1 15 (final)
app b - photos.docx



APPENDIX C

Foundation Drawing and Records of Boreholes Previous Investigation (Geocres No. 40I15-027)

RECORD OF BOREHOLE No2

METRIC 18

W P 100-90-01 LOCATION Co-ords. 4,760,373 N; 186,252 E ORIGINATED BY AA
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Test & washboring COMPILED BY AK
 DATUM Geodetic DATE 1990 08 01 CHECKED BY CM

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
262.7	Ground surface																
0.0	Organic Clayey Silt and Topsoil incl. Firm (Fill)		1	SS	5		262										Water Levels on 1990 08 10
	with Gravel		2	SS	12		261										43 41 (16)
	Stiff		3	SS	11		260										
259.8			4	SS	8		259										
2.9	Clayey Silt (Laminated)		5	SS	7		258										
	Stiff to Firm		6	SS	7		257										
	Grey		7	SS	100		256										
256.8			8	SS	110		255										
5.9	Silty Sand to Silt Occ. gravel Tr. clay (Glacial Till) Very Dense Grey						254										
254.9							253										
7.8	Sandy Gravel Very Dense Grey																
253.3																	
9.4	End of Borehole																
	Artesian pressure controlled by sealing with "Benseal".																

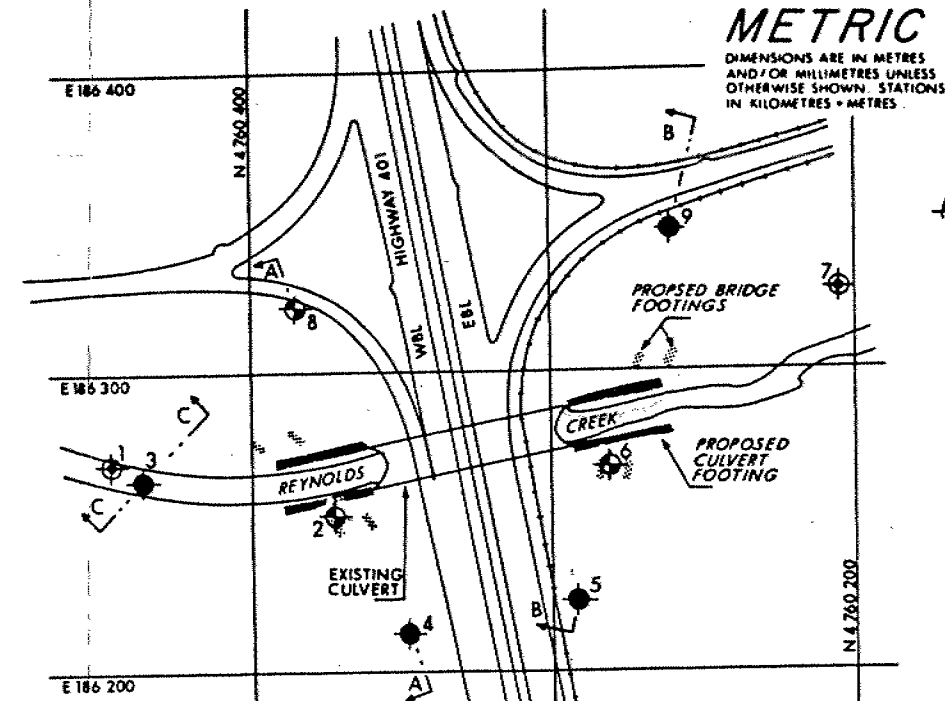
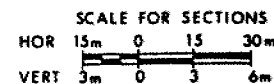
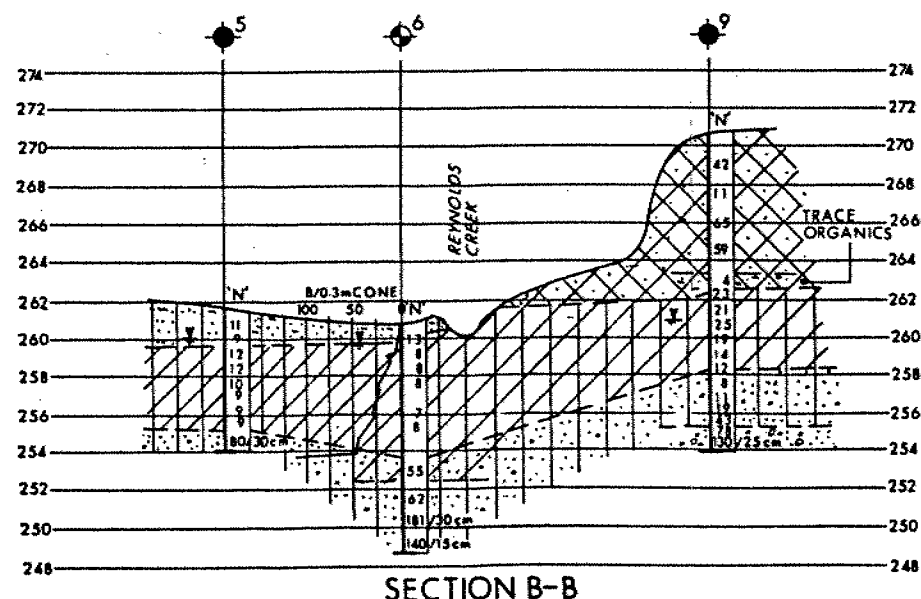
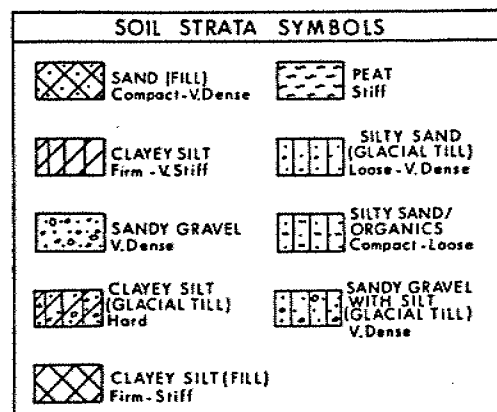
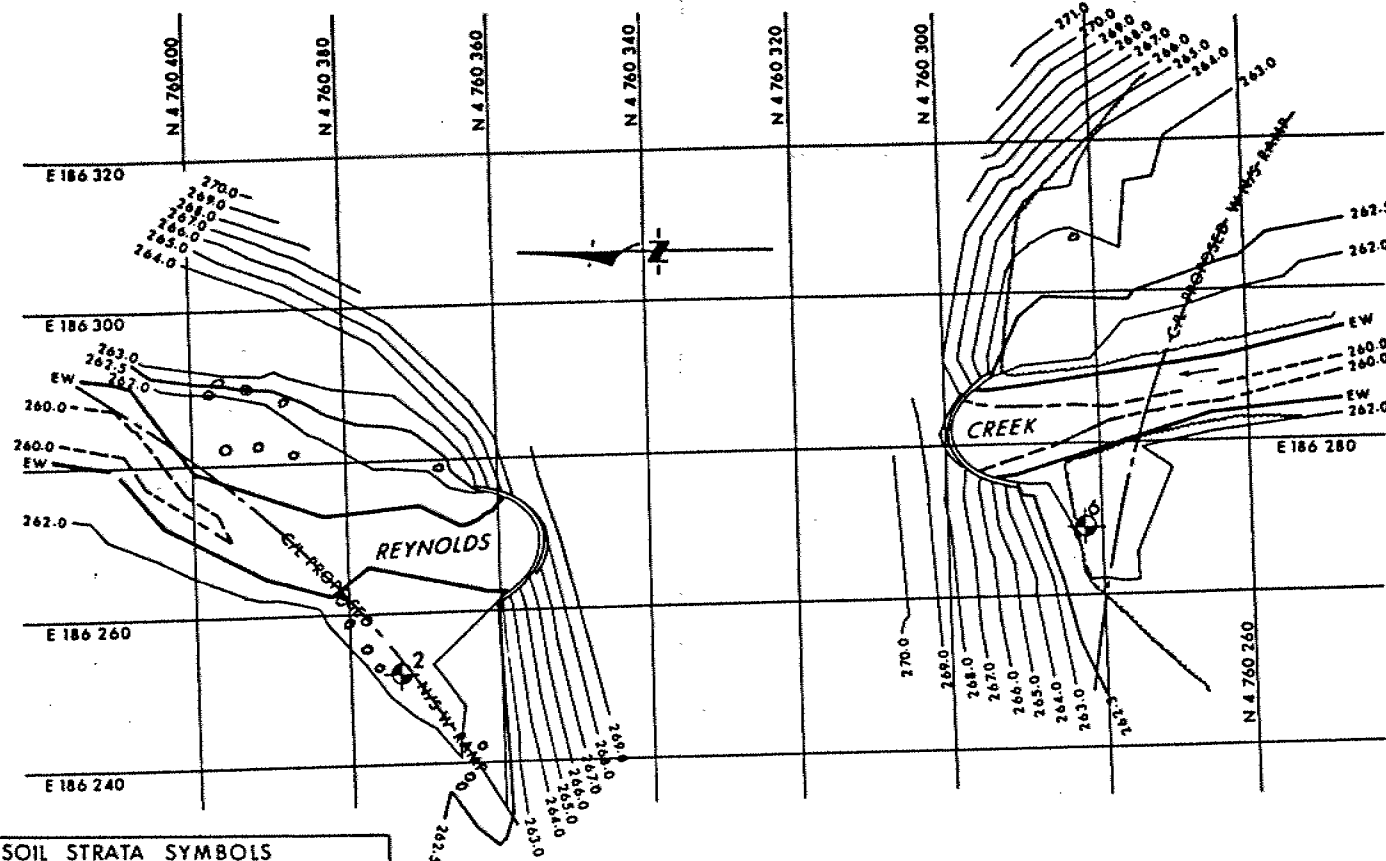
OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 6

