

Golder Associates Ltd.

309 Exeter Road, Unit #1
London, Ontario, Canada N6L 1C1
Telephone: (519) 652-0099
Fax: (519) 652-6299



**FOUNDATION INVESTIGATION AND DESIGN REPORT
SHORT SPAN CULVERTS
HIGHWAY 3 WIDENING
GWP 315-98-00
MINISTRY OF TRANSPORTATION - SOUTHWESTERN REGION**

Submitted to:

Delcan Corporation
1069 Wellington Road South, Suite 214
London, Ontario
N6E 2H6

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LIST OF ABBREVIATIONS

LIST OF SYMBOLS

RECORD OF BOREHOLE SHEETS

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PART A
FOUNDATION INVESTIGATION REPORT

SHORT SPAN CULVERTS
HIGHWAY 3 WIDENING
GWP 315-98-00
MINISTRY OF TRANSPORTATION - SOUTHWESTERN REGION

1.0 INTRODUCTION

Golder Associates Ltd. (Golder Associates) has been retained by Delcan Corporation (Delcan) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out foundation investigations as part of the detail design work for GWP 315-98-00. The project involves the first phase of the reconstruction and widening of Highway 3 (Talbot Trail) between Windsor and Leamington. The project limits for GWP 315-98-00 extend along Highway 3 from just west of Essex Road 34 (Talbot Street North) easterly to just east of Essex Road 8 (Maidstone Avenue West) in Essex County, Ontario.

In conjunction with the widening, the scope of work for this project includes:

- rehabilitation or replacement of selected culverts within the project limits;
- slotted left turn lanes at all intersections;
- Revision or upgrading of illumination at four intersections;
- Revision or upgrading of traffic signals at two intersections;
- Replacement or relocation of existing traffic counting stations;
- Drainage improvements; and,
- Upgrading of existing signage.

Five structural culverts and four short span culverts are to be widened and two short span culverts replaced .

This report addresses the foundation investigation for the proposed extension of the south ends of five non-rigid frame open footing (NRFO) culverts located on Highway 3 in South Sandwich Township at Stations 18+655 and 19+245 and in Maidstone Township at Stations 12+908, 13+210 and 13+890 and the replacement of the two corrugated steel pipe (CSP) culverts located on Highway 3 in South Sandwich (SS) at Station 20+475 and in Maidstone (M) at Station 10+775. Except for the culvert at Station 13+890 M, which has a span greater than 3 metres, all other culverts are less than 3 metres in width/diameter and are considered short span culverts.

The culvert at Station 13+890 M was added to the investigation after the original proposal was submitted. The boreholes at this location provide preliminary information in the event that the project limits are extended.

The purpose of the foundation investigation is to determine the subsurface conditions at the location of the proposed works 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 P61-3113-1 dated August 17, 2006 and our letter dated November 14, 2006. The work was carried out in accordance with our Quality Control Plan for Foundations Engineering dated September 18, 2006.

Delcan provided Golder Associates with a base plan and profile for this project in digital format which included the top elevations of the culverts.

2.0 SITE DESCRIPTION

GWP 315-98-00 extends along Highway 3 from 0.5 kilometres west of Essex Road 34 (Talbot Street North) within the Town of Tecumseh easterly to 0.6 kilometres east of Essex Road 8 (Maidstone Avenue West) in the Town of Essex. West of Manning Road, Highway 3 is within South Sandwich Township. East of Manning Road, it is within Maidstone Township. The chainage equation at Manning Road is 20+981.675 South Sandwich (SS) = 10+000.000 Maidstone (M). The west project limit is located at Station 17+700 SS and the east project limit is situated at Station 13+600 M.

The location of the project is shown on the Key Plan, Figure 1.

The land use in the vicinity of the site is predominantly agricultural. The adjacent topography is generally flat to slightly rolling with a ground surface elevation between 190 and 195 metres.

2.1 Site Geology

The site is situated on the Essex Clay Plain, a subregion of the physiographic region of southern Ontario known as the St. Clair Clay Plain.¹ This subregion is described as a bevelled till plain with little relief that has been locally smoothed by shallow deposits of lacustrine clay deposited in depressions in the till. The prevailing soil type is reported to be the Brookston clay loam.

The available surficial geology mapping for the project area indicates that the predominant surficial soils are clayey silt till.² The till is reportedly underlain by limestone, dolomite and shale of the Middle Devonian era and by dolomite of the Upper Silurian era. The overburden thickness within the project area ranges from 27 to 41 metres.³

¹ L.J. Chapman and D.F. Putnam, 1984. *The Physiography of Southern Ontario*. Third Edition. Ontario Geological Survey, Special Volume 2.

² Vagners, U. J., 1972. *Quaternary Geology of the Windsor-Essex Area (Western and Eastern Parts), Southern Ontario*. Ontario Department of Mines and Northern Affairs, Preliminary Maps P. 749 and P.750, Geological Series.

³ Vagners, U.J., Sado, E.V., and Yundt, S.E. 1973. *Drift Thickness of the Windsor-Essex Area (Western and Eastern Parts), Southern Ontario*; Ontario Division of Mines, Preliminary Maps P.814 and P.815, Drift Thickness Series.

3.0 INVESTIGATION PROCEDURES

The field work for this portion of the investigation was carried out from November 27 to December 1, 2006, at which time sixteen boreholes, numbered 101 through 116, were drilled in the areas of the proposed culvert extensions and culvert replacements. The boreholes were advanced to depths ranging from 4.4 to 5.9 metres.

The investigation for these boreholes was carried out using a Deitrich 50 track-mounted power auger supplied and operated by a specialist drilling contractor. Samples of the overburden were obtained at intervals of 0.75 metres using 50 millimetre outside diameter split spoon sampling equipment in accordance with the standard penetration test (SPT) procedures.

Groundwater conditions in the boreholes were observed throughout the drilling operations and these observations are provided on the corresponding Record of Borehole sheets. Boreholes were backfilled in accordance with current regulations, MTO recommended procedures and Ontario Regulation 128/03.

The field work was supervised on a full-time basis by an experienced member of our engineering staff who arranged for utility locates, directed the drilling, sampling and in-situ testing operations, logged the boreholes and cared for the samples obtained. The soil samples were identified in the field, placed in labelled containers and transported to Golder Associates' London laboratory for further examination and testing. Index and classification tests consisting of water content determinations, grain size distribution analyses and Atterberg limits determinations were carried out on selected samples. The results of the field and laboratory testing are given on the Record of Borehole sheets and in Appendix A.

Temporary traffic control was provided in accordance with the Ontario Traffic Manual, Temporary Conditions, Book 7, dated March 2001.

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 culvert locations and coordinates, ground surface elevations and depths of the associated boreholes.

<u>BOREHOLE</u>	<u>LOCATION (m)</u>		<u>GROUND SURFACE ELEVATION</u>	<u>BOREHOLE DEPTH</u>
	<u>Northing</u>	<u>Easting</u>	(m)	(m)
101	4 672 599.3	274 314.0	192.51	4.42
102	4 672 624.8	274 324.6	193.25	5.94
103	4 671 098.6	275 834.3	193.87	5.18
104	4 671 091.7	275 812.2	193.56	5.18
105	4 670 862.2	276 020.4	193.42	5.18
106	4 670 886.1	276 034.8	194.35	5.94
107	4 670 363.2	276 469.5	193.64	5.18
108	4 670 372.5	276 498.1	194.36	5.94
109	4 672 630.0	274 342.6	192.53	5.18
110	4 673 418.1	273 331.6	190.80	5.18
111	4 674 506.2	271 870.7	190.23	5.94
112	4 674 483.9	271 864.6	189.85	5.18
113	4 674 129.2	272 321.7	190.08	5.18
114	4 674 144.7	272 335.2	190.22	5.18
115	4 673 381.0	273 300.7	191.51	5.18
116	4 673 396.5	273 314.2	191.27	5.18

The existing culverts have the following characteristics:

<u>STATION</u>	<u>DIMENSIONS (m)</u>	<u>TOP ELEVATION (m)</u>		<u>CONSTRUCTION</u>
		(Lt)	(Rt)	
South Sandwich				
18+655 - (Delisle Drain)	2.45 x 1.47 x 29.91	189.81	189.83	NRFO
19+245 - (Malden Road West Drain)	2.45 x 1.45 x 26.86	190.63	190.64	NRFO
20+475	0.6 x 23.73	191.11	191.08	CSP
Maidstone				
10+775	1.20 x 26.54	191.71	191.74	CSP
12+908 - (Maidstone-Colchester Townline Drain)	1.23 x 1.22 x 54.90	193.39	193.35	NRFO
13+210 - (Dooley Drain)	1.52 x 1.55 x 25.60	193.60	193.59	NRFO
13+890	3.10 x 1.52 x 26.84	193.31	193.26	NRFO

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 and 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 sampling and observations of drilling resistance and represent transitions between soil types rather than exact planes of geological change. Subsurface conditions will vary between and beyond the borehole locations.

In general, the boreholes drilled at the proposed culvert extensions and culvert replacements typically encountered topsoil and fill materials underlain by an extensive deposit of clayey silt till to silty clay till.

The locations of the boreholes are shown on the attached 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.

4.1.1 Station 18+655 SS (Delisle Drain)

Boreholes 111 and 112 were drilled in the area of the proposed extension of the culvert at Station 18+655 SS.

Topsoil and Fill

Clayey topsoil layers with thicknesses of 150 and 300 millimetres were encountered at ground surface in boreholes 111 and 112, respectively.

A 0.5 metre thick layer of sand fill was encountered underlying the topsoil in borehole 111 at elevation 190.1 metres.

Clayey Silt Till

Beneath the topsoil in borehole 112 and beneath the sand fill in borehole 111, a layer of stiff to hard clayey silt till was encountered at approximately elevation 189.6 metres. The clayey silt till had N values of 10 to 50 blows per 0.3 metres with a single measured natural water content of 20 per cent. The results of a grain size analysis of a sample of the clayey silt till recovered from the standard penetration testing are presented on Figure A-2 of Appendix A. Although not

specifically encountered in the boreholes, the presence of cobbles and boulders in the till strata should be anticipated.

The clayey silt till is of low plasticity based on a single sample with plastic and liquid limits of 12 and 34 per cent, respectively, and a plasticity index of 22 per cent. The Atterberg limits data are shown on the Plasticity Chart, Figure A-4.

4.1.2 Station 19+245 SS (Malden Road West Drain)

Boreholes 113 and 114 were drilled in the area of the proposed extension of the culvert at Station 19+245 SS.

Topsoil

Clayey topsoil layers with thicknesses of 460 and 760 millimetres were encountered at ground surface in boreholes 113 and 114, respectively.

Clayey Silt Till

Beneath the topsoil in boreholes 113 and 114, a layer of stiff to hard clayey silt till was encountered at approximately elevation 189.5 metres. The clayey silt till had N values of 10 to 45 blows per 0.3 metres with a water content of 16 per cent. The results of grain size analyses of two clayey silt till samples recovered from the standard penetration testing are presented on Figure A-2. Although not specifically encountered in the boreholes, the presence of cobbles and boulders in the till strata should be anticipated.

The clayey silt till is of low plasticity based on a plastic limit of 17 per cent, liquid limits ranging from 32 to 35 per cent (with an average liquid limit of 34 per cent) and a plasticity index ranging from 16 to 18 per cent (with an average plasticity index of 17 per cent). The Atterberg limits data are shown on the Plasticity Chart, Figure A-4.

4.1.3 Station 20+475 SS

Boreholes 110, 115 and 116 were drilled in the area of the proposed replacement of the culvert at Station 20+475 SS.

Topsoil and Fill

Clayey topsoil layers with an average thickness of 150 millimetres were encountered at ground surface in boreholes 110, 115 and 116.

