



January 17, 2012

FOUNDATION INVESTIGATION REPORT

**HIGHWAY 11 NBL AND SBL WILDLIFE CROSSING CULVERT
AT STATION 12+169 (NBL) AND STATION 12+181 (SBL), SITE 43-371
TOWNSHIP OF NORTH HIMSWORTH, ONTARIO
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5416-06-00, WP 5415-11-01/02**

Submitted to:
URS Canada Inc.
75 Commerce Valley Drive East
Markham, ON L3T 7N9



GEOCRES NO. 31L-156

Report Number: 09-1191-0042-R05

Distribution:

- 1 e-copy: Ministry of Transportation, Ontario, North Bay, Ontario (Northeastern Region)
- 1 e-copy: Ministry of Transportation, Ontario, Downsview, Ontario (Foundations Section)
- 1 e-copy: URS Canada Inc., Markham, Ontario
- 1 Copy: Golder Associates Ltd., Sudbury, Ontario

REPORT





Table of Contents

1.0 INTRODUCTION.....	3
2.0 SITE DESCRIPTION.....	3
3.0 INVESTIGATION PROCEDURES	4
4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS	5
4.1 Regional Geology	5
4.2 Subsurface Conditions.....	6
4.2.1 Fill	6
4.2.2 Peat.....	7
4.2.3 Sand.....	7
4.2.4 Silt to Sand and Silt.....	7
4.2.5 Clayey Silt to Silty Clay	8
4.2.6 Sand and Gravel	8
4.2.7 Bedrock/ Refusal.....	9
4.2.8 Groundwater Conditions	9
5.0 CLOSURE.....	9



FOUNDATION REPORT HIGHWAY 11 NBL AND SBL WILDLIFE CROSSING CULVERT

CONTRACT DRAWING

APPENDICES

Appendix A Record of Boreholes and Drillholes

List of Symbols and Abbreviations

Lithological and Geotechnical Rock Description Terminology

Record of Boreholes – WL-1 to WL-8

Record of Drillholes – WL-1, WL-5 and WL-8

Appendix B Laboratory Test Results

Figure B1 Grain Size Distribution – Sand and Gravel to Sand (Fill)

Figure B2 Grain Size Distribution – Sand

Figure B3 Grain Size Distribution – Silt to Sand and Silt

Figure B4 Plasticity Chart – Clayey Silt to Silty Clay

Figure B5 Grain Size Distribution – Clayey Silt to Silty Clay

Figure B6 Grain Size Distribution – Sand and Gravel



1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by URS Canada Inc. (URS) on behalf of Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the proposed Wildlife Crossing under the Highway 11 Northbound Lanes (NBL) at Station 12+169 and Southbound Lanes (SBL) at Station 12+181 north of Powassan, Ontario. This project is part of the rehabilitation of Highway 11 NBL and SBL from 1.5 km south of Highway 534, northerly 3.5 km and NBL only from 2.0 km north of Highway 534 northerly 9.5 km to 1.5 km south of Highway 654 in the Township of North Himsforth. The general location of this section of the Highway 11 alignment is shown on the Key Plan on the Contract Drawing following the text of this report.

This report addresses the investigation carried out for the proposed Wildlife Crossing on Highway 11 NBL at Station 12+169 and SBL at Station 12+181 only. Separate reports will be submitted detailing the foundation investigations for other culverts for this project. The final General Arrangement (GA) drawing for the proposed Wildlife Crossing was provided to Golder by URS.

Based on the information from URS, the Wildlife Crossing will consist of a 4 m (inside dimension) square concrete box culvert aligned beneath each of the Highway 11 NBL and SBL embankments. Each culvert will have a length of about 14 m. A 1.7 m grade raise and associated embankment widening (i.e. about 3 m on each side) will be required for the NBL embankment to accommodate the new culvert. The existing SBL embankment geometry will generally remain unchanged. The NBL and SBL embankments in the proposed culvert area are about 2 m and 4 m high, respectively, relative to the ground surface at the median. The invert of the NBL culvert at the east and west ends will be Elevation 258.7 m and 258.5 m, respectively, and the invert of the SBL culvert at the east and west ends will be Elevation 258.4 m and 258.3 m, respectively.

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

The culvert alignment was located in the field by Golder relative to stakes installed by Callon Dietz Inc. (Callon Dietz), a professional surveying company retained by URS, and referencing plan drawings provided by URS. The investigated area is shown in plan on the Contract Drawing.

2.0 SITE DESCRIPTION

The proposed Wildlife Crossing will be located in the Township of North Himsforth on Highway 11, approximately 1 km north of Hills Siding Road.

In general, the topography in the area of the overall project limits is flat with numerous bedrock outcrops separated by swamps in low-lying areas or creeks. The ground surface at the borehole locations advanced at the Wildlife Crossing site ranges between Elevations 263.7 m and 259.8 m. The existing NBL and SBL embankments are about 2 m and 4 m high, respectively, and the SBL embankment is constructed of rock fill and covered in sections of the exterior slopes with granular material. While there appears to be signs of surficial erosion of the granular material due to surface water runoff, the embankments appear to be stable and there do not appear to be any signs of pavement distress of the roadway surface at the location of the proposed culvert crossing.



3.0 INVESTIGATION PROCEDURES

The fieldwork for the investigation associated with the proposed Wildlife Crossing was carried out between November 22 and 25, 2010, and on June 1, 2011, during which time a total of eight (8) boreholes (WL-1 to WL-8) and five (5) Dynamic Cone Penetration Tests (DCPTs) were advanced at the proposed Wildlife Crossing location. Further, as discussed below, on June 22, 2011, one piezometer was installed adjacent to Borehole WL-5. The field investigation was carried out using a Track Mounted D-50 supplied and operated by Walker Drilling Ltd., of Utopia, Ontario, or Track Mounted CME-55 operated by Landcore Drilling (Landcore), of Sudbury, Ontario (for the boreholes at the toes of the embankments) and a Truck Mounted CME-55 supplied and operated by Landcore (for the boreholes at the roadway lanes/shoulders). The location of the boreholes is shown on the Contract Drawing.

The boreholes were advanced through the overburden using 108 mm inside diameter hollow-stem augers. Soil samples were obtained continuously or at intervals of depth of about 0.75 m, using a 50 mm outer diameter (O.D.) split-spoon sampler, carried out in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586-08a). DCPTs were advanced generally within about 1.5 m of Boreholes WL-1 to WL-5 (one DCPT for each borehole) to determine the depth to refusal. Samples of the bedrock were obtained using either 'NQ' or 'HQ' size rock core barrel in three of the boreholes (WL-1, WL-5 and WL-8). All boreholes were backfilled with bentonite upon completion in accordance with Ontario Regulation 903 (as amended).

The boreholes were advanced to depths ranging between 3.8 m and 8.3 m below existing ground surface. Between 2.3 m and 3.1 m of bedrock was cored in Boreholes WL-1, WL-5 and WL-8, while Boreholes WL-2 to WL-4 were advanced to auger refusal. Boreholes WL-6 and WL-7 were terminated as no further casing penetration was noted, likely on or in proximity to the bedrock surface.

