REPORT

January 17, 2014

FOUNDATION INVESTIGATION REPORT

HIGHWAY 540 GRAHAM CREEK BRIDGE, SITE 49-18
TOWNSHIP OF BIDWELL, MANITOULIN ISLAND, ONTARIO
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5465-09-00, WP 5261-10-01

Submitted to:
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GEOCRES NO. 42G-15

Report Number: 12-1191-0014-R05

Distribution:

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Golder Associates

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PART A

FOUNDATION INVESTIGATION REPORT

HIGHWAY 540, GRAHAM CREEK BRIDGE, SITE 49-18

TOWNSHIP OF BIDWELL, MANITOULIN ISLAND, ONTARIO

MINISTRY OF TRANSPORTATION, ONTARIO

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Golder Associates

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by McIntosh Perry Consulting Engineers Ltd. (McIntosh Perry) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the replacement of the Graham Creek Bridge (Site 49-18) in the Township of Bidwell on Manitoulin Island, Ontario. The Key Plan showing the general location of this section of Highway 540 and the location of the investigated area are shown on Drawing 1.

The purpose of this investigation is to establish the subsurface conditions at the location of the bridge by borehole drilling, in situ testing and laboratory testing on selected samples.

2.0 SITE DESCRIPTION

The Graham Creek Bridge is located in the Township of Bidwell on Highway 540, approximately 19.3 km west of Highway 6. The land use in the area is generally rural (i.e., farm land) with a few residences in the vicinity of the site.

In general, the topography in the area of the overall project limits is generally flat with gently rolling hills. The banks adjacent to the creek are vegetated with grass and large trees. The creek flows from east to west and is approximately 4 m wide at the bridge location.

We understand the original Graham Creek Bridge structure was constructed in the 1930s and was subsequently widened in 1964 to accommodate two-lane traffic. The existing structure consists of a 7.3 m long and 11 m wide, single-span bridge. Based on the "*Graham's Creek Bridge (Widening) Plan-Elevation-Cross-Section*" drawing (Drawing No. D-5237-1, dated Feb. 1963) provided by the MTO, the existing bridge is supported by shallow footings with the top of the footings at about 2 m below the designed highway grade. The existing embankment side slopes are formed at approximately 3 horizontal to 1 vertical (3H:1V) on both the west and east sides of the creek. There are full width pavement cracks located near the bridge abutments.

The existing highway grade at the bridge is at about Elevation 242.3 m and the creek level measured by Golder on July 3, 2013, was Elevation 240.0 m. The existing highway embankment grade is about 1.5 m above the surrounding ground surface adjacent to the creek.

Photographs taken at the site are included following the text of the report.

3.0 INVESTIGATION PROCEDURES

The fieldwork for the investigation was carried out between July 2 and 4, 2013, during which time a total of six boreholes (G1 to G6) were advanced at the site. Boreholes G1 to G4 were advanced near the ends of the existing bridge abutments and Boreholes G5 and G6 were advanced along the north and south approaches, respectively. The locations of the boreholes are shown on Drawing 1.

The field investigation was carried out using a track-mounted CME-850 drill rig supplied and operated by Landcore Drilling of Sudbury, Ontario. The boreholes were advanced through the overburden using 108 mm inside diameter hollow-stem augers. Soil samples were obtained at intervals of depth of about 0.75 m, using a

50 mm outer diameter split-spoon sampler, operated by an automatic hammer on the drill rig, in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586-08a). Samples of the bedrock were obtained using NW casing and 'NQ' size rock core barrels in Boreholes G1 to G4. The groundwater levels in the open boreholes were observed during the drilling operations as described on the Record of Borehole sheets in Appendix A. The boreholes were backfilled upon completion in accordance with Ontario Regulation 903 (as amended by Ontario Regulation 372).

The fieldwork was supervised throughout by members of our technical staff who: located the boreholes; arranged for the clearance of underground services; supervised the drilling and sampling operations; logged the boreholes; and examined and cared for the soil and bedrock samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Sudbury Geotechnical Laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing (water contents and grain size distribution) was carried out on selected soil samples. In addition, uniaxial compressive strength (UCS) testing was carried out on two selected specimens of the bedrock core recovered from the boreholes. The geotechnical laboratory testing was completed according to MTO LS standards. The results of the laboratory testing are included on the Record of Borehole sheets in Appendix A and on the figures contained in Appendix B.

A sample of the creek water was obtained using appropriate sampling protocols and submitted to a specialist analytical laboratory under chain of custody procedures for testing for a suite of parameters. The results of the analytical testing are summarized in Table B1 in Appendix B.

The as-drilled borehole locations and ground surface elevations were measured and surveyed by members of our technical staff, referenced to stations on the highway. The MTM NAD 83 northing and easting coordinates, ground surface elevations referenced to Geodetic datum and borehole depths at each borehole location are presented on the Record of Borehole sheets in Appendix A and are summarized below.

Borehole	Location (m)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
G1	5083298.1	219108.9	242.3	7.5
G2	5083298.2	219114.9	242.3	7.2
G3	5083287.1	219109.1	242.3	7.3
G4	5083287.4	219114.8	242.3	7.1
G5	5083317.1	219114.7	242.2	1.4
G6	5083270.7	219108.9	242.2	3.8

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on the Physiography of Southern Ontario (Ministry of Northern Development and Mines)[1], the site is located within limestone plains bordering with areas of sand plains and shallow till deposits.

Based on geological mapping in the area (Ministry of Northern Development and Mines)[2], the bedrock in the area consists typically of sandstone, shale, dolostone and siltstone and the site borders on the Amabel Formation from the Silurian Period and the Georgian Bay Formations from the Ordovician Period.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced for this investigation, together with the results of the laboratory tests carried out on selected soil samples, are given on the attached Record of Borehole and Drillhole sheets in Appendix A. The results of the laboratory testing are provided in Appendix B. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling, observations of drilling progress and the results of SPTs. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations. The inferred soil stratigraphy based on the results of the boreholes is shown in profile on Drawing 1.

In general, the subsurface conditions encountered at the site generally consist of embankment fill overlying native silty sand to gravelly sandy silt overlying bedrock. A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Asphalt

A 125 mm to 190 mm thick layer of asphalt was encountered at ground surface (Elevation 242.3 m to 242.2 m) in each of the boreholes.