A 1.2 metre thick layer of clayey silt fill was encountered underlying the topsoil in borehole 116. The clayey silt fill had a standard penetration test N value of 12 blows per 0.3 metres.

Clayey Silt Till

Beneath the topsoil in borehole 110 and the fill material in borehole 116, a layer of stiff to hard clayey silt till was encountered from approximately elevation 190.7 metres in borehole 110 and elevation 190.0 metres in borehole 116. The clayey silt till had N values of 10 to 42 blows per 0.3 metres with natural water contents of 10 to 17 per cent. The results of grain size testing on samples of the clayey silt till recovered from the standard penetration testing are presented on Figure A-2. Although not specifically encountered in the boreholes, the presence of cobbles and boulders in the till strata should be anticipated.

The clayey silt till is of low to intermediate plasticity based on plastic limits ranging from 12 to 17 per cent (for an average plastic limit of 15 per cent), liquid limits ranging from 20 to 36 per cent (for an average liquid limit of 30 per cent) and plasticity indices ranging from 8 to 20 per cent (for an average plasticity index of 15 per cent). The Atterberg limits data are shown on the Plasticity Chart, Figure A-4.

Clayey Silt

A 0.8 metre thick layer of clayey silt with silt seams was encountered interlayered with the clayey silt till in borehole 110 at approximately elevation 187.9 metres. The clayey silt had an N value of 27 blows per 0.3 metres.

Silty Clay Till

Beneath the topsoil in borehole 115, a layer of very stiff to hard silty clay till was encountered at elevation 191.3 metres. The silty clay till had N values of 16 to 43 blows per 0.3 metres and a water content of 18 per cent. The results of a grain size analysis of a sample of the silty clay till recovered from the standard penetration testing are shown on Figures A-3. Although not specifically encountered in the borehole, the presence of cobbles and boulders in the till should be expected.

The silty clay till is of intermediate plasticity with plastic and liquid limits of 17 and 36 per cent, respectively, and a plasticity index of 19 per cent. The Atterberg limits data are shown on Figure A-5.

4.1.4 Station 10+775 M

Boreholes 101, 102 and 109 were drilled in the area of the proposed replacement of the culvert at Station 10+775 M.

Topsoil and Fill

Clayey topsoil layers with thicknesses of 100 to 180 millimetres were encountered at ground surface in boreholes 101 and 109.

A 0.3 metre thick layer of sand and gravel fill was encountered at ground surface in borehole 102. Below the sand and gravel fill, a 0.3 metre thick layer of sand fill was encountered at approximately elevation 193.0 metres. A 2.2 metre thick layer of clayey silt fill was encountered below the sand fill at elevation 192.7 metres. The clayey silt fill had standard penetration test N values of 8 to 15 blows per 0.3 metres.

A 0.2 metre thick buried topsoil layer was encountered within the clayey silt fill at elevation 191.8 metres in borehole 102.

Clayey Silt Till

Beneath the topsoil in boreholes 101 and 109 and the fill materials in borehole 102, a layer of stiff to hard clayey silt till was encountered from about elevation 190.5 to 192.4 metres. The clayey silt till had N values of 8 to 44 blows per 0.3 metres with water contents of 15 to 17 per cent. The results of grain size testing on samples of the clayey silt till recovered from the standard penetration testing are presented on Figure A-1. Although not specifically encountered in the boreholes, the presence of cobbles and boulders in the till strata should be anticipated.

The clayey silt till is of low plasticity based on plastic limits ranging from 14 to 17 per cent (with an average plastic limit of 16 per cent), liquid limits ranging from 33 to 35 per cent (with an average liquid limit of 34 per cent) and plasticity indices ranging from 17 to 18 per cent (with an average plasticity index of 18 per cent). The Atterberg limits data are shown on the Plasticity Chart, Figure A-4.

4.1.5 Station 12+908 M (Maidstone-Colchester Townline Drain)

Boreholes 103 and 104 were drilled in the area of the proposed extension of the culvert at Station 12+908 M.

Topsoil and Fill

Clayey topsoil with a thickness of 230 millimetres was encountered at ground surface in borehole 104.

A 0.2 metre thick layer of sand and gravel fill was encountered at ground surface in borehole 103. Below the sand and gravel fill, a 1.1 metre thick layer of clayey silt fill was encountered at elevation 193.6 metres. The clayey silt fill had a standard penetration test N value of 13 blows per 0.3 metres.

Clayey Silt Till

Beneath the topsoil in borehole 104 and the fill materials in borehole 103, a layer of stiff to hard clayey silt till was encountered from about elevation 192.5 to 193.3 metres. The clayey silt till had N values of 14 to 40 blows per 0.3 metres with a single measured water content of 17 per cent. The results of a grain size analysis of a sample of the clayey silt till recovered from the standard penetration testing are presented on Figure A-1 of Appendix A. Although not specifically encountered in the boreholes, the presence of cobbles and boulders in the till strata should be anticipated.

The clayey silt till is of low plasticity based on plastic and liquid limits of 13 and 35 per cent, respectively, and a plasticity index of 22 per cent. The Atterberg limits data are shown on the Plasticity Chart, Figure A-4.

4.1.6 Station 13+210 M (Dooley Drain)

Boreholes 105 and 106 were drilled in the area of the proposed extension of the culvert at Station 13+210 M.

Topsoil and Fill

Clayey topsoil with a thickness of 300 millimetres was encountered at ground surface in borehole 105.

A 0.8 metre thick layer of sand and gravel fill was encountered at ground surface in borehole 106. Below the sand and gravel fill, a 0.3 metre thick layer of sand fill was encountered at elevation 193.6 metres. The sand fill had a standard penetration test N value of 12 blows per 0.3 metres. A 1.0 metre thick layer of clayey silt fill was encountered below the sand fill at elevation 192.3 metres. The clayey silt fill had a standard penetration test N value of 8 blows per 0.3 metres.

Silty Clay Till

Beneath topsoil in borehole 105 and the fill materials in borehole 106, a layer of stiff to hard silty clay till was encountered from approximately elevation 192.3 to 193.1 metres. The silty clay till had N values of 9 to 32 blows per 0.3 metres with natural water contents of 16 and 17 per cent. The results of grain size testing on samples of the silty clay till recovered from the standard penetration testing are presented on Figure A-3. Although not specifically encountered in the boreholes, the presence of cobbles and boulders in the till strata should be anticipated.

The silty clay till is of intermediate plasticity based on average plastic and liquid limits of 16 and 36 per cent, respectively, and a plasticity index of 20 per cent. The Atterberg limits data are shown on the Plasticity Chart, Figure A-5.

4.1.7 Station 13+890 M

Boreholes 107 and 108 were drilled in the area of the proposed extension of the culvert at Station 13+890 M.

Topsoil and Fill

Clayey topsoil with a thickness of 150 millimetres was encountered at ground surface in borehole 107.

A 0.2 metre thick layer of sand and gravel fill was encountered at ground surface in borehole 108. Below the sand and gravel fill, a 0.9 metre thick layer of sand fill was encountered at elevation 194.2 metres. The sand fill had a standard penetration test N value of 18 blows per 0.3 metres. A 1.1 metre thick layer of clayey silt fill was encountered below the sand fill at elevation 193.3 metres. The clayey silt fill had a standard penetration test N value of 7 blows per 0.3 metres.

Silty Clay Till

Beneath the topsoil in borehole 107 and the fill materials in borehole 108, a layer of stiff to hard silty clay till was encountered from about elevation 192.2 to 193.5 metres. The silty clay till had N values of 10 to 35 blows per 0.3 metres with natural water contents of 16 to 19 per cent. The results of grain size testing on samples of the silty clay till recovered from the standard penetration testing are presented on Figure A-3. Although not specifically encountered in the boreholes, the presence of cobbles and boulders in the till strata should be anticipated.

The silty clay till is of intermediate plasticity based on plastic limits ranging from 13 to 19 per cent (with an average plastic limit of 17 per cent), liquid limits ranging from 37 to 39 per cent (with an average liquid limit of 38 per cent) and plasticity indices ranging from 19 to 26 per cent (with an average plasticity index of 21 per cent). The Atterberg limits data are shown on the Plasticity Chart, Figure A-5.

4.2 Groundwater Conditions

Groundwater conditions were observed during and on completion of drilling and sampling. Details of the groundwater conditions at each culvert location are provided on the Records of Boreholes and are discussed individually in the following paragraphs.

The groundwater levels are expected to fluctuate seasonally and are likely to be higher during periods of sustained precipitation or spring melt.

4.2.1 Station 18+655 SS (Delisle Drain)

Boreholes 111 and 112 were dry during and on completion of drilling. The long-term groundwater table based on the change in soil colour is inferred to be near elevation 188 metres. The water level at the inlet/south end of the Delisle Drain at Station 18+655 SS was measured at elevation 188.66 metres on November 30, 2006.

4.2.2 Station 19+245 SS (Malden Road West Drain)

Boreholes 113 and 114 were dry during and on completion of drilling. The closest piezometer is at the Malden Road Drain culvert at Station 19+320. The water level in borehole 11 was measured at elevation 187.4 metres on December 14, 2006 approximately two weeks after installation. The long-term groundwater table based on the change in soil colour is inferred to be near elevation 188 metres. The water level at the inlet/south end of the Malden Road West Drain culvert was measured at elevation 189.43 metres on November 30, 2006.

4.2.3 Station 20+475 SS

Boreholes 110, 115 and 116 were dry during and on completion of drilling. The long-term groundwater table based on the change in soil colour is inferred to be near elevation 189 metres. The water level in the existing culvert at Station 20+475 SS was measured at elevation 190.57 metres at the inlet/north end of the culvert on November 29, 2006 and 190.87 metres at the outlet/south end of the culvert on December 1, 2006.

4.2.4 Station 10+775 M

Boreholes 101, 102 and 109 were dry during and on completion of drilling. The long-term groundwater table based on the change in soil colour is inferred to be near elevation 190 metres. The water level at the outlet/north end of the existing culvert at Station 10+775 M was measured at elevation 191.11 metres and at the inlet/south end at elevation 191.12 metres on November 28, 2006.

4.2.5 Station 12+908 M (Maidstone - Colchester Townline Drain)

Boreholes 103 and 104 were dry during and on completion of drilling. The long-term groundwater table based on the change in soil colour is inferred to be near elevation 191 metres. The water level at the outlet/south end of the Maidstone-Colchester Townline Drain culvert was measured at elevation 192.22 metres on November 27, 2006.

4.2.6 Station 13+210 M (Dooley Drain)

Boreholes 105 and 106 were dry during and on completion of drilling. The long-term groundwater table based on the change in soil colour is inferred to be near elevation 191 metres. The water level at the outlet/south end of the Dooley Drain was measured at elevation 192.30 metres on November 28, 2006.

4.2.7 Station 13+890 M

Boreholes 107 and 108 were dry during and on completion of drilling. The long-term groundwater table based on the change in soil colour is inferred to be near elevation 191 metres. The water level at the outlet/south end of the existing culvert at Station 13+890 M was measured at elevation 191.96 metres on November 28, 2006.

5.0 MISCELLANEOUS

The investigation was carried out using equipment supplied and operated by London Soil Test Limited which is an Ontario Ministry of Environment licensed well contractor. The field operations were supervised by Mr. Mike Arthur under the direction of 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 of Types C and D aggregates. This report was prepared by Ms. Dirka U. Prout, P. Eng. under the direction of the Project Manager, Mr. Philip R. Bedell, P. Eng. This report was reviewed by Mr. Fintan J. Heffernan, P. Eng., the Designated MTO Contact and Quality Control Auditor for this assignment.

GOLDER ASSOCIATES LTD.

