



December 2011

FOUNDATION INVESTIGATION AND DESIGN REPORT

Inspection Canopy
Putnam South Commercial Vehicle Inspection Facility
GWP 4100-04-00

Submitted to:

Mr. George McCluskey, P.Eng., Associate
Dillon Consulting Limited
1400-130 Dufferin Avenue
London, Ontario
N6A 5R2

REPORT



A world of
capabilities
delivered locally

Report Number: 11-1132-0082-2000-R03

Geocres No. 40115-34

Distribution:

5 Copies - Dillon Consulting Limited
2 Copies - Golder Associates Ltd.





Table of Contents

PART A - FOUNDATION INVESTIGATION REPORT

1.0 INTRODUCTION.....	1
2.0 SITE DESCRIPTION.....	2
2.1 Site Geology.....	2
3.0 INVESTIGATION PROCEDURES	3
4.0 SUBSURFACE CONDITIONS.....	4
4.1 General.....	4
4.2 Soil Conditions.....	4
4.2.1 Topsoil and Fill.....	4
4.2.2 Clayey Silt Till	5
4.2.3 Sandy Silt.....	5
4.2.4 Sandy Silt Till	5
4.3 Groundwater Conditions	5
5.0 MISCELLANEOUS	7

PART B - FOUNDATION DESIGN REPORT

6.0 ENGINEERING RECOMMENDATIONS.....	8
6.1 General.....	8
6.2 Foundations.....	8
6.2.1 Engineered Fill	9
6.2.2 Caissons	9
6.3 Resistance to Lateral Loads	9
6.3.1 Spread Footings.....	9
6.3.2 Caissons	9
6.4 Slab-on-Grade	10
6.5 Excavations	11
6.6 Groundwater.....	11
7.0 MISCELLANEOUS	12



FOUNDATION INVESTIGATION AND DESIGN REPORT INSPECTION CANOPY, GWP 4100-04-00

LIST OF ABBREVIATIONS

LIST OF SYMBOLS

RECORD OF BOREHOLE SHEETS

FIGURE 1 - Key Plan

DRAWING 1 - Borehole Locations and Soil Strata

APPENDICES

APPENDIX A

Laboratory Test Data



PART A

FOUNDATION INVESTIGATION REPORT

INSPECTION CANOPY
PUTNAM SOUTH CVIF
GWP 4100-04-00



1.0 INTRODUCTION

Golder Associates Ltd. (Golder Associates) has been retained by Dillon Consulting Limited (Dillon) on behalf of Coco Paving Inc. to carry out foundation investigations as part of the design-build work for GWP 4100-04-00. The project consists of the detail design and construction of the new Commercial Vehicle Inspection Facilities at the Putnam north and south sites. This report addresses the new inspection canopy to be constructed at the Putnam south site. The location of the site is shown on the Key Plan, Figure 1.

The purpose of the foundation investigation was to determine the subsurface conditions at the location of the new inspection canopy 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 Golder Associates' letter dated June 14, 2011.

Dillon provided Golder Associates with preliminary drawings for this project in digital format.



2.0 SITE DESCRIPTION

The Putnam South CVIF is located immediately south of Highway 401 about 1.5 kilometres west of the Highway 401/Putnam Road interchange as shown on the Key Plan, Figure 1. Currently, a primary scale lane is oriented parallel to Highway 401 with the scale and existing inspection building located in the eastern portion of the site. South of the scale lane, a “race track” configured, asphalt surfaced parking/inspection area is present. A raised sewage disposal system is located immediately east of the inspection area.

The existing truck inspection station is located at the crest of a moraine in the generally rolling regional topography. The lands in the existing truck inspection station have been constructed on variable thicknesses of fill materials to create a relatively level area. The station entrance ramp rises to the east and the exit ramp declines to the east similar to the adjacent Highway 401.

The topography in the area of the site ranges from about elevation 282 metres near the bullnose of the entrance ramp to about elevation 291 metres in the inspection area.

The adjacent land use is rural agricultural.

2.1 Site Geology

The site is located within the physiographic region of Southwestern Ontario¹ known as the Stratford Till Plain which is a product of the Huron ice lobe. Throughout the area, the till is a fairly uniform, brown calcareous silty clay.

¹ Chapman and Putnam, 1985, The Physiography of Southern Ontario, 3rd Edition, Ontario Geological Series



3.0 INVESTIGATION PROCEDURES

The field work for this component of the investigation was carried out on September 12 and 13, 2011 during which time three boreholes (boreholes 1, 4 and 5) were drilled at the approximate locations shown on Drawing 1. The table below provides the borehole locations, ground surface elevations at the borehole locations and the depths of the boreholes.

Borehole	Location (m)		Ground Surface Elevation	Borehole Depth
	Northing	Easting	(m)	(m)
1	4,760,359	429,817	291.24	8.08
4	4,760,349	429,747	291.15	8.08
5	4,760,331	429,675	291.33	8.08

It should be noted that ten boreholes (numbered 1 to 10, inclusive) were drilled for the various CVIF components and the results are provided in the associated Foundation Investigation and Design Reports. Boreholes 1, 4 and 5 are relevant to the new inspection canopy.