4.2.2 Embankment Fill

Embankment fill up to 4.3 m thick was encountered below the asphalt in each of the boreholes. The embankment fill consisted of brown sand to gravel, trace to some silt and trace to some clay. In Borehole G1, the augers were noted to be grinding on cobbles between 0.8 m and 1.5 m depth and in Borehole G4, at a depth of 2.9 m; Borehole G5 was terminated on auger refusal at 1.4 m depth likely on cobbles or boulders within the fill.

Standard Penetration Test (SPT) 'N'-values in the embankment fill range between 5 blows and 41 blows per 0.3 m of penetration indicating a loose to dense relative density.

[1] Ministry of Northern Development and Mines, 2007, Physiography of Southern Ontario, MRD228.
[2] Ministry of Northern Development and Mines, 1991. *Bedrock Geology of Ontario*, Southern Sheet, Map 2544.

Grain size distribution tests were carried out on three samples of the embankment fill and the results are shown on Figure B1 in Appendix B.

The natural water content measured on samples of the embankment fill is between 7 per cent and 18 per cent.

4.2.3 Silty Sand to Sand and Silt

A 0.2 m to 2.9 m thick deposit of grey, silty sand to sand and silt, trace to some gravel, trace to some clay was encountered below the embankment fill in Boreholes G2 to G4 and G6. The surface of the silty sand to sand and silt was encountered between Elevation 241.3.m and 238.8 m.

The SPT 'N'-value within the silty sand to sand and silt deposit range from 5 blows to 22 blows per 0.3 m penetration, indicating a loose to compact relative density.

Grain size distribution tests were carried out on five samples of this deposit and the results are shown on Figure B2 in Appendix B.

Atterberg limits testing was carried out on two samples of the sand and silt, deposit. Test results from one sample yielded a liquid limit of 34 per cent, a plastic limit of 24 per cent and plasticity index of 10 per cent as shown in Figure B3 in Appendix B. The second sample was determined to be non-plastic. Based on the grain size distributions and Atterberg limits test results, these samples were classified as sand and silt of slight plasticity.

The natural water content measured on samples of the deposit is between 8 per cent and 28 per cent.

4.2.4 Bedrock / Refusal

Bedrock was cored in Boreholes G1 to G4. The bedrock surface/refusal depths and elevations are presented below.

Borehole No.	Depth to Bedrock/ Refusal (m)	Bedrock Surface/ Refusal Elevation (m)	Notes
G1	4.5	237.8	Bedrock Cored for 3.0 m
G2	3.7	238.6	Bedrock Cored for 3.4 m
G3	4.5	237.8	Bedrock Cored for 2.9 m
G4	3.8	238.5	Bedrock Cored for 3.3 m
G6	3.8	238.4	Auger Refusal at 3.8 m

The retrieved bedrock core is described as a fine grained, fresh, grey, dolomitic limestone, as presented in the Record of Drillhole sheets in Appendix A. Photographs of the retrieved bedrock core samples are shown on Figure B4 in Appendix B.

The Total Core Recovery during bedrock coring was 100 per cent. The Rock Quality Designation measured on the core samples ranges from 60 per cent to 92 per cent, indicating a rock mass of fair to excellent quality as per Table 3.10 of the Canadian Foundation Engineering Manual (CFEM, 2006).

Laboratory UCS testing was carried out on two core samples of the bedrock. The UCS values are presented below and the test results indicate the bedrock is medium strong to strong as per Table 3.5 of the CFEM (2006).

Borehole	Elevation (m)	UCS (MPa)
G2	238.2	39
G3	235.8	53

4.2.5 Groundwater Conditions

Unstabilized groundwater levels measured in the open boreholes upon completion of drilling are summarized in the table below. Borehole G5 was noted to be dry upon completion of drilling.

Borehole No.	Depth to Groundwater Level (m)	Groundwater Elevation (m)
G1	2.0	240.3
G2	2.1	240.2
G3	2.0	240.3
G4	2.0	240.3
G6	1.7	240.5

Groundwater levels encountered in the boreholes during and shortly after drilling may not be representative of static groundwater levels since the groundwater levels in the boreholes may not have stabilized on completion of drilling. The water in the creek was at Elevation 240.0 m as measured on July 4, 2013. The high water level is Elevation 240.5 m. Groundwater levels in the area are subject to seasonal fluctuations and to fluctuations after precipitation events and snowmelt.

5.0 CLOSURE

The field personnel supervising the drilling program was Mr. Mathew Riopelle. This report was prepared by Mr. David Muldowney, P.Eng., and the technical aspects were reviewed by Mr. André Bom, P.Eng. Mr. Fintan Heffernan, P.Eng., Golder's Designated MTO Contact for this project, carried out a quality control review and reviewed the technical aspects of the report.

Report Signature Page

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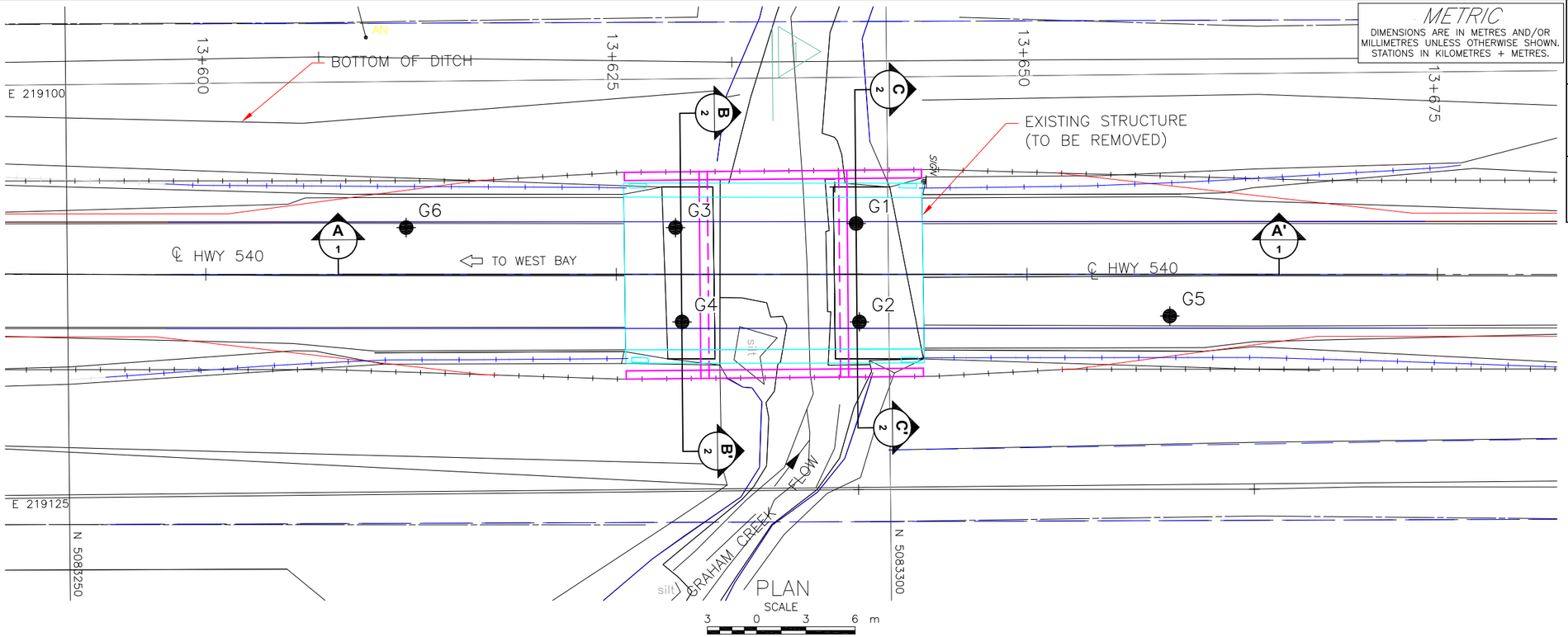