Dirka U. Prout, P. Eng.
Geotechnical Engineer

Philip R. Bedell, P. Eng.
Principal

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

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PART B
FOUNDATION DESIGN REPORT

SHORT SPAN CULVERTS
HIGHWAY 3 WIDENING
GWP 315-98-00
MINISTRY OF TRANSPORTATION - SOUTHWESTERN REGION

6.0 ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides our recommendations on the foundation aspects of the proposed extensions of the south ends of the four short span culverts located on Highway 3 in South Sandwich at Stations 18+655 and 19+245 and in Maidstone at Stations 12+908, and 13+210, as well as the replacement of the two short span culverts located on Highway 3 in South Sandwich at Station 20+475 and in Maidstone at Station 10+775. Preliminary foundation recommendations have been included for the extension of the south end of structural culvert at 13+890 Maidstone.

It should be noted that the interpretation and recommendations are intended for use only by the design engineer. Where comments are made on construction they are provided only in order 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.

6.2 Foundations

A series of improvements is planned for Highway 3 from 0.5 kilometres west of Essex County Road 34 (Talbot Road) and 0.6 kilometres east of Essex County Road 8 (Maidstone Avenue West). The major improvement will be widening of Highway 3 from 2 lanes to 4 lanes. This will require drainage improvements within the project limits, including extension or replacement of several short span culverts as described above.

The subsoils encountered in the boreholes advanced during the investigation typically consist of topsoil and surficial fills over stiff to hard clayey silt till or silty clay till. Although not specifically encountered in the boreholes, the presence of cobbles and boulders in the clayey silt and silty clay tills should be anticipated. The groundwater table was not encountered in these clayey soils during the investigation.

All culverts should be designed to withstand the appropriate weight of fill and traffic loading. Site specific recommendations are provided in the following sections. Footing excavations should penetrate all existing fill and buried topsoil so that foundations for both new culverts and the culvert extensions bear directly on the native clayey silt till or native silty clay till soils. The excavation base should be free of debris, loose or frozen material and ponded water. The cleaned excavation base should be inspected by qualified geotechnical personnel prior to installation of the culvert with the final 0.5 metres of excavation completed when the geotechnical personnel are present on site.

Design information for the proposed culverts and extensions was provided by Delcan. The founding elevations of the five culverts which require extensions have been inferred based on the invert elevations and dimensions of the existing culverts. The culvert extensions will likely be cast-in-place elements or CSP and, therefore, inlet and outlet seals are not necessary. Grade raises at the culvert extensions are expected to be minimal, therefore camber is not required.

Further comments pertaining to each specific culvert are provided in the following discussion.

6.2.1 Station 18+655 SS (Delisle Drain)

The existing NRFO culvert at this location will be extended at the inlet/south end by 19 metres. Currently the culvert is 2.45 x 1.47 x 29.91 metres with an invert at about elevation 188.3 metres.

Based on the information from boreholes 111 and 112, the culvert can be founded on the very stiff to hard clayey silt till at or below elevation 187.1 metres. Boreholes 111 and 112 were dry during and on completion of drilling. The long-term groundwater table is inferred to be near elevation 188 metres. The water level at the inlet of the Delisle Drain was measured at elevation 188.66 metres during the investigation. Minimal groundwater seepage is expected at the founding depths. The culvert at this location may be designed using a factored geotechnical resistance at Ultimate Limit States (ULS) of 450 kilopascals (kPa) and an unfactored geotechnical resistance at Serviceability Limit States (SLS) of 300 kPa with an unfactored coefficient of sliding of 0.58.

6.2.2 Station 19+245 SS (Malden Road West Drain)

The existing NRFO culvert at this location will be extended at the inlet/south end by 23 metres. Currently the culvert is 2.45 x 1.45 x 26.86 metres with an invert at about elevation 189.2 metres.

Based on the information from boreholes 113 and 114, the culvert can be founded on the very stiff to hard clayey silt till at or below elevation 188.0 metres. Boreholes 113 and 114 were dry during and on completion of drilling. The long-term groundwater table is inferred to be near elevation 188 metres. The water level at the inlet of the Malden Road West Drain at Station 19+245 SS was measured at elevation 189.43 metres during the investigation. Minimal groundwater seepage is expected at the founding depths. The culvert at this location may be designed using a factored geotechnical resistance at ULS of 500 kilopascals (kPa) and an unfactored geotechnical resistance at SLS of 350 kPa with an unfactored coefficient of sliding of 0.58.

6.2.3 Station 20+475 SS

The existing corrugated steel pipe (CSP) culvert at this location is 600 millimetres in diameter and 23.73 metres long with an invert at about elevation 190.5 metres and the existing culvert will be replaced. Based on the information from boreholes 110, 115 and 116, a bedding grade in the stiff to hard clayey silt till or silty clay till at or below elevation 189.9 to 190.2 metres can be used for design. Boreholes 110, 115 and 116 were dry during and on completion of drilling. The long-term groundwater table is inferred to be near elevation 189 metres. The water level in the existing culvert at Station 20+475 SS was measured at elevation 190.57 metres at the inlet/north end of the culvert on November 29, 2006 and 190.87 metres at the outlet/south end of the culvert on December 1, 2006. Minimal groundwater seepage is expected at the founding depths. If the culvert at this location is replaced with a concrete culvert, a factored geotechnical resistance at ULS of 500 kilopascals (kPa) and an unfactored geotechnical resistance at SLS of 350 kPa with an unfactored coefficient of sliding of 0.58 may be used for design.

Rip rap should be provided at the outlet as specified in OPSD 810.010 for erosion protection.

6.2.4 Station 10+775 M

The existing corrugated steel pipe (CSP) culvert at this location is 1200 millimetres in diameter and 26.54 metres long with an invert at about elevation 190.5 metres and the existing culvert will be replaced. Based on the information from boreholes 101, 102 and 109, the culvert bedding can be founded on the very stiff to hard clayey silt till at or below elevation 190.4 metres. Boreholes 101, 102 and 109 were dry during and on completion of drilling. The long-term groundwater table is inferred to be at elevation 190 metres. The water level at the outlet/north end of the existing culvert at Station 10+775 M was measured at elevation 191.11 metres and at the inlet/south end at elevation 191.12 metres on November 28, 2006. Minimal groundwater seepage is expected at the founding depths. If the culvert at this location is replaced with a concrete culvert, a factored geotechnical resistance at ULS of 400 kilopascals (kPa) and an unfactored geotechnical resistance at SLS of 275 kPa with an unfactored coefficient of sliding of 0.58 may be used for design.

Rip rap should be provided at the outlet as specified in OPSD 810.010 for erosion protection.

6.2.5 Station 12+908 M (Maidstone - Colchester Townline Drain)

The existing NRFO culvert at this location will be extended at the outlet/south end by 33 metres. Currently the culvert is 1.23 x 1.22 x 54.90 metres with an invert at about elevation 192.1 metres.

Based on the information from boreholes 103 and 104, the culvert can be founded on the very stiff to hard clayey silt till at or below elevation 190.9 metres. Boreholes 103 and 104 were dry

during and on completion of drilling. The long-term groundwater table is inferred to be near elevation 191 metres. The water level at the outlet of the Maidstone-Colchester Townline Drain at Station 12+908 M was measured at elevation 192.22 metres during the investigation. Minimal groundwater seepage is expected at the founding depths. The culvert at this location may be designed using a factored geotechnical resistance at ULS of 450 kilopascals (kPa) and an unfactored geotechnical resistance at SLS of 300 kPa with an unfactored coefficient of sliding of 0.58.

Rip rap should be provided at the outlet as specified in OPSD 810.010 for erosion protection.

6.2.6 Station 13+210 M (Dooley Drain)

The existing NRFO culvert at this location will be extended at the outlet/south end by 23 metres. Currently the culvert is 1.53 x 1.55 x 25.60 metres with an invert at about elevation 192.0 metres.

Based on the information from boreholes 105 and 106, the culvert can be founded on the very stiff to hard silty clay till at or below elevation 190.8 metres. Boreholes 105 and 106 were dry during and on completion of drilling. The long-term groundwater table is inferred to be near elevation 191 metres. The water level at the outlet of the Dooley Drain culvert was measured at elevation 192.30 metres during the investigation. Minimal groundwater seepage is expected at the founding depths. The culvert at this location may be designed using a factored geotechnical resistance at ULS of 375 kilopascals (kPa) and an unfactored geotechnical resistance at SLS of 250 kPa with an unfactored coefficient of sliding of 0.50.

Rip rap should be provided at the outlet as specified in OPSD 810.010 for erosion protection.

6.2.7 Station 13+890 M

The existing NRFO culvert at this location will be extended at the outlet/south end by 23 metres. Currently the culvert is 3.10 x 1.52 x 26.84 metres with an invert at about elevation 191.7 metres.

Based on the information from boreholes 107 and 108, the culvert can be founded on the very stiff to hard silty clay till at or below elevation 190.5 metres. Boreholes 107 and 108 were dry during and on completion of drilling. The long-term groundwater table based on the change in soil colour is inferred to be near elevation 191 metres. The water level at the outlet of the existing culvert at Station 13+890 M was measured at elevation 191.96 metres during the investigation. Minimal groundwater seepage is expected at the founding depths. For preliminary design, a factored geotechnical resistance at ULS of 350 kilopascals (kPa) and an unfactored geotechnical resistance at SLS of 225 kPa with an unfactored coefficient of sliding of 0.50 may be used.

Rip rap should be provided at the outlet as specified in OPSD 810.010 for erosion protection.

6.3 Frost Protection

All footings for NRFO culverts should be provided with 1.2 metres of earth cover or thermal equivalent for frost protection purposes. For CSP culverts, backfill transition (frost taper) will be required in accordance with OPSD 803.030 or 803.031, as applicable, if the frost penetration line is situated below the top of the culvert. Frost taper for NRFO culverts should be placed in accordance with OPSD 803.010.

6.4 Backfill and Bedding

Culvert backfill should consist of free-draining, non-frost susceptible granular materials such as OPSS Granular A or Granular B, Type III. All backfill should be placed and compacted according to OPSS 501.

Heavy compaction equipment should not be used adjacent to the walls and roof of the culverts or within 900 millimetres or less of the crown of CSP culverts. The height of backfill and/or bedding adjacent to the culvert walls should be maintained equal on both sides of the structure during all stages of backfill placement. Temporary diversion of surface water flow may be required during culvert installation. Adequate erosion protection, such as suitable non-woven geotextile and rip rap, as determined by a hydraulic assessment, should be provided at the outlets and inlets.

New Circular Corrugated Steel Pipe Culverts

The roadway fill should be placed and compacted at each culvert location to provide a minimum of 1.0 metres of cover over the pipe. The culvert area should then be subexcavated to the proposed underside of bedding elevation. The excavation should exceed the diameter of the pipe by at least 300 or 500 millimetres on each side for a 600 or 1200 millimetre diameter pipe, respectively, to allow for good workmanship and effective compaction of the fill.

All circular corrugated steel pipe culverts installed in open cut excavations should be constructed in accordance with MTO Special Provision 421S01. Granular A would be considered suitable bedding for the CSP culvert replacements. The bedding should be placed in 300 millimetre thick loose lifts. The granular fill should be placed to provide at least 150 millimetres of cover over the pipe.

Fill and/or backfill above the bedding may consist of the excavated materials, provided all topsoil, organics and other deleterious materials, as well as excessively wet materials, are wasted. Alternatively, approved earth borrow may be used.

All bedding, backfill and cover materials should be placed in accordance with OPSD 802.010.

NRFO Culvert Extensions

All backfill and cover materials should be placed in accordance with OPSD 803.010.

Bedding materials are not required if cast-in-place structures are constructed. Precast elements should be placed on a levelling course with a minimum thickness of 75 millimetres comprised of uncompacted Granular A or approved free draining fine aggregates.