The investigation was carried out using an all terrain vehicle mounted CME 750 power auger supplied and operated by a specialist drilling contractor. In each borehole, samples of the overburden were obtained at 0.75 metre intervals of depth using 50 millimetre outside diameter split spoon sampling equipment in accordance with the standard penetration test (SPT) procedures. The boreholes were terminated about 8.1 metres below the existing pavement or ground surface.

Groundwater conditions in the boreholes were observed throughout the drilling operations and a piezometer was installed in borehole 4 to monitor groundwater levels. Following completion of drilling and sampling, the boreholes were backfilled in accordance with current MTO procedures and Ontario Regulation 903 (as amended by Ontario Regulation 372).

The field work was monitored on a full-time basis by an experienced member of our engineering staff who located the boreholes in the field, monitored the drilling, sampling and in situ testing operations, logged the boreholes and surveyed their locations. The samples were identified in the field, placed in labelled containers and transported to our London laboratory for further examination and testing. Index and classification tests, consisting of water content determinations, 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.



4.0 SUBSURFACE CONDITIONS

4.1 General

The detailed subsurface soil and groundwater conditions encountered in boreholes, together with the results of the in situ testing and the laboratory testing carried out on selected samples, are given on the attached Record of Borehole sheets following the text of this report and in Appendix A. The stratigraphic boundaries shown on the Record of Borehole sheets and on the profile on Drawing 1 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.

In general, the boreholes encountered surficial topsoil or the existing pavement structure and fill materials which were underlain by layers of buried topsoil and generally clayey silt till.

4.2 Soil Conditions

4.2.1 Topsoil and Fill

A layer of topsoil about 0.1 metres thick was encountered at the ground surface in borehole 5.

Asphalt was encountered at the pavement surface in boreholes 1 and 4. The asphalt layers were about 0.1 metres thick. Granular base and subbase materials were encountered beneath the asphalt in boreholes 1 and 4. These granular layers were a total of 0.5 and 0.4 metres thick in borehole 1 and 4, respectively.

Beneath the surficial topsoil or pavement structure, clayey silt fill materials were encountered in all of the boreholes. The stiff to hard clayey silt fill was about 1.7 to 3.6 metres thick. The clayey silt fill had N values, as determined in the standard penetration testing, of 12 to 30 blows per 0.3 metres with in situ water contents of about 13 to 19 per cent. The clayey silt fill had corresponding plastic and liquid limits of 17 and 31 per cent, respectively, based on a single Atterberg limits determination and the results are shown on Figure A-3.

A grain size distribution curve for a sample of the clayey silt fill recovered from the standard penetration testing is provided on Figure A-1.

Layers of compact buried topsoil were encountered within the fill in borehole 1 and beneath the fill in boreholes 4 and 5 between elevations 288.6 and 289.5 metres. The buried topsoil layers were about 0.3 to 1.1 metres thick at the borehole locations. The buried topsoil layers had N values of 18 to 30 blows per 0.3 metres with water contents of about 18 to 22 per cent.



4.2.2 Clayey Silt Till

Beneath the surficial topsoil and fill, very stiff to hard clayey silt till was encountered in all of the boreholes between about elevation 287.5 and 289.2 metres. A lower layer of clayey silt till was also encountered beneath the sandy silt in borehole 1. Boreholes 4 and 5 were terminated in the clayey silt till after exploring it for about 4.4 to 6.0 metres. The clayey silt till layers were about 1.5 and 2.0 metres thick in borehole 1. The clayey silt till had N values of 24 to 63 blows per 0.3 metres with water contents of 14 to 26 per cent and an average water content of about 18 per cent. The clayey silt till had average plastic and liquid limits of about 17 and 30 per cent, respectively, based on six Atterberg limits determinations. The Atterberg limits data are provided on Figure A-3.

Grain size distribution curves for samples of the clayey silt till recovered from the standard penetration testing are provided on Figure A-2. Although not specifically encountered in the boreholes, cobbles and boulders should be expected in the clayey silt till.

4.2.3 Sandy Silt

A layer of sandy silt about 0.3 metres thick was encountered within the clayey silt till in borehole 1 at elevation 286.1 metres. The dense sandy silt had an N value of 47 blows per 0.3 metres for a test partially completed in the layer.

4.2.4 Sandy Silt Till

Beneath the clayey silt till, borehole 1 encountered and was terminated in a layer of very dense sandy silt till. The sandy silt till was encountered at elevation 283.8 metres and was explored for about 0.6 metres prior to terminating the borehole. The sandy silt till had an N value of 56 blows per 0.3 metres.

Although not specifically encountered in the borehole, cobbles and boulders should be expected in the sandy silt till.

4.3 Groundwater Conditions

Boreholes 4 and 5 remained dry during drilling on September 13, 2011 and a piezometer was installed in borehole 4 to monitor the groundwater levels. The piezometer was dry to elevation 283.3 metres on September 30, 2011.

Groundwater was encountered in borehole 1 during drilling on September 12, 2011 at a depth of about 5.2 metres below the pavement surface or at about elevation 286.1 metres.



FOUNDATION INVESTIGATION AND DESIGN REPORT INSPECTION CANOPY, GWP 4100-04-00

The inferred long term groundwater level is at about elevation 285 metres. Groundwater levels should be expected to fluctuate seasonally and in response to significant precipitation events.



