Golder Associates Ltd.

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

FOUNDATION INVESTIGATION REPORT
LAMBTON COUNTY ROAD 79 UNDERPASS (SITE 14-355)
STRUCTURAL REHABILITATION
HIGHWAY 402 AND LAMBTON COUNTY ROAD 79 IMPROVEMENTS
GWP 3158-06-00
WATFORD, ONTARIO

Submitted to:

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

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder Associates) has been retained by Delcan Corporation (Delcan) on behalf of Waste Management (WM) to carry out foundation investigations as part of the design package for improvements for the Highway 402/Lambton County Road 79 (Nauvoo Road) interchange and Lambton County Road 79 south of the interchange to the new entrance of the Warwick Landfill in the Township of Warwick, Ontario.

The proposed works are being undertaken in conjunction with the Warwick Landfill Expansion Project. The design package is to be completed in accordance with Ministry of Transportation, Ontario (MTO) standards. The scope of work for this project consists of the geotechnical field investigation and design of the following components of the project:

- rehabilitation of the Lambton County Road 79 Underpass Structure (Site 14-355);
- profile grade adjustments (filling) on Lambton County Road 79;
- profile grade adjustments on portions of the existing E-N/S, S-W, N-E and W-N/S ramps;
- replacement of the existing S-E and N-W ramps with new ramps;
- possible pavement upgrades on the existing E-N/S ramp;
- paved shoulders along Lambton County Road 79 from Highway 402 to the landfill entrance;
- roadway improvements along Lambton County Road 79 at the new landfill entrance;
- culvert extensions on Lambton County Road 79; and
- a culvert extension on Highway 402.

This report addresses the foundations engineering aspects of the proposed abutment modifications and the rehabilitation of the embankment side slopes at the Highway 402/Lambton County Road 79 Underpass structure. The foundation investigation and reporting was conducted in accordance with MTO standards for detail design.

The purpose of the foundation investigation is to determine the subsurface conditions at the locations 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 WM Project Terms of Reference, in our proposal P71-3118 dated June 26, 2007, and our letter pertaining to additional foundation engineering services (07-1130-128-4) dated September 14, 2007. The work was conducted in accordance with our letter dated September 14, 2007.

Delcan provided Golder with preliminary drawings for this project in digital format for the two span structure. The preliminary general arrangement drawing indicates that new semi-integral abutment systems and concrete barrier walls on the deck and wingwalls are to be constructed with reconstruction of the approach slabs. It also indicates that the deck and soffit are to be rehabilitated.

The Department of Transportation and Communications Ontario Drawings for the Highway 79 Underpass W.P. 42-66-11 dated March 1972 provided by Delcan shows that the pier is founded on a strip footing 3.2 metres wide. The underside of footing is at about elevation 229.8 metres. The abutments are founded on 325 millimetre nominal diameter, concrete filled, steel tube piles. The drawings indicate that these are friction piles which were not to be driven below elevation 228.6 metres. The approximate bottom of pile cap elevation is at 234.2 metres. The approximate top of deck elevation is 238.75 metres at the centreline of the pier. The underpass structure is 18.29 metres wide with a total span length of 81.38 metres.

2.0 SITE DESCRIPTION

This project consists of the upgrading of the Highway 402/Lambton County Road 79 (Nauvoo Road) interchange with rehabilitation of the underpass structure, profile adjustments on Lambton County Road 79 and the affected ramps, construction of a new S-E ramp and N-W ramp and possible upgrading of the pavement on the E-N/S ramp. In addition, short span and structural culverts in the areas of the roadway improvements are to be extended and Lambton County Road 79 is to be upgraded in the vicinity of the entrance to the new Waste Management landfill. The location of the interchange is shown on the Key Plan, Figure 1.

The surrounding area is predominately agricultural lands with woodlots immediately north of the interchange. A former construction yard is located immediately north of the interchange and a former gas storage yard is located south of the interchange, both to the west of Lambton County Road 79. The adjacent topography is generally flat with a ground surface elevation ranging from 232 metres to 235 metres based on the topographical mapping for Watford, Map No. 40-I/13e.

Lambton County Road 79 is a two lane road with 3.35 metre wide lanes and variable width lanes leading to the Highway 402 ramps. The existing Lambton County Road 79 underpass structure is a two span simply supported steel box girder bridge constructed in 1978 and designated as Site Number 14-355. The bridge carries traffic on Lambton County Road 79 over Highway 402. Both spans are 41.76 metres long and the existing deck has an overall width of 18.29 metres. The subject section of Highway 402 is a divided rural freeway with two 3.65 metre wide lanes and one outer variable width speed change lane and paved shoulders in each direction. The interchange has ramps in the northeast and southwest quadrants only. Photographs of the structure are shown in Appendix C.

During a site reconnaissance carried out on September 13, 2007 by the Project Manager and Senior Field Supervisor, it was noted that signs of instability and post construction movements were present in the form of tension cracks in portions of the approach fills. The distress was documented in our September 14, 2007 letter to Delcan.

The side slopes parallel to Lambton County Road 79 and the abutment face slopes parallel to Highway 402 were measured at both approaches using an Abney hand level. At the north approach, the side slopes were found to be 25 and 23 degrees in the northwest and northeast quadrants, respectively. However, the slopes facing Highway 402 were found to be 30 and 33 to 34 degrees in the northwest and northeast quadrants, respectively. At the southern approach, the both side slopes were approximately 25 degrees. The slopes facing Highway 402 were found to be 30 and 29 degrees in the southwest and southeast quadrants, respectively.

Cracks or distresses behind the slope crest were not observed. Cracking of the slope face was noted in the northeast and southeast quadrants of the approach fills as shown in Photographs 3 to 7 in Appendix C. Differential settlements between the structure and the curbs and gutters on the

approach slabs and approach fills was noted at all four corners of the bridge. These settlements were most apparent at the southeast corner of the bridge. The slope face is moderately well vegetated with grass. However, several bare spots were evident. Beneath the structure, the slopes are covered with rip rap.

2.1 Site Geology

The project is located in the physiographic region of southern Ontario known as the Horseshoe Moraines as identified in "The Physiography of Southern Ontario", by Chapman and Putnam (1984). The southwestern limb of the region consists of two, and in some places three, morainic ridges composed of pale brown, hard, calcareous, fine-textured till with a moderate degree of stoniness.

Based on the Ontario Department of Mines and Northern Affairs Preliminary Map P.1972 entitled "Quaternary Geology of the Strathroy Area", the project area is reportedly located in predominantly clayey silt to silty clay till.

The surface of the subcropping rock is reported to be about 27 metres below ground surface based on Ontario Geological Survey Preliminary Map P.2453. According to Geological Survey of Canada Map 1263A, “Geology Toronto – Windsor Area”, the rock belongs to the Kettle Point formation and consists of black bituminous shale with greenish-grey silty shale interbeds.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out on November 21 and November 28, 2007 at which time four boreholes were drilled at the locations indicated on Drawing 1.

The as-drilled borehole locations, ground surface elevations and depths of the boreholes drilled by Golder are as follows:

BOREHOLE	LOCATION (m)		GROUND SURFACE ELEVATION	BOREHOLE DEPTH
	Northing	Easting	(m)	(m)
201	4,761,446.1	355,406.5	234.44	3.35
202	4,761,609.5	355,406.1	234.51	3.35
203	4,761,461.1	355,397.4	237.96	8.84
204	4,761,624.5	355,397.9	237.89	8.84

The soil stratigraphy encountered in the boreholes is shown on the attached Record of Borehole sheets. The boreholes at the top of the embankment were drilled using a truck mounted CME 45

power auger supplied and operated by a specialist drilling contractor. The boreholes on the embankment side slopes were advanced by Golder staff using manual drilling techniques.

Standard penetration testing and sampling was carried out at suitable intervals of depth in each of the boreholes using 35 millimetre inside diameter split spoon sampling equipment. In the manually drilled boreholes, hand augering equipment was used to advance the holes, the testing was carried out using a 31.8 kilogram hammer and the driving resistances recorded were adjusted to represent approximate N values. Groundwater conditions in the boreholes were observed throughout the drilling operations and the boreholes were backfilled in accordance with current MTO procedures and Ontario Regulation 128/03. Standpipes were installed in boreholes 203 and 204 to monitor groundwater conditions.

The field work was supervised on a full-time basis by an experienced member of our engineering staff who directed the drilling, sampling and in situ testing operations, logged the boreholes and determined the ground surface elevations and borehole locations. The borehole elevations are referenced to benchmarks provided by Callon Dietz Inc. It is understood that the benchmark elevations are referenced to geodetic datum.

The samples were identified in the field, placed in labelled containers and transported to our London laboratory for further examination and routine classification 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 testing are shown on the Record of Borehole sheets and in Appendix A.

In addition, the results of six previous boreholes and cone penetration tests by others have been included in this report. The previous boreholes were included in the following report:

- Department of Highways, Ontario, Geocres 40I13-31 entitled “Foundation Investigation Report for Proposed Crossing at Hwy. 79 and C.A.H. 402, Line ‘C’, Twp. Of Warwick, Co. of Lambton, District #1 (Chatham). W.O. 71-11042 – W.P. 42-66-11” dated April, 1976.

The locations of the previous boreholes are shown on Drawing 1 and the Records of Boreholes, together with the laboratory results, are provided in Appendix B.

The locations of the boreholes drilled for the previous investigation are as follows:

BOREHOLE	LOCATION (m)		GROUND SURFACE ELEVATION	BOREHOLE DEPTH
	Northing	Easting	(m)	(m)
1	4,761,589.7	355,389.6	232.29	20.12
2	4,761,590.7	355,379.7	232.23	6.55
3	4,761,547.1	355,398.9	232.41	6.55
4	4,761,548.6	355,378.8	232.17	22.92
5	4,761,507.1	355,398.9	232.32	21.52
6	4,761,506.2	355,379.4	232.17	6.55

The locations of the previous boreholes are approximate and have been inferred based on the borehole locations provided in Geocres Report No. 40I13-31.

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 Records of Boreholes from the previous investigation are included in Appendix B along with the pertinent laboratory data. 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 encountered thin layers of surficial topsoil or the pavement structure and silty clay fill associated with the existing embankment underlain by extensive deposits of silty clay and clayey silt. Silt layers were encountered within the silty clay and clayey silt deposits.