The groundwater conditions and water levels in the open boreholes were observed during the drilling operations and are described on the Record of Borehole sheets in Appendix A. On June 22, 2011, a piezometer was installed in an unsampled borehole advanced about 1.5 m west of Borehole WL-5 to permit monitoring of the groundwater level at this location. The piezometer consists of a 19 mm diameter PVC pipe with a 1.5 m long slotted screen sealed within the clayey silt and sand and gravel deposit as encountered at Borehole WL-5. The borehole annulus surrounding the piezometer screen was backfilled with sand and the remainder of the borehole was backfilled with bentonite. The piezometer details and water level readings are described on the Record of Borehole sheet in Appendix A.

The fieldwork was supervised throughout by a member of our technical staff who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing 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 content, Atterberg limits and grain size distribution) was carried out on selected soil samples. The results of the laboratory testing are included in Appendix B.



FOUNDATION REPORT HIGHWAY 11 NBL AND SBL WILDLIFE CROSSING CULVERT

Survey stakes were installed near the east toe of the NBL embankment by Callon Dietz prior to drilling. The as-drilled borehole locations, in stations and offsets, were measured in reference to the stakes and were subsequently converted into MTM NAD 83 coordinates in AutoCAD. Borehole elevations were surveyed by a member of our technical staff in reference to the ground surface elevations at the horizontal control points along Highway 11. The borehole locations shown on the Contract Drawing are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum.

The as-drilled borehole locations, ground surface elevations at the drilled locations and borehole depths are summarized below.

Borehole	Location (m)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
WL-1	5112708.7	315701.2	260.3	6.5
WL-2	5112712.6	315692.7	262.2	5.9
WL-3	5112715.9	315684.5	262.3	5.9
WL-4	5112718.4	315672.8	259.8	3.8
WL-5	5112724.2	315667.3	259.9	7.6
WL-6	5112726.1	315655.5	263.6	7.5
WL-7	5112729.5	315646.9	263.7	7.7
WL-8	5112730.3	315640.9	261.9	8.3

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

As delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984)¹, this section of Highway 11 lies within the physiographic region known as the Number 11 Strip, which extends along Highway 11 from Gravenhurst to North Bay. This part of the Number 11 Strip physiographic region is near the southwest shoreline of glacial Lake Algonquin. As a result, the streams entering Lake Algonquin deposited sand as delta features and silt and clay settled in deeper offshore water. Sand and gravel was also deposited as an esker which follows the strip from Bondfield to Gravenhurst.

The bedrock in the area consists typically of crystalline granite gneisses of the Powassan Domain of the Central Gneiss Belt, a subdivision of the Grenville Structural Province, as described in *Geology of Ontario*, OGS Special Volume 4².

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

² *Geology of Ontario*, 1991. Ontario Geological Society Special Volume 4, Part 2. Ministry of Northern Development and Mines, Ontario.



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 sheets in Appendix A. The results of the laboratory testing are provided in Appendix B. The inferred stratigraphy as encountered in the boreholes is shown on the Contract Drawing. The stratigraphic boundaries shown on the Record of Borehole sheets and in profile on the Contract Drawing are inferred from non-continuous sampling, observations of drilling progress and the results of SPTs and in situ testing. 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.

It should be noted that the orientation (i.e. north, south, east, west) stated in the text of the report is typically referenced to project north (along the Highway 11 alignment) and therefore may differ from that shown on the drawing which represents magnetic north.

In general, the subsurface stratigraphy along the proposed Wildlife Crossing alignment consists of pavement surface layer of asphalt, granular fill and rock fill in the existing embankment footprint, and peat at ground surface in the highway median, underlain by deposits of silts, sands, clayey silt to silty clay and/or sand and gravel, underlain by bedrock.

4.2.1 Fill

The following boreholes were advanced through the existing embankments and encountered fill material from ground surface:

- Boreholes WL-2 and WL-3 were advanced through the east and west shoulders of the NBL embankment, respectively;
- Boreholes WL-6 and WL-7 were advanced through the east and west shoulders of the SBL embankment, respectively; and
- Borehole WL-8 was advanced on the SBL embankment west slope.

The ground surface at Boreholes WL-2, WL-3 and WL-6 to WL-8 ranges between Elevation 263.7 m and 261.9 m.

Boreholes WL-3, WL-6 and WL-7 encountered a layer of asphalt between 65 mm and 210 mm thick from pavement surface. In Borehole WL-3, a second lift of asphalt about 75 mm thick was encountered below a 260 mm thick layer of sand and fill layer. Underlying the asphalt in Boreholes WL-3, WL-6 and WL-7 and from ground surface in Borehole WL-2, a layer of fill comprised of sand and gravel to sand, trace to some silt was encountered, ranging in thickness between 0.5 m and 3.8 m. In Borehole WL-3, the sand and gravel to sand fill contains cobbles at various depths.



FOUNDATION REPORT HIGHWAY 11 NBL AND SBL WILDLIFE CROSSING CULVERT

The SPT 'N'-values measured within the fill are between 9 blows and 45 blows per 0.3 m of penetration, indicating a loose to dense relative density.

The grain size distribution of four samples of the fill deposit is shown on Figure B1 in Appendix B.

The measured water content on samples of this deposit varies between about 2 percent and 15 percent.

Underlying the sand and gravel to sand fill in Boreholes WL-6 and WL-7 and from ground surface in Borehole WL-8, the boreholes penetrated through a layer of blast rock fill between 4.7 m and 6.0 m thick. The top of the blast rock was encountered between Elevation 262.9 m and 261.8 m. The total core recovery of the rock fill pieces is between 30 percent and 70 percent.

4.2.2 Peat

A 0.6 m thick deposit of fibrous or amorphous peat was encountered at ground surface corresponding to Elevation 259.8 m and 259.9 m in Boreholes WL-4 and WL-5 advanced in the median, respectively.

The SPT 'N'-values measured within the peat deposit are 2 blows and 6 blows per 0.3 m of penetration, suggesting a soft to firm consistency.

4.2.3 Sand

A 1.4 m thick deposit of brown sand, trace to some gravel, some silt, slightly organic was encountered from ground surface (Elevation 260.3 m) in Borehole WL-1.

An SPT 'N'-value measured within this deposit is 6 blows per 0.3 m of penetration, indicating a loose relative density.

The grain size distribution of one sample of the deposit is shown on Figure B2 in Appendix B.

The natural water content measured on one sample of this deposit is about 15 percent.

4.2.4 Silt to Sand and Silt

A deposit of brown to grey silt to sand and silt was encountered below the sand in Borehole WL-1 and below the peat in Boreholes WL-4 and WL-5. The top of this deposit was encountered between Elevation 259.3 m and 258.9 m and the deposit ranges in thickness between 0.8 m and 1.5 m. Borehole WL-4 further encountered an approximately 0.9 m thick layer of grey sandy silt underlying a clay silt to silty clay deposit (described below) at Elevation 257.7 m.