5.0 MISCELLANEOUS

This investigation was carried out using equipment supplied and operated by Lantech Drilling Services Inc., an Ontario Ministry of Environment licensed well contractor. The field operations were supervised by Mr. Dan Babcock, P.Eng. under the direction of Mr. Michael E. Beadle, P.Eng.. The laboratory testing was carried out at Golder Associates' London laboratory under the direction of Mr. Chris M. Sewell. The laboratory is an accredited participant in the MTO Soil and Aggregate Proficiency Program and is certified by the Canadian Council of Independent Laboratories for testing Types C and D aggregates. This report was prepared by Mr. Michael E. Beadle, P.Eng. under the direction of the Team Leader, 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.

ORIGINAL SIGNED

Michael E. Beadle, P.Eng.

ORIGINAL SIGNED

Philip R. Bedell, P.Eng.
Senior Consultant

ORIGINAL SIGNED

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

MEB/PRB/FJH/ly

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

n:\active\2011\1132-geo\1132-0000\11-1132-0082 dillon - gwp 3100-04-00 - putnam cvif\ph 2000 - foundations\reports\03\1111320082-2000-r03 dec 6 11 (final)-part a&b fdn-inspection canopy.docx



PART B
FOUNDATION DESIGN REPORT
INSPECTION CANOPY
PUTNAM SOUTH CVIF
GWP 4100-04-00



6.0 ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides recommendations based on our interpretation of the factual information obtained during the investigation and is intended for the guidance of 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

Based on the information available, the pavements in the area of the inspection canopy will be at about elevation 291.7 to 292.2 metres, or about 1 metre above current grade at the borehole locations. Further, some 2.1 to 3.7 metres of fill and buried topsoil are present within the canopy footprint. The fill and buried topsoil are not considered suitable for the support of the inspection canopy foundations. Therefore, based on the results of the investigation, the proposed inspection canopy can be founded on conventional spread and/or strip footings bearing on the native clayey silt till between about elevation 287.5 metres (boreholes 1 and 4) and 289.2 metres (borehole 5). Foundations constructed in this manner may be designed using a factored geotechnical resistance at Ultimate Limit States (ULS) of 400 kilopascals and a geotechnical resistance at Serviceability Limit States (SLS) of 250 kilopascals. The SLS criterion is for 25 millimetres of total settlement based on a 1.0 metre minimum footing width. Resistance to uplift should be based on a groundwater level at the ground surface.

All exposed founding surfaces should be inspected by the geotechnical engineer prior to pouring concrete. It is preferable that the final 0.5 metres of excavation be carried out while the geotechnical engineer is on site.

If the footings cannot be poured the same day as the excavation, a 75 millimetre thick lean concrete working slab should be provided in the base of the excavation immediately following inspection by the geotechnical engineer.

At least 1.2 metres of soil cover or thermal equivalent should be provided over the footings.

The soils at the site are not considered to be aggressive to concrete. Thus, normal GU (formerly Type 10) cement may be used. For seismic site response, Site Class C is appropriate.



6.2.1 Engineered Fill

Alternatively, the proposed inspection canopy could be founded on a compacted Granular A engineered fill extending to native undisturbed soils between about elevation 287.5 metres (boreholes 1 and 4) and 289.2 metres (borehole 5). Following careful removal of the existing fill and buried topsoil and following inspection of the subgrade by the geotechnical engineer, an engineered fill could be constructed to support the canopy using compacted Granular A placed in maximum 300 millimetre thick loose lifts. The engineered fill should extend beyond the footprint of the inspection canopy footings by 1 metre plus the thickness of the fill required beneath the footings. Full time geotechnical inspections and materials testing will be required during construction of any engineered fill.

6.2.2 Caissons

The canopy foundations could also be constructed on drilled, cast in place piles (caissons). Caissons at least 0.76 metres in diameter extending at least one diameter into the clayey silt till can be designed using a factored geotechnical resistance at ULS of 600 kilopascals and a geotechnical resistance at SLS of 400 kilopascals. All caisson excavations should be inspected by the geotechnical engineer prior to pouring concrete.

6.3 Resistance to Lateral Loads

6.3.1 Spread Footings

Resistance to lateral forces/sliding resistance between the concrete spread footings and the subsoil should be calculated in accordance with the Ontario Building Code. Assuming that the founding soils are not softened/disturbed during excavation and footing construction, the following unfactored angle of friction between the concrete and the founding soils, and corresponding unfactored coefficient of friction, $\tan \delta$, may be used:

	<u>Angle of Friction</u> (degrees)	<u>$\tan \delta$</u>
Footings on clayey silt till	30	0.58
Footings on Granular A engineered fill	32	0.62

6.3.2 Caissons

The lateral loads exerted by the caissons will be resisted by cohesive soils. The lateral resistance of the cohesive soils along the shaft is represented by a constant distribution with depth and given by $9c_u B$ where c_u is



the undrained shear strength in kilopascals and B is the shaft diameter in metres. The unfactored lateral force resisted by a shaft of length L (in metres) is given by:

$$P = 9 c_u B (L - 1.5B)$$

The above equation is based on the assumption that the lateral geotechnical resistance acts over a width equal to 3 times the shaft diameter. Also, large deformations (lateral movement) would be required to fully mobilize lateral shaft resistance. A resistance factor of 0.5 should be applied to obtain the factored lateral resistance at ULS.