6.5 Lateral Earth Pressures for Design

The lateral pressures acting on the proposed culvert extensions or culvert replacement will depend on the backfill soils and, where used, the type and method of placement of the backfill materials behind the wall, as well as the subsequent lateral movement of the structure. The following recommendations are made concerning the design of the culvert walls in accordance with the Canadian Highway Bridge Design Code (CHBDC).

Backfill behind the culvert walls should consist of select, free-draining granular fill meeting the specifications of OPSS Granular A or Granular B, Type III but with less than 5 per cent passing the No. 200 sieve.

Where backfill soils are placed and compacted behind the walls, a compaction surcharge equal to 12 kilopascals should be included in the lateral earth pressures for structural design, in accordance with the CHBDC. Compaction equipment should be used in accordance with OPSS 501.06.

For walls backfilled with granular fill as noted above, the following parameters (unfactored) may be assumed:

Fill unit weight:	22 kN/m ³
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Coefficients of lateral earth pressure:	
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‘active’ or unrestrained, K_a	0.31
---------------------------------	------

‘at rest’ or restrained, K_o	0.47
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If the wall support allows lateral yielding (unrestrained structure), active earth pressures may be used in the geotechnical design of the structure. The granular fill should be placed in a zone with a minimum width of 1.2 metres at the foundation level, against a cut slope with a maximum inclination of 1 horizontal to 1 vertical. If the culvert wall support does not allow lateral yielding (restrained structure), at rest pressures should be assumed for geotechnical design. In this case, the granular fill should be placed in a zone with a width equal to at least 1.2 metres behind the culvert walls.

Resistance to sliding may be based on an angle of internal friction of 30 degrees for the clayey silt till and 27 degrees for the silty clay till. The unfactored coefficient of passive pressure for the portion of the culvert wall and footing below the invert may be taken as 3.0 for the clayey silt till and 2.7 for the silty clay till.

6.6 Excavations and Temporary Cut Slopes

Following diversion of flows in the existing channels, all topsoil, fill, organic material and other deleterious materials should be stripped from the proposed founding area prior to construction of the replacement culverts and culvert extensions. Any disturbed or deleterious materials encountered should also be removed and low areas brought to grade using compacted Granular A. In areas where groundwater flow may preclude the use of Granular A, 19 millimetre crushed stone placed on a separation geotextile should be used.

Excavations for the culvert extensions will encounter surficial topsoil and fills and the very stiff to hard clayey silt till or silty clay till. The presence of cobbles and boulders which may be present in the till should be anticipated.

Surficial water seepage into the excavations should be expected and will be heavier during periods of sustained precipitation. In addition to diverting the existing culvert flows, pumping from well filtered sumps located at the base of the excavations may be required to provide groundwater control during foundation excavations. However, the overall amount of groundwater inflow is expected to be minimal.

All excavations should be carried out in accordance with the current edition of the Ontario Occupational Health and Safety Act and Regulations For Construction Projects. The excavation side slopes should be maintained at an inclination of 1 horizontal to 1 vertical or flatter in accordance with the current Occupation Health and Safety Act (OSHA). Based on the current OSHA, all fill materials may be classified as Type 3 soils. The clayey silt till and silty clay till may be classified as Type 2 soils.

6.7 Surface and Groundwater Control

Appropriate grading should be carried out prior to construction to direct surface flows away from the open excavations.

Depending on the time of year and the prevailing weather conditions during construction, control of drain flows may be required. Construction should be scheduled to preclude excavation during spring conditions. Control of drain or channel flows, depending on their magnitude, may be handled by pumping from sumps in conjunction with temporary earthen cofferdams constructed

on the native clayey silt till. If excessive flows are present, temporary diversion of the channel may be required.

Based on the results of the investigation, it is considered that, typically, groundwater control can be accomplished using properly constructed and filtered sumps in the base of the excavations.

6.8 Additional Comments

Culvert end treatment is not considered necessary as the potential for uplift, piping or undermining is considered to be very low.

The reconstructed profile results in a minimal grade raise compared to the existing road profile. Therefore post construction settlements are expected to be minimal and camber of the replacement culverts is not considered necessary.

Erosion protection for the culvert backfill should be provided, as appropriate. Consideration could be given to using suitable non-woven geotextile and rip rap, as required, to provide erosion protection based on hydraulic requirements. In addition, sediment control such as silt fences and erosion control blankets may be required during construction and diversion of the watercourses to mitigate migration of fine soil particles.

7.0 MISCELLANEOUS

This report was prepared by Ms. Dirka U. Prout, P.Eng. under the direction of the Project Manager, Mr. Philip R. Bedell, P. Eng. This report was reviewed by Mr. Fintan J. Heffernan, P.Eng., the Designated MTO Contact and Quality Control Auditor for this assignment.

GOLDER ASSOCIATES LTD.

Dirka U. Prout, P. Eng.
Geotechnical Engineer

Philip R. Bedell, P. Eng.
Principal

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

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APPENDIX A
LABORATORY TEST DATA

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.)

Consistency

	<u>kPa</u>	<u>psf</u>
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

(b) Cohesive Soils

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)

PROJECT <u>06-1130-177</u>		RECORD OF BOREHOLE No 101		1 OF 1	METRIC
G.W.P. <u>315-98-00</u>	LOCATION <u>N 4672599.3 ; E 274314.0</u>	ORIGINATED BY <u>MA</u>			
DIST <u> </u> HWY <u>3</u>	BOREHOLE TYPE <u>Power Auger, Solid Stem</u>	COMPILED BY <u>LMK</u>			
DATUM <u>GEODETIC</u>	DATE <u>November 27, 2006</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 (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W _p W W _L WATER CONTENT (%)				GR	SA	SI	CL	
								20	40	60	80	100	○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL						× LAB VANE
192.51	GROUND SURFACE																				
0.10	TOPSOIL, clayey Brown CLAYEY SILT, trace sand, trace gravel (TILL) Stiff to Hard Brown becoming Grey at about elev. 188.9m																				
			1	SS	11																
			2	SS	19																
			3	SS	35																
			4	SS	35																
			5	SS	28																
188.09																					
4.42	END OF BOREHOLE																				
	Borehole dry during drilling November 27, 2006.																				

ONL_MTO 06-1130-177-EE.GPJ LDN_MTO.GDT 2/28/07

RECORD OF BOREHOLE No 102

1 OF 1

METRIC

PROJECT 06-1130-177
G.W.P. 315-98-00 LOCATION N 4672624.8 ; E 274324.6 ORIGINATED BY MA
DIST HWY 3 BOREHOLE TYPE Power Auger, Solid Stem COMPILED BY LMK
DATUM GEODETIC DATE November 27, 2006 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	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
193.25	GROUND SURFACE																			
0.00	FILL, sand and gravel Grey						193													
0.28	FILL, sand, trace silt, some gravel																			
0.56	FILL, clayey silt, trace gravel, trace topsoil Very Stiff Brown		1	SS	15															
191.79							192													
1.46	TOPSOIL, clayey Brown																			
1.62	FILL, clayey silt, trace gravel, trace organic material Stiff Grey		2	SS	8															
							191													
			3	SS	12															
190.51																				
2.74	CLAYEY SILT, trace sand, trace gravel (TILL) Very Stiff to Hard Brown becoming Grey at about elev. 188.4m		4	SS	35		190													
			5	SS	44															
							189													
			6	SS	37															
			7	SS	18		188													
187.31																				
5.94	END OF BOREHOLE																			
	Borehole dry during drilling November 27, 2006.																			

PROJECT <u>06-1130-177</u>		RECORD OF BOREHOLE No 103		1 OF 1 METRIC	
G.W.P. <u>315-98-00</u>		LOCATION <u>N 4671098.6 ;E 275834.3</u>		ORIGINATED BY <u>MA</u>	
DIST <u> </u> HWY <u>3</u>		BOREHOLE TYPE <u>Power Auger, Solid Stem</u>		COMPILED BY <u>LMK</u>	
DATUM <u>GEODETIC</u>		DATE <u>November 27, 2006</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
													20	40	60					
193.87	GROUND SURFACE																			
0.00	FILL, sand and gravel, trace topsoil Brown																			
0.24	FILL, clayey silt, trace sand, trace gravel, trace organic material Stiff Brown		1	SS	13															
192.50																				
1.37	CLAYEY SILT, trace sand, trace gravel (TILL) Very Stiff to Hard Brown becoming Grey at about elev. 189.5m		2	SS	19															
			3	SS	32															
			4	SS	40															
			5	SS	39															
			6	SS	26															
188.69																				
5.18	END OF BOREHOLE Borehole dry during drilling November 27, 2006.																			

ONL_MTO 06-1130-177-EE.GPJ LDN_MTO.GDT 2/28/07

PROJECT <u>06-1130-177</u>		RECORD OF BOREHOLE No 104		1 OF 1		METRIC	
G.W.P. <u>315-98-00</u>		LOCATION <u>N 4671091.7 ; E 275812.2</u>		ORIGINATED BY <u>MA</u>			
DIST <u> </u> HWY <u>3</u>		BOREHOLE TYPE <u>Power Auger, Solid Stem</u>		COMPILED BY <u>LMK</u>			
DATUM <u>GEODETIC</u>		DATE <u>November 27, 2006</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
								○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × LAB VANE											
193.56	GROUND SURFACE							20	40	60	80	100								
0.00	TOPSOIL, clayey Brown																			
0.23	CLAYEY SILT, trace sand, trace gravel (TILL) Stiff to Hard Brown becoming Grey at about elev. 190.0m		1	SS	14															
			2	SS	16															
			3	SS	37															
			4	SS	36															
			5	SS	18															
			6	SS	17															
188.38	END OF BOREHOLE																			
5.18	Borehole dry during drilling November 27, 2006.																			

ONL_MTO 06-1130-177-EE.GPJ LDN_MTO.GDT 2/28/07

PROJECT <u>06-1130-177</u>		RECORD OF BOREHOLE No 105		1 OF 1		METRIC	
G.W.P. <u>315-98-00</u>		LOCATION <u>N 4670862.2 ; E 276020.4</u>		ORIGINATED BY <u>MA</u>			
DIST <u> </u> HWY <u>3</u>		BOREHOLE TYPE <u>Power Auger, Solid Stem</u>		COMPILED BY <u>LMK</u>			
DATUM <u>GEODETIC</u>		DATE <u>November 28, 2006</u>		CHECKED BY <u> </u>			

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									
193.42	GROUND SURFACE																			
0.00	TOPSOIL, clayey Brown																			
0.30	SILTY CLAY, trace sand, trace gravel (TILL) Stiff to Hard Brown becoming Grey at about elev. 190.5m		1	SS	11															
			2	SS	9															
			3	SS	30															
			4	SS	28															
			5	SS	15															
			6	SS	14															
188.24	END OF BOREHOLE																			
5.18	Borehole dry during drilling November 28, 2006.																			

PROJECT 06-1130-177		RECORD OF BOREHOLE No 106		1 OF 1	METRIC
G.W.P. 315-98-00		LOCATION N 4670886.1 ; E 276034.8		ORIGINATED BY MA	
DIST _____ HWY 3		BOREHOLE TYPE Power Auger, Solid Stem		COMPILED BY LMK	
DATUM GEODETIC		DATE November 28, 2006		CHECKED BY _____	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL LIMIT MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					w _p w w _L				
194.35	GROUND SURFACE						20	40	60	80	100						
0.00	FILL, sand and gravel, trace silt Grey																
193.59																	
0.76	FILL, sand, trace silt Compact Brown		1	SS	12												
1.06	FILL, clayey silt, trace sand, trace gravel, trace topsoil Stiff Brown		2	SS	8												
192.25																	
2.10	SILTY CLAY, trace sand, trace gravel (TILL) Very Stiff to Hard Brown becoming Grey at about elev. 190.8m		3	SS	18												
			4	SS	31												
			5	SS	32												
			6	SS	18												
			7	SS	16												
188.41																	
5.94	END OF BOREHOLE Borehole dry during drilling November 28, 2006.																