The SPT 'N'-values measured within this deposit range between 4 blows and 17 blows per 0.3 m of penetration, indicating a loose to compact relative density.

The grain size distribution of two samples of the deposit is shown on Figure B3 in Appendix B.



The natural water content measured on three samples of this deposit ranges between 17 percent and 22 percent.

4.2.5 Clayey Silt to Silty Clay

A deposit of grey to brown clayey silt to silty clay, trace to some sand was encountered underlying the fill in Boreholes WL-2 and WL-3 and below the sand and silt deposit in Boreholes WL-4 and WL-5. The top of this deposit is at Elevation 258.5 m and 258.4 m and the thickness of the deposit ranges from 0.7 m to 1.0 m.

SPT 'N'-values measured within the clayey silt to silty clay deposit are between 5 blows and 10 blows per 0.3 m of penetration, suggesting a firm to stiff consistency.

Atterberg limits testing was carried out on three samples of this deposit and the test results are shown on Figure B4 in Appendix B. The test results indicate liquid limits between about 30 percent and 36 percent, plastic limits of about 16 percent or 17 percent and plasticity indices between about 14 percent and 20 percent. The results of the Atterberg limits testing indicate that the material is classified as clayey silt of low plasticity to silty clay of intermediate plasticity.

The grain size distribution of four samples of the deposit is shown on Figure B5 in Appendix B.

The natural water content measured on four samples of the clayey silt to silty clay deposit is between about 22 percent and 31 percent.

4.2.6 Sand and Gravel

A deposit of brown and grey sand and gravel, some silt was encountered underlying the silt to sandy silt deposit in Boreholes WL-1 and WL-4, below the clayey silt to silty clay deposit in Boreholes WL-2, WL-3 and WL-5 and below the blast rock fill in Boreholes WL-6 and WL-7. The top of the deposit was encountered between Elevation 257.8 m and 256.8 m and the thickness of the deposit ranges from about 0.4 m to 2.4 m. The bottom of the deposit is defined by refusal to further auger advancement or no further casing penetration or by bedrock coring.

The SPT 'N'-values measured within this deposit range between 9 blows and 57 blows per 0.3 m of penetration, indicating a loose to dense relative density, while an 'N'-value of 13 blows per 0.08 m of penetration was recorded at the contact with bedrock.

A grain size distribution of two samples of this deposit is shown on Figure B6 in Appendix B.

The natural water content measured on four samples of this deposit ranges between 11 percent and 19 percent.



FOUNDATION REPORT HIGHWAY 11 NBL AND SBL WILDLIFE CROSSING CULVERT

4.2.7 Bedrock/ Refusal

Bedrock was encountered and cored in Boreholes WL-1, WL-5 and WL-8. The bedrock surface was inferred from auger refusal or resistance to casing advancement in the remaining boreholes. These refusal depths, while they do not confirm bedrock elevations, may be inferred to indicate potential proximity to the bedrock interface. The bedrock surface (inferred or actual) was encountered at depths and elevations presented below.

Borehole No.	Depth to Bedrock Surface (m)	Bedrock Surface Elevation (m)	Refusal Type
WL-1	3.3	257.0	Bedrock Cored
WL-2	5.9	256.3	Auger Refusal
WL-3	5.9	256.4	Auger Refusal
WL-4	3.8	256.0	Auger Refusal
WL-5	4.5	255.4	Bedrock Cored
WL-6	7.5	256.1	No further Casing Penetration
WL-7	7.7	256.0	No further Casing Penetration
WL-8	6.0	255.9	Bedrock Cored

Based on the bedrock core samples, the bedrock generally consists of gneiss, and may be described as fresh, medium to coarse grained, pinkish grey. The Rock Quality Designation (RQD) measured on the core samples ranges from 68 percent to 100 percent, but is typically greater than 80 percent, indicating a rock mass of fair but generally good to excellent quality (as per Table 3.10, CFEM 2006). The Total Core Recovery (TCR) of the samples recovered is 100 percent.

4.2.8 Groundwater Conditions

In general, the samples taken in the boreholes were wet with free water noted in some samples of cohesionless material. Water levels observed in the boreholes upon completion of drilling range from 0.9 m to 5.2 m below existing ground surface, ranging between Elevation 259.0 m and 256.6 m. The water level in the standpipe piezometer installed in a borehole immediately adjacent to Borehole WL-5 after installation on June 22, 2011, was measured at 1.0 m below ground surface, corresponding to Elevation 258.9 m and on July 6, 2011, the water level in the standpipe was measured at 0.6 m below existing ground surface, corresponding to Elevation 259.3 m. Groundwater elevations will vary depending on seasonal fluctuations, precipitation and local soil permeability.

5.0 CLOSURE


The field personnel supervising the drilling program were Mr. Ed Savard and Mr. Mathew Riopelle. This report was prepared by Mr. Luigi Gianfrancesco, EIT, and the technical aspects were reviewed by Mr. André Bom, P.Eng. Mr. Jorge M. A. Costa, P.Eng., Golder's Designated MTO Contact for this project, carried out a quality control review of the report.




FOUNDATION REPORT HIGHWAY 11 NBL AND SBL WILDLIFE CROSSING CULVERT

Report Signature Page

GOLDER ASSOCIATES LTD.


