

FOUNDATION INVESTIGATION REPORT

CONTRACT NO. 2007-2029

Ministry Of Transportation



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**FOUNDATION INVESTIGATION REPORT
SLOPE RESTORATION AT STATION 15+718
HIGHWAY 405 W-N/S RAMP AT STANLEY AVENUE
HIGHWAY 405 REHABILITATION FROM QEW TO
QUEENSTON-LEWISTON BORDER CROSSING
G.W.P. 2445-04-00**

Submitted to:

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by McCormick Rankin Corporation (MRC) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services associated with the rehabilitation of Highway 405 from the QEW to the Queenston-Lewiston Border Crossing, in the Region of Niagara. Foundation engineering services are required for slope restoration work on the currently distressed south embankment slope at approximately Station 15+718 on the Highway 405 W- N/S ramp at Stanley Avenue; foundation engineering services may also be required for a proposed retaining wall along the Stanley Avenue W-N/S Ramp and a new overhead sign structure, if widening of the Stanley Avenue W-NS Ramp is determined to be necessary.

This report addresses the geotechnical investigation component of the rehabilitation works carried out for the slope restoration at approximately Station 15+718 on the Highway 405 W-NS ramp at Stanley Avenue.

The terms of reference and scope of work for the geotechnical investigation are outlined in MTO's Request for Quotation (RFQ) document for Agreement No. 2005-E-0058, issued in April 26, 2006, and in Section 3.5.6 of MRC's *Technical Proposal* for G.W.P. 2445-04-00.

2.0 SITE DESCRIPTION

The site of the slope distress is located some 200 m west of Stanley Avenue on Highway 405 W-N/S ramp at approximately Station 15+718, in the Region of Niagara. At the distress location, the existing slope is approximately 6.5 m high, with current grades at the toe and crest of the slope at approximately Elevation 180.4 m and Elevation 186.5 m, respectively.

The site is bordered by Stanley Avenue about 200 m to the east, Highway 405 and Townline Road to the north, Saint Paul Avenue to the west and Mountain/Portage Road to the south. An old farm of relatively flat land is located directly south of the site extending back from the crest of the slope; a small farm pond is located about 250 m south of the slope.

A site visit by Golder geotechnical staff was conducted on September, 7 2006 to observe the conditions of the embankment slope. The embankment slope was approximately 6.5 m in height and was inclined at about 25.5 degrees to the horizontal (approximately 2.3 horizontal to 1 vertical), based on slope inclination measurements taken using a hand-held Abney level. The distress has manifested as an erosion gully that is about 4 m wide within the upper slope and approximately 1.5 m to 2 m deep; the erosion gully extends down-slope becoming narrower near the toe of the slope. A 200 mm diameter clay drainage tile was protruding from the face of the eroded area at a depth of about 1.5 m from the crest of the slope; a broken piece of the clay pipe had been placed at the top of the slope during our site visit and sloughed soils were observed on the erosion gully below the tile. The erosion gully was partially filled with rock blocks. During the site visit, about 25 mm depth of water was flowing from the drainage tile; during a subsequent visit while taking water level measurement in a borehole on October 19, 2006, the drainage tile appeared to be flowing about one-quarter full and the outflow appeared to be relatively free of sediment. Tall vegetation surrounded the sloughed area (refer to Photographs 1 to 4 in Appendix A).

The adjacent areas of the embankment slope were generally well vegetated with no visual signs of surficial erosion, sloughing or slope instability at the time of the site visit.

3.0 INVESTIGATION PROCEDURES

The field work for the subsurface investigation was carried out on September 20 and 21, 2006, at which time two boreholes, Boreholes 1 and 2, were respectively put down at the toe and crest of the slope, immediately to the west of the distressed area approximately at the locations shown on Drawing 1. The boreholes were advanced using a CME 55 track mounted drill rig supplied and operated by DBW Drilling Ltd. of Ajax, Ontario.

Boreholes 1 and 2 were advanced to 4.6 m and 11.7 m depth below present ground surface, respectively. Samples of the overburden were obtained at 0.75 m to 1.5 m intervals of depth using 50 mm outside diameter split-spoon samplers in accordance with the Standard Penetration Test (SPT) procedure. The boreholes were advanced 2.5 m and 2.9 m into the bedrock using an 'NQ' size rock core barrel. Bedrock was encountered in Boreholes 1 and 2 at about 2.1 m and 8.8 m of depth, respectively.

A standpipe piezometer was installed in Borehole 2, screened within the lower silt deposit. The piezometer consists of 25 mm diameter PVC pipe with a slotted tip installed within a 2.1 m long filter sand pack. A 0.3 m bentonite seal was placed on top of the filter sand followed by cement grout to about 1.8 m below the ground surface, where a 1.8 m bentonite seal was placed around the piezometer casing extending to the ground surface.

The field work was monitored on a full-time basis by a member of Golder's staff who located the boreholes in the field, directed the sampling and in situ testing operations, and logged the boreholes. The soil and bedrock samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Mississauga for further examination and laboratory testing. Index and classification tests, consisting of water content determinations, Atterberg limits and grain size distribution analyses, were carried out on selected soil samples.