The passive resistance in front of the caisson within the upper 1.2 metres below the ground surface should be neglected in the design of the foundation to account for frost action.

Where an undrained shear strength, c_u , is provided, the undrained capacity of the caisson should be checked to determine whether the drained or undrained case will govern. In this case, the lateral resistance for the length of the caisson within cohesive soil should be calculated assuming an unfactored passive lateral pressure distribution varying linearly from $2 c_u$ at the surface to $9 c_u$ at a depth of three pile diameters and beyond acting over the actual width of the caisson. A resistance factor of 0.5 should be applied to this calculated lateral resistance in order to obtain the factored lateral geotechnical resistance.

The following may be used for design of the caissons:

Soil Type	Undrained Shear Strength, C_u (kPa)
Clayey Silt Fill	100
Buried Topsoil	nil
Clayey Silt Till	200

6.4 Slab-on-Grade

It is understood that a slab-on-grade will be constructed beneath the canopy. The slab-on-grade will be supported on either engineered fill or earth fill, depending on the foundation alternative selected.

The subgrade for the slab-on-grade should be proofrolled under the direction of the foundation engineer and any softened areas subexcavated and replaced with compacted Granular A. Should earth fill be used to bring the slab to subgrade level, 500 millimetres of compacted Granular A should be provided beneath the slab. Alternatively, if a granular engineered fill is used, the slab can be placed directly on the fill materials. For design purposes, a modulus of subgrade reaction of 100 megapascals per metre (MPa/m) may be used for the design of slabs constructed on engineered fill or Granular A as described above.

Appropriate load transfer devices should be used. Further, sawcut crack control joints should be provided at regular intervals. The slab should be kept structurally separate from the foundation elements.



6.5 Excavations

Excavations for the foundations will encounter the surficial topsoil and existing pavement structure, clayey silt fill, buried topsoil and clayey silt till. Cobbles and boulders should be expected in the till strata.

Conventional open cut excavations can be used for this component of the work. The excavation side slopes should not exceed an inclination of 1 horizontal to 1 vertical. Based on the current Occupational Health and Safety Act, the fill and buried topsoil would be classified as Type 3 soils and the clayey silt till would be classified as a Type 2 soil.

For Caissons, a temporary liner will be required to permit inspection and cleaning of the base.

6.6 Groundwater

It is anticipated that groundwater control, when required, can be adequately handled using appropriately sized and filtered sumps.

Surface water should be directed away from the open cut excavations.



7.0 MISCELLANEOUS

This report was prepared by Mr. Michael E. Beadle, P.Eng. under the direction of the Team Leader, 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.

ORIGINAL SIGNED

Michael E. Beadle, P.Eng.

ORIGINAL SIGNED

Philip R. Bedell, P.Eng.
Senior Consultant

ORIGINAL SIGNED

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

MEB/PRB/FJH/ly

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

n:\active\2011\1132-geo\1132-0000\11-1132-0082 dillon - gwp 3100-04-00 - putnam cvif\ph 2000 - foundations\rpts\r03\1111320082-2000-r03 dec 6 11 (final)-part a&b fdn-inspection canopy.docx

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

III. SOIL DESCRIPTION

(a) Cohesionless Soils

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

(b) Cohesive Soils

Consistency

	c_u, s_u	
	<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

Dynamic Cone Penetration Resistance; N_d :

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

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

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

IV. SOIL TESTS

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

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

LIST OF SYMBOLS

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

I. General

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

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

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

PROJECT 11-1132-0082
W.P. 4100-04-00 LOCATION N 4760359.3 ; E 429817.1 ORIGINATED BY DB
DIST HWY 401 BOREHOLE TYPE POWER AUGER, HOLLOW STEM COMPILED BY WDF/LMK
DATUM GEODETIC DATE September 12, 2011 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE	20	40	60						80	100	10
291.24	GROUND SURFACE																			
0.09	ASPHALT						291													
0.30	FILL, crushed granular base Brown																			
0.60	FILL, sand and gravel, with cobbles Brown		1	SS	20															
	FILL, clayey silt, trace sand, trace gravel Stiff to very stiff Brown		2	SS	12		290													
288.80							289													
2.44	TOPSOIL, silty Compact Black		3	SS	21															
288.34																				
2.90	FILL, clayey silt, trace sand, trace gravel, trace topsoil Very stiff Brown		4	SS	16		288													
287.58																				
3.66	CLAYEY SILT TILL, trace to some sand, trace gravel Hard Brown		5	SS	31		287								1	12 50 37				
			6	SS	63															
286.06							286													
5.18	SANDY SILT, with clayey silt layers Dense Brown		7	SS	47															
285.75																				
5.49	CLAYEY SILT TILL, trace sand, trace gravel Hard Brown becoming grey at about elev. 284.2m		8	SS	40		285								2	7 48 43				
			9	SS	51		284													
283.77																				
7.47	SANDY SILT TILL, some gravel Very dense Brown		10	SS	56															
283.16																				
8.08	END OF BOREHOLE																			
	Groundwater encountered at about elev. 286.1m during drilling on September 12, 2011.																			