The locations and elevations of the boreholes, together with the interpreted stratigraphic profiles, are shown on the attached Drawings 1 and 2. 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 Pavement Structure

Borehole 204 was drilled on the shoulder of Lambton County Road 79 and encountered 240 millimetres of asphalt at the surface. The asphalt was underlain by approximately 220 millimetres of granular roadbase materials.

4.1.2 Topsoil and Fill

Surficial topsoil layers, between 90 and 150 millimetres thick, were found at the ground surface in boreholes 201 to 203. Layers of buried silty topsoil were encountered in boreholes 201, 203 and 204 from elevations 232.2 to 232.4 metres.

Silty clay fill was encountered in all of the boreholes drilled at the site beneath the pavement structure or surficial topsoil. The thickness of the silty clay fill varied from 2.2 to 5.2 metres. The silty clay fill was firm to very stiff with N values of 6 to 23 blows per 0.3 metres and had water contents ranging from 12 to 25 per cent with an average water content of about 19 per cent. The average plastic and liquid limits of the silty clay fill, based on the results of four Atterberg limits determinations, were 20 per cent and 38 per cent, respectively, with an average plasticity

index of 18 per cent. The results of the Atterberg limits testing are presented on the Plasticity Chart, Figure A-3, and indicate a clayey soil of intermediate plasticity.

The results of the grain size testing of four samples of silty clay fill recovered from the standard penetration testing are presented on Figure A-1.

4.1.3 Silty Clay

Silty clay was encountered near elevation 232.0 metres beneath the clayey fill in borehole 202 and below the buried topsoil in boreholes 201, 203 and 204 drilled during the current investigation, and at ground surface in the previous boreholes. Boreholes 201 to 204 were terminated in the silty clay after exploring it for some 0.6 to 1.0 metres.

The silty clay was stiff to hard with N values of 12 to 35 blows per 0.3 metres and water contents of 18 to 29 per cent with an average water content of about 22 per cent. The plastic and liquid limits, based on a single Atterberg limits determination, were 20 per cent and 37 per cent, respectively, with a plasticity index of 17 per cent. The results of the Atterberg limits testing are presented on the Plasticity Chart, Figure A-3, and indicate an inorganic clayey soil of intermediate plasticity. The results of grain size testing of a sample of silty clay recovered from the standard penetration testing are presented on Figure A-2 of Appendix A.

Soil described as clayey silt with traces of sand was found in the boreholes from the previous investigation. The grain size distribution envelope and plasticity chart for the clayey silt materials are shown in Figures 1 and 2, respectively, of Appendix B. Based on comparison of the Atterberg limits and gradation of the samples from the previous boreholes with those from the current investigation, it is interpreted that this material is predominantly clayey silt with an approximately 5 metre thick surficial zone of slightly higher plasticity to about elevation 227.5 metres. In all boreholes except borehole 1, the samples above elevation 227.5 metres generally had liquid limits of 35 per cent or greater and clay and silt contents of approximately 60 per cent and 40 per cent, respectively. The following discussion will consider soils in the previous boreholes with intermediate plasticity above elevation 227.5 metres to be silty clay.

Silty clay is inferred to be present in boreholes 2 to 6 from the ground surface to approximately elevation 227.5 metres. Partings of silt and/or fine sand were found in the silty clay. A layer of dense silt was encountered between elevations 227.9 and 229.5 metres.

The silty clay in the previous boreholes is very stiff to hard with N values ranging from 17 to 62 blows per 0.3 metres. Water contents of 18 to 25 per cent were measured in the silty clay. The average plastic and liquid limits of eight samples were 21 and 36 per cent, respectively, with an average plasticity index of 15 per cent.

4.1.4 Silt

Layers of silt 0.7 to 1.0 metres thick was encountered between layers of silty clay near elevation 230.0 metres in boreholes 203 and 204 and between elevations 227.9 and 229.5 metres in boreholes 3 to 5.

The silt was compact to dense but typically dense with N values of 21 to 32 blows per 0.3 metres and a water content of 25 per cent. The results of grain size testing of a single sample of the silt recovered from the standard penetration testing conducted in borehole 204 are presented on Figure A-4 of Appendix A.

4.1.5 Clayey Silt

As discussed in Section 4.1.3, clayey silt was found in borehole 1 and from elevation 227.5 metres in boreholes 2 to 6. Clayey silt was not found in any of the shallower current boreholes.

The clayey silt was very stiff to hard with N values of 15 to 75 blows per 0.3 metres and water contents ranging from 14 to 22 percent with an average of 17 per cent. Two field vane tests conducted in softer zones indicated undrained shear strengths of 108 and 153 kilopascals with sensitivities of 2.2 and 1.8, respectively. Geocres Report 40I13-31 cites the results of two unspecified laboratory tests that were conducted to determine shear strength. The test results are not identified on the logs, but the report notes that undrained strengths of 86.2 and 205.9 kilopascals were obtained.

The average plastic and liquid limits of the clayey silt, based on 12 samples recovered from the boreholes, were 18 per cent and 28 per cent, respectively, with an average plasticity index of 10 per cent. The grain size distribution envelope and plasticity chart for the clayey silt materials are shown in Figures 1 and 2 of Appendix B.

4.2 Bedrock

Shale to shaley limestone bedrock was found in the deeper boreholes of the previous investigation beneath the clayey silt from elevation 212.5 metres in borehole 1, from elevation 210.7 metres in borehole 4 and from elevation 210.8 metres in borehole 5. Weathered samples were retrieved from the split spoon samples in boreholes 1 and 5. In borehole 5, a 1.4 metre length of BX core was obtained with a reported core recovery of 75 per cent.

4.3 Groundwater Conditions

Groundwater conditions were observed during and on completion of drilling and sampling. Boreholes 201 and 202 were both dry during drilling.

Standpipes were installed in boreholes 203 and 204 prior to backfilling. In borehole 203, groundwater was encountered during drilling within the silt layer at about elevation 230.0 metres. The most recent groundwater level readings were obtained on January 30, 2008. On that date, the groundwater level measured in the standpipe was at elevation 232.0 metres or 5.9 metres below the embankment surface. In borehole 204, groundwater was encountered during drilling within the silt layer at about elevation 230.0 metres. The most recent groundwater level readings were obtained on January 30, 2008. On that date, a groundwater level at elevation 231.0 metres or 6.8 metres below the embankment surface was measured in the standpipe.

During the previous investigation, the boreholes encountered groundwater from about elevation 230.7 metres to about 231.6 metres.

Details of the groundwater conditions encountered and subsequently measured in the installations are provided on the Record of Borehole sheets and are summarized below.

BOREHOLE	GROUND SURFACE ELEVATION (m)	ENCOUNTERED GROUNDWATER LEVEL		INSTALLATION	MEASURED GROUNDWATER LEVEL					
					November 28, 2007		December 19, 2007		January 30, 2008	
		Depth (m)	Elevation (m)		Depth (m)	Elevation (m)	Depth (m)	Elevation (m)	Depth (m)	Elevation (m)
201	234.44	Dry	Dry	-	-	-	-	-	-	-
202	234.51	Dry	Dry	-	-	-	-	-	-	-
203	237.96	8.0	230.0	Standpipe	8.56	229.40	5.24	232.72	5.94	232.02
204	237.89	7.9	230.0	Standpipe	8.79	229.10	6.17	231.79	6.80	231.09
1	232.29	0.9	231.4	-	-	-	-	-	-	-
2	232.23	0.9	231.3	-	-	-	-	-	-	-
3	232.41	0.8	231.6	-	-	-	-	-	-	-
4	232.17	1.1	231.1	-	-	-	-	-	-	-
5	232.32	0.9	231.4	-	-	-	-	-	-	-
6	232.17	1.3	230.9	-	-	-	-	-	-	-

The inferred groundwater level based on the measured and encountered groundwater levels is about elevation 231.5 metres, approximately 1.5 metres above the interface between the brown and grey clayey silt and silty clay.

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

5.0 MISCELLANEOUS

The investigation was carried out using equipment supplied and operated by Aardvark Drilling Inc., which is an Ontario Ministry of Environment licensed well contractor. The field operations were supervised by Mr. Daniel R. P. Babcock under the direction of Mr. David J. Mitchell. The routine 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. 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

DB/DUP/PRB/FJH/cr
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TABLE I

COMPARISON OF REMEDIATION ALTERNATIVES FOR APPROACH SLOPES

Site 14-355
Lambton County Road 79 Underpass
Structural Rehabilitation
Highway 402 and Lambton County Road 79 Improvements
GWP 3158-06-00

REMEDIATION OPTION	ADVANTAGES	DISADVANTAGES	ESTIMATED COSTS	RISKS/ CONSEQUENCES
Slope Flattening	• Improves global and local stability	• This strategy will result in encroachment onto Highway 402 • High potential to be costly particularly if realignment affects design of interchange on each side of structure • Potential for lengthy construction	• Supply and place fills: $30 to $50 per m^3; lower end for earth fill, higher end for granular fills	• May require costly realignment of Highway 402 and ramps • Highly disruptive to traffic • This option may not be compatible with the existing and proposed configuration of the interchange
Slope Flattening with Toe Wall	• Improves global and local stability • Does not encroach into travelled area • Preferred technical option.	• Viewed as having poor aesthetics	• Supply and place fills: $30 to $50 per m^3; lower end for earth fill, higher end for granular fills • Wall construction: $420 to $550 per m^2 for concrete cantilever wall and $300 to $600 per m^2 for RSS wall	• Use of architectural wall facings can improve aesthetics
Toe Berm (in combination with slope flattening)	• Improves overall stability • Avoids wall construction	• Encroaches onto travelled area • Surficial failures could still occur above berm • May be difficult to establish vegetation on granular berm	• Sub-excavation of existing fills and supply and place fills: $65 to $75 per m^3	• Does not resolve surficial failures occurring on upper slope