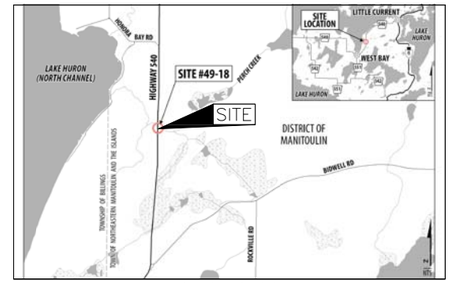
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 5261-10-01

HIGHWAY 540
GRAHAM CREEK CULVERT SITE 49-18
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

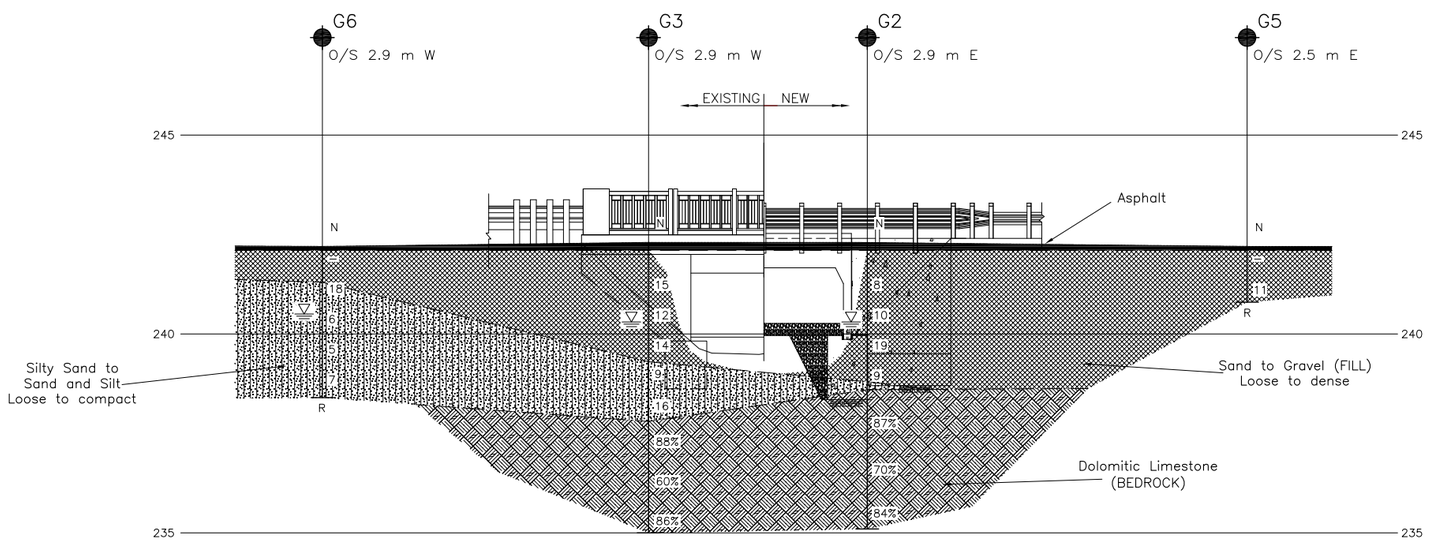
Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA



KEY PLAN
N.T.S.

LEGEND

- Borehole
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% — Rock Quality Designation (RQD)
- R — Refusal
- WL upon completion of drilling



A-A' / 1 CENTRELINE PROFILE
HIGHWAY 540
HORIZONTAL SCALE
3 0 3 6 m
1.5 0 1.5 3 m
VERTICAL SCALE

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
G1	242.3	5083298.1	219108.9
G2	242.3	5083298.2	219114.9
G3	242.3	5083287.1	219109.1
G4	242.3	5083287.4	219114.8
G5	242.2	5083317.1	219114.7
G6	242.2	5083270.7	219108.9

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 McIntosh Perry, drawing file no. 12-0960-1-LDC-TERRAIN GRAHAM Jan2014 GA FOR GOLDER.dwg, received January 16, 2014. Key plan file no. KM11684 – 49-18 location Map – June 26 2012.jpg, received August 24, 2012.