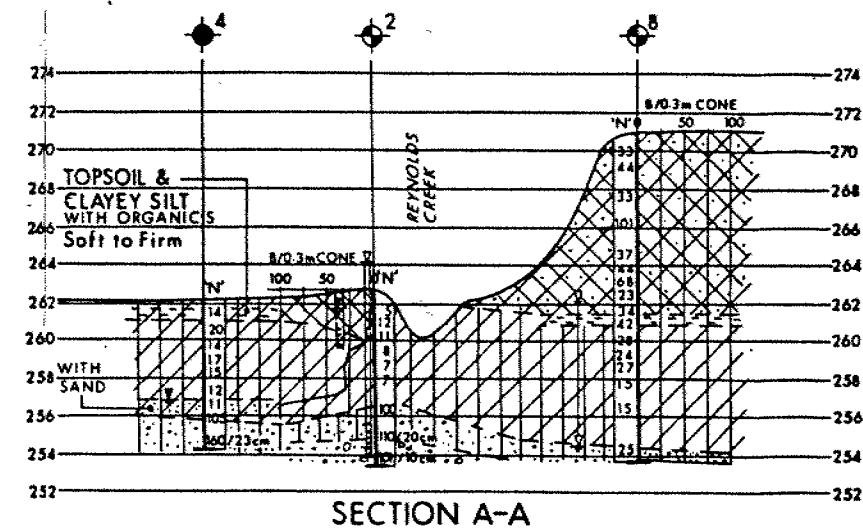
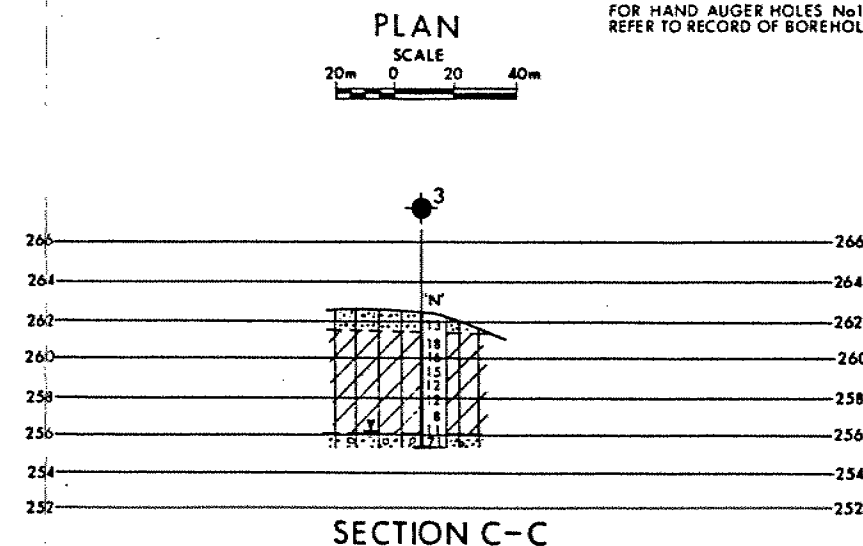
METRIC 22