COMPARISON OF REMEDIATION ALTERNATIVES FOR APPROACH SLOPES

REMEDIATION OPTION	ADVANTAGES	DISADVANTAGES	ESTIMATED COSTS	RISKS/ CONSEQUENCES
Slope Reconstruction and Reprofiling	• Improves global and local stability • Does not encroach into travelled area	• Excavations in close proximity to the existing abutment may require temporary shoring • May be difficult to establish vegetation on granular berm • Requires disposal of sub-excavated fills	• Remove existing fill and supply and place Granular A fills: $50 to $70 per m^3 • Shoring: $300 per m^2 (if required)	• If excavations adjacent to the structure are not properly supported, the abutment foundations may experience excessive movement
Slope reinforcement (using geogrid)	• Improves global and local stability with steeper slope than for slope flattening • Finished appearance similar to existing slope • Possibility of reusing existing fill • Does not encroach into travelled area	• Uncertainties with long-term performance of geogrid reinforcement • If slope is steeper than 2 horizontal to 1 vertical, increased difficulty with performing maintenance activities (grass cutting etc.) on a steeper slope	• $200 to $300 per m^2.	• Must use reinforcement that is proven to be effective for the long-term • Stresses imposed on reinforcement during construction must be considered during design
Soil Nailing	• Improves global and local stability • Flexible method	• Operation of heavy equipment, trucks, etc. near the wall must be limited during construction • Requires experienced specialist contractor • Placement of nails may be limited by obstructions or buried utilities	• $215 to 325 per m^2	• Requires clear area behind wall for installation of nails • May need to limit truck traffic on Underpass structure

NOTES: 1. Costs are very preliminary estimates and are intended to provide a comparison between alternatives rather than actual construction costs. Cost of traffic protection and slope restoration not included.
2. Table to be read in conjunction with accompanying report.

Prepared By: DUP
Checked By: PRB

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

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.)

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, 60º 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 cm^2 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.

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

(b) Cohesive Soils

Consistency	c_u, s_u kPa	c_u, s_u 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

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
v	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 l
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 = σ'_p/σ'_{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 δ
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)

Golder Associates
London, Ontario

RECORD OF BOREHOLE No 201

1 OF 1 **METRIC**

PROJECT 07-1130-128-4-2 | G.W.P. 3158-06-00 | DIST | HWY 402 | DATUM GEODETIC

LOCATION N 4761446.1 ;E 355406.5 | BOREHOLE TYPE MANUAL AUGER (UNCASED) | DATE November 21, 2007

ORIGINATED BY DB | COMPILED BY JAS | CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
234.44	GROUND SURFACE										
0.09	TOPSOIL, silty Brown		1	SS	6		234				
	FILL, silty clay, trace to some sand, trace gravel Firm to very stiff Brown		2	SS	17						
			3	SS	23		233				1 13 55 31
232.15			4	SS	13						
2.35	TOPSOIL, silty Compact Brown		5	SS	20		232				
	SILTY CLAY, trace sand, trace gravel Very stiff Brown		6	SS	22						
231.09											
3.35	END OF BOREHOLE										

Borehole dry during drilling on November 21, 2007

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates
London, Ontario

RECORD OF BOREHOLE No 202

1 OF 1

METRIC

PROJECT 07-1130-128-4-2
G.W.P. 3158-06-00
LOCATION N 4761609.5 ;E 355406.1
ORIGINATED BY DB
DIST HWY 402
BOREHOLE TYPE MANUAL AUGER (UNCASED)
COMPILED BY JAS
DATUM GEODETIC
DATE November 21, 2007
CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
234.51	GROUND SURFACE										
0.09	TOPSOIL, silty Brown										
	FILL, silty clay, trace to some sand, trace gravel, trace topsoil Stiff to very Stiff Brown		1	SS	9		234		○		
			2	SS	15		233		○		
232.22											
2.29	SILTY CLAY, trace sand, trace gravel, trace topsoil		3	SS	13		232		○		
231.77	Stiff Brown										
2.74	SILTY CLAY, trace sand, silt lenses Very stiff Brown		4	SS	25				○		
231.16											
3.35	END OF BOREHOLE Borehole dry during drilling on November 21, 2007										

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

Golder Associates
London, Ontario

RECORD OF BOREHOLE No 203

1 OF 1

METRIC

PROJECT 07-1130-128-4-2
G.W.P. 3158-06-00
DIST HWY 402
DATUM GEODETIC

LOCATION N 4761461.1 ;E 355397.4
BOREHOLE TYPE POWER AUGER (UNCASED)
DATE November 28, 2007

ORIGINATED BY DB
COMPILED BY JAS
CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
237.96	GROUND SURFACE										
0.00	TOPSOIL, silty						Cold Patch				
0.15 / 237.50	Brown										
0.46	FILL, sand and gravel, trace silt (crushed) Brown										
	FILL, silty clay, trace sand, trace gravel Stiff to very stiff Brown		1	SS	12		237				
			2	SS	10						
							236				
			3	SS	18		Cuttings				
							235				
			4	SS	19						2 7 56 35
			5	SS	14		234				
							Bentonite				
			6	SS	21		233				
232.41			7	SS	20		Cuttings				
5.55 / 232.02	TOPSOIL, silty Compact Brown						232				
5.94	SILTY CLAY, trace to some sand, trace gravel Stiff Brown		8	SS	12						4 15 49 32
231.25											
6.71	SILTY CLAY, trace sand Hard Brown		9	SS	35		231				
230.04			10	SS	35		230				
7.92 / 229.73	SILT, trace clay Dense Brown										
8.23	SILTY CLAY, trace sand Very stiff Grey		11	SS	20						
229.12											
8.84	END OF BOREHOLE										

Groundwater encountered at about elev. 230.0m during drilling on November 28, 2007.

Water level measured in standpipe at elev. 229.40m on November 28, 2007.

Water level measured in standpipe at elev. 232.72m on December 19, 2007.

Water level measured in standpipe at elev. 232.37m on January 7, 2008.

Water level measured in standpipe at elev. 232.05m on January 17, 2008.

Water level measured in standpipe at elev. 232.02m on January 30, 2008.

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

LDN_MTO_01 07-1130-128-4_2.GPJ LDN_MTO.GDT 4/16/08

Golder Associates
London, Ontario

RECORD OF BOREHOLE No 204

1 OF 1

METRIC

PROJECT 07-1130-128-4-2
G.W.P. 3158-06-00
DIST HWY 402
DATUM GEODETIC

LOCATION N 4761624.5 ;E 355397.9
BOREHOLE TYPE POWER AUGER (UNCASED)
DATE November 28, 2007

ORIGINATED BY DB
COMPILED BY JAS
CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
237.89	GROUND SURFACE										
0.00	ASPHALT						Cold Patch				
0.24	FILL, sand and gravel, trace silt (crushed) Brown										
0.46	FILL, silty clay, trace sand, trace gravel, sand pockets Stiff to very stiff Brown		1	SS	16		237				
			2	SS	13		236				1 5 57 37
							Cuttings				
			3	SS	20		235				
			4	SS	10						0 3 58 39
			5	SS	21		234				
							Bentonite				
			6	SS	20		233				
232.25			7	SS	17						
5.64	TOPSOIL, silty						232				
231.95	Compact Brown						Cuttings				
5.94	SILTY CLAY, trace sand Very stiff Brown		8	SS	22						
			9	SS	23		231				
230.03			10	SS	31		230				0 1 91 8
7.86	SILT, trace clay										
229.66	Dense Brown										
8.23	SILTY CLAY, with silt lenses Stiff Grey		11	SS	14						
229.05											
8.84	END OF BOREHOLE										

Groundwater encountered at about elev. 230.0m during drilling on November 28, 2007.

Water level measured in standpipe at elev. 229.10m on November 28, 2007.

Water level measured in standpipe at elev. 231.79m on December 19, 2007.

Water level measured in standpipe at elev. 231.03m on January 7, 2008.

Water level measured in standpipe at elev. 231.18m on January 17, 2008.

Water level measured in standpipe at elev. 231.09m on January 30, 2008.

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

REFERENCE

DRAWING BASED ON CANMAP STREETFILES V2005.4

NOTES

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

ALL LOCATIONS ARE APPROXIMATE ONLY.