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

PROJECT 11-1132-0082
W.P. 4100-04-00 LOCATION N 4760349.1 ; E 429747.2 ORIGINATED BY DB
DIST HWY 401 BOREHOLE TYPE POWER AUGER, HOLLOW STEM COMPILED BY WDF/LMK
DATUM GEODETIC DATE September 13, 2011 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
291.15	GROUND SURFACE							20 40 60 80 100						
0.08	ASPHALT													
0.20	FILL, crushed granular base													
0.48	Brown													
	FILL, sand and gravel, with cobbles													
	Brown		1	SS	21									
	FILL, clayey silt, trace to some sand,													
	trace gravel		2	SS	20									
	Stiff to very stiff													
	Brown													
288.56			3	SS	13									1 11 48 40
2.59	TOPSOIL, silty													
	Compact		4	SS	18									
	Black													
287.49														
3.66	CLAYEY SILT TILL, trace to some		5	SS	26									1 10 51 38
	sand, trace gravel													
	Very stiff to hard		6	SS	32									
	Brown													
			7	SS	46									
			8	SS	34									
			9	SS	31									
			10	SS	37									1 14 51 34
283.07														
8.08	END OF BOREHOLE													
	Borehole dry during drilling on September 13, 2011.													
	Piezometer dry to elev. 283.23m on September 30, 2011.													