André Bom, P.Eng.
Geotechnical Engineer



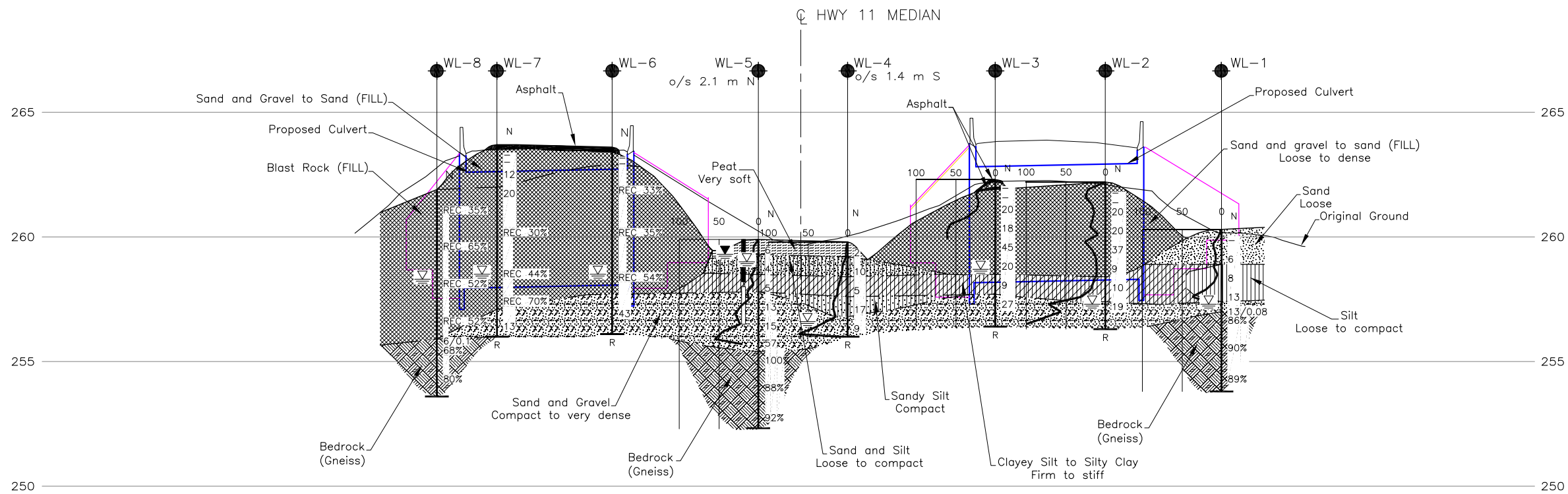
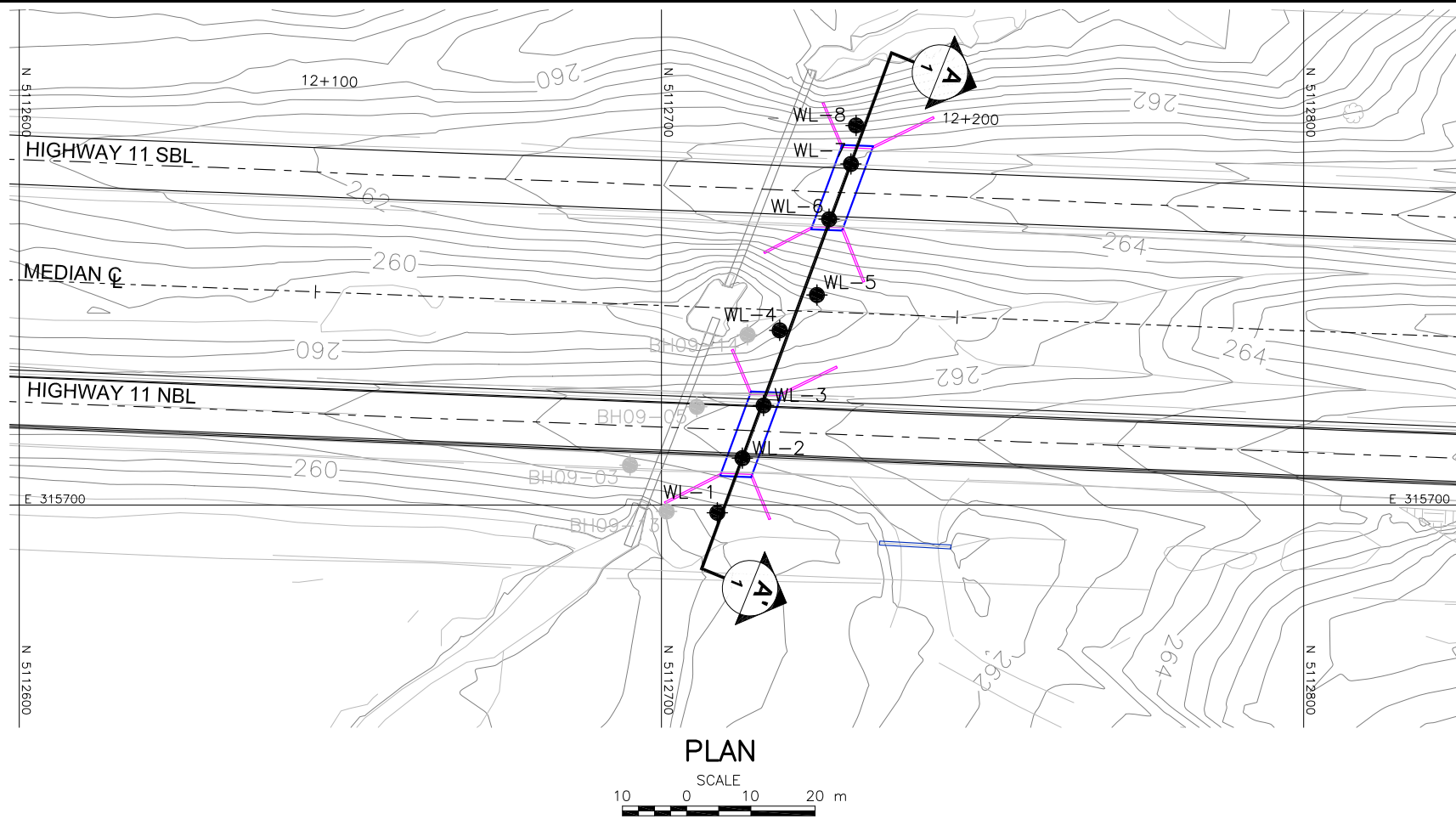

Jorge M.A. Costa, P.Eng.
Designated MTO Contact, Principal



LG/AB/JMAC/lb/cl

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

n:\active\2009\1190 sudbury\1191\09-1191-0042 urs hwy 11 culverts powassan\reporting\final\r05 - wildlife crossing\09-1191-0042-r05 final rpt 12jan17 wlc.docx



CONT No.
WP No. 5415-11-01/02

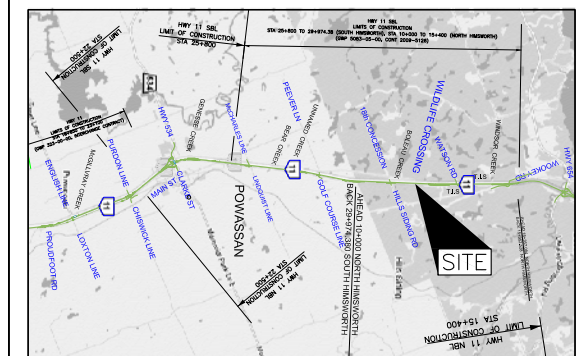


HIGHWAY 11
WILDLIFE CROSSING NBL AT STA 12+169 AND
SBL AT STA 12+181
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA



LEGEND

- Borehole - Current Investigation
- N Standard Penetration Test Value
- R Refusal
- 100% Rock Quality Designation (RQD)
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL upon completion of drilling
- WL in piezometer, measured on JULY 06, 2011
- Seal
- Piezometer

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
WL-1	260.3	5112708.7	315701.2
WL-2	262.2	5112712.6	315692.7
WL-3	262.3	5112715.9	315684.5
WL-4	259.8	5112718.4	315672.8
WL-5	259.9	5112724.2	315667.3
WL-6	263.6	5112726.1	315655.5
WL-7	263.7	5112729.5	315646.9
WL-8	261.9	5112730.3	315640.9

NOTES

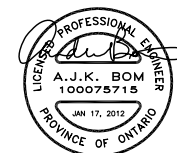
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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 URS, drawing file nos. BasePlan HWY 11.dwg dated JUNE 04, 2010, drawing file Wild Life Crossing_GA.dwg recieved Jan 12, 2012. Drawing file Keyplan.dwg recieved June 3, 2011.