PROJECT

LAMBTON COUNTY ROAD 79 UNDERPASS
HIGHWAY 402 & LAMBTON COUNTY ROAD 79 IMPROVEMENTS
GWP 3158-06-00

TITLE

KEY PLAN

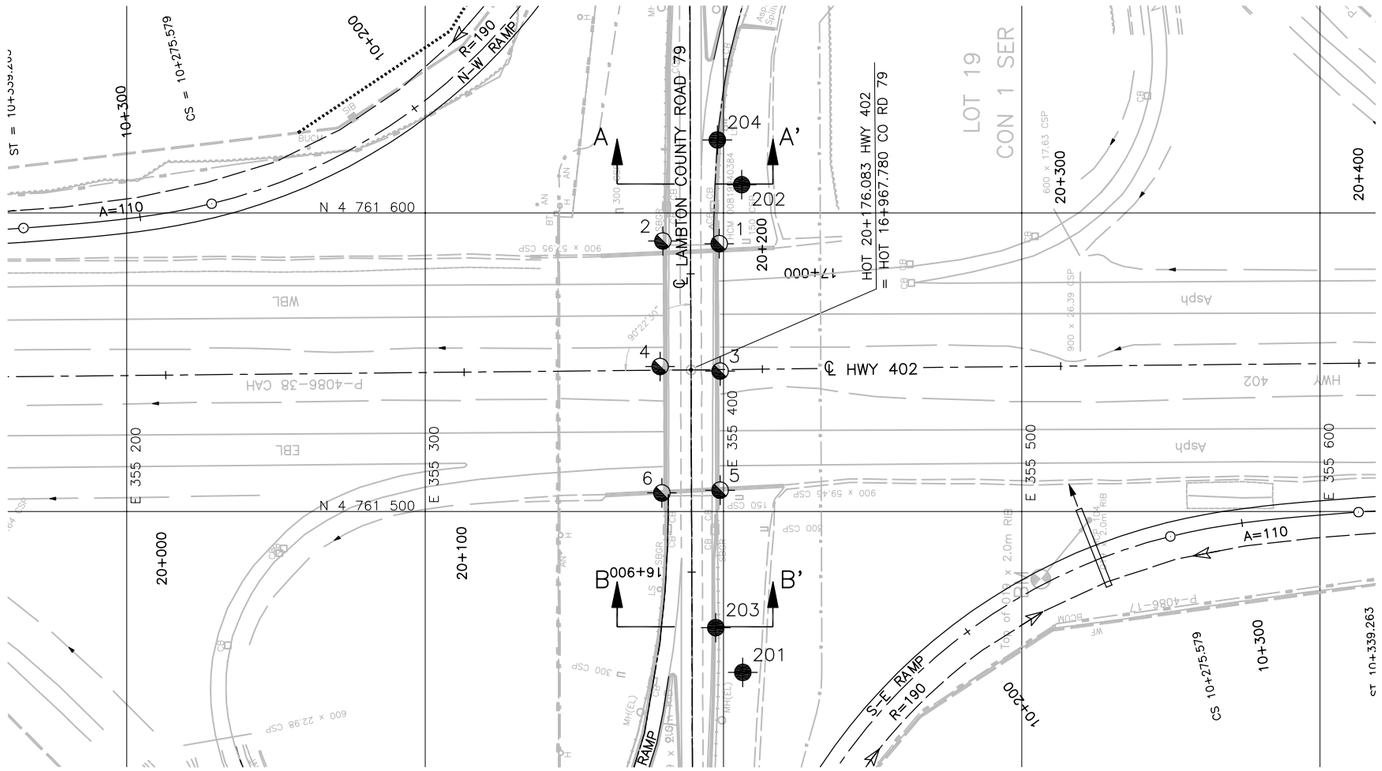
Golder Associates
LONDON, ONTARIO

PROJECT No.		07-1130-128-4	FILE No.	0711301284-2-F01001
			SCALE AS SHOWN	REV. 0
CADD	WDF	Apr. 15/08		
CHECK				

FIGURE 1

Drawing file: 0711301284-2-F01001.dwg Apr 15, 2008 - 2:58pm

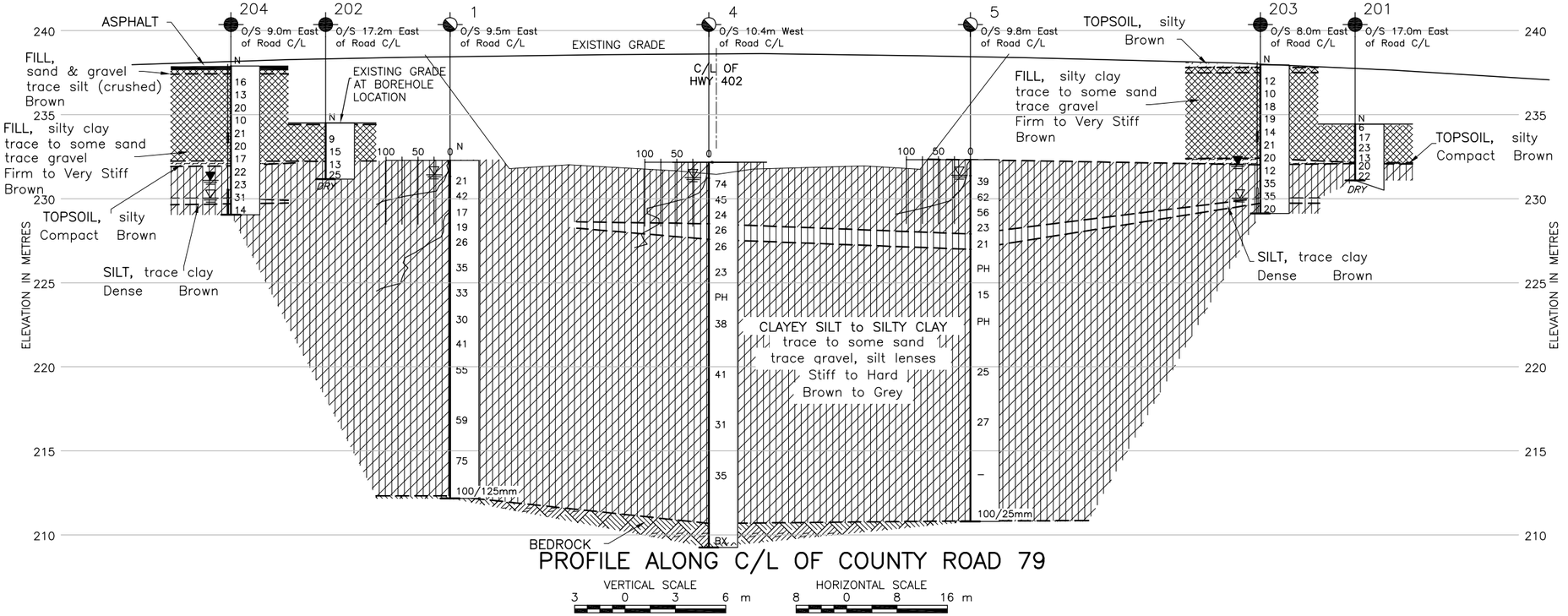
MINISTRY OF TRANSPORTATION, ONTARIO



METRIC

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

PLAN
SCALE
20 0 20 40 m



PROFILE ALONG C/L OF COUNTY ROAD 79

VERTICAL SCALE
3 0 3 6 m

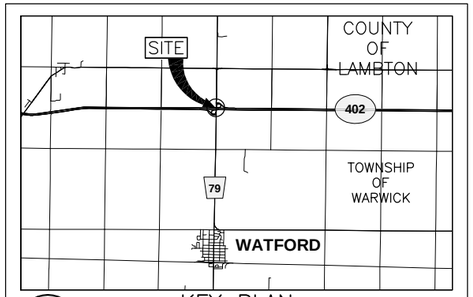
HORIZONTAL SCALE
8 0 8 16 m

CONT No.
WP No. 3158-06-00

SHEET

HWY 402/LAMBTON CTY RD 79 IMPROVEMENTS
LAMBTON COUNTY ROAD 79 UNDERPASS
BOREHOLE LOCATION AND SOIL STRATA

Golder Associates Ltd.
LONDON, ONTARIO, CANADA



LEGEND

- Borehole – Current Investigation
- Borehole and Cone – Previous Investigation (by Others)
- Seal
- Standpipe
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL in standpipe, measured on JAN 30, 2008.
- WL encountered during drilling
- DRY Borehole dry during drilling

No.	ELEVATION	CO-ORDINATES (MTM Zone 11) NORTHING	EASTING
201	234.44	4 761 446.1	355 406.5
202	234.51	4 761 609.5	355 406.1
203	237.96	4 761 461.1	355 397.4
204	237.89	4 761 624.5	355 397.9
Borehole Elevation & Co-ordinates (inferred from Previous Data)			
1	232.29	4 761 589.7	355 398.6
2	232.23	4 761 590.7	355 379.7
3	232.41	4 761 547.1	355 398.9
4	232.17	4 761 548.6	355 378.8
5	232.32	4 761 507.1	355 398.9
6	232.17	4 761 506.2	355 379.4