The borehole locations were surveyed by J.D. Barnes, Ontario Land Surveyor (OLS) following completion of the drilling operations. The borehole locations (including NAD83 MTM northing and easting coordinates) and ground surface elevations (referenced to geodetic datum) provided by MRC are summarized below and are shown on Drawing 1.

<i>Borehole Number</i>	<i>Borehole Location</i>	<i>MTM NAD83 Northing (m)</i>	<i>MTM NAD83 Easting (m)</i>	<i>Ground Surface Elevation (m)</i>
1	Toe of Embankment	4778453	338192	180.5
2	Crest of Embankment	4778438	338200	186.9

4.0 SITE GEOLOGY AND STRATIGRAPHY

4.1 Regional Geology

The area of the Highway 405 W-N/S ramp at Stanley Avenue lies within the Iroquois Plain physiographic region, as delineated in *The Physiography of Southern Ontario*¹ and *Urban Geology of Canadian Cities*².

The area of the slope distress is located on the Niagara Escarpment, which separates the lower Iroquois Plain to the north from the Haldimand Clay Plain physiographic region to the south of the escarpment. In the Niagara Region, the escarpment base is located at about Elevation 105 m and the top reaches to about Elevation 190 m. The escarpment itself consists of dolostone, limestone, sandstone and shale bedrock, mantled by relatively thin deposits of silty clay till, sandy silt till, sands, and silts. The depth to bedrock on the escarpment is shallow, varying typically between about 1 m and 6 m.

4.2 Site Stratigraphy

As part of the subsurface investigation at this site, two boreholes were advanced at the toe and the crest of the south slope of the W-N/S ramp approximately 200 m east of Stanley Avenue, at the locations shown on Drawing 1.

The detailed subsurface soil and groundwater conditions encountered in the boreholes, and the results of in-situ and laboratory testing carried out on selected soil samples, are given on the Record of Borehole/Drillhole sheets and Figures 1 and 2. The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. Subsoil conditions will vary between and beyond the borehole locations. The inferred soil stratigraphy based on the results of the boreholes at the toe and crest of the slope is also shown on Drawing 1.

In summary, the soils encountered in Borehole 1 drilled at the toe of the slope consist of a layer of rip-rap at the ground surface underlain by a sandy silt deposit, and by bedrock at about Elevation 178.5 m. In Borehole 2 at the crest of the south embankment slope, the subsoils encountered consist of a layer of topsoil underlain by a clayey silt deposit which is in turn underlain by a silt deposit. The silt deposit extends to approximately Elevation 178.1 m where bedrock was encountered.

¹ Chapman, L.J. and D.F. Putnam. *The Physiography of Southern Ontario*, Ontario Geological Survey Special Volume 2, Third Edition, 1984. Accompanied by Map P.2715, Scale 1:600,000.

² J. Menzies and E.M. Taylor. "Urban Geology of St. Catharines-Niagara Falls, Region Niagara". In *Urban Geology of Canadian Cities*, Geological Association of Canada Special Paper 42, Ed. P.F. Karrow and O.L. White, 1998.

In both boreholes, bedrock consists of dolostone with interlayers of limestone with occasional calcium carbonate inclusions.

A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Topsoil / Rip-Rap

About 500 mm of 100 mm-to-150 mm size stone rip-rap was encountered in Borehole 1, which was advanced at the toe of slope. At the crest of the slope an approximately 200 mm thick layer of topsoil was encountered in Borehole 2.

4.2.2 Clayey Silt

A 1.1 m thick layer of reddish brown clayey silt containing trace sand and gravel was encountered in Borehole 2 at about Elevation 186.7 m, directly below the topsoil. Two SPT “N” values obtained within this material recorded 26 and 20 blows per 0.3 m of penetration, indicating that this material has a very stiff consistency.

The result of an Atterberg limit test on a sample of this deposit is provided on Figure 1 and indicates a plastic limit of 18 percent and a liquid limit of 34 percent, which corresponds to a plasticity index of 16 percent; this material is classified as a clayey silt of low plasticity. The natural water content from the same sample is about 22 percent.

4.2.3 Sandy Silt to Silt

A layer of reddish brown to brown sandy silt to silt containing trace clay and trace to some gravel was encountered directly below the rip-rap layer in Borehole 1 and below the clayey silt deposit in Borehole 2. This deposit is 1.6 m and 6.5 m thick at the locations of Boreholes 1 and 2, respectively. The surface of the sandy silt to silt deposit was encountered at Elevation 180.1 m at the location of Borehole 1 and at Elevation 184.6 m at the location of Borehole 2.

The results of two grain size distribution tests carried out on selected samples of this material are provided on Figure 2 and indicate that the deposit is slightly coarser in Borehole 1. Measured SPT “N” values within the sandy silt to silt deposit typically range from 44 to greater than 100 blows per 0.3 m of penetration, with the exception of one SPT “N” value measured at 28 blows per 0.3 m of penetration obtained within the saturated zone just above the bedrock surface in Borehole 2. The SPT “N” results indicate that the sandy silt to silt deposit typically has a dense to very dense relative density.

Seven natural water content measurements obtained on select samples from the sandy silt to silt deposit ranged from about 5 percent to 24 percent.

4.2.4 Bedrock

Bedrock, consisting of dolostone containing interlayers of limestone, underlies the sandy silt to silt deposit at this site. The depth to the bedrock surface and its elevation as encountered at the locations of Boreholes 1 and 2 is presented below.