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NO.	DATE	BY	REVISION

Geocres No. 41G-15

HWY. 540	PROJECT NO. 12-1191-0014		DIST.
SUBM'D. DAM	CHKD.	DATE: JAN 2014	SITE: 49-18
DRAWN: TB	CHKD. AB	APPD. FJH	DWG. 1

PLOT DATE: January 17, 2014
FILENAME: \\golder.gds\GAL\Sudbury\CAD-GIS\CAD\Projects\2012\12-1191-0014 Manitoulin and Timmins\Graham Creek\12191001440O1_Graham.dwg

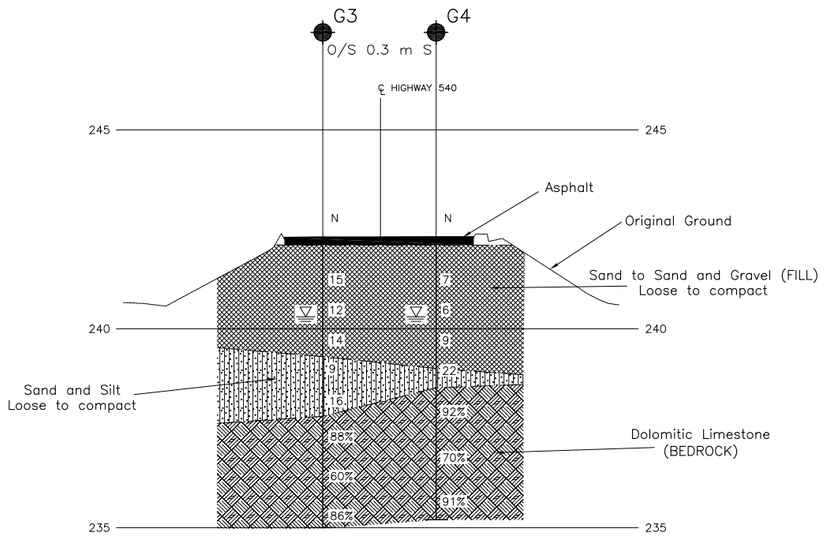
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 5261-10-01

HIGHWAY 540
GRAHAM CREEK CULVERT SITE 49-18
SOIL STRATA

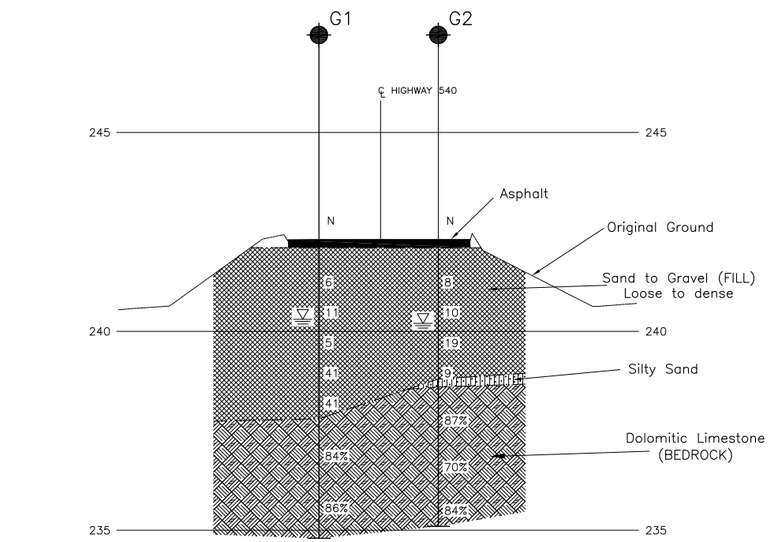
SHEET

Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA



B-B' / 2 SECTION AT STA 13+629
HIGHWAY 540

HORIZONTAL SCALE
3 0 3 6 m
1.5 0 1.5 3 m
VERTICAL SCALE



C-C' / 2 SECTION AT STA 13+640
HIGHWAY 540

HORIZONTAL SCALE
3 0 3 6 m
1.5 0 1.5 3 m
VERTICAL SCALE

LEGEND

⊕	Borehole
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
100%	Rock Quality Designation (RQD)
▽	WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
G1	242.3	5083298.1	219108.9
G2	242.3	5083298.2	219114.9
G3	242.3	5083287.1	219109.1
G4	242.3	5083287.4	219114.8

NOTES

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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 McIntosh Perry, drawing file no. 11-684-Graham Creek Cross Sections Abutment.dwg, received July 19, 2013.

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NO.	DATE	BY	REVISION

Geocres No. 41G-15

HWY. 540		PROJECT NO. 12-1191-0014	DIST.
SUBM'D. DAM	CHKD.	DATE: JAN 2014	SITE: 49-18
DRAWN: TB	CHKD. AB	APPD. FJH	DWG. 2

Photograph 1: Graham Creek Bridge facing west (August 2013)

Photograph 2: Graham Creek Bridge facing east (August 2013)

Photograph 3: Graham Creek Bridge facing north (October 2012)

Photograph 4: Graham Creek Bridge facing south (July 2013)

APPENDIX A

Record of Boreholes and Drillholes

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
FoS	factor of safety

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
υ	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 multiplied by acceleration due to gravity)

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	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_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
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 = $\tan\delta$
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

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
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
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.) drive open 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) Non-Cohesive (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.

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel / Silty Clay with sand / Clayey Silt with sand

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS 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 and structure are preserved.

BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 m to 2 m
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	Less than 6 mm

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

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

CORE CONDITION

Total Core Recovery (TCR)

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 varied 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 Core Axis

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

Description and Notes

An abbreviation 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

JN Joint
FLT Fault
SH Shear
VN Vein
FR Fracture
SY Stylolite
BD Bedding
FO Foliation
CO Contact
AXJ Axial Joint
KV Karstic Void
MB Mechanical Break

PL Planar
CU Curved
UN Undulating
IR Irregular
K Slickensided
PO Polished
SM Smooth
SR Slightly Rough
RO Rough
VR Very Rough

Golder Associates

RECORD OF BOREHOLE No G1

1 OF 1 **METRIC**

PROJECT 12-1191-0014 | W.P. 5261-10-01 | LOCATION N 5083298.1; E 219108.9 | ORIGINATED BY MR
DIST | HWY 540 | BOREHOLE TYPE 108 mm I.D. Continous Flight Solid Stem Augers, NW Casing, NQ Coring | COMPILED BY DAM
DATUM GEODETIC | DATE July 2, 2013 | CHECKED BY AB

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 × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
242.3	GROUND SURFACE										
0.0	ASPHALT (180 mm)						242				
0.2	Gravelly sand to gravel, trace to some silt (FILL) Loose to dense Brown Moist to wet		1	SS	6						
	Auger grinding on cobbles between 0.8 m and 1.5 m depth.						241				
	Switched to NW Casing at 2.3 m depth.		2	SS	11	▽			○		25 58 (17)
			3	SS	5		240				
			4	SS	41		239				
			5	SS	41						
237.8							238				
4.5	DOLOMITIC LIMESTONE (BEDROCK) Bedrock cored from 4.5 m depth to 7.5 m depth. For coring details see Record of Drillhole G1.		1	RC	REC 100%						RQD = 84%
			2	RC	REC 100%		237				RQD = 86%
234.8							236				
7.5	END OF BOREHOLE Notes: 1. Water level at a depth of 2.0 m below ground surface (Elev. 240.3 m) upon completion of drilling.						235				