NO.	DATE	BY	REVISION
Geocres No. 31L-156			
HWY. 11			PROJECT NO. 09-1191-0042 DIST.
SUBM'D. LG	CHKD. AB	DATE: JAN 2012	SITE: 43-371
DRAWN: JJJ	CHKD.	APPD: JMAC	DWG. 1



APPENDIX A

Record of Boreholes and Drillholes



LIST OF SYMBOLS

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

1. 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
V	volume
W	weight

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. 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 multiplied by 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



LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) 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, 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.

V. MINOR SOIL CONSTITUENTS

Percent 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 (cohesionless) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

III. SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index	N
Relative Density	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	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.



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

<u>Description</u>	<u>Bedding Plane Spacing</u>
Very thickly bedded	> 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	< 6 mm

JOINT OR FOLIATION SPACING

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

GRAIN SIZE

<u>Terms</u>	<u>Size*</u>
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 (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 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 separation) 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 separation such as fractures, bedding planes and foliation planes or mechanically induced fractures 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	⊥ - Perpendicular To
FO - Foliation / Schistosity	- Parallel To
CL - Cleavage	P - Polished
SH - Shear Plane / Zone	K - Slickensided
VN - Vein	SM - Smooth
F - Fault	R - Rough
CO - Contact	ST - Stepped
J - Joint	PL - Planar
FR - Fracture	U - Undulating
MF - Mechanical Fracture	C - Curved

PROJECT		09-1191-0042		RECORD OF BOREHOLE No WL-1				1 OF 1 METRIC					
W.P.		5416-06-00		LOCATION		N 5112708.7; E 315701.2		ORIGINATED BY		MR			
DIST		HWY 11		BOREHOLE TYPE		108 mm I.D. Continuous Flight, Hollow Stem Augers		COMPILED BY		AMW			
DATUM		Geodetic		DATE		November 22, 2010		CHECKED BY		AB			
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		W _p W W _L			
260.3	GROUND SURFACE												
0.0	SAND, trace to some gravel, some silt, slightly organic Loose Brown Moist		1	AS	-								14 67 (19)
258.9			2	SS	6								
1.4	SILT, some sand, trace to some clay Loose to compact Grey to brown Moist		3	SS	8								0 18 69 13
			4	SS	13								
257.4													
257.0	SAND and GRAVEL, some silt Compact Brown Wet		5	SS	13/0.08								
3.3	GNEISS (BEDROCK) Bedrock cored from 3.3 m depth to 6.5 m depth. For coring details see Record of Drillhole WL-1.		1	RC	REC 100%								RQD = 86%
			2	RC	REC 100%								RQD = 90%
			3	RC	REC 100%								RQD = 89%
253.8													
6.5	END OF BOREHOLE Notes: 1. Water level at a depth of 3.0 m below ground surface (Elev. 257.3 m) upon completion of drilling. 2. Advanced DCPT 1 m west of Borehole WL-1. Refusal (hammer bouncing) at a depth of 2.8 m below ground surface (Elev. 257.5 m).												

PROJECT: 09-1191-0042

RECORD OF DRILLHOLE: WL-1

SHEET 1 OF 1

LOCATION: N 5112708.7 ; E 315701.2

DRILLING DATE: November 22, 2010

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: D-50 Turbo Track

DRILLING CONTRACTOR: Walker Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.		RUN No.	COLOUR % 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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
				DEPTH (m)	FLUSH			RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA						HYDRAULIC CONDUCTIVITY				Diametral Point Load Index (MPa)	RMC -Q ⁺ AVG.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
								TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	10 ⁰	10 ¹	10 ²	10 ³																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
		Refer to Previous Page		257.0																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		</

DEPTH SCALE

1 : 50

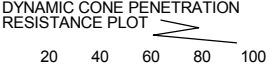


LOGGED: MR


CHECKED: AB

SUD-RCK 09-1191-0042-4000.GPJ GAL-MISS GDT 17/01/12 DATA INPUT:

PROJECT 09-1191-0042				RECORD OF BOREHOLE No WL-2				1 OF 1 METRIC								
W.P. 5416-06-00		LOCATION N 5112712.6; E 315692.7				ORIGINATED BY EHS										
DIST _____ HWY 11		BOREHOLE TYPE 108 mm I.D. Continuous Flight, Hollow Stem Augers				COMPILED BY AMW										
DATUM Geodetic		DATE November 23, 2010				CHECKED BY AB										
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			20 40 60 80 100	20 40 60 80 100	W _p W W _L	WATER CONTENT (%)	kN/m ³			GR SA SI CL	
262.2 0.0	GROUND SURFACE Sand and gravel to sand, trace to some silt (FILL) Loose to dense Brown Moist		1	AS	-	▽	262						16 60 (24)			
			2	AS	-		261									
			3	SS	20		260									
			4	SS	20		259									
			5	SS	37		258									
			6	SS	9		257									
258.4 3.8	CLAYEY SILT, trace to some sand, slightly organic Stiff Grey Moist		7	SS	10											
257.4 4.8	SAND and GRAVEL, trace to some silt Compact Grey Wet		8	SS	19											
256.3 5.9	END OF BOREHOLE AUGER REFUSAL Notes: 1. Water level at a depth of 4.9 m below ground surface (Elev. 257.3 m) upon completion of drilling. 2. Advanced DCPT 0.5 m south of Borehole WL-2. Refusal (hammer bouncing) at a depth of 5.7 m below ground surface (Elev. 256.5 m).															

PROJECT 09-1191-0042			RECORD OF BOREHOLE No WL-3			1 OF 1 METRIC					
W.P. 5416-06-00			LOCATION N 5112715.9; E 315684.5			ORIGINATED BY EHS					
DIST _____ HWY 11			BOREHOLE TYPE 108 mm I.D. Continuous Flight, Hollow Stem Augers			COMPILED BY AMW					
DATUM Geodetic			DATE November 23, 2010			CHECKED BY AB					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT  SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p — W — W _L WATER CONTENT (%)	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
262.3	GROUND SURFACE										
0.0	ASPHALT (65 mm)		1	AS	-						
0.4	Sand and gravel, trace silt (FILL) Brown Moist ASPHALT (75 mm)		2	AS	-						
	Sand and gravel to sand, trace to some silt, containing cobbles (FILL) Loose to dense Brown Moist Cobbles at 1.5 m and 1.8 m depth.		3	SS	20						21 69 (10)
			4	SS	18						
			5	SS	45						
			6	SS	20						
258.5	CLAYEY SILT, trace to some sand Stiff Grey to brown Moist		7	SS	9						1 16 65 18
257.7	SAND and GRAVEL, some silt Compact Brown Wet		8	SS	27						
256.4	END OF BOREHOLE AUGER REFUSAL										
5.9	Notes: 1. Water level at a depth of 3.6 m below ground surface (Elev. 258.7 m) upon completion of drilling. 2. Advanced DCPT 1.5 m north of Borehole WL-3. Refusal (hammer bouncing) at a depth of 2.4 m below ground surface (Elev. 259.9 m).										