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

RECORD OF BOREHOLE No 5

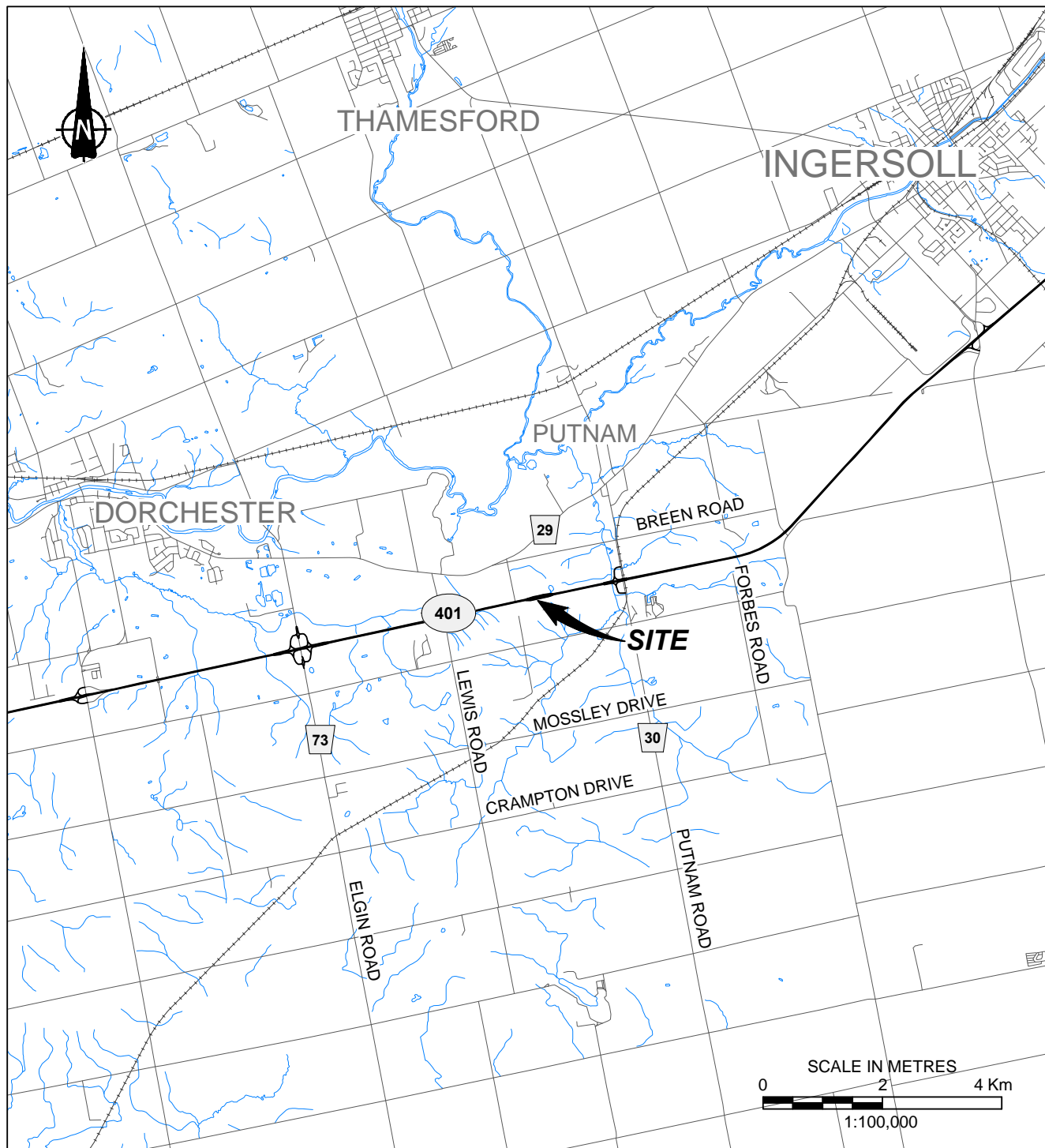
1 OF 1

METRIC

PROJECT 11-1132-0082
W.P. 4100-04-00 LOCATION N 4760330.7 ; E 429674.5 ORIGINATED BY DB
DIST HWY 401 BOREHOLE TYPE POWER AUGER, HOLLOW STEM COMPILED BY WDF/LMK
DATUM GEODETIC DATE September 13, 2011 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W _P W W _L				
291.33	GROUND SURFACE							20 40 60 80 100						
0.08	TOPSOIL, silty Black						291							
	FILL, clayey silt, trace to some sand, trace gravel Very stiff to hard Brown		1	SS	20		290							
289.53			2	SS	30									
1.80	TOPSOIL, silty						289							
289.20	Compact Black		3	SS	25		288							
2.13	CLAYEY SILT TILL, trace sand, trace gravel Very stiff to hard Brown becoming grey at about elev. 284.6m becoming brown at about elev. 283.4m		4	SS	43		287							
			5	SS	46									
			6	SS	37		286							
			7	SS	45		285							
			8	SS	33									
			9	SS	24		284							
			10	SS	28									
283.25	END OF BOREHOLE													
8.08	Borehole dry during drilling on September 13, 2011.													

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



REFERENCE

DRAWING BASED ON CANMAP STREETFILES V2008.4.

NOTES

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

ALL LOCATIONS ARE APPROXIMATE.

PROJECT

FOUNDATION INVESTIGATION
NEW INSPECTION CANOPY
PUTNAM SOUTH CVIF, GWP 4100-04-00

TITLE

KEY PLAN







PROJECT No. 11-1132-0082			FILE No. 1111320082-2000-F03001	
CADD	DCH/AMG	NOV. 17/11	SCALE	AS SHOWN
CHECK				REV.
			FIGURE 1	



NEW INSPECTION CANOPY
HIGHWAY 401/PUTNAM SOUTH CVIF
BOREHOLE LOCATIONS AND SOIL STRATA



	Borehole – Current Investigation
	Seal
	Piezometer
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
<i>DRY</i>	Borehole dry during drilling
	WL encountered during drilling

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.

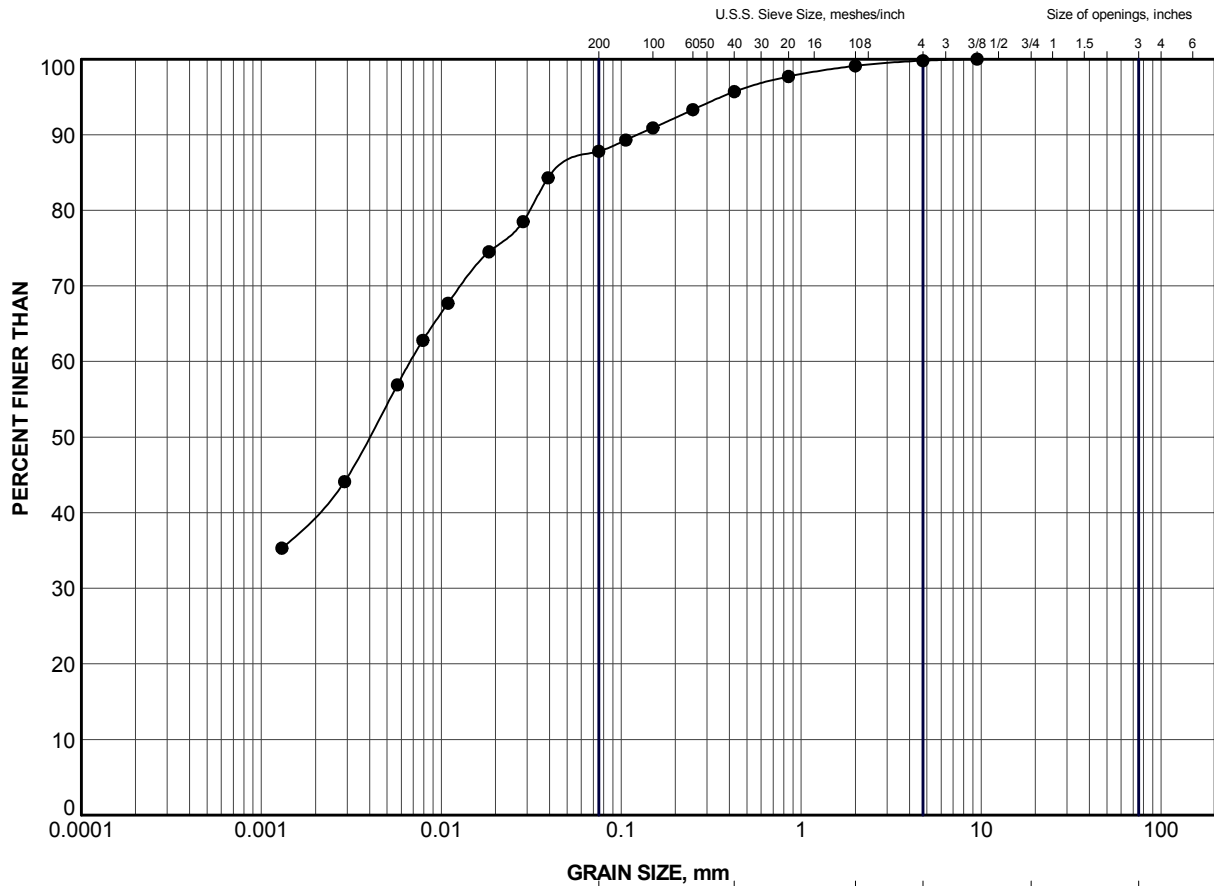
Bose plans provided in digital format by Dillon Consulting