<i>Borehole Location</i>	<i>Borehole Number</i>	<i>Ground Surface Elevation (m)</i>	<i>Depth to Bedrock (m)</i>	<i>Bedrock Surface Elevation (m)</i>
Toe of Slope	1	180.5	2.1	178.4
Crest of Slope	2	186.9	8.8	178.1

The bedrock was confirmed by coring 2.5 m and 2.9 m at the two borehole locations. The dolostone bedrock at the site is a member of the Clinton Group; it is moderately to slightly weathered, thinly bedded, grey, medium strong rock. Rock Quality Designation (RQD) values measured on recovered bedrock core samples typically ranged from about 16 percent to 87 percent, indicating that the bedrock ranges from very poor to good quality. The discontinuities observed in the rock core are typically horizontal, associated with the bedding planes.

A description of some of the terms used in the description of the bedrock samples from this site is provided on the *Lithological and Geotechnical Rock Description Terminology* sheet which precedes the Record of Borehole sheets included with this report.

4.3 Groundwater Conditions


The water levels noted during and after the drilling and coring operations in the boreholes are presented on the Record of Borehole sheets and summarized below. One piezometer was installed in Borehole 2 within the very dense to compact sandy silt to silt stratum. Details of the piezometer installation are shown in the Record of Borehole Sheet 2 following the text of this report. The water level in the piezometer is summarized in the table below.

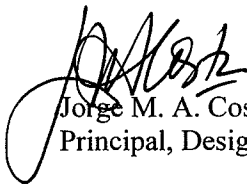
Borehole	Installations	Ground Surface Elevation (m)	Ground Water Level Depth (m)	Ground Water Level Elevation (m)	Date
1	Open Borehole	180.5	Dry	-	September 21, 2006
2	Piezometer	186.9	7.8	179.1	September 22, 2006
			8.4	178.5	October 19, 2006

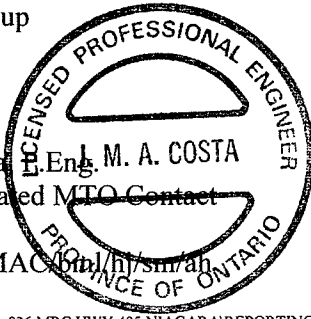
5.0 CLOSURE


This Geotechnical Investigation Report was prepared by Mr. Brian Lapos, EIT and reviewed by Mrs. Houda Jadi, P.Eng., a Geotechnical Engineer with Golder. Mr. Jorge Costa, a Designated MTO Contact and Principal with Golder, conducted an independent review of the report.

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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.) drive open sampler for a distance of 300 mm (12 in.)

Consistency

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

(b) Cohesive Soils

c_u, s_u

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
*	Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)

(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

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERING STATE

Fresh: no visible sign of weathering.

Faintly weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock texture and structure are preserved.

BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	> 2 m
Thickly bedded	0.6 m to 2m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	< 6 mm

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	> 3 m
Wide	1 - 3 m
Moderately close	0.3 - 1 m
Close	50 - 300 mm
Very close	< 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	> 60 mm
Coarse Grained	2 - 60 mm
Medium Grained	60 microns - 2 mm
Fine Grained	2 - 60 microns
Very Fine Grained	< 2 microns

Note: * Grains >60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varies from 0% for completely broken core to 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to (W.R.T.) Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

Description and Notes

An abbreviated description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

B - Bedding	P - Polished
FO - Foliation/Schistosity	S - Slickensided
CL - Cleavage	SM - Smooth
SH - Shear Plane/Zone	R - Ridged/Rough
VN - Vein	ST - Stepped
F - Fault	PL - Planar
CO - Contact	FL - Flexured
J - Joint	UE - Uneven
FR - Fracture	W - Wavy
MF - Mechanical Fracture	C - Curved
- Parallel To	
⊥ - Perpendicular To	

PROJECT		RECORD OF BOREHOLE No 1				1 OF 1 METRIC	
W.P.		LOCATION		ORIGINATED BY			
DIST		BOREHOLE TYPE		COMPILED BY			
DATUM		DATE		CHECKED BY			
06-1111-036		N 4778453.0 ; E 338192.0		MSM			
2445-04-00		CONTINUOUS FLIGHT HOLLOW STEM AUGERS		SB			
Central HWY 405		Sept. 21, 2006		HJ			
Geodetic							

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa												
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%)									
						20	40	60	80	100	20	40	60	80	100	10	20	30		
180.5	GROUND SURFACE																			
0.0	100 mm to 150 mm size cobbles (RIP-RAP)																			
180.1																				
0.5	Sandy SILT, some gravel, trace clay Dense to very dense Reddish brown Moist		1	SS	42															18 23 52 7
178.4			2	SS	>100															
2.1	Dolostone (BEDROCK)																			
	Bedrock cored from 2.1 m to 4.6 m depth. For bedrock coring details refer to Record of Drillhole 1.																			
178.4																				
177.9																				
175.9																				
4.6	END OF BOREHOLE																			
	NOTE: 1. Borehole dry upon completion of drilling.																			