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

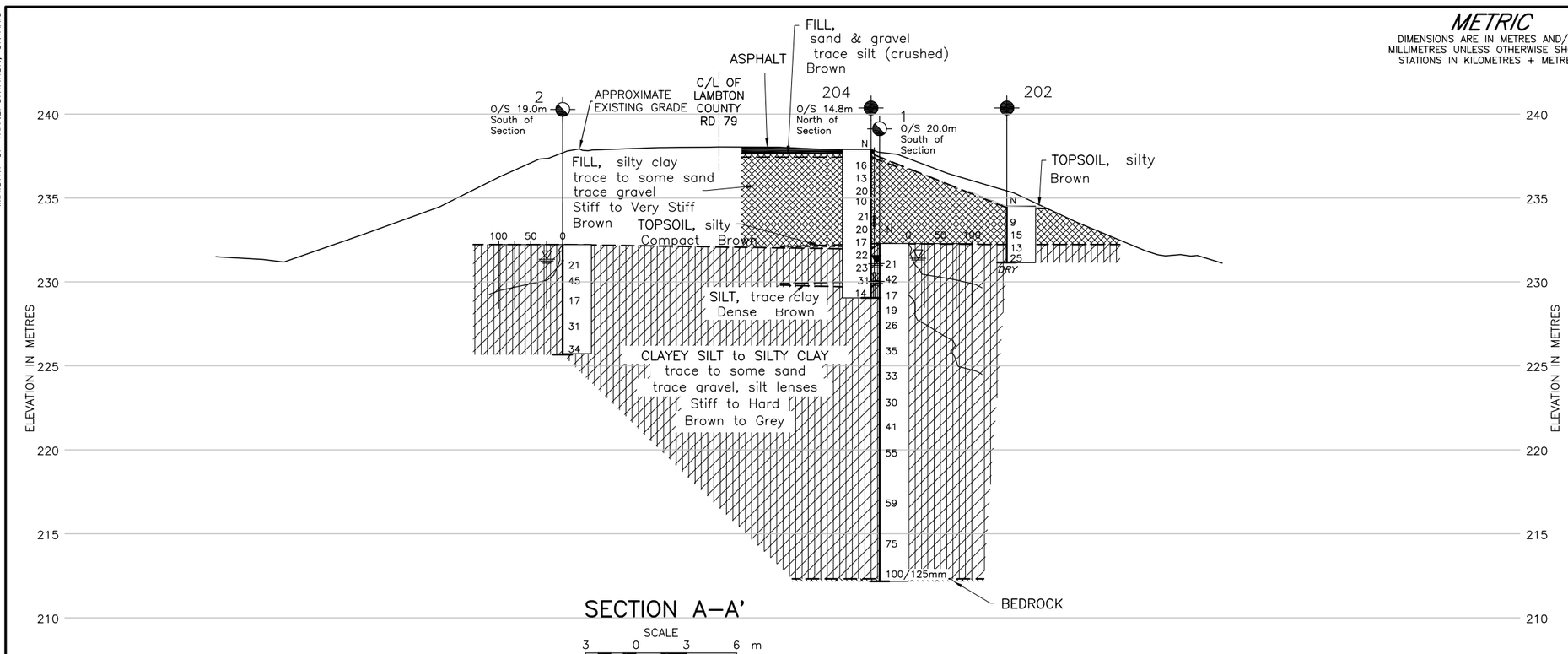
NO.	DATE	BY	REVISION

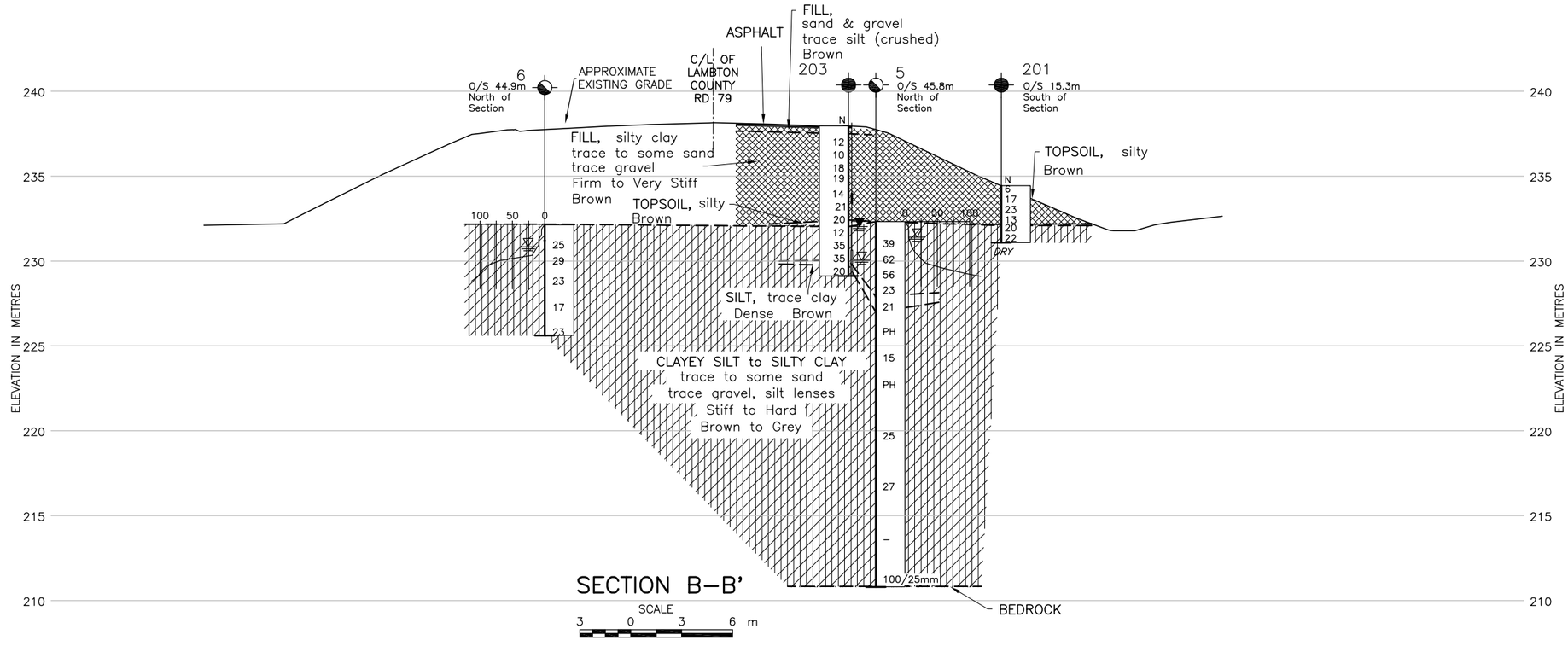
Geocres No. 40I13-54

HWY. 402	PROJECT NO. 07-1130-128-4		DIST.
SUBM'D. DB	CHKD. DUP	DATE: APR 15/08	SITE: 14-355
DRAWN: WDF	CHKD.	APPD.	DWG. 1

PLOT DATE: April 15, 2008
FILENAME: N:\active\2007\1130 - Geotechnical\1130-1000\07-1130-128-4 DELCAN - FNDS NEW N TO W RAMP - WATFORD\Drafting\AutoCAD files\1-4 -2 SS07113012B4-2-001001.dwg

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





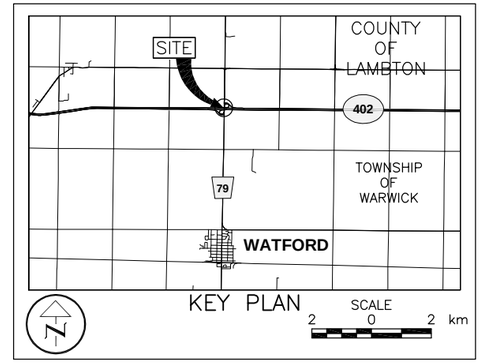
CONT No.
WP No. 3158–06–00

SHEET

HWY 402/LAMBTON CTY RD 79 IMPROVEMENTS
LAMBTON COUNTY ROAD 79 UNDERPASS
SOIL STRATA

Golder Associates

Golder Associates Ltd.
LONDON, ONTARIO, CANADA



LEGEND

- Borehole – Current Investigation
- Borehole and Cone – Previous Investigation (by Others)
- Seal
- Standpipe
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL in standpipe, measured on JAN 30, 2008.
- WL encountered during drilling
- *DRY* — Borehole dry during drilling

No.	ELEVATION	CO–ORDINATES (MTM Zone 11) NORTHING	EASTING
201	234.44	4 761 446.1	355 406.5
202	234.51	4 761 609.5	355 406.1
203	237.96	4 761 461.1	355 397.4
204	237.89	4 761 624.5	355 397.9
Borehole Elevation & Co–ordinates (inferred from Previous Data)			
1	232.29	4 761 589.7	355 398.6
2	232.23	4 761 590.7	355 379.7
3	232.41	4 761 547.1	355 398.9
4	232.17	4 761 548.6	355 378.8
5	232.32	4 761 507.1	355 398.9
6	232.17	4 761 506.2	355 379.4

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

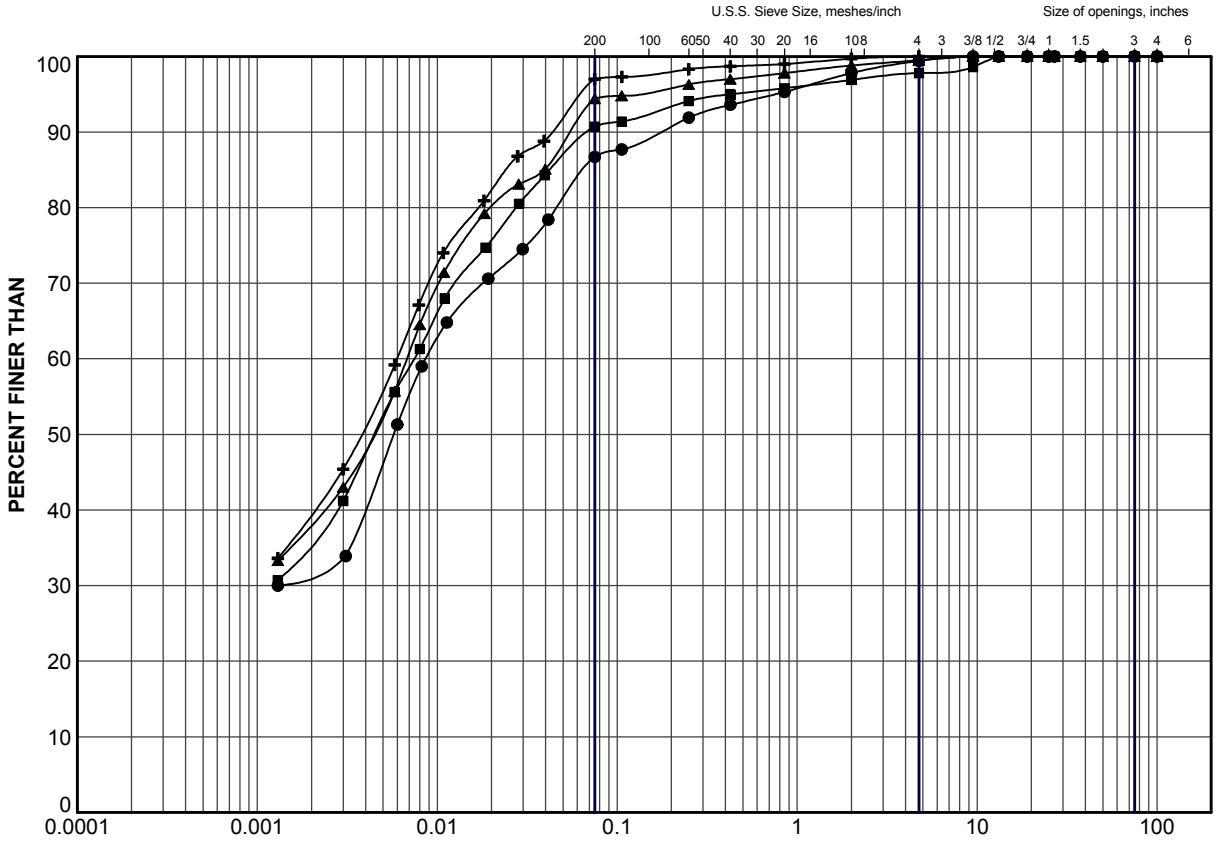
NO.	DATE	BY	REVISION

Geocres No. 40I13–54

HWY. 402	PROJECT NO. 07–1130–128–4		DIST.
SUBM'D. DB	CHKD. DUP	DATE: APR 15/08	SITE: 14–355
DRAWN: WDF	CHKD.	APPD.	DWG. 2

APPENDIX A

LABORATORY TEST DATA



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	201	3	233.0
■	203	4	234.7
▲	204	2	236.2
✚	204	4	234.6