NO.	DATE	BY	REVISION	
Geocres No. 40115-34				
HWY.	401	PROJECT NO.	11-1132-0082	DIST.
SUBM'D.	MB	CHKD.	DATE: Nov. 17/11	SITE:
DRAWN: DCH / AMG		CHKD.	APPD.	DWG. 1



APPENDIX A


Laboratory Test Data

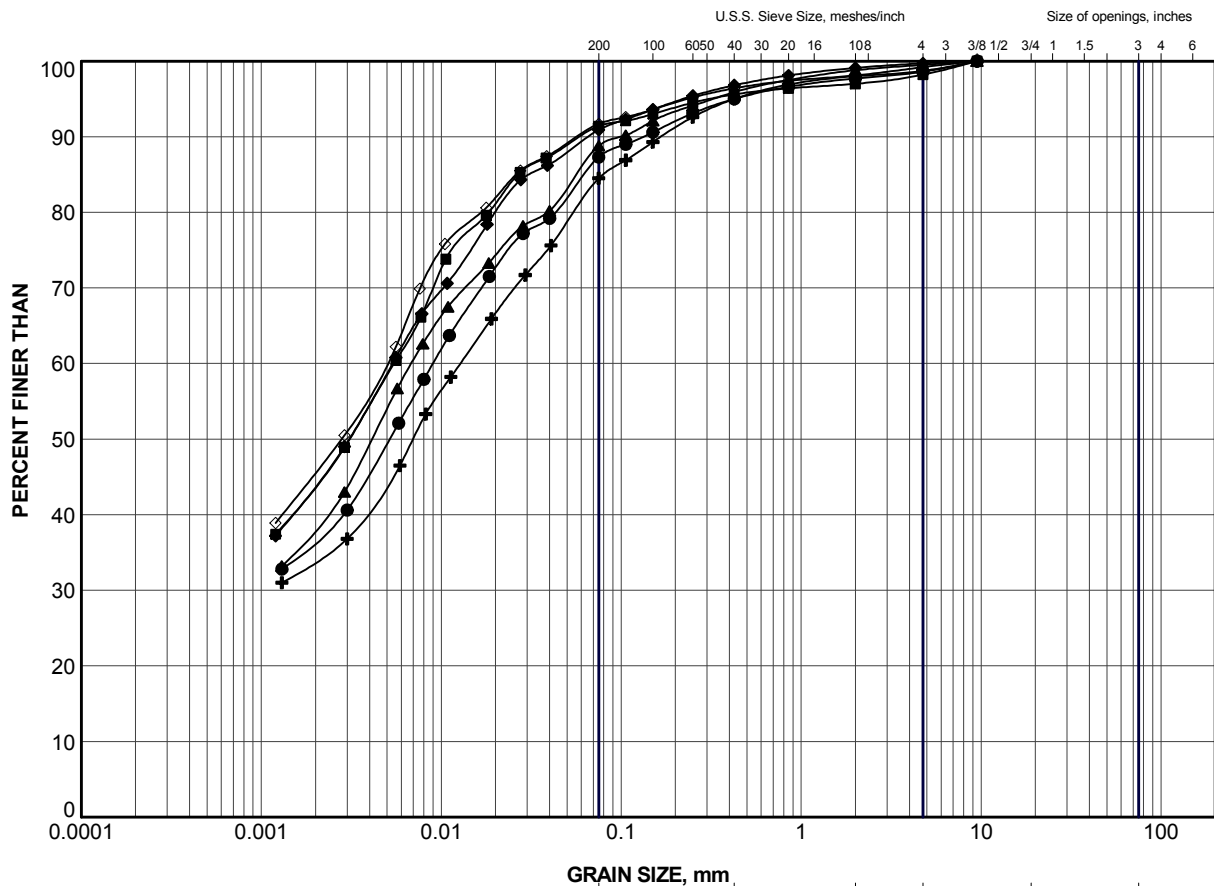


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	4	3A	288.7


PROJECT		FOUNDATION INVESTIGATION NEW INSPECTION CANOPY PUTNAM SOUTH CVIF GWP 4100-04-00			
TITLE		GRAIN SIZE DISTRIBUTION FILL, clayey silt			
 Golder Associates LONDON, ONTARIO		PROJECT No.		11-1132-0082	
		FILE No.		1111320082-2000-F030A1	
		DRAWN		DCH	
		CHECK		Oct 25/11	
		SCALE		N/A	
		REV.			
		FIGURE A-1			