SUD-MTO 001 09-1191-0042-4000.GPJ GAL-MISS.GDT 17/01/12 DATA INPUT:

PROJECT		09-1191-0042		RECORD OF BOREHOLE No WL-4		1 OF 1 METRIC							
W.P.		5416-06-00		LOCATION		N 5112718.4; E 315672.8							
DIST		HWY 11		BOREHOLE TYPE		108 mm I.D. Continuous Flight, Hollow Stem Augers							
DATUM		Geodetic		DATE		November 23, 2010							
						ORIGINATED BY MR							
						COMPILED BY AMW							
						CHECKED BY AB							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT <div style="text-align: center;">  </div>	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								
259.8	GROUND SURFACE												
0.0	PEAT (Amorphous), some silt, trace clay, trace sand		1	SS	2								
259.2	Soft												
0.6	Brown Moist												
258.4	SAND and SILT, trace gravel, slightly organic		2	SS	10								
1.4	Loose Grey Moist to wet												
257.7	SILTY CLAY, trace to some sand		3	SS	5								0 9 67 24
2.1	Firm Grey Moist												
256.8	Sandy SILT, trace gravel		4	SS	17								
3.0	Compact Grey Wet												
256.0	SAND and GRAVEL, some silt		5	SS	9								33 49 (18)
3.8	Loose Grey Wet												
END OF BOREHOLE AUGER REFUSAL Notes: 1. Water level at a depth of 3.2 m below ground surface (Elev. 256.6 m) upon completion of drilling. 2. Advanced DCPT 1 m north of Borehole WL-4. Refusal (hammer bouncing) at a depth of 3.8 m below ground surface (Elev. 256.0 m)													

PROJECT 09-1191-0042				RECORD OF BOREHOLE No WL-5				1 OF 1 METRIC									
W.P. 5416-06-00				LOCATION N 5112724.2; E 315667.3				ORIGINATED BY MR									
DIST HWY 11				BOREHOLE TYPE 108 mm I.D. Continuous Flight, Hollow Stem Augers				COMPILED BY AMW									
DATUM Geodetic				DATE November 23, 2010				CHECKED BY AB									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
<div style="display: flex; justify-content: space-between; font-size: small;"> <div> 20 40 60 80 100 UNCONFINED + FIELD VANE QUICK TRIAXIAL X REMOULDED </div> <div> 20 40 60 W_p W W_L </div> </div>																	
259.9	GROUND SURFACE																
0.0	PEAT (Fibrous), some sand, some silt Firm Brown Moist		1	SS	6												
259.3																	
0.6	SAND and SILT, trace clay, slightly organic Loose Grey Wet		2	SS	4											1 36 57 6	
258.5																	
1.4	CLAYEY SILT, some sand Firm Grey Wet		3	SS	5											0 16 66 18	
257.8																	
2.1	SAND and GRAVEL, some silt Compact to very dense Grey to brown Wet		4	SS	13												
			5	SS	15												
			6	SS	57												
255.4																	
4.5	GNEISS (BEDROCK)																
	Bedrock cored from 4.5 m depth to 7.6 m depth.		1	RC	REC 100%											RQD = 100%	
	For coring details see Record of Drillhole WL-5.		2	RC	REC 100%											RQD = 88%	
			3	RC	REC 100%											RQD = 92%	
252.3																	
7.6	END OF BOREHOLE																
Notes: 1. Water level at a depth of 0.9 m below ground surface (Elev. 259.0 m) upon completion of drilling. 2. Advanced DCPT 1 m south of Borehole WL-5. Refusal at a depth of 4.2 m (hammer bouncing) below ground surface (Elev. 255.7 m). 3. On June 22, 2011, a piezometer was installed about 1.5 m west of Borehole WL-5. The water level measured in the piezometer after the installation was 1.0 m below ground surface (Elev. 258.9 m). On July 6, 2011, the water level was measured at a depth of 0.6 m below ground surface (Elev. 259.3 m).																	

SUD-MTO 001 09-1191-0042-4000.GPJ GAL-MISS.GDT 17/01/12 DATA INPUT:

PROJECT: 09-1191-0042

RECORD OF DRILLHOLE: WL-5

SHEET 1 OF 1

LOCATION: N 5112724.2 ; E 315667.3

DRILLING DATE: November 23, 2010

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: D-50 Turbo Track

DRILLING CONTRACTOR: Walker Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.		RUN No.	COLOUR % RETURN	FLUSH	RECOVERY				FRACT. INDEX METRES	DISCONTINUITY DATA						HYDRAULIC CONDUCTIVITY				Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
				DEPTH (m)					TOTAL CORE %	SOLID CORE %	R.Q.D. %	B Angle		DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	10 ⁶	10 ⁵	10 ⁴	10 ³				
		Refer to Previous Page		255.4																						
5	November 23, 2010 HQ Coring	GNEISS Medium to coarse grained Fresh Pinkish grey		4.5	1	GREY 100%																				
6				2	GREY 100%																					
7				3	GREY 100%																					
		END OF DRILLHOLE		252.3	7.6																					
8																										
9																										
10																										
11																										
12																										
13																										
14																										

DEPTH SCALE

1 : 50



LOGGED: MR

CHECKED: AB

SUD-RCK 09-1191-0042-4000.GPJ GAL-MISS GDT 17/01/12 DATA INPUT:

PROJECT 09-1191-0042				RECORD OF BOREHOLE No WL-6				1 OF 1 METRIC									
W.P. 5416-06-00		LOCATION N 5112726.1; E 315655.5				ORIGINATED BY MR											
DIST _____ HWY 11		BOREHOLE TYPE 108 mm I.D. Continuous Flight, Hollow Stem Augers, NW Casing, NQ Coring				COMPILED BY AMW											
DATUM Geodetic		DATE November 24, 2010				CHECKED BY AB											
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									
263.6	GROUND SURFACE																
0.0	ASPHALT (210 mm)																
0.2	Sand and gravel to sand, trace silt (FILL)		1	AS	-												
262.9	Brown		2	AS	-												
0.7	Moist																
	Blast rock (FILL)																
				RC	REC 33%												
				RC	REC 35%												
				RC	REC 54%												
257.7																	
5.9	SAND and GRAVEL, some silt, trace clay Dense Grey Wet		3	SS	43												32 44 (24)
256.1																	
7.5	END OF BOREHOLE NO FURTHER CASING PENETRATION Note: 1. Water level at a depth of 5.1 m below ground surface (Elev. 258.5 m) upon completion of drilling.																