PROJECT: 06-1111-036

RECORD OF DRILLHOLE: 1

SHEET 1 OF 1

LOCATION: N 4778453.0 ;E 338192.0

DRILLING DATE: Sept. 21, 2006

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME-55 Bombardier

DRILLING CONTRACTOR: DBW DRILLING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm/min)	FLUSH	COL- OUR % RETURN	JN - - Joint FLT - Fault SHR - Shear VN - Vein CJ - Conjugate				BD- Bedding FO- Foliation CO- Contact OR- Orthogonal CL - Cleavage				PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular				PO - Polished K - Slickensided SM- Smooth Ro - Rough MB- Mechanical Break				BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.	NOTES WATER LEVELS INSTRUMENTATION
									RECOVERY		R.Q.D. %	FRACT INDEX PER 0.3 m	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY K, cm/sec		Diametral Point Load Index (MPa)	RMC -Q AVG.						
									TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t. CORE AXIS	CORE D.D.C	TYPE AND SURFACE DESCRIPTION	10 10 10 10	10 10 10 10								
									80 60 40 20	80 60 40 20																
		CONTINUED FROM BOREHOLE LOG		178.45																						
	NQ Coring	Dolostone containing interlayers of limestone and calcium carbonate mineral inclusion (BEDROCK - Clinton Group) Moderately to slightly weathered Thinly bedded Medium strong Grey		2.05																						
3				1	0.4	100																				
				2	0.1	100																				
4																										
														</												

DEPTH SCALE

1 : 50



LOGGED: MSM

CHECKED: HJ

MIS-RCK 004 06-1111-036.GPJ GAL-MISS.GDT 11/107 MSM

PROJECT 06-1111-036			RECORD OF BOREHOLE No 2			1 OF 1 METRIC													
W.P. 2445-04-00			LOCATION N 4778438.0; E 338200.0			ORIGINATED BY MSM													
DIST Central HWY 405			BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGERS			COMPILED BY SB													
DATUM Geodetic			DATE Sept. 21, 2006			CHECKED BY HJ													
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa			WATER CONTENT (%)			γ			GR SA SI CL		
186.9	GROUND SURFACE							20 40 60 80 100	20 40 60 80 100	10 20 30									
0.0	TOPSOIL																		
0.2	CLAYEY SILT, trace gravel, sand and clay Very stiff Reddish brown Moist		1	SS	26		186												
			2	SS	20		185												
184.6	SILT, trace to some clay and trace sand Very dense to compact Brown Moist to wet		3	SS	58/0.22		184												
			4	SS	94/0.18		183												
			5	SS	68/0.15		182												
			6	SS	55		181												
			7	SS	44		180												
			8	SS	28		179												
178.1	Dolostone (BEDROCK)						178												
8.8	Bedrock cored from 8.8 m to 11.7 m depth. For bedrock coring details refer to Record of Drillhole 2.						177												
							176												
175.2	END OF BOREHOLE																		
11.7	NOTES: 1. Water level measured in Piezometer upon completion of installation at 7.6 m below ground surface (Elev. 178.9 m). 2. Water level measured in Piezometer on Sep. 22, 2006 at 7.8 m depth (Elev. 178.7 m). 3. Water level measured in Piezometer on Oct. 19, 2006 at 8.4 m depth (Elev. 178.1 m).																		

MIS-MTO 001 06-1111-036.GPJ GAL-MISS GDT 11/1/07 MSM

PROJECT: 06-1111-036

RECORD OF DRILLHOLE: 2

SHEET 1 OF 1

LOCATION: N 4778438.0 ;E 338200.0

DRILLING DATE: Sept. 21, 2006

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME-55 Bombardier

DRILLING CONTRACTOR: DBW DRILLING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm/min)	FLUSH	COL- OUR % RETURN	JN - - Joint		BD- Bedding		PL - Planar		PO- Polished		BR - Broken Rock		NOTES WATER LEVELS INSTRUMENTATION
									FLT - Fault		FO- Foliation		CU- Curved		K - Slickensided		NOTE: For additional abbreviations refer to list of abbreviations & symbols.		
									SHR- Shear		CO- Contact		UN- Undulating						
									VN - Vein		OR- Orthogonal		ST - Stepped		SM- Smooth				
		CJ - Conjugate		CL - Cleavage		IR - Irregular		Ro - Rough		MB- Mechanical Break									