PROJECT

LAMBTON COUNTY ROAD 79 UNDERPASS
HIGHWAY 402 & LAMBTON COUNTY ROAD 79 IMPROVEMENTS
GWP 3158-06-00

TITLE

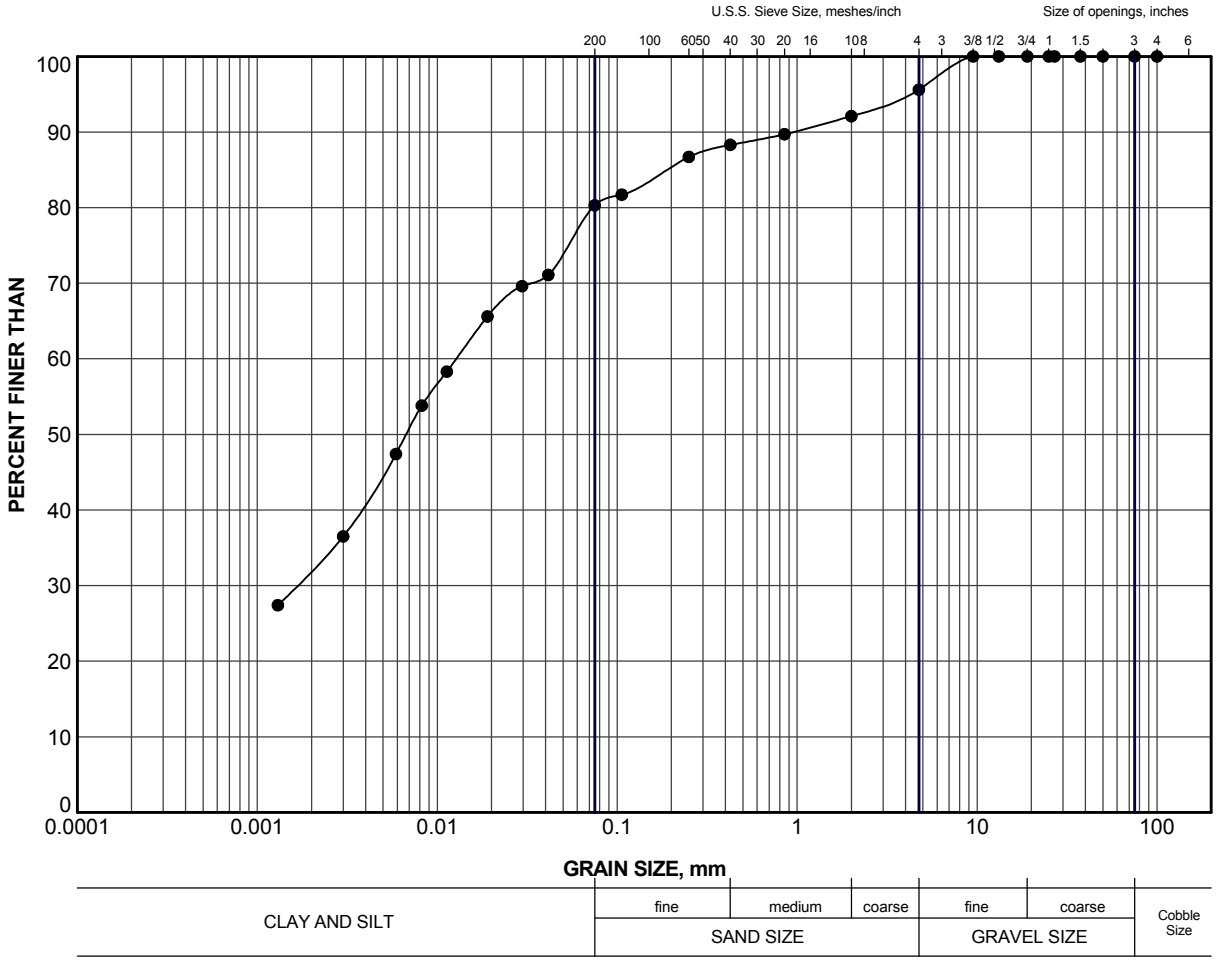
GRAIN SIZE DISTRIBUTION

FILL, silty clay

Golder Associates
LONDON, ONTARIO

PROJECT No. 07-1130-128-4			FILE No. 0711301284-2-R010a1	
			SCALE N/A	REV.
DRAWN	WDF	Feb. 28/08		
CHECK			**FIGURE A-1**	

LDN_MTO_NEW GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	203	8	231.7

PROJECT

LAMBTON COUNTY ROAD 79 UNDERPASS
HIGHWAY 402 & LAMBTON COUNTY ROAD 79 IMPROVEMENTS
GWP 3158-06-00

TITLE

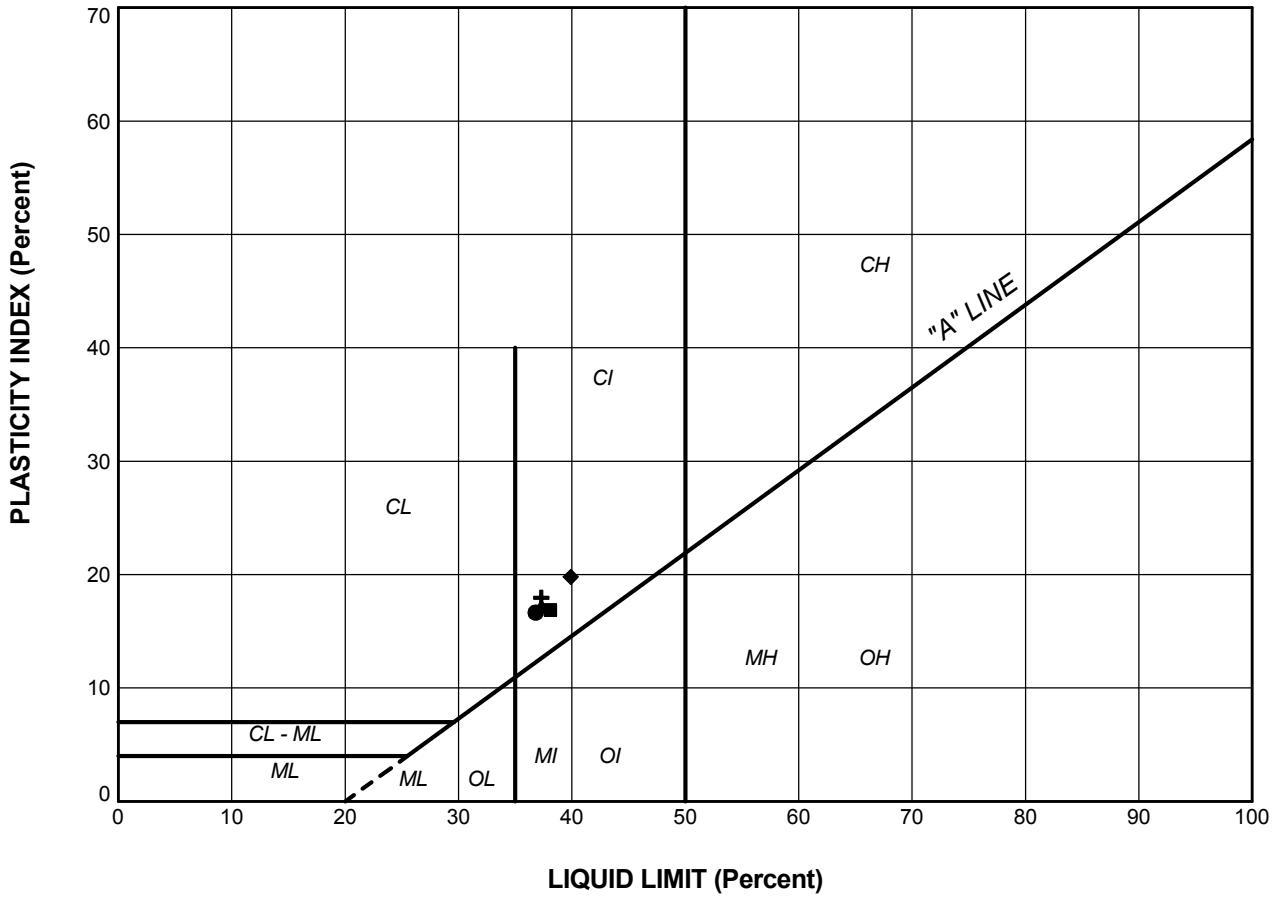
GRAIN SIZE DISTRIBUTION

SILTY CLAY

Golder Associates
LONDON, ONTARIO

PROJECT No. 07-1130-128-4			FILE No. 0711301284-2-R010a2	
			SCALE N/A	REV.
DRAWN	WDF	Feb. 28/08		
CHECK			**FIGURE A-2**	

LDN_MTO_NEW GLDR_LDN.GDT



SOIL TYPE	PLASTICITY
C = Clay	L = Low
M = Silt	I = Intermediate
O = Organic	H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
FILL, silty clay					
●	201	3	36.8	20.2	16.7
■	203	4	38.1	21.2	16.9
✚	204	2	37.3	19.4	18.0
◆	204	4	39.9	20.1	19.8
SILTY CLAY					
▲	203	8	37.3	20.1	17.2