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

PROJECT: 12-1191-0014

RECORD OF DRILLHOLE: G1

SHEET 1 OF 1

LOCATION: N 5083298.1 ;E 219108.9

DRILLING DATE: July 2, 2013

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 850 Track Mount

DRILLING CONTRACTOR: Landcore Drilling

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.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	COLOUR % RETURN / FLUSH	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY k, cm/s	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		~SEE PREVIOUS PAGE~		237.8																
5	July 2, 2013 NW NQ Coring	DOLOMITIC LIMESTONE Fine grained Grey Fresh		4.5	1	GREY 100%							JNIRRo JNIRRo JNIRRo JNIRRo JNIRRo JNCURo (Clay in-fill)							
6													JNIRRo JNIRRo JNIRRo JNIRRo JNIRRo JNIRRo							
7					2	GREY 100%							JNIRRo (Clay in-fill) JNIRRo (Clay in-fill)							
				234.8									JNIRRo							
		END OF DRILLHOLE		7.5									JNIRRo							
8																				
9																				
10																				
11																				
12																				
13																				
14																				

SUD-RCK 1211910014.GPJ GAL-MISS.GDT 06/09/13 DATA INPUT:

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: MR

CHECKED: AB

Golder Associates

RECORD OF BOREHOLE No G2

1 OF 1 **METRIC**

PROJECT 12-1191-0014 | W.P. 5261-10-01 | DIST | HWY 540 | DATUM GEODETIC

LOCATION N 5083298.2; E 219114.9 | BOREHOLE TYPE 108 mm I.D. Continous Flight Hollow Stem Augers, NW Casing, NQ Coring | DATE July 3, 2013

ORIGINATED BY MR | COMPILED BY DAM | CHECKED BY AB

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 × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
242.3	GROUND SURFACE										
0.0	ASPHALT (190 mm)										
0.2	Sand to sand and gravel, trace to some clay, trace silt (FILL) Loose to compact Brown Moist to wet		1	SS	8		242				
			2	SS	10	▽	241				
			3	SS	19		240				
	Switched to NW Casing at 3.0 m depth.		4A	SS	9		239		○		35 49 13 3
238.8			4B						○		17 50 25 8
3.7	Silty SAND, some gravel, trace to some clay Grey Wet		1	RC	REC 100%		238				RQD = 87%
	DOLOMITIC LIMESTONE (BEDROCK) Bedrock cored from 3.7 m depth to 7.2 m depth. For coring details see Record of Drillhole G2.		2	RC	REC 100%		237				RQD = 70%
235.1			3	RC	REC 100%		236				RQD = 84%
7.2	END OF BOREHOLE Notes: 1. Water level at a depth of 2.1 m below ground surface (Elev. 240.2 m) upon completion of drilling.										

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

SUD-MTO 001 1211910014.GPJ GAL-MISS.GDT 06/09/13 DATA INPUT:

PROJECT: 12-1191-0014

RECORD OF DRILLHOLE: G2

SHEET 1 OF 1

LOCATION: N 5083298.2 ;E 219114.9

DRILLING DATE: July 3, 2013

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 850 Track Mount

DRILLING CONTRACTOR: Landcore Drilling

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.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	COLOUR % RETURN / FLUSH	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY k, cm/s	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		~SEE PREVIOUS PAGE~		238.6																
4	NW	DOLOMITIC LIMESTONE Fine grained Medium strong Grey Fresh Broken rock between 4.4 m and 4.5 m, between 4.7 m and 4.8 m, between 5.0 m and 5.1 m, and between 5.4 m and 5.5 m depths.		3.7	1	GREY 100%							JNIRRo JNIRRo JNIRRo							UCS=39 MPa
5	July 3, 2013 NQ Coring				2	GREY 100%							JNIRRo JNIRRo (Clay in-fill) BR JNIRRo JNIRRo JNIRRo BR BR JNIRRo JNIRRo JNIRRo BR							
6																				
7					3	GREY 100%							JNIRRo JNIRRo JNIRRo JNIRRo							
		END OF DRILLHOLE		235.1 7.2																
8																				
9																				
10																				
11																				
12																				
13																				

DEPTH SCALE

1 : 50

LOGGED: MR

CHECKED: AB

Golder Associates

SUD-RCK 1211910014.GPJ GAL-MISS.GDT 06/09/13 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No G3

1 OF 1 **METRIC**

PROJECT 12-1191-0014 | W.P. 5261-10-01 | LOCATION N 5083287.1; E 219109.1 | ORIGINATED BY MR

DIST | HWY 540 | BOREHOLE TYPE 108 mm I.D. Continous Flight Hollow Stem Augers, NW Casing, NQ Coring | COMPILED BY DAM

DATUM GEODETIC | DATE July 3, 2013 | CHECKED BY AB

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, × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
242.3	GROUND SURFACE						242				
0.0	ASPHALT (190 mm)										
0.2	Sand and gravel, some silt, trace clay (FILL) Compact Brown Moist to wet		1	SS	15						
			2	SS	12	▽	241				
	Switched to NW Casing at 2.3 m depth.		3	SS	14		240		○		33 52 12 3
239.3											
3.0	SAND and SILT some gravel, trace to some clay Loose to compact Grey Wet		4	SS	9		239		○		17 29 44 10
			5	SS	16						
237.8							238				
4.5	DOLOMITIC LIMESTONE (BEDROCK) Bedrock cored from 4.5 m depth to 7.3 m depth. For coring details see Record of Drillhole G3.		1	RC	REC 100%						RQD = 88%
			2	RC	REC 100%		237				RQD = 60%
			3	RC	REC 100%		236				RQD = 86%
235.0											
7.3	END OF BOREHOLE Notes: 1. Water level at a depth of 2.0 m below ground surface (Elev. 240.3 m) upon completion of drilling.						235				

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

SUD-MTO 001 1211910014.GPJ GAL-MISS.GDT 06/09/13 DATA INPUT:

PROJECT: 12-1191-0014

RECORD OF DRILLHOLE: G3

SHEET 1 OF 1

LOCATION: N 5083287.1 ;E 219109.1

DRILLING DATE: July 3, 2013

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 850 Track Mount

DRILLING CONTRACTOR: Landcore Drilling

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.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	COLOUR / % RETURN / FLUSH	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY k, cm/s	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		~SEE PREVIOUS PAGE~		237.8																
5	July 3, 2013 NQ Coring NW	DOLOMITIC LIMESTONE Fine grained Strong Grey Fresh		4.5	1	GREY 100%							JNIRRo							
					2	GREY 100%							JNIRRo JNIRRo JNIRRo JNIRRo JNIRRo JNIRRo JNIRRo							
6													JNIRRo JNIRRo							
					3	GREY 100%							JNIRRo JNIRRo JNIRRo							UCS=53 MPa
7				235.0									JNIRRo JNIRRo							
		END OF DRILLHOLE		7.3																
8																				
9																				
10																				
11																				
12																				
13																				
14																				

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: MR
CHECKED: AB

SUD-RCK 1211910014.GPJ GAL-MISS.GDT 06/09/13 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No G4

1 OF 1 **METRIC**

PROJECT 12-1191-0014 | W.P. 5261-10-01 | LOCATION N 5083287.4; E 219114.8 | ORIGINATED BY MR
DIST HWY 540 | BOREHOLE TYPE 108 mm I.D. Continous Flight Hollow Stem Augers, NW Casing, NQ Coring | COMPILED BY DAM
DATUM GEODETIC | DATE July 4, 2013 | CHECKED BY AB

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 × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
242.3	GROUND SURFACE										
0.0	ASPHALT (180 mm)										
0.2	Sand, trace to some gravel (FILL) Loose Brown Moist to wet		1	SS	7		242				
			2	SS	6	▽	241				
			3	SS	9		240				
239.0	Auger grinding on cobbles at 2.9 m depth.		4A 4B	SS	22		239		○		12 36 34 8
3.3 238.5	SAND and SILT, some gravel, trace to some clay Compact										
3.8	Grey Wet		1	RC	REC 100%		238				RQD = 92%
	DOLOMITIC LIMESTONE (BEDROCK) Bedrock cored from 3.8 m depth to 7.1 m depth. For coring details see Record of Drillhole G4.		2	RC	REC 100%		237				RQD = 70%
			3	RC	REC 98%		236				RQD = 91%
235.2											
7.1	END OF BOREHOLE Notes: 1. Water level at a depth of 2.0 m below ground surface (Elev. 240.3 m) upon completion of drilling.										

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

SUD-MTO 001 1211910014.GPJ GAL-MISS.GDT 06/09/13 DATA INPUT:

PROJECT: 12-1191-0014

RECORD OF DRILLHOLE: G4

SHEET 1 OF 1

LOCATION: N 5083287.4 ;E 219114.8

DRILLING DATE: July 4, 2013

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 850 Track Mount

DRILLING CONTRACTOR: Landcore Drilling

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.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	COLOUR / % RETURN / FLUSH	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY k, cm/s	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		~SEE PREVIOUS PAGE~		238.5																
4		DOLOMITIC LIMESTONE Fine grained Grey Fresh		3.8	1	GREY 100%							JNIRRo JNIRRo							
													JNIRRo JNIRRo JNIRRo							
5					2	GREY 100%							JNIRRo JNIRRo JNIRRo							
													JNIRRo							
													JNIRRo JNIRRo JNIRRo JNIRRo							
6													JNIRRo							
					3	GREY 100%							JNIRRo							
7				235.2									JNIRRo							
		END OF DRILLHOLE		7.1																
8																				
9																				
10																				
11																				
12																				
13																				

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: MR

CHECKED: AB

SUD-RCK 1211910014.GPJ GAL-MISS.GDT 06/09/13 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No G5

1 OF 1 **METRIC**

PROJECT 12-1191-0014
W.P. 5261-10-01
LOCATION N 5083317.1; E 219114.7
ORIGINATED BY MR
DIST HWY 540
BOREHOLE TYPE 108 mm I.D. Continous Flight Hollow Stem Augers
COMPILED BY DAM
DATUM GEODETIC
DATE July 4, 2013
CHECKED BY AB

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 × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
242.2	GROUND SURFACE										
0.0	Asphalt (125 mm)										
0.1	Sand to gravelly sand (FILL) Compact Brown Moist		1	AS	-		242				
			2	SS	11		241				
240.8											
1.4	END OF BOREHOLE AUGER REFUSAL Notes: 1. Borehole dry upon completion of drilling.										

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

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

SUD-MTO 001 1211910014.GPJ GAL-MISS.GDT 16/09/13 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No G6

1 OF 1 **METRIC**

PROJECT 12-1191-0014
W.P. 5261-10-01
DIST HWY 540
DATUM GEODETIC

LOCATION N 5083270.7; E 219108.9
BOREHOLE TYPE 108 mm I.D. Continous Flight Hollow Stem Augers
DATE July 4, 2013

ORIGINATED BY MR
COMPILED BY DAM
CHECKED BY AB

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 × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
242.2	GROUND SURFACE										
0.0	ASPHALT (125 mm)										
0.1	Sand, trace gravel (FILL) Brown Moist		1	AS	-		242				
241.3											
0.9	SAND and SILT, some clay, trace to some gravel Loose to compact Brown to grey Moist to wet		2	SS	18		241		⊖		7 33 40 20
			3	SS	6	▽			○	NP	0 53 30 17
			4	SS	5		240				
			5	SS	7		239				
238.4											
3.8	END OF BOREHOLE AUGER REFUSAL										

Notes:

1. Water level at a depth of 1.7 m below ground surface (Elev. 240.5 m) upon completion of drilling.

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

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

APPENDIX B

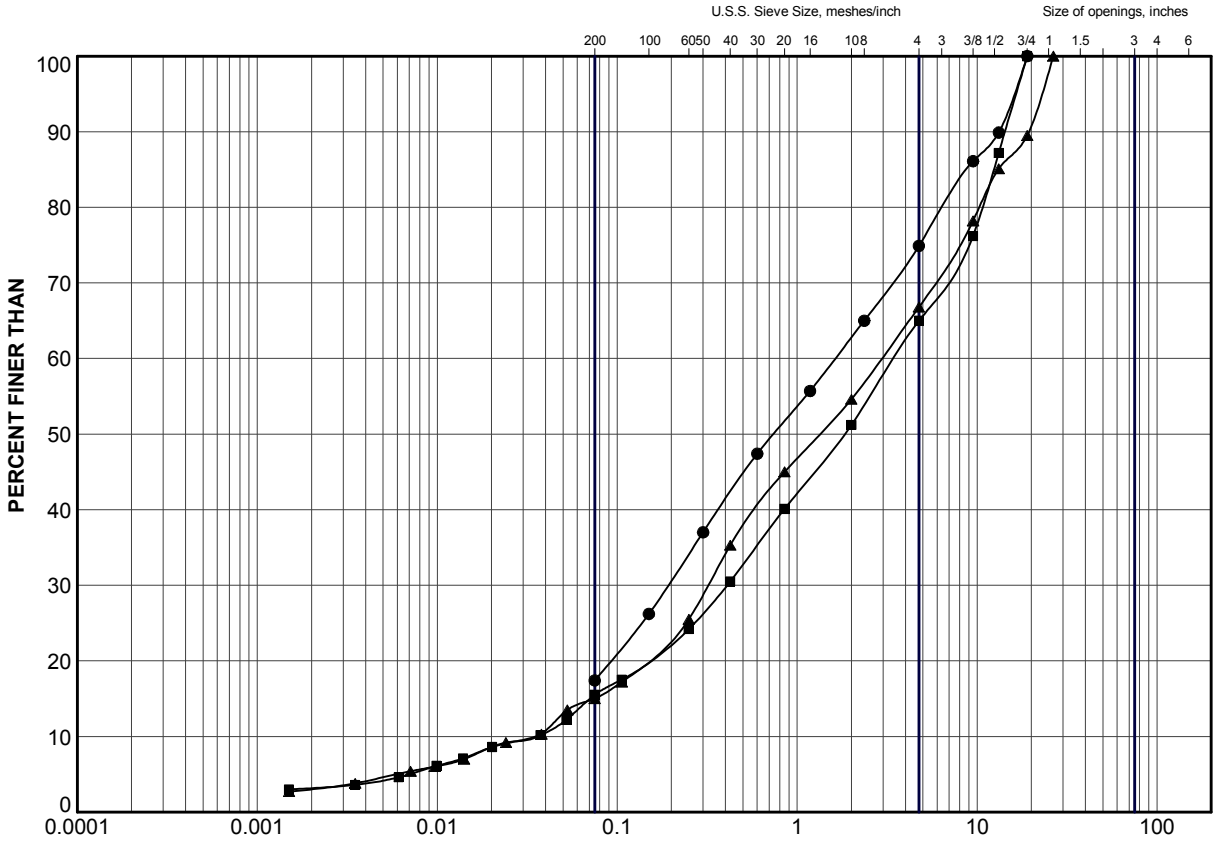
Laboratory Test Results

Table B1 - Summary of Analytical Testing of Creek Water

Parameter	Units	Method Detection Limit	Result
Resistivity	ohm-cm	n/a	2600
Conductivity	µmho/cm	1	390
pH	n/a	n/a	8.30
Sulphate	mg/L	1	Not Detected
Chloride	mg/L	1	2

Notes:
1. Sample obtained August 5, 2013.
2. Analytical testing carried out by Maxxam Analytics Inc.

Prepared by: DAM
Reviewed by: AB



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	G1	2	240.5
■	G2	4A	238.8
▲	G3	3	239.7

PROJECT

HIGHWAY 540
GRAHAM CREEK BRIDGE

TITLE

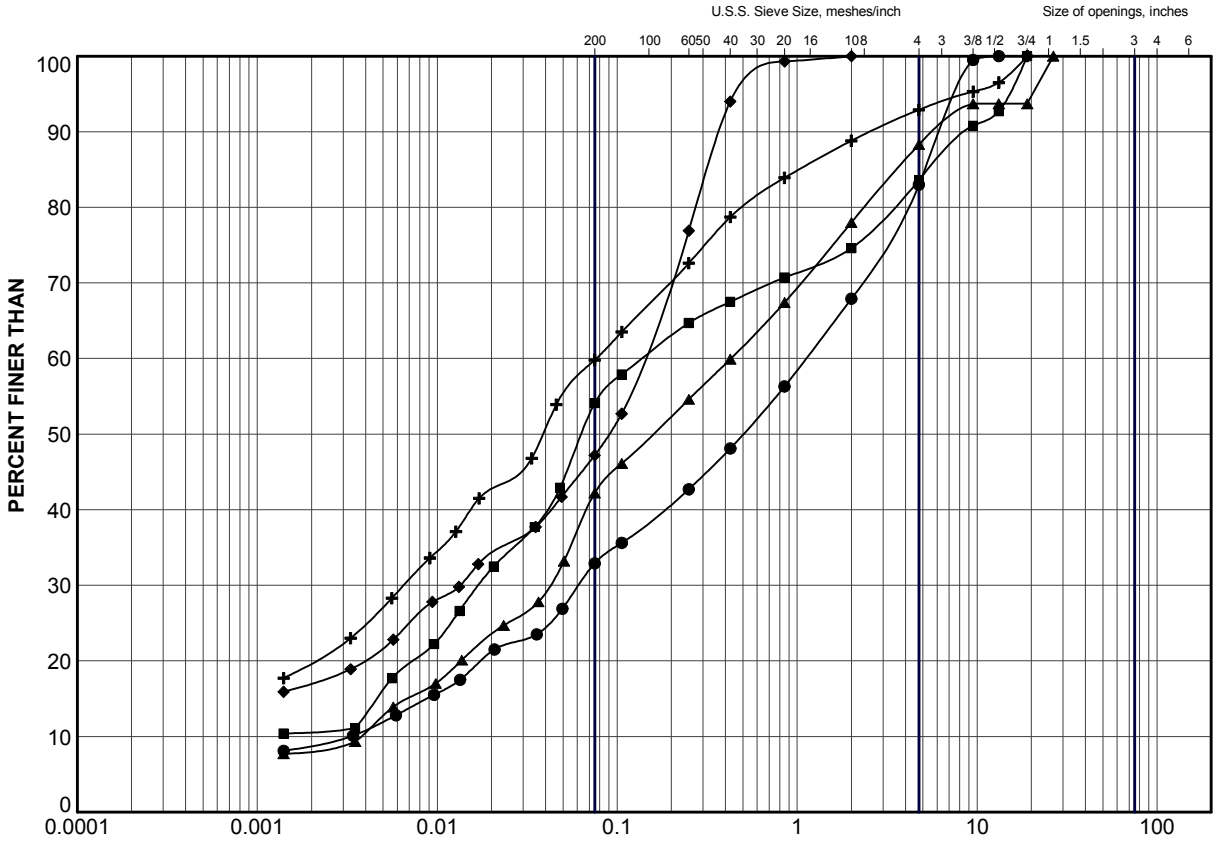
GRAIN SIZE DISTRIBUTION

GRAVELLY SAND to SAND and GRAVEL (FILL)