PROJECT <u>06-1130-177</u>		RECORD OF BOREHOLE No 107		1 OF 1		METRIC	
G.W.P. <u>315-98-00</u>		LOCATION <u>N 4670363.2 ; E 276469.5</u>		ORIGINATED BY <u>MA</u>			
DIST <u> </u> HWY <u>3</u>		BOREHOLE TYPE <u>Power Auger, Solid Stem</u>		COMPILED BY <u>LMK</u>			
DATUM <u>GEODETIC</u>		DATE <u>November 28, 2006</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	
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	20	40	60	80	100	w _p	w		w _L				
193.64	GROUND SURFACE																				
0.00	TOPSOIL, clayey Brown																				
0.15	SILTY CLAY, trace sand, trace gravel (TILL) Stiff to Hard Brown becoming Grey at about elev. 190.6m		1	SS	10																
			2	SS	18																
			3	SS	35								○	┌──────────┐				1	15	45	39
			4	SS	29																
			5	SS	17																
			6	SS	16																
188.46	END OF BOREHOLE																				
5.18	Borehole dry during drilling November 28, 2006.																				

PROJECT <u>06-1130-177</u>		RECORD OF BOREHOLE No 108		1 OF 1 METRIC	
G.W.P. <u>315-98-00</u>		LOCATION <u>N 4670372.5 ; E 276498.1</u>		ORIGINATED BY <u>MA</u>	
DIST <u> </u> HWY <u>3</u>		BOREHOLE TYPE <u>Power Auger, Solid Stem</u>		COMPILED BY <u>LMK</u>	
DATUM <u>GEODETIC</u>		DATE <u>November 28, 2006</u>		CHECKED BY <u> </u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIQUID MOISTURE LIMIT 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 (%)							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					w _p w w _L							
194.36	GROUND SURFACE							20	40	60	80	100								
0.00	FILL, sand and gravel Grey						194													
0.21	FILL, sand, trace silt, some gravel Compact Brown																			
193.29			1	SS	18															
1.07	FILL, clayey silt, trace sand, trace gravel, trace topsoil Stiff to Firm Brown		2	SS	7		193													
192.23																				
2.13	SILTY CLAY, trace sand, trace gravel (TILL) Stiff to Hard Brown becoming Grey at about elev. 190.0m		3	SS	12		192									4	17	43	36	
			4	SS	31		191													
			5	SS	29		190													
			6	SS	19												0	15	46	39
188.42			7	SS	14		189													
5.94	END OF BOREHOLE																			
	Borehole dry during drilling November 28, 2006.																			

PROJECT <u>06-1130-177</u>		RECORD OF BOREHOLE No 109		1 OF 1 METRIC	
G.W.P. <u>315-98-00</u>		LOCATION <u>N 4672630.0 ; E 274342.6</u>		ORIGINATED BY <u>MA</u>	
DIST <u> </u> HWY <u>3</u>		BOREHOLE TYPE <u>Power Auger, Solid Stem</u>		COMPILED BY <u>LMK</u>	
DATUM <u>GEODETIC</u>		DATE <u>November 28, 2006</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
192.53	GROUND SURFACE																				
0.00	TOPSOIL, clayey Brown																				
0.18	CLAYEY SILT, trace sand, trace gravel (TILL) Stiff to Hard Brown becoming Grey at about elev. 188.8m						192											1	18	46	35
			1	SS	8																
			2	SS	8																
			3	SS	36																
			4	SS	43																
			5	SS	25																
187.35	END OF BOREHOLE		6	SS	20		188														
5.18	Borehole dry during drilling November 28, 2006.																				

PROJECT <u>06-1130-177</u>		RECORD OF BOREHOLE No 110		1 OF 1		METRIC	
G.W.P. <u>315-98-00</u>		LOCATION <u>N 4673418.1 ; E 273331.6</u>		ORIGINATED BY <u>MA</u>			
DIST <u> </u> HWY <u>3</u>		BOREHOLE TYPE <u>Power Auger, Solid Stem</u>		COMPILED BY <u>LMK</u>			
DATUM <u>GEODETIC</u>		DATE <u>November 29, 2006</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	
								○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × LAB VANE												
190.80	GROUND SURFACE																				
0.00	TOPSOIL, clayey Brown																				
0.15	CLAYEY SILT, trace sand, trace gravel (TILL) Stiff to Hard Brown		1	SS	10																
			2	SS	35																
			3	SS	40																
187.90																					
2.90	CLAYEY SILT, trace sand, trace gravel with silt seams Very stiff Grey		4	SS	27																
187.14																					
3.66	CLAYEY SILT, trace sand, trace gravel (TILL) Very Stiff Grey		5	SS	18																
			6	SS	21																
185.62																					
5.18	END OF BOREHOLE Borehole dry during drilling November 29, 2006.																				

PROJECT <u>06-1130-177</u>		RECORD OF BOREHOLE No 111		1 OF 1 METRIC	
G.W.P. <u>315-98-00</u>		LOCATION <u>N 4674506.2 ; E 271870.7</u>		ORIGINATED BY <u>MA</u>	
DIST <u> </u> HWY <u>3</u>		BOREHOLE TYPE <u>Power Auger, Solid Stem</u>		COMPILED BY <u>LMK</u>	
DATUM <u>GEODETIC</u>		DATE <u>November 30, 2006</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	
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	20	40	60	80	100	w _p	w		w _L				
190.23	GROUND SURFACE																				
0.00	TOPSOIL, clayey Brown																				
0.15	FILL, sand, trace gravel, trace silt Brown																				
189.56	CLAYEY SILT, trace sand, trace gravel (TILL) Stiff to Hard Brown becoming Grey at about elev. 186.6m		1	SS	11																
0.67			2	SS	15																
			3	SS	39																
			4	SS	50																
			5	SS	26																
			6	SS	18																
			7	SS	16																
184.29	END OF BOREHOLE																				
5.94	Borehole dry during drilling November 30, 2006.																				

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PROJECT <u>06-1130-177</u>		RECORD OF BOREHOLE No 112		1 OF 1		METRIC	
G.W.P. <u>315-98-00</u>		LOCATION <u>N 4674483.9 ; E 271864.6</u>		ORIGINATED BY <u>MA</u>			
DIST <u> </u> HWY <u>3</u>		BOREHOLE TYPE <u>Power Auger, Solid Stem</u>		COMPILED BY <u>LMK</u>			
DATUM <u>GEODETIC</u>		DATE <u>November 30, 2006</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/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 x LAB VANE					w _p w w _L							
189.85	GROUND SURFACE							20	40	60	80	100								
0.00	TOPSOIL, clayey Brown																			
0.30	CLAYEY SILT, trace sand, trace gravel (TILL) Stiff to Hard Brown becoming Grey at about elev. 186.3m		1	SS	10		189													
			2	SS	14		188													
			3	SS	41		187													
			4	SS	32		186													
			5	SS	23		185													
184.67	END OF BOREHOLE		6	SS	17															
5.18	Borehole dry during drilling November 30, 2006.																			

PROJECT <u>06-1130-177</u>		RECORD OF BOREHOLE No 113		1 OF 1	METRIC
G.W.P. <u>315-98-00</u>		LOCATION <u>N 4674129.2 ; E 272321.7</u>		ORIGINATED BY <u>MA</u>	
DIST <u> </u> HWY <u>3</u>		BOREHOLE TYPE <u>Power Auger, Solid Stem</u>		COMPILED BY <u>LMK</u>	
DATUM <u>GEODETIC</u>		DATE <u>November 30, 2006</u>		CHECKED BY <u> </u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT						PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT			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							
190.08	GROUND SURFACE																					
0.00	TOPSOIL, clayey Brown																					
189.62																						
0.46	CLAYEY SILT, trace sand, trace gravel (TILL) Stiff to Hard Brown becoming Grey at about elev. 187.0m		1	SS	10																	
			2	SS	29																	
			3	SS	45																	
			4	SS	27																	
			5	SS	27																	
			6	SS	17																	
184.90	END OF BOREHOLE																					
5.18	Borehole dry during drilling November 30, 2006.																					

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PROJECT <u>06-1130-177</u>		RECORD OF BOREHOLE No 114		1 OF 1 METRIC	
G.W.P. <u>315-98-00</u>		LOCATION <u>N 4674144.7 ; E 272335.2</u>		ORIGINATED BY <u>MA</u>	
DIST <u> </u> HWY <u>3</u>		BOREHOLE TYPE <u>Power Auger, Solid Stem</u>		COMPILED BY <u>LMK</u>	
DATUM <u>GEODETIC</u>		DATE <u>November 30, 2006</u>		CHECKED BY <u> </u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIQUID MOISTURE LIMIT 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	
								20	40	60	80	100	W _p	W	W _L						
190.22	GROUND SURFACE																				
0.00	TOPSOIL, clayey Brown																				
189.46	CLAYEY SILT, trace sand, trace gravel (TILL) Stiff to Hard Brown becoming Grey at about elev. 187.2m		1	SS	12																
0.76			2	SS	26																
			3	SS	42																
			4	SS	33																
			5	SS	20																
			6	SS	17																
185.04	END OF BOREHOLE																				
5.18	Borehole dry during drilling November 30, 2006.																				

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PROJECT <u>06-1130-177</u>		RECORD OF BOREHOLE No 115		1 OF 1	METRIC
G.W.P. <u>315-98-00</u>		LOCATION <u>N 4673381.0 :E 273300.7</u>		ORIGINATED BY <u>MA</u>	
DIST <u> </u> HWY <u>3</u>		BOREHOLE TYPE <u>Power Auger, Solid Stem</u>		COMPILED BY <u>LMK</u>	
DATUM <u>GEODETIC</u>		DATE <u>December 1, 2006</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					W _p	W	W _L		WATER CONTENT (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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191.51	GROUND SURFACE							20	40	60	80	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								