DEPTH SCALE

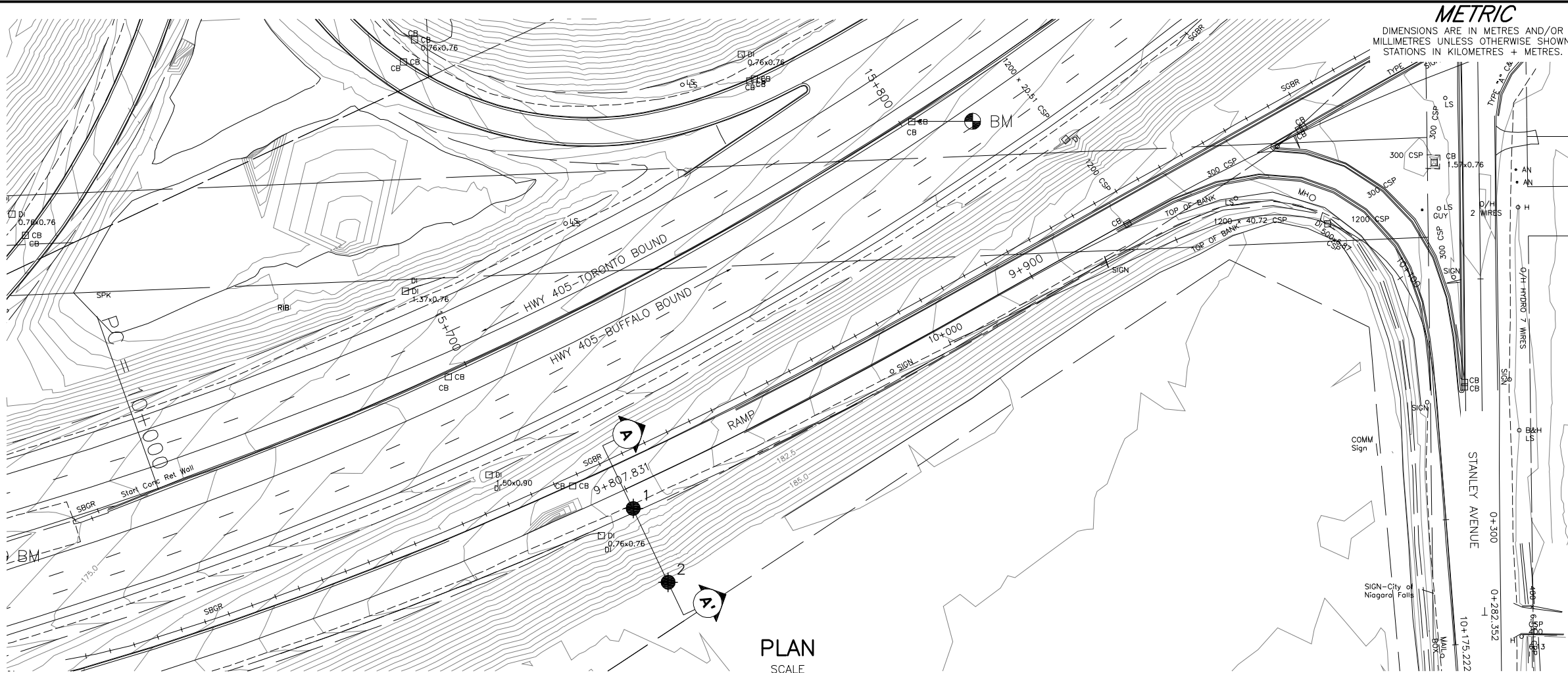
1 : 50



LOGGED: MSM

CHECKED: HJ

MIS-RCK 004 06-1111-036.GPJ GAL-MISS.GDT 11/107 MSM



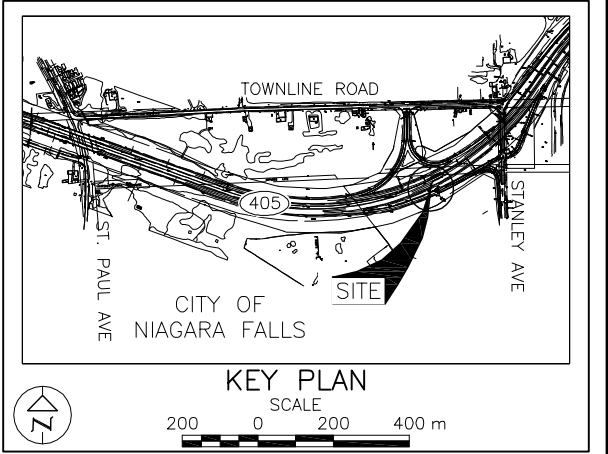
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.