PROJECT

LAMBTON COUNTY ROAD 79 UNDERPASS
HIGHWAY 402 & LAMBTON COUNTY ROAD 79 IMPROVEMENTS
GWP 3158-06-00

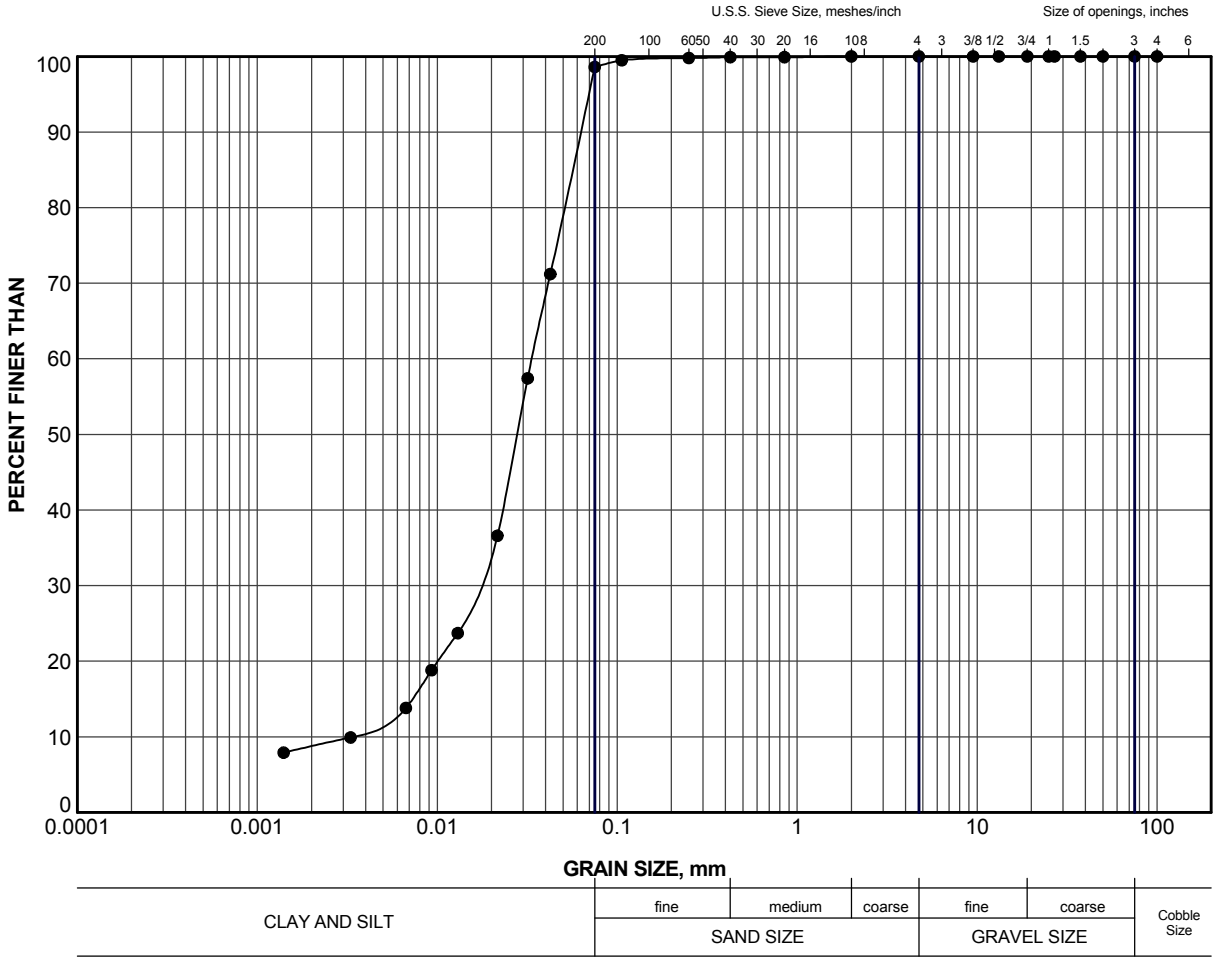
TITLE

PLASTICITY CHART

Golder Associates
LONDON, ONTARIO

PROJECT No.	07-1130-128-4		FILE No.	0711301284-2-R010a3	
			SCALE	N/A	REV.
DRAWN	WDF	Feb. 28/08			
CHECK			FIGURE A-3		

MTO_PI GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	204	10	230.0

PROJECT

LAMBTON COUNTY ROAD 79 UNDERPASS
HIGHWAY 402 & LAMBTON COUNTY ROAD 79 IMPROVEMENTS
GWP 3158-06-00

TITLE

GRAIN SIZE DISTRIBUTION

SILT

Golder Associates
LONDON, ONTARIO

PROJECT No. 07-1130-128-4			FILE No. 0711301284-2-R010a4	
			SCALE N/A	REV.
DRAWN	WDF	Feb. 28/08		
CHECK			**FIGURE A-4**	

LDN_MTO_NEW GLDR_LDN.GDT

APPENDIX B

RECORDS OF PREVIOUS BOREHOLES (GEOCRES REPORT NO. 40I13-31)

MINISTRY C RANSPORTATION AND COMMUNICATIONS-ON IO

ENGINEERING SERVICES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE Nº 1

WP 42-66-11 LOCATION Hwy. 79 Sta. 330 + 01 31' Rt. ORIGINATED BY AP

DIST 1 HWY 402 BORING DATE May 19, 1971 COMPILED BY KW

DATUM Geodetic BOREHOLE TYPE Bombardier Flight Auger and Cone CHECKED BY

ELEV / DEPTH (232.29m)	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV
762.1	Ground Level					
0.0	Brown / Grey Clayey silt, traces of sand. Occasional silt and/or fine sand partings. Very Stiff to hard		1	SS	21	760
			2	SS	42	
			3	SS	17	
			4	SS	19	750
			5	SS	26	
			6	SS	35	740
			7	SS	33	
			8	SS	30	730
			9	SS	41	
			10	SS	55	720
			11	SS	59	710
			12	SS	75	
697.1						700
65.0	Weathered Shale		13	SS	100/5"	
66.0	End of Borehole Probable Bedrock					690

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE

141 / 130

LIQUID LIMIT w_L PLASTIC LIMIT w_P WATER CONTENT w

WATER CONTENT % (20 40 60)

UNIT WEIGHT γ

REMARKS	% GR	SA	SI	CL
	0	10	74	16
	0	1	67	32
	0	3	73	24
	0	2	71	27
	0	3	67	30
	2	15	57	26

20 / 15 5 / 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

ENGINEERING SERVICES BRANCH – GEOTECHNICAL OFFICE – SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 2

WP 42-66-11 LOCATION Hwy. 79 Sta. 330 + 04 31' Lt. ORIGINATED BY AP

DIST 1 HWY 402 BORING DATE May 25, 1971 COMPILED BY KW

DATUM Geodetic BOREHOLE TYPE CME Flight Auger & Cone CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) SHEAR STRENGTH: o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE	LIQUID LIMIT w_L, PLASTIC LIMIT w_P, WATER CONTENT w (w_P — w — w_L), WATER CONTENT % (20 40 60)	UNIT WEIGHT γ	REMARKS
ELEV / DEPTH (232.23m) 761.9	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	ELEV				% GR SA SI CL
0.0	Ground Level					760				
			1	SS	21					
	Brown		2	SS	45					0 1 62 37
	Grey									
			3	SS	17	750				
	Clayey silt to silty clay, traces of sand									
	Occ. silt and/or fine sand partings.		4	SS	31					0 0 60 40
740.4	Very Stiff to hard		5	SS	34					0 5 69 26
21.5	End of borehole					740				

20
15 ⊙ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY O' 'ANSPORTATION AND COMMUNICATIONS - ONT 'O

ENGINEERING SERVICES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE Nº 3

WP 42-66-11 LOCATION Hwy 79 Sta. 328 + 61 32' Rt ORIGINATED BY AP

DIST 1 HWY 402 BORING DATE May 20, 1971 COMPILED BY KW

DATUM Geodetic BOREHOLE TYPE Bombardier Flight Auger and Cone CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w (w_P — w — w_L) / WATER CONTENT % (20 40 60)	UNIT WEIGHT γ	REMARKS % GR SA SI CL
(232.41m) 762.5	Ground Level					760				
	Brown Grey silt, traces of sand & clay		1	SS	30					
			2	SS	42					0 2 64 34
			3	SS	32	750				0 5 85 10
	Clayey silt, traces of sand. Occ. silt and/or sand partings		4	SS	31					1 1 58 40
741.0	Very Stiff to Hard		5	SS	19					
21.5	End of borehole					740				

15 20 10 ◇ 5 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY O[F] TRANSPOPTATION AND COMMUNICATIONS–ON[T]IO

ENGINEERING SER[V]ES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE № 4

WP 42-66-11 LOCATION Hwy. 79 · Sta. 328 + 66 34' Lt. ORIGINATED BY AP

DIST [1] HWY 402 BORING DATE May 26, 1971 COMPILED BY KW

DATUM Geodetic BOREHOLE TYPE CME Flight Auger, NX Casing, BX Core and Cone CHECKED BY

ELEV / DEPTH (232.17m)	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER ELEV
761.7	Ground Level					760
			1	SS	14	
	Brown Grey		2	SS	45	
			3	SS	24	750
	Silt, traces of sand & Clay		4	SS	26	
			5	SS	26	
			6	SS	23	740
			7	TW	PH	
	Clayey silt, traces to some sand (increasing with depth) traces of gravel in lower regions (below elev. 740). Occ. silt and/or sand partings.		8	SS	38	730
			9	SS	41	720
	Very Stiff to hard.		10	SS	31	710
			11	SS	35	700
691.2						
70.5	Bedrock					690
686.5	Shaley Limestone		12	BX	75%	
75.2	End of Borehole					680

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE

LIQUID LIMIT —— w_L PLASTIC LIMIT - - - w_P WATER CONTENT —— w

w_P w w_L

WATER CONTENT % (20 40 60)

UNIT WEIGHT γ

REMARKS	% GR	SA	SI	CL
	0	3	60	37
	0	2	90	8
	0	2	63	35
	2	13	65	20
	3	18	53	26

20 15 ◇ 5 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

ENGINEERING SERVICES BRANCH – GEOTECHNICAL OFFICE – SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 5

WP 42-66-11 LOCATION Hwy. 79 Sta. 327 + 30 32' Rt. ORIGINATED BY AP

DIST 1 HWY 402 BORING DATE May 21, 1971 COMPILED BY KW

DATUM Geodetic BOREHOLE TYPE Bombardier Flight Auger and Cone CHECKED BY

ELEV / DEPTH (232.32m)	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER ELEV
762.2	Ground Level					
0.0	Brown / Grey Silt, some sand traces of clay		1	SS	39	
			2	SS	62	
			3	SS	56	
			4	SS	23	
			5	SS	21	
			6	TW	PH	
			7	SS	15	
	Clayey silt, traces to some sand (increasing with depth) traces of gravel in lower regions (below elev. 740). Occ. silt and/or sand partings.		8	TW	PH	
			9	SS	25	
	Very stiff to hard		10	SS	27	
			11	SS	–	
691.7 70.5	Weathered Shale		12	SS	100/1"	
70.6	End of Borehole Probable Bedrock					

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH PSF
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
400 800 1200 1600 2000