ONL_MTO 06-1130-177-EE.GPJ LDN_MTO.GDT 2/28/07

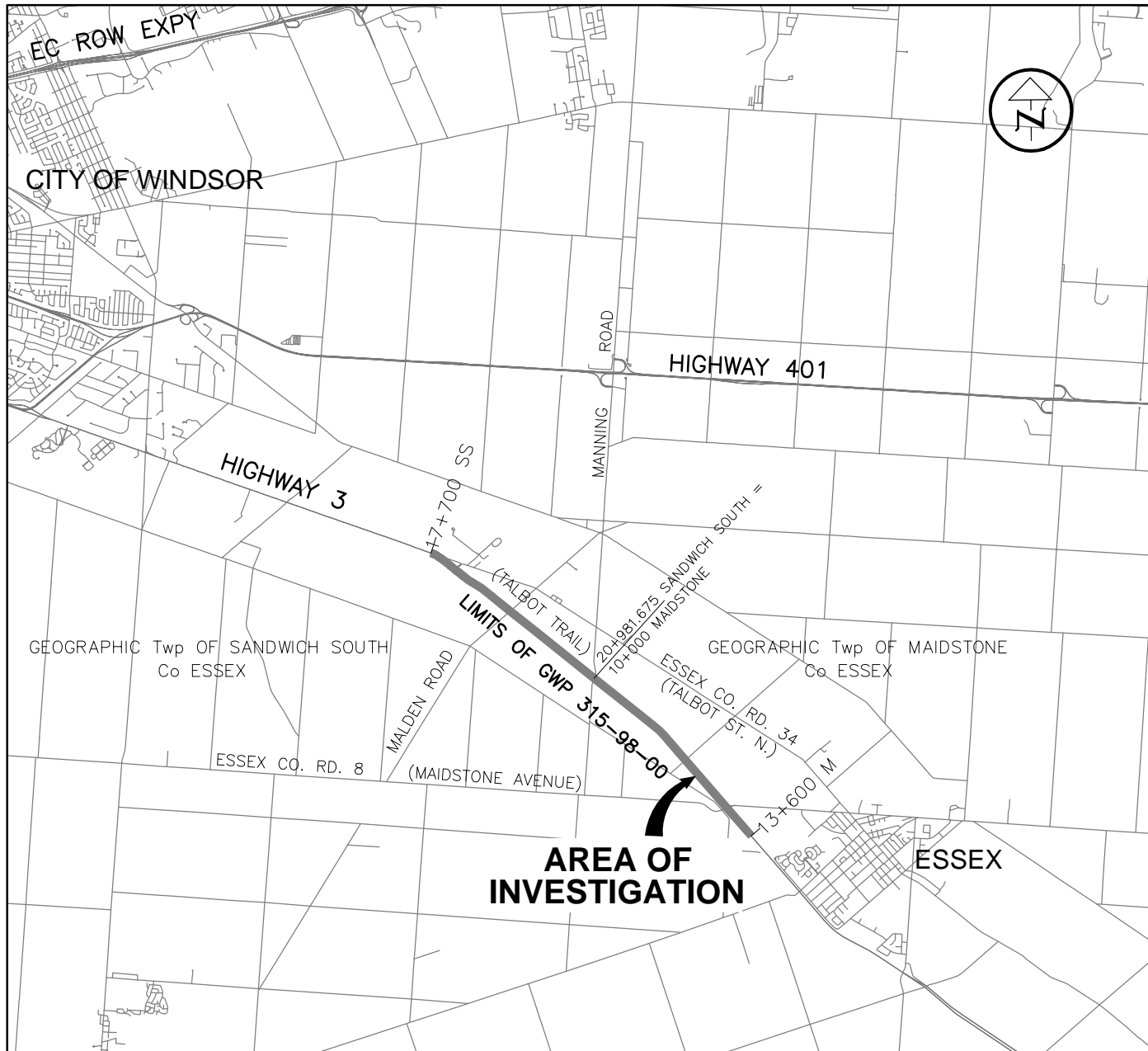
RECORD OF BOREHOLE No 116

1 OF 1

METRIC

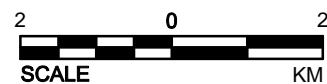
PROJECT 06-1130-177
G.W.P. 315-98-00 LOCATION N 4673396.5 ; E 273314.2 ORIGINATED BY MA
DIST HWY 3 BOREHOLE TYPE Power Auger, Solid Stem COMPILED BY LMK
DATUM GEODETIC DATE December 1, 2006 CHECKED BY

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										
								○ UNCONFINED	+	FIELD VANE								
191.27	GROUND SURFACE						● QUICK TRIAXIAL	×	LAB VANE	WATER CONTENT (%)								
0.10	TOPSOIL, clayey Brown						20 40 60 80 100											
	FILL, clayey silt, trace sand, trace gravel and clay tile		1	SS	12													
189.96	Stiff Brown																	
1.31	CLAYEY SILT, trace sand, trace gravel (TILL) Very Stiff to Hard Brown becoming Grey at about elev. 188.3m		2	SS	20													
			3	SS	36													
			4	SS	42													
			5	SS	27													
			6	SS	20													
186.09	END OF BOREHOLE																	
5.18	Borehole dry during drilling December 1, 2006.																	




NOTE

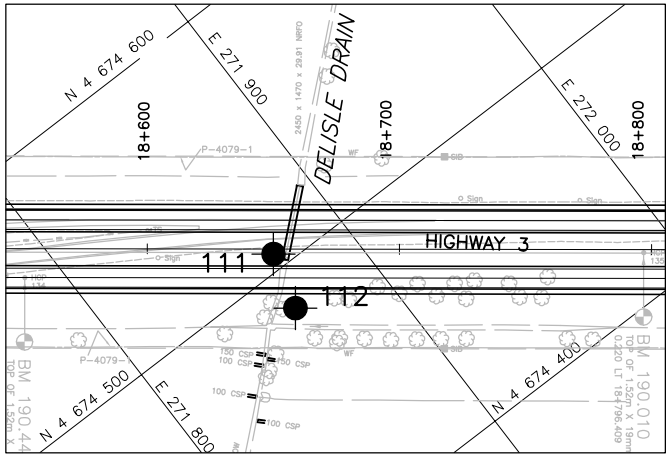
SS = TOWNSHIP OF SANDWICH SOUTH
M = TOWNSHIP OF MAIDSTONE



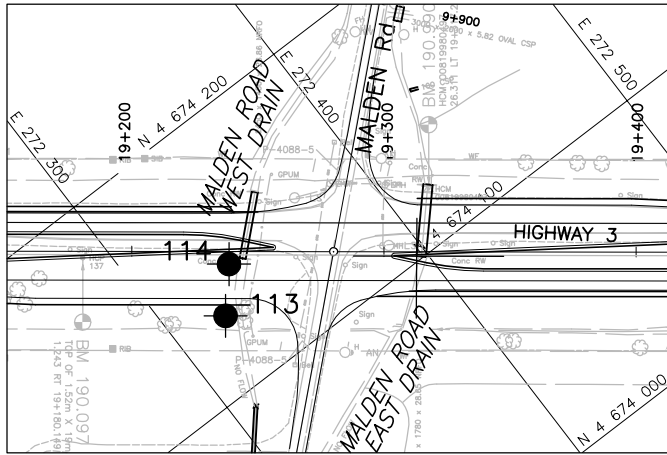
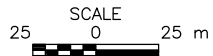
NOTE

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

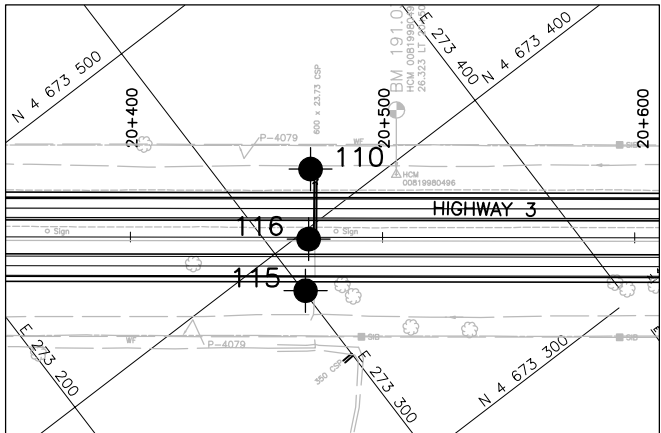
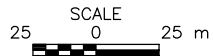
PROJECT		SHORT SPAN CULVERTS HIGHWAY 3 WIDENING GWP 315-98-00			
TITLE		KEY PLAN			
 Golder Associates LONDON, ONTARIO		PROJECT No. 06-1130-177-0-5		FILE No. 061130177-EE001	
		CADD	WDF	Jan 09/07	SCALE AS SHOWN
		CHECK			REV. 0
FIGURE 1					



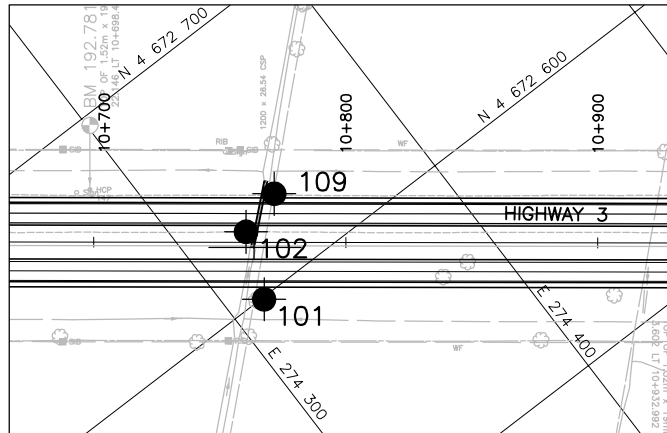
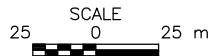
PLAN 18+655 SS



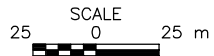
PLAN 19+245 SS



PLAN 20+475 SS

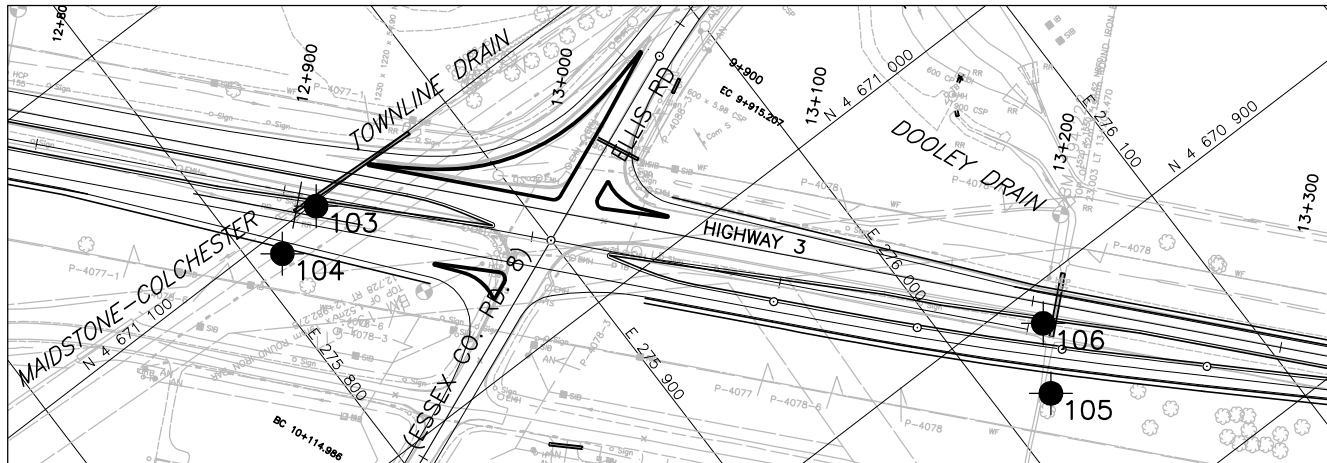


PLAN 10+775 M

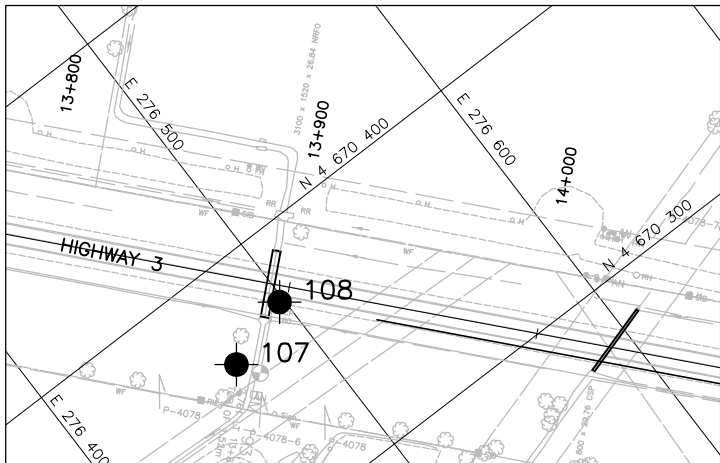
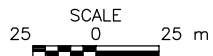


NOTE

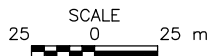
SS = TOWNSHIP OF SANDWICH SOUTH
M = TOWNSHIP OF MAIDSTONE