W P 100-90-01 LOCATION Co-ords. 4,760,282 N; 186,268 E ORIGINATED BY JK
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger and Dynamic Cone Test, Washboring COMPILED BY AK
 DATUM Geodetic DATE 1990 07 31 CHECKED BY CM

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						
260.9	Ground surface							20 40 60 80 100	20 40 60 80 100	10 20 30			GR SA SI CL	
0.0	Sandy Silt with organics Topsoil													
259.9			1	SS	13									WL on 1990 07 31
1.0	Clayey Silt (Laminated)		2	SS	8									
			3	SS	8									
	Firm		4	SS	8									
			5	TW	PH									
	Grey		6	SS	7									
			7	SS	8									
	becoming stiff to very stiff with depth		8	TW	PH									
253.5														
7.4	Clayey Silt with sand and gravel (Glacial Till)		9	SS	55									
252.5	Hard - Grey [Transition Zone]													
8.4	Silty Sand with gravel (Glacial Till)		10	SS	62									20 65 (15)
	Very Dense													
	Grey		11	SS	181	30cm								Wash casing installed Borehole advanced by triconing.
248.6			12	SS	140	15cm								
12.3	End of Borehole													



NOTE
FOR HAND AUGER HOLES No1 & 7
REFER TO RECORD OF BOREHOLE SHEETS

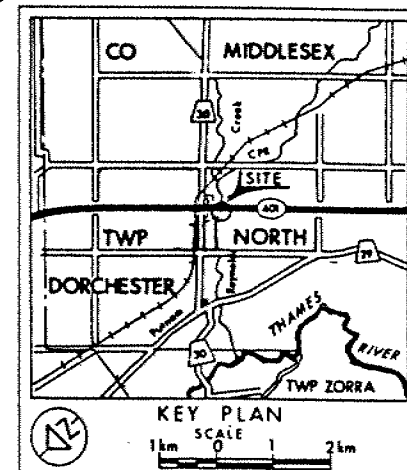


CONT No
WP No 479-89-06/07









REYNOLDS CREEK	SHEET
BORE HOLE LOCATIONS & SOIL STRATA	



STRATA ENGINEERING CORP.



LEGEND

-  Bore Hole
-  Dynamic Cone Penetration Test (Cone)
-  Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
-  Well at time of investigation 0708 1990
-  Hand Auger Hole
-  Head
-  ARTESIAN WATER Encountered
-  Stand Pipe

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	262.1	4 760 448	186 269
2	262.7	4 760 373	186 252
3	262.6	4 760 437	186 264
4	262.2	4 760 348	186 212
5	261.8	4 760 292	186 223
6	260.9	4 760 282	186 268
7	260.8	4 760 205	186 327
8	271.0	4 760 385	186 321
9	270.8	4 760 261	186 347

NOTE

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV.			
DATE	8y		DESCRIPTION

Graceros No 40115-27

HWY No 401		OIST 2
SUBMD A A	CHECKED A A	DATE NOV 06 1990 SITE 19-305
DRAWN A K	CHECKED A A	LDWG 4798906-02A

REF NO E-92-401-1-2 &
PLATE NO 92-401/45-0

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Ltd.
309 Exeter Road, Unit #1
London, Ontario, N6L 1C1
Canada
T: +1 (519) 652 0099