CONT No.
GWP No. 2445-04-00

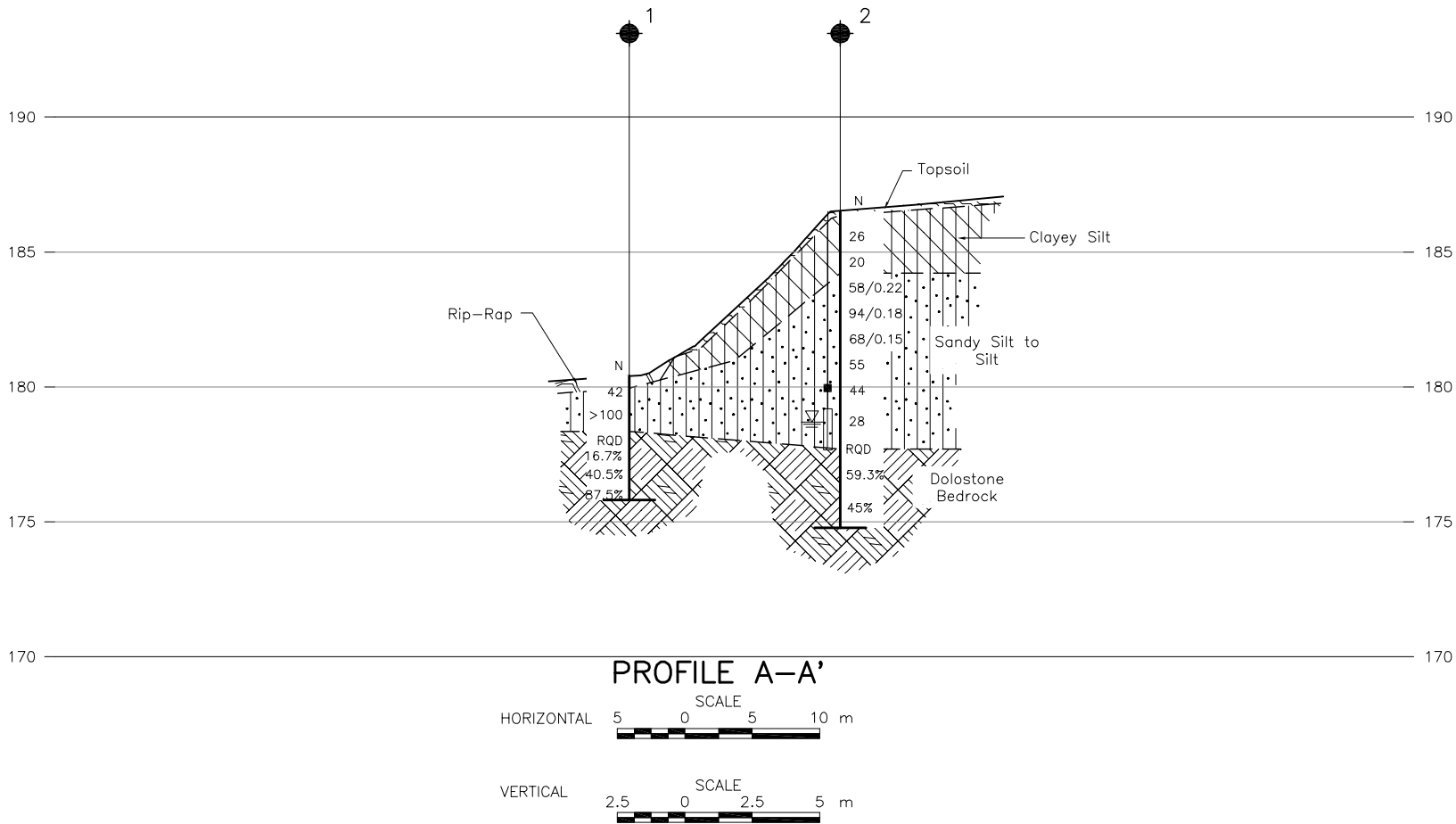
HIGHWAY 405
SLOPE RESTORATION AREA STA. 15+718
BOREHOLE LOCATIONS AND
SOIL STRATA

SHEET

 **Golder Associates Ltd.**
MISSISSAUGA, ONTARIO, CANADA



LEGEND			
 Borehole location			
No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
1	180.5	4778453	338192
2	186.9	4778438	338200



NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

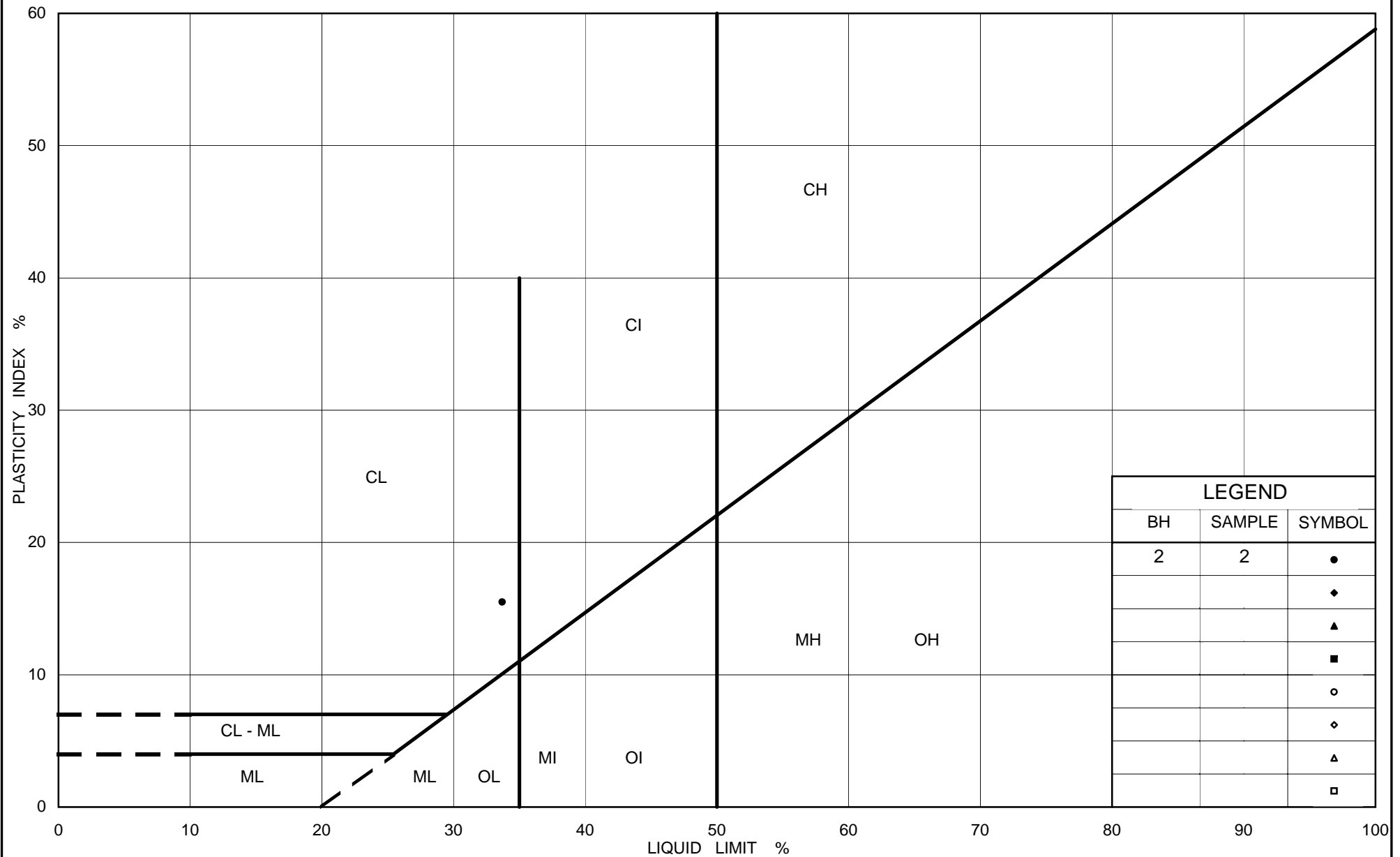
The boundaries between soil strata have been established only at borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