PLAN 12+908 M and 13+210 M



PLAN 13+890 M



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

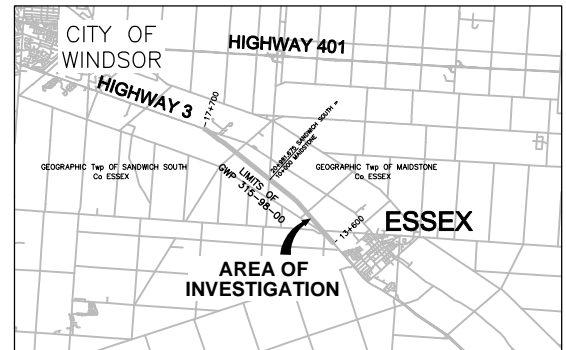
CONT No.
WP No. 315-98-00

SHORT SPAN CULVERTS
HIGHWAY 3

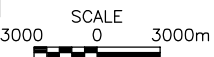
BOREHOLE LOCATIONS



Golder Associates Ltd.
LONDON, ONTARIO, CANADA



KEY PLAN



LEGEND

● Borehole – Current Investigation

No.	ELEVATION	CO-ORDINATES (MTM Zone 11)	
		NORTHING	EASTING
101	192.51	4 672 599.3	274 314.0
102	193.25	4 672 624.8	274 324.6
103	193.87	4 671 098.6	275 834.3
104	193.56	4 671 091.7	275 812.2
105	193.42	4 670 862.2	276 020.4
106	194.35	4 670 886.1	276 034.8
107	193.64	4 670 363.2	276 469.5
108	194.36	4 670 372.5	276 498.1
109	192.53	4 672 630.0	274 342.6
110	190.80	4 673 418.1	273 331.6
111	190.23	4 674 506.2	271 870.7
112	189.85	4 674 483.9	271 864.6
113	190.08	4 674 129.2	272 321.7
114	190.22	4 674 144.7	272 335.2
115	191.51	4 673 381.0	273 300.7
116	191.27	4 673 396.5	273 314.2

NOTES

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

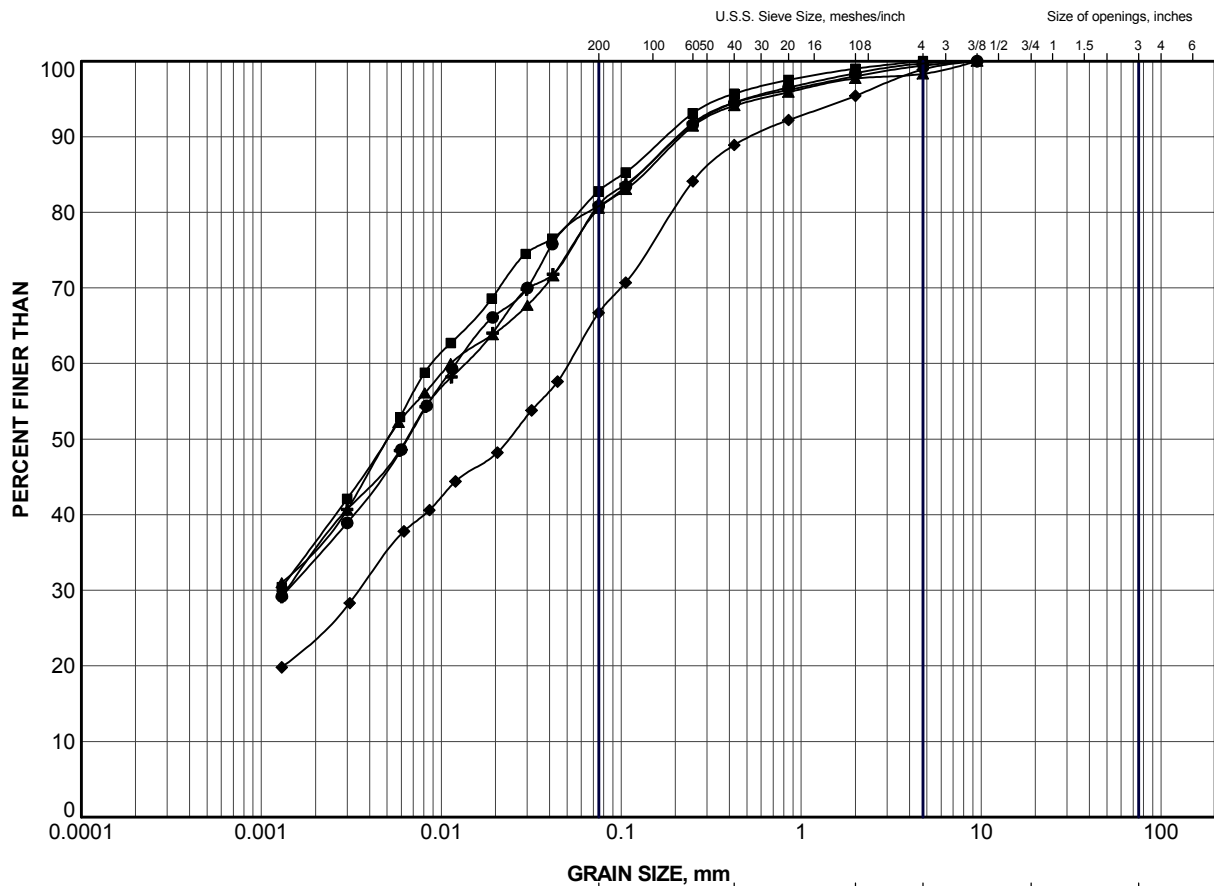
The boundaries between soil strata have been established only at borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REFERENCE

Base plans provided in digital format by DELCAN.

NO.	DATE	BY	REVISION
Geocres No.		40J2-92	
HWY.	3	PROJECT NO.	06-1130-177-0-5
SUBM'D.		DUP	DIST.
DRAWN:		WDF	CHKD.
		CAB	DATE: Feb. 15/07
		APPD.	SITE:
		DWG.	1


APPENDIX A
LABORATORY TEST DATA

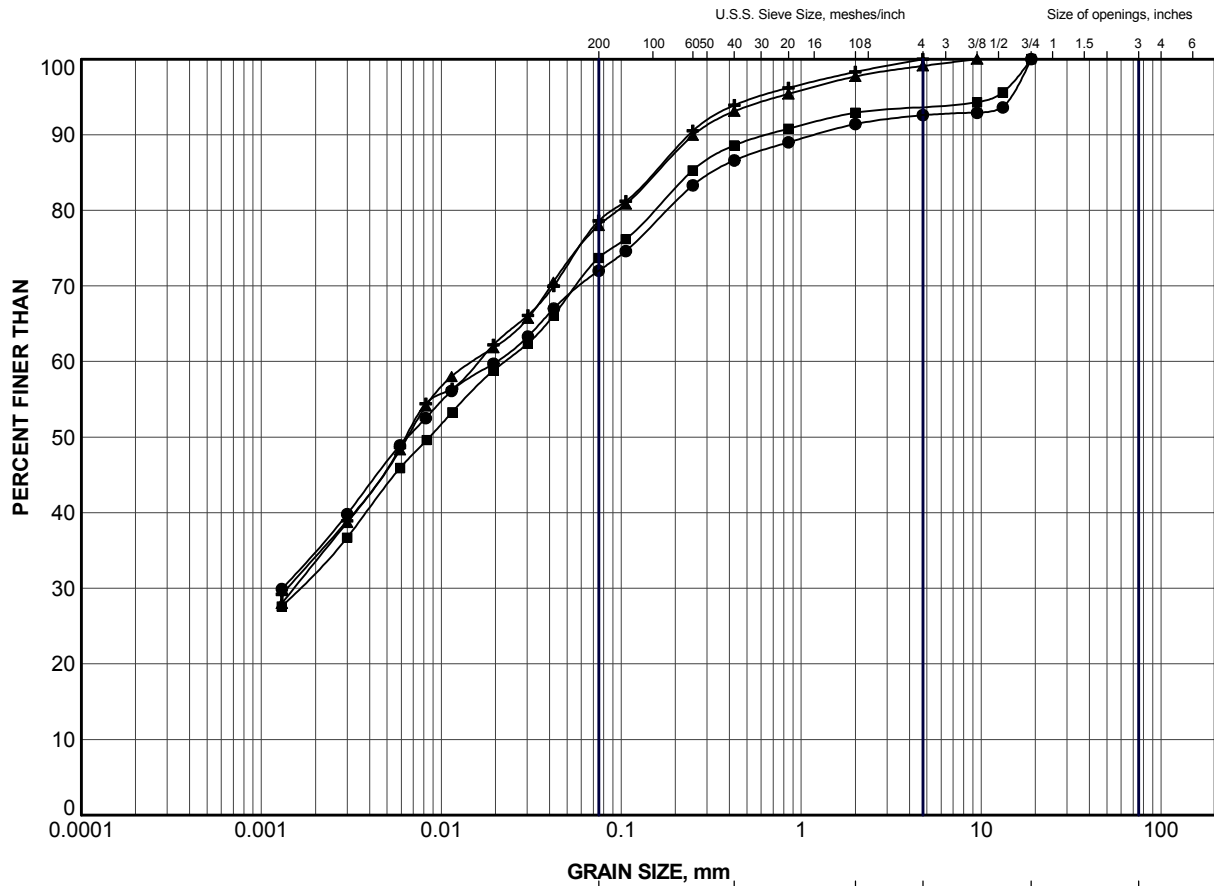


GRAVEL SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	101	4	189.2
■	102	6	188.5
▲	103	3	191.4
+	109	4	189.3
◆	110	5	186.8


PROJECT		SHORT SPAN CULVERTS HIGHWAY 3 WIDENING GWP 315-98-00			
TITLE		GRAIN SIZE DISTRIBUTION CLAYEY SILT (TILL)			
 Golder Associates LONDON, ONTARIO		PROJECT No.		06-1130-177	
		FILE No.		06-1130-177-EE.GPJ	
		SCALE		N/A	
DRAWN		WDF		Jan 02/07	
CHECK					
		FIGURE A-1			