SUD-MTO 001 09-1191-0042-4000.GPJ GAL-MISS.GDT 17/01/12 DATA INPUT:

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

PROJECT <u>09-1191-0042</u>		RECORD OF BOREHOLE No WL-8		1 OF 1 METRIC	
W.P. <u>5416-06-00</u>		LOCATION <u>N 5112730.3; E 315640.9</u>		ORIGINATED BY <u>EHS</u>	
DIST <u> </u> HWY <u>11</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight, Hollow Stem Augers, NW Casing, NQ Coring</u>		COMPILED BY <u>JJL</u>	
DATUM <u>Geodetic</u>		DATE <u>June 1, 2011</u>		CHECKED BY <u>AB</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID LIMIT LIMIT CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20	40	60	80	100	W _p	W	W _L		
261.9	GROUND SURFACE																
0.0	Blast rock (FILL)																
				RC	REC 35%												
				RC	REC 65%												
				RC	REC 52%												
				RC	REC 52%												
255.9				SS	6/0 1												
6.0	GNEISS (BEDROCK)			1	RC	REC 100%											
	Bedrock cored from 6.0 m depth to 8.3 m depth.			2	RC	REC 100%											
	For coring details see Record of Drillhole WL-8.																
253.6	END OF BOREHOLE																
8.3	Notes: 1. Water level at a depth of 3.6 m below ground surface (Elev. 258.3 m) upon completion of drilling.																

SUD-MTO 001 09-1191-0042-4000.GPJ GAL-MISS.GDT 17/01/12 DATA INPUT:

PROJECT: 09-1191-0042

RECORD OF DRILLHOLE: WL-8

SHEET 1 OF 1

LOCATION: N 5112730.3 ; E 315640.9

DRILLING DATE: June 1, 2011

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Landcore Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % 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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
							FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA												HYDRAULIC CONDUCTIVITY				Dipmetral Point Load Index (MPa)	RMC -Q' AVG.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
								TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION												Jr	Ja			Jn	k, cm/s	10 ⁻⁶	10 ⁻⁵	10 ⁻⁴																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
6	June 1, 2011 NQ Coring	Refer to Previous Page		255.9																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														

DEPTH SCALE

1 : 50



LOGGED: EHS

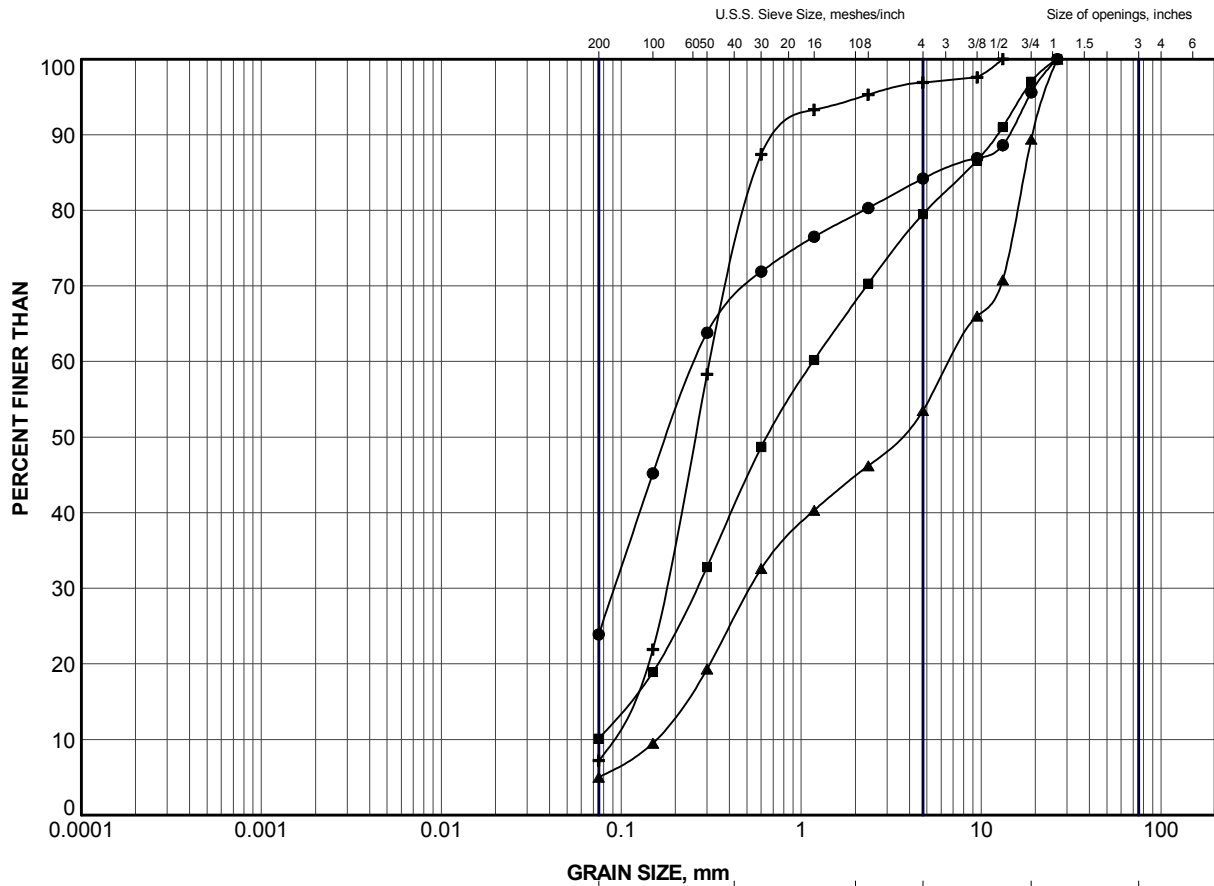
CHECKED: AB

SUD-RCK 09-1191-0042-4000.GPJ GAL-MISS GDT 17/01/12 DATA INPUT:



APPENDIX B


Laboratory Test Results

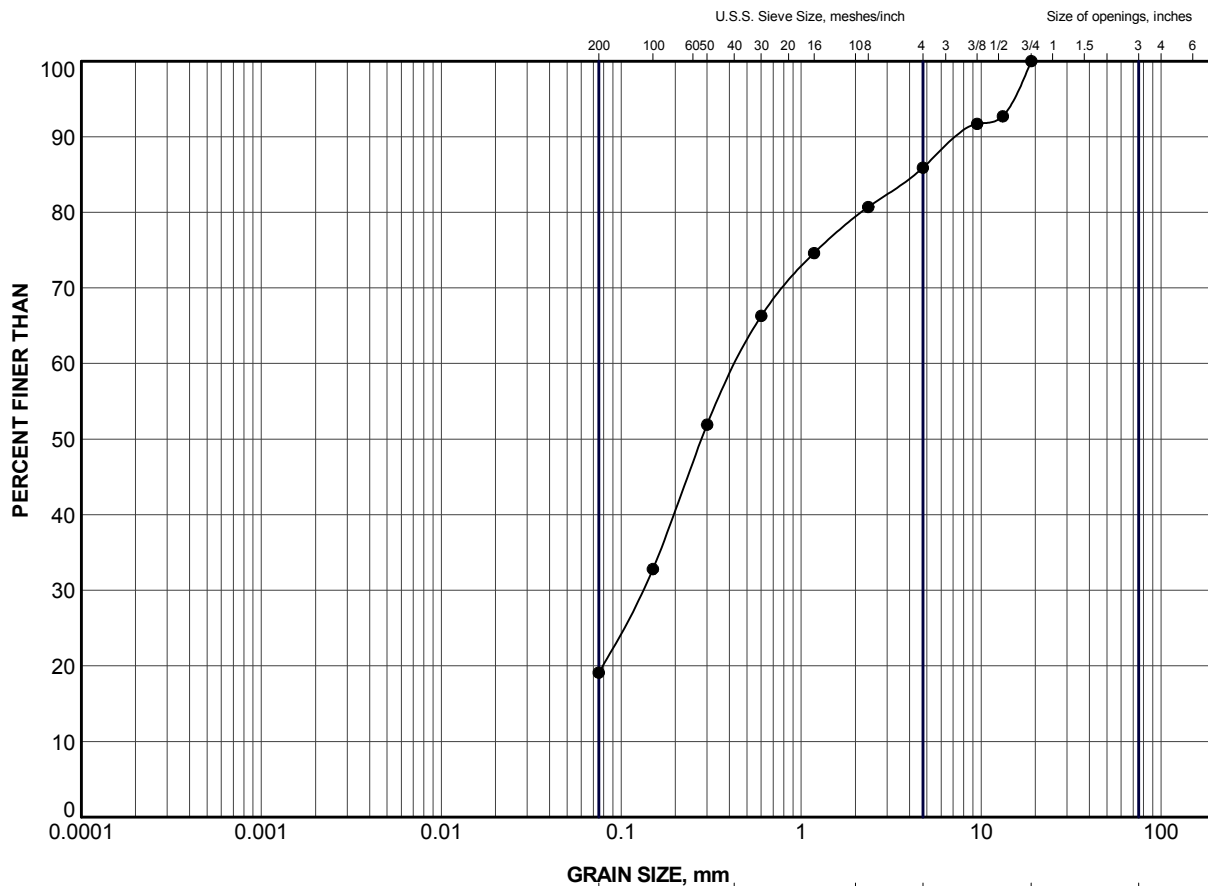


CLAY AND SILT	GRAVEL SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	WL-2	4	260.4
■	WL-3	3	261.2
▲	WL-7	1	263.5
✚	WL-7	3	262.6


PROJECT				
HIGHWAY 11 WILDLIFE CROSSING 12+169 NBL & 12+181 SBL				
TITLE				
GRAIN SIZE DISTRIBUTION SAND AND GRAVEL TO SAND (FILL)				
PROJECT No.		09-1191-0042		FILE No 09-1191-0042-4000.GPJ
DRAWN	JJL	Jan 2012	SCALE	N/A
CHECK	AB	Jan 2012	REV.	
APPR	JMAC	Jan 2012		
				FIGURE B1

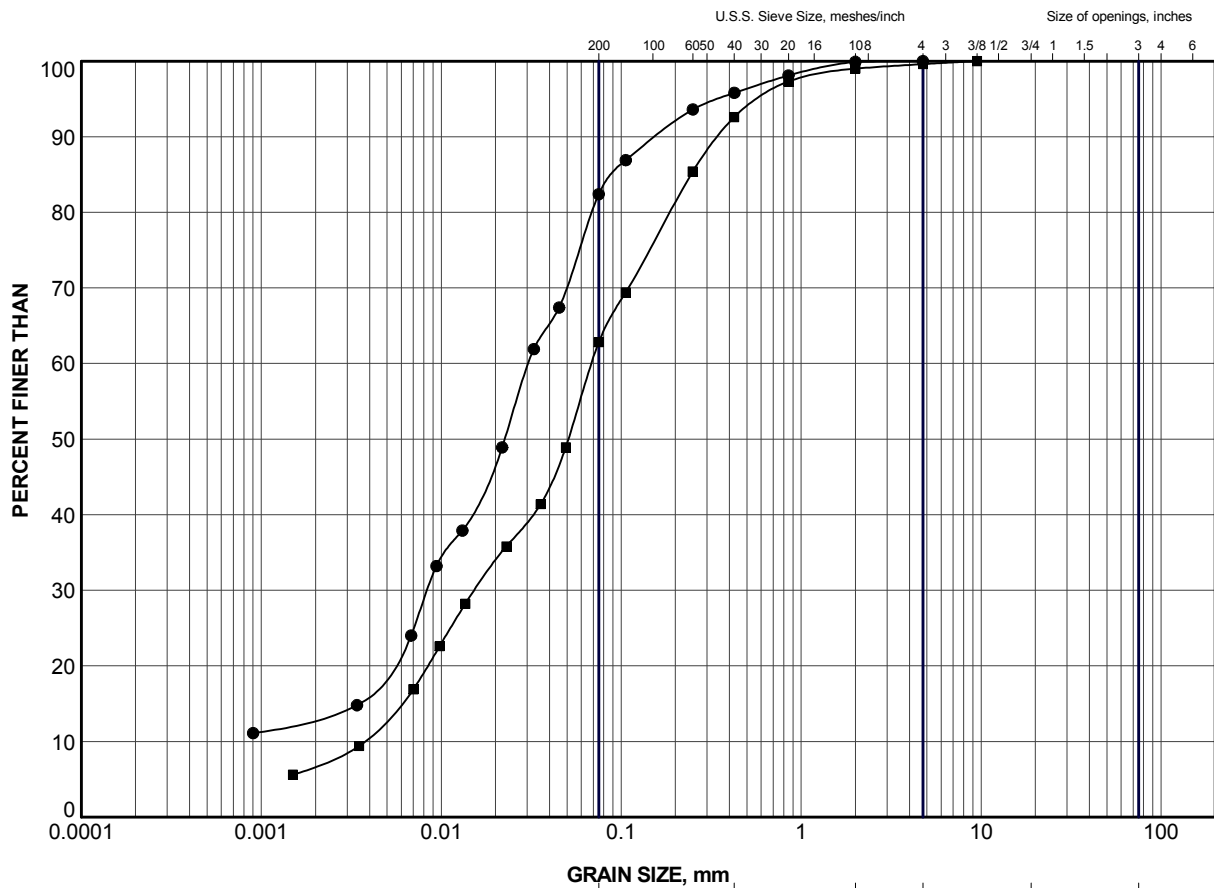


GRAVEL SIZE, mm						Cobble Size
CLAY AND SILT	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	WL-1	1	260.0

PROJECT				
HIGHWAY 11 WILDLIFE CROSSING 12+169 NBL & 12+181 SBL				
TITLE				
GRAIN SIZE DISTRIBUTION SAND				
PROJECT No.		09-1191-0042		FILE No 09-1191-0042-4000.GPJ
DRAWN	JJL	Jan 2012	SCALE	N/A
CHECK	AB	Jan 2012	REV.	
APPR	JMAC	Jan 2012		
 Golder Associates SUDBURY, ONTARIO				FIGURE B2