The complete foundation investigation and design report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plans provided in digital format by Mc Cormick Rankin Corporation, drawing file nos. 6583 existing Hwy405 mapping.dwg and h5405xb2.dwg, received August 3, 2006.

NO.	DATE	BY	REVISION
Geocres No.			
HWY. 405		PROJECT NO. 06-1111-036	DIST. CENTRAL
SUBM'D. HJ	CHKD. HJ	DATE: OCT 2006	SITE:
DRAWN: MSM	CHKD. BML	APPD. LCC	DWG. 1



Ministry of Transportation

Ontario

PLASTICITY CHART

Clayey Silt

FIG No.1

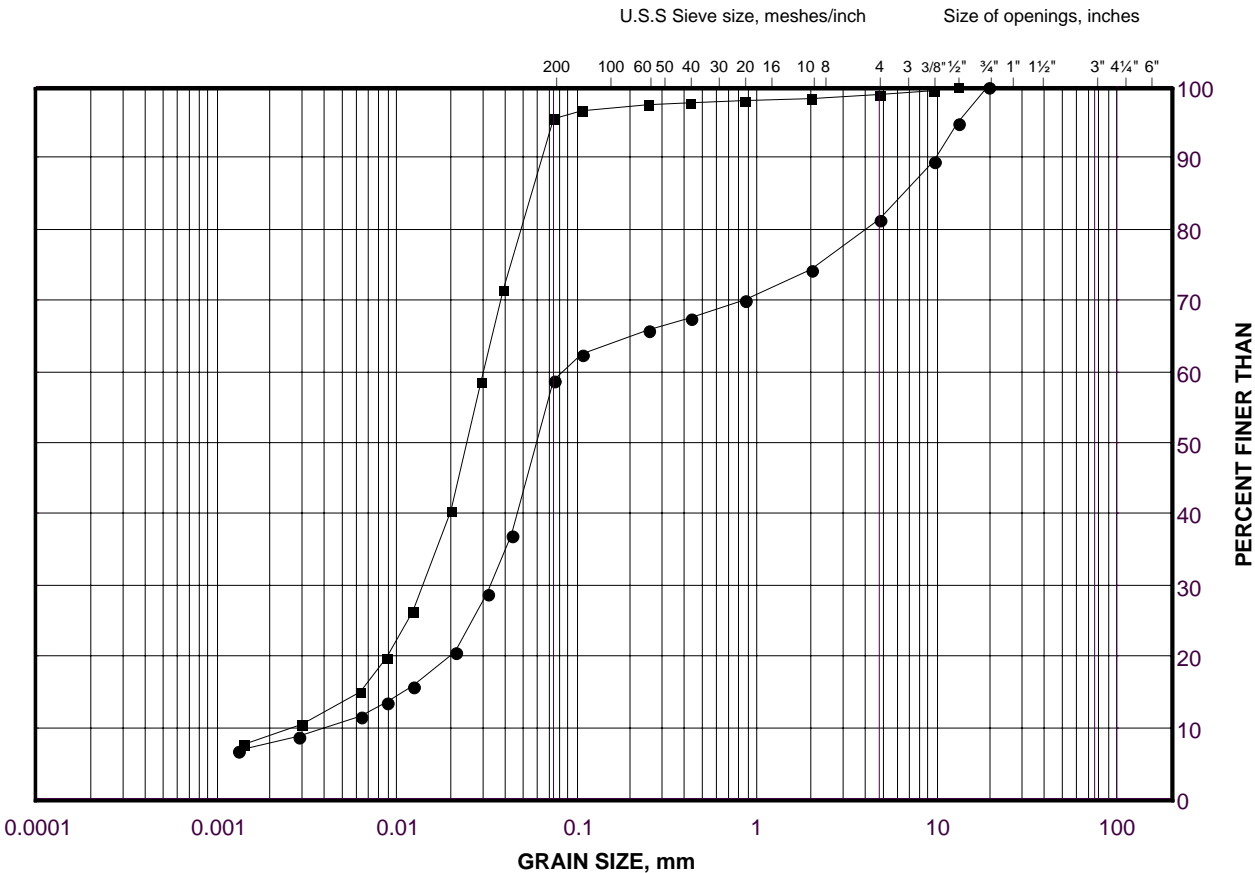
Project No. 06-1111-036

Date: October, 2006

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sandy Silt to Silt

FIGURE 2



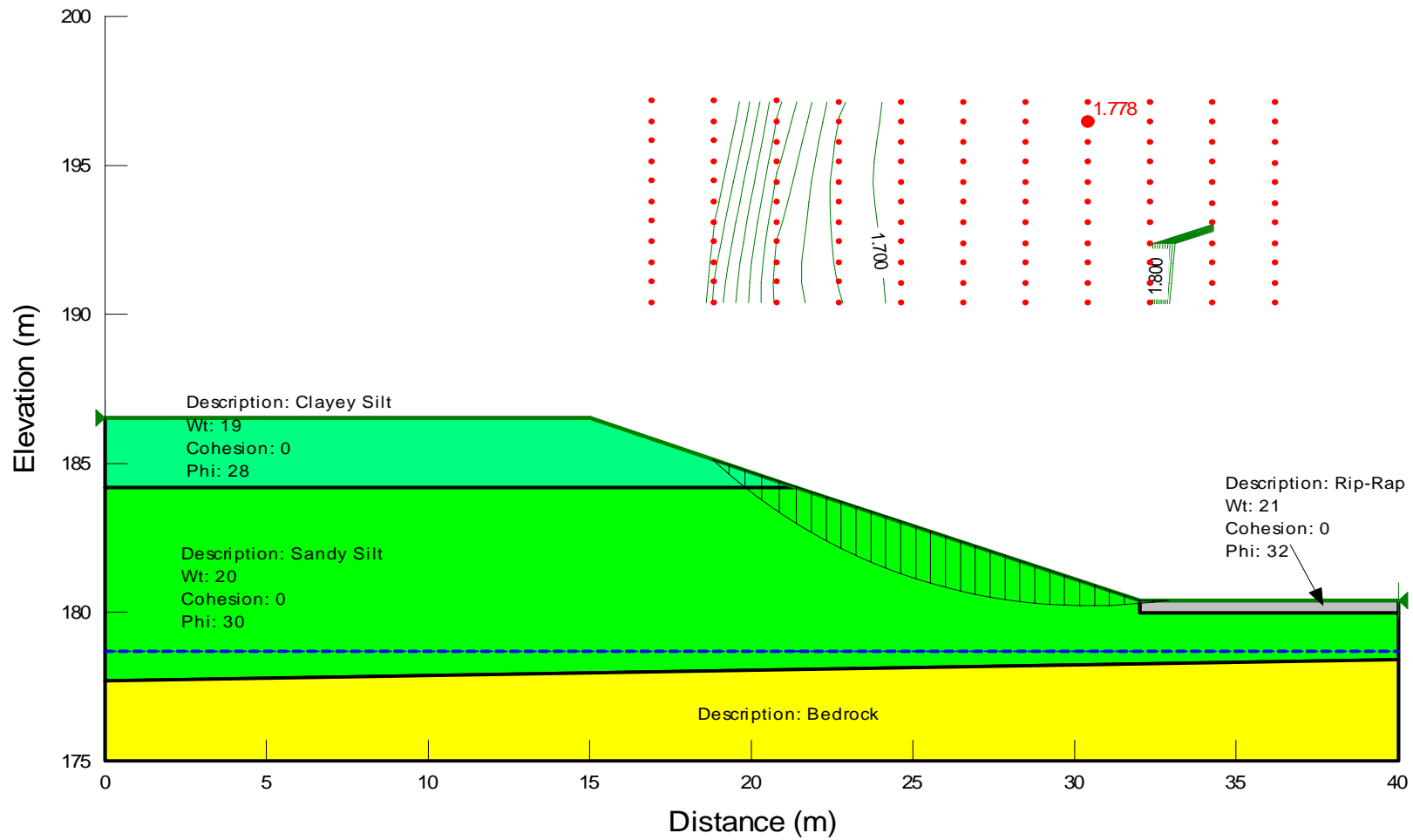
SILT AND CLAY SIZES			FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED			SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	1	1	179.3
■	2	6	181.6

Results of Slope Stability Analysis

Figure 3



Date: October 2006
Project: 06-1111-036

Golder Associates

Drawn: BML
Checked: HJ

APPENDIX A
PHOTOGRAPHS

**Slope Restoration at Station 15+718
Highway 405 W-N/S Ramp at Stanley Avenue**



**Photo Nos. 3 & 4 – Top of the Erosion
Gully, September, 2006**

Photo Nos. 1 & 2 - General View, September, 2006

**Slope Restoration at Station 15+718
Highway 405 W-N/S Ramp at Stanley Avenue**



Photo No. 5 - Clay Drainage Tile- March, 2006 (Photo taken by MTO)



Photo No. 6: Erosion Gully- March, 2006 (Photo taken by MTO)