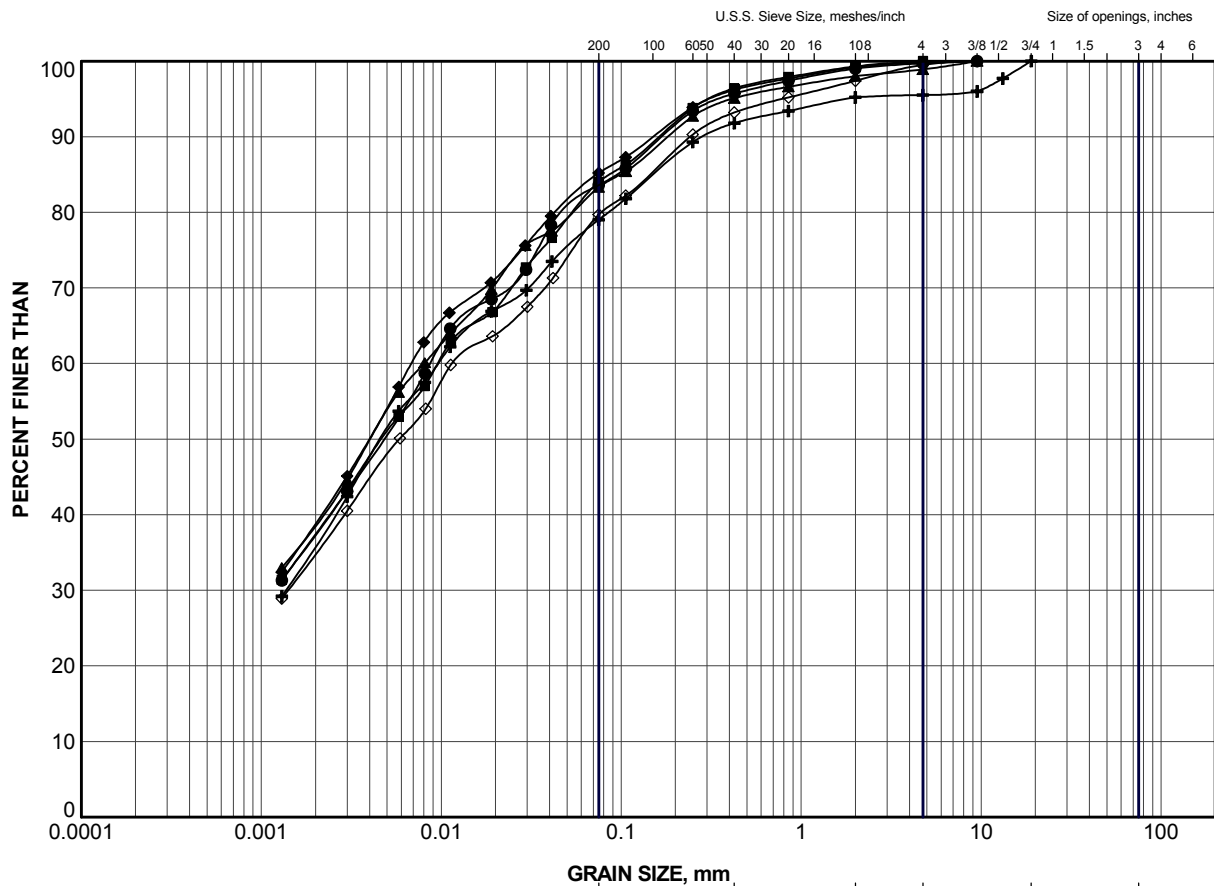


CLAY AND SILT	GRAVEL SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	111	6	185.4
■	113	2	188.3
▲	114	4	186.9
+	116	3	188.8


PROJECT		SHORT SPAN CULVERTS HIGHWAY 3 WIDENING GWP 315-98-00			
TITLE		GRAIN SIZE DISTRIBUTION CLAYEY SILT (TILL)			
 Golder Associates LONDON, ONTARIO		PROJECT No.		06-1130-177	
		FILE No.		06-1130-177-EE.GPJ	
		SCALE		N/A	
		REV.			
DRAWN		WDF		Jan 10/07	
CHECK					
		FIGURE A-2			

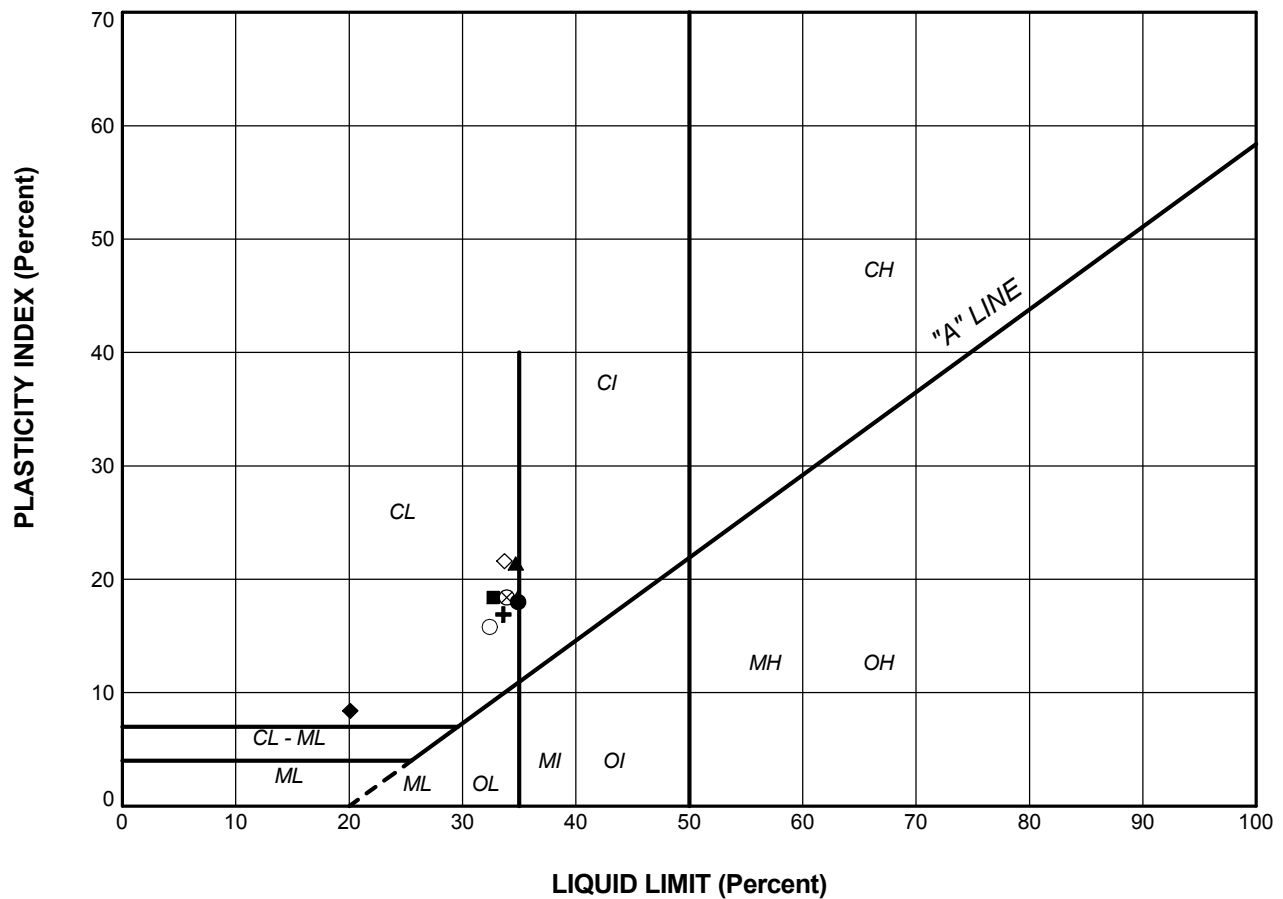


CLAY AND SILT	SAND SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	105	3	190.9
■	106	5	190.3
▲	107	3	191.1
+	108	3	191.8
◆	108	6	189.6
◇	115	5	187.5

PROJECT				SHORT SPAN CULVERTS HIGHWAY 3 WIDENING GWP 315-98-00			
TITLE				GRAIN SIZE DISTRIBUTION SILTY CLAY (TILL)			
PROJECT No.		06-1130-177		FILE No.		06-1130-177-EE.GPJ	
DRAWN		WDF		SCALE		N/A	
CHECK		Jan 10/07		REV.			
 Golder Associates LONDON, ONTARIO				FIGURE A-3			

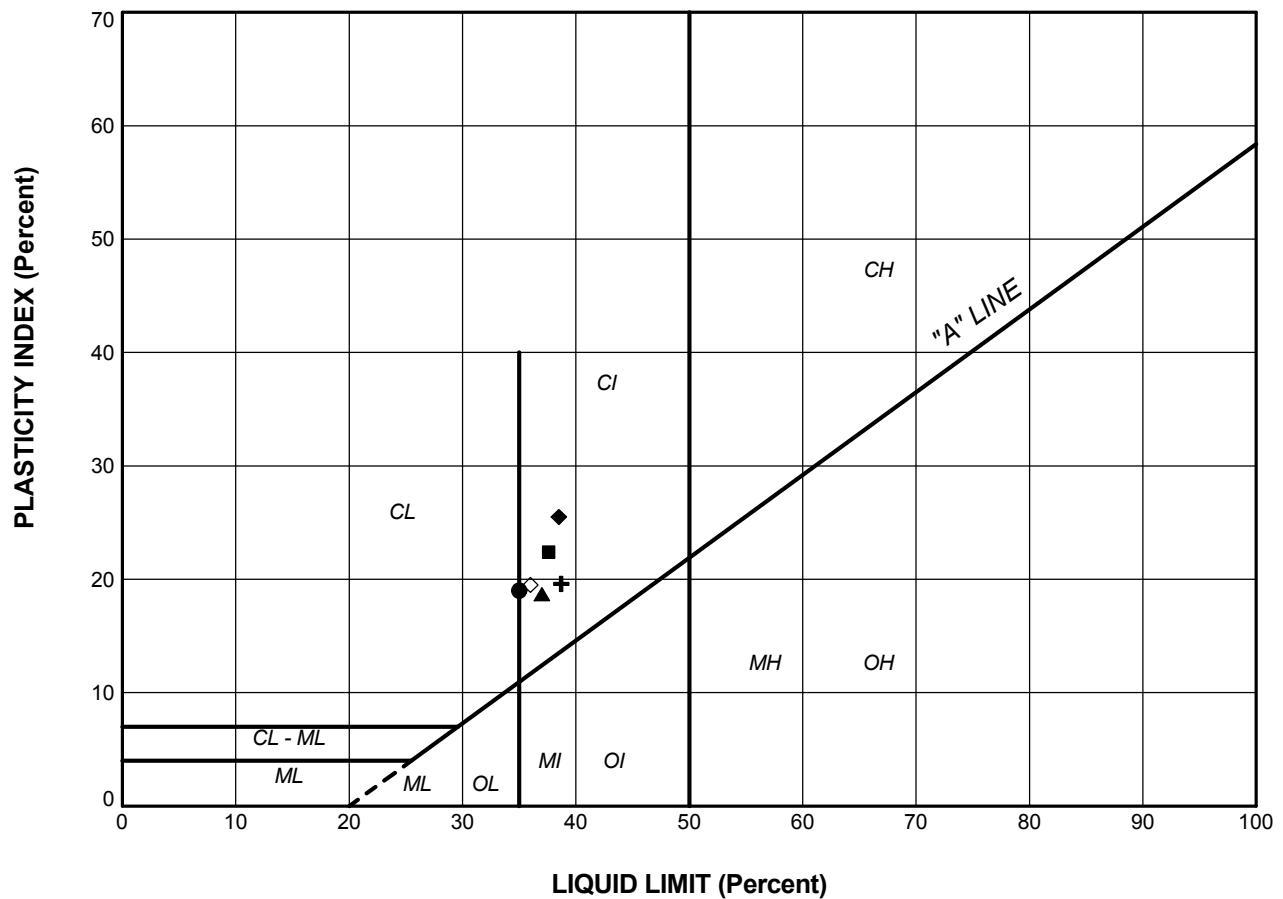



LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	101	4	34.9	16.9	18.0
■	102	6	32.7	14.3	18.4
▲	103	3	34.7	13.3	21.4
+	109	4	33.6	16.7	16.9
◆	110	5	20.1	11.7	8.4
◇	111	6	33.7	12.1	21.6
○	113	2	32.4	16.6	15.8
△	114	4	34.9	16.5	18.4
⊗	116	3	33.9	15.5	18.4

PROJECT		SHORT SPAN CULVERTS HIGHWAY 3 WIDENING GWP 315-98-00	
TITLE		PLASTICITY CHART CLAYEY SILT (TILL)	
PROJECT No. 06-1130-177		FILE No. 06-1130-177-EE.GPJ	
DRAWN	WDF	Jan 10/07	SCALE N/A REV.
CHECK			FIGURE A-4





PROJECT		SHORT SPAN CULVERTS HIGHWAY 3 WIDENING GWP 315-98-00	
TITLE		PLASTICITY CHART SILTY CLAY (TILL)	
PROJECT No. 06-1130-177		FILE No. 06-1130-177-EE.GPJ	
DRAWN	WDF	Jan 10/07	SCALE N/A
CHECK			REV.
 Golder Associates LONDON, ONTARIO			FIGURE A-5