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	12-1191-0014		FILE No.	1211910014.GPJ
DRAWN	JJL	Sep 2013	SCALE N/A	REV.
CHECK	AB	Sep 2013		
APPR	FJH	Sep 2013	**FIGURE B1**	

SUD-MTO GSD (NEW) GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	G2	4B	238.7
■	G3	4	239.0
▲	G4	4B	238.8
+	G6	2	241.1
◆	G6	3	240.4

PROJECT

HIGHWAY 540
GRAHAM CREEK BRIDGE

TITLE

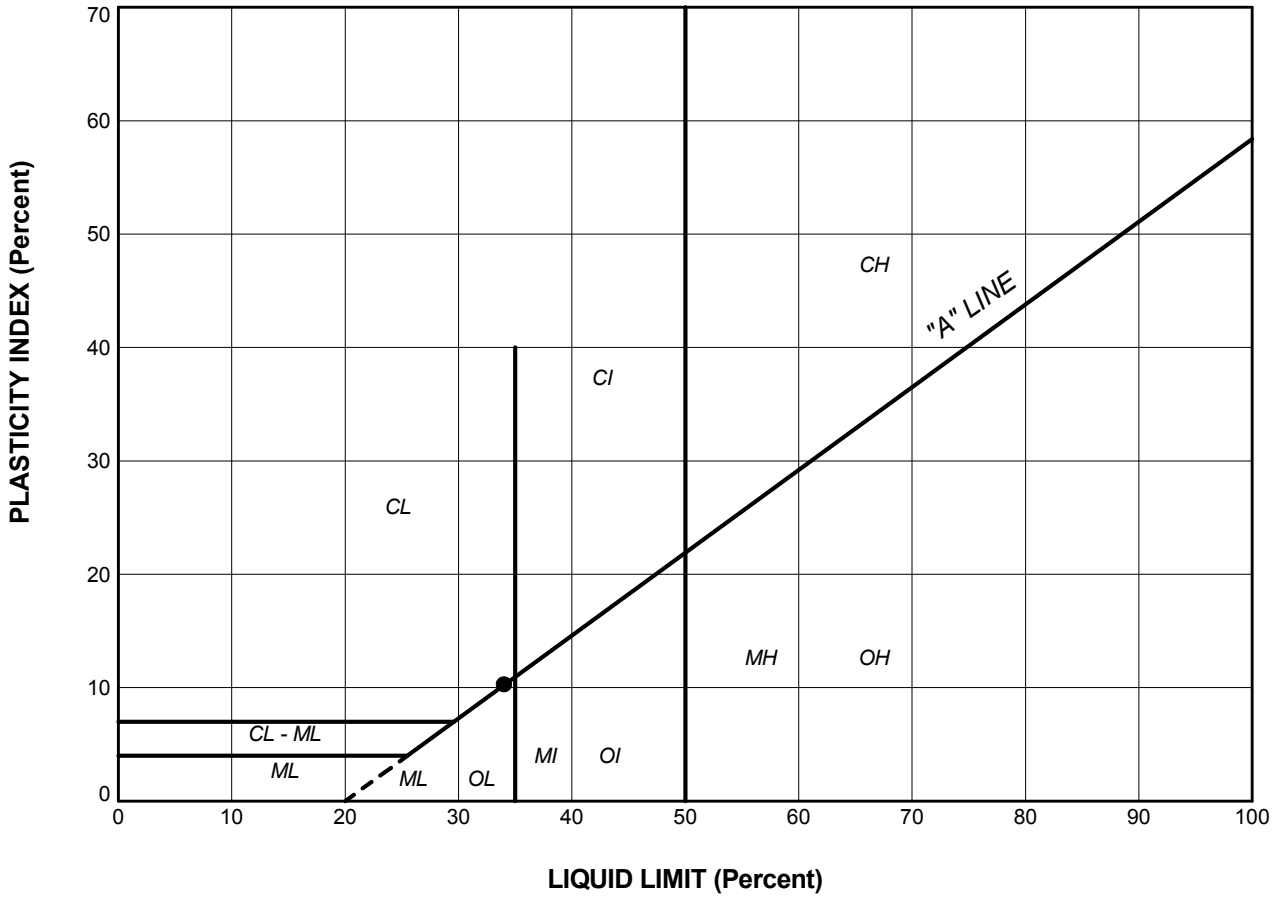
GRAIN SIZE DISTRIBUTION

SILTY SAND to SAND and SILT

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	12-1191-0014		FILE No.	1211910014.GPJ
DRAWN	JJL	Sep 2013	SCALE N/A	REV.
CHECK	AB	Sep 2013		
APPR	FJH	Sep 2013	**FIGURE B2**	

SUD-MTO GSD (NEW) GLDR_LDN.GDT



SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	G6	2	34.0	23.7	10.3

PROJECT

HIGHWAY 540
GRAHAM CREEK BRIDGE

TITLE

PLASTICITY CHART

SAND and SILT

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	12-1191-0014		FILE No.	1211910014.GPJ
DRAWN	JJL	Sep 2013	SCALE N/A	REV.
CHECK	AB	Sep 2013		
APPR	FJH	Sep 2013	**FIGURE B3**	

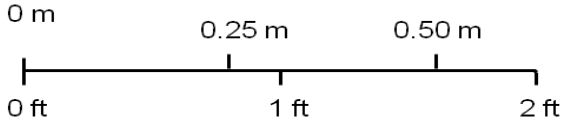
SUD-MTO PL (NEW) GLDR_LDN.GDT

Borehole G1
Elevation 237.8 m to 234.8 m

Borehole G2
Elevation 238.6 m to 235.1 m

Borehole G3
Elevation 237.8 m to 235.0 m

Borehole G4
Elevation 238.5 m to 235.2 m



PROJECT
HWY 540
GRAHAM CREEK BRIDGE

TITLE
BEDROCK CORE

Golder Associates

PROJECT No. 12-1191-0014			FILE No. ----	
DESIGN	DAM	Sept. 2013	SCALE AS SHOWN	REV.
CADD	--		**FIGURE B4**	
CHECK	AB	Sept. 2013		
REVIEW	FJH	Sept. 2013		

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