760 750 740 730 720 710 700 690

133
167
St = 1/2
8200
St = 8

LIQUID LIMIT w_L
PLASTIC LIMIT w_P
WATER CONTENT w
w_P w w_L
WATER CONTENT %
20 40 60

UNIT WEIGHT γ

REMARKS	% GR	SA	SI	CL
	0	2	67	41
	0	5	81	14
	0	1	64	35
	4	9	62	25
	7	20	54	19

20
15 ⊹ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS - ONTARIO

ENGINEERING SERVICES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 6

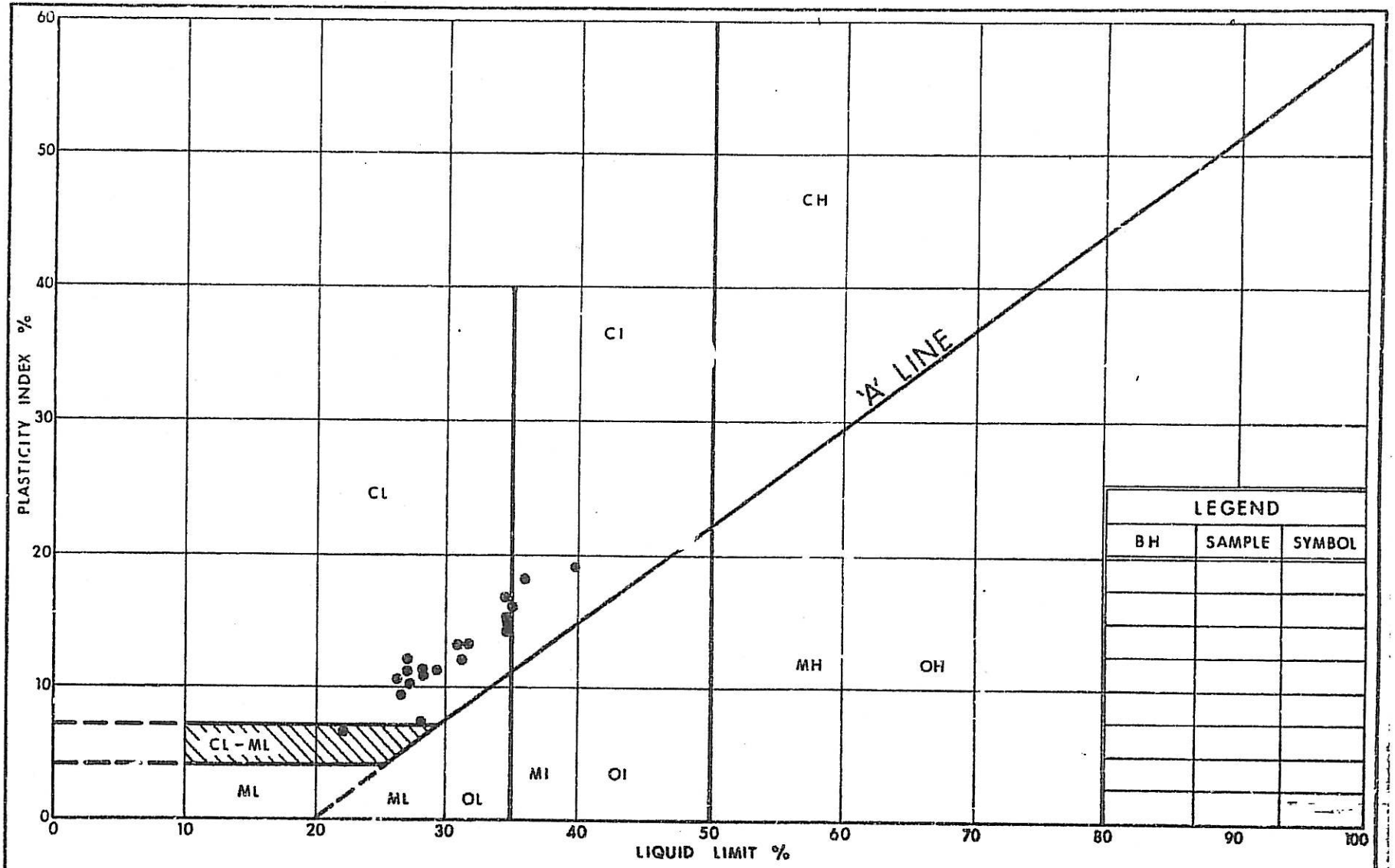
WP 42-66-11 LOCATION Hwy. 79 Sta. 327 + 27 32' Lt. ORIGINATED BY AP

DIST 1 HWY 402 BORING DATE May 25, 1971 COMPILED BY KW

DATUM Geodetic BOREHOLE TYPE CME Flight Auger & Cone CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT	LIQUID LIMIT W_L / PLASTIC LIMIT W_P / WATER CONTENT W	UNIT WEIGHT	REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	ELEV	20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	W_P W W_L WATER CONTENT % 20 40 60	γ	% GR SA SI CL
(232.17m) 761.7	Ground Level									
0.0						760				
			1	SS	25	▽				0 2 58 40
	Clayey silt, traces of sand.		2	SS	29					
	Occ. silt and/or		3	SS	23	750				
	partings.									
			4	SS	17					0 2 70 28
	Very stiff to hard									
740.2			5	SS	23	740				
21.5	End of borehole									

20
15 ⊹ 5 % STRAIN AT FAILURE
10



Ministry of Transportation and Communications
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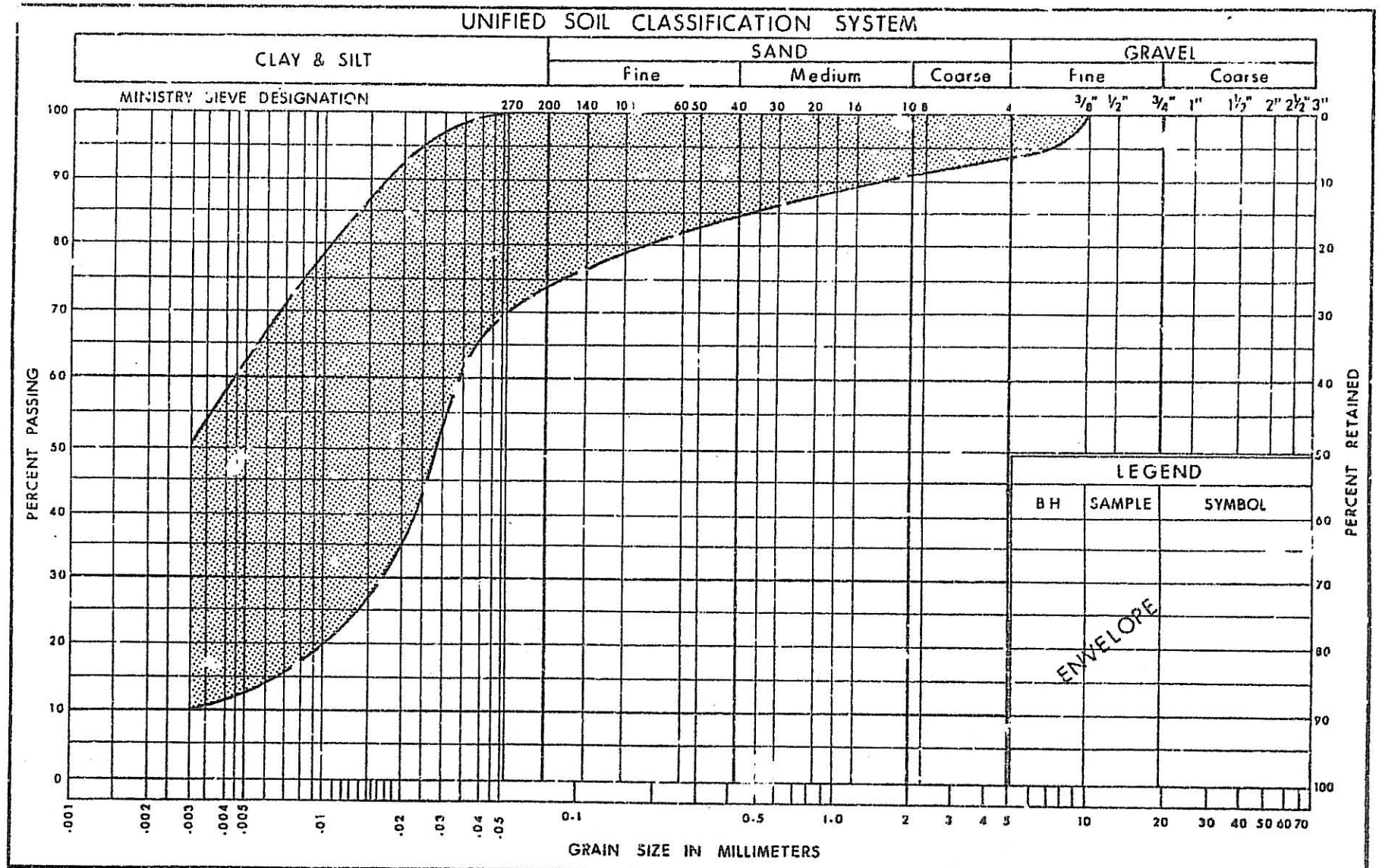
PLASTICITY CHART
CLAYEY SILT
TRACE OF SAND, OCC. SILT &/OR SAND PARTINGS

FIG No	1
W P	42-66-11

66



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ENGINEERING SERVICES BRANCH

GRAIN SIZE DISTRIBUTION
CLAYEY SILT
TRACE OF SAND, OCC. SILT &/OR SAND PARTINGS

FIG No 2
W P 42 - 66 - 11

67

APPENDIX C

PHOTOGRAPHS

SITE PHOTOGRAPHS

Photo 1: South approach Lambton County Road 79 Underpass Structure.

Photo 2: Lambton County Road 79 Underpass Structure, looking east from shoulder of eastbound lanes. NS-E ramp at right of photo.

SITE PHOTOGRAPHS

Photo 3: Tension crack along southwest approach fill.

Photo 4: Vertical cracking at abutment in north face of southwest approach fill.

SITE PHOTOGRAPHS

Photo 5: Tension cracks near toeof south face of northwest approach fill.

Photo 6: Loss of vegetation on south face of northwest approach fill.

SITE PHOTOGRAPHS

Photo 7: Tension cracks near top of south face of northwest approach fill.

Photo 8: General view of soffit over eastbound lanes, looking towards the south abutment. Rip-rap slope protection is visible at bottom of photograph.