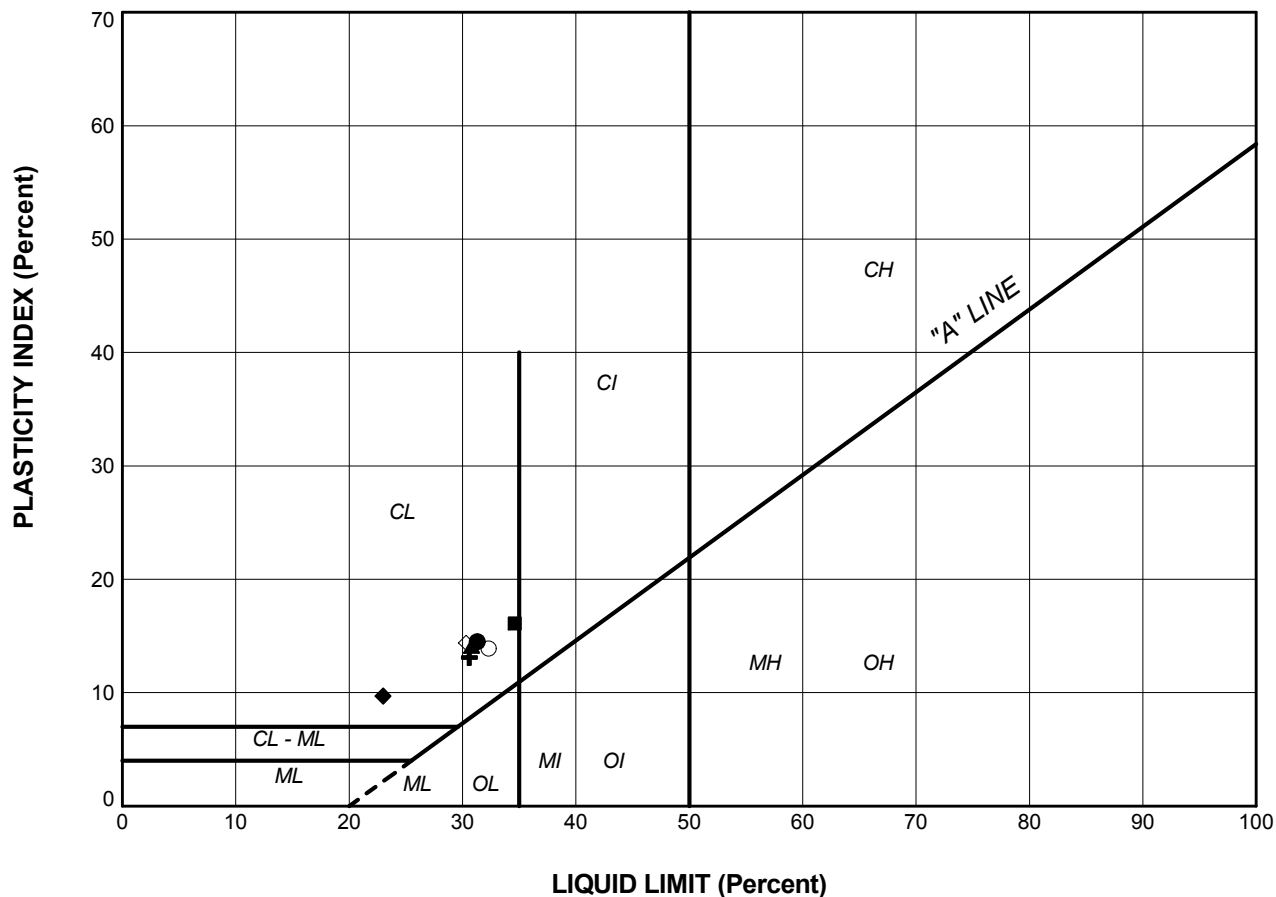


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	1	5	287.2
■	1	8	284.9
▲	4	5	287.1
+	4	9	284.1
◆	5	3	288.8
◇	5	7	285.8

PROJECT		FOUNDATION INVESTIGATION NEW INSPECTION CANOPY PUTNAM SOUTH CVIF GWP 4100-04-00			
TITLE		GRAIN SIZE DISTRIBUTION CLAYEY SILT TILL			
 Golder Associates LONDON, ONTARIO		PROJECT No.		11-1132-0082	FILE No. 1111320082-2000-F030A2
		DRAWN	DCH	Oct 25/11	SCALE N/A
		CHECK			REV.
		FIGURE A-2			



LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
FILL					
▲	4	3A	30.8	16.7	14.1
CLAYEY SILT TILL					
●	1	5	31.3	16.8	14.5
■	1	8	34.6	18.5	16.1
+	4	5	30.6	17.5	13.1
◆	4	9	23.0	13.3	9.7
◇	5	3	30.3	15.9	14.4
○	5	7	32.3	18.4	13.9

PROJECT		FOUNDATION INVESTIGATION NEW INSPECTION CANOPY PUTNAM SOUTH CVIF GWP 4100-04-00			
TITLE		PLASTICITY CHART			
 Golder Associates LONDON, ONTARIO	PROJECT No.	11-1132-0082	FILE No.	1111320082-2000-F030A3	
	DRAWN	LMK	Nov 04/11	SCALE	N/A
	CHECK			REV.	
			FIGURE A-3		

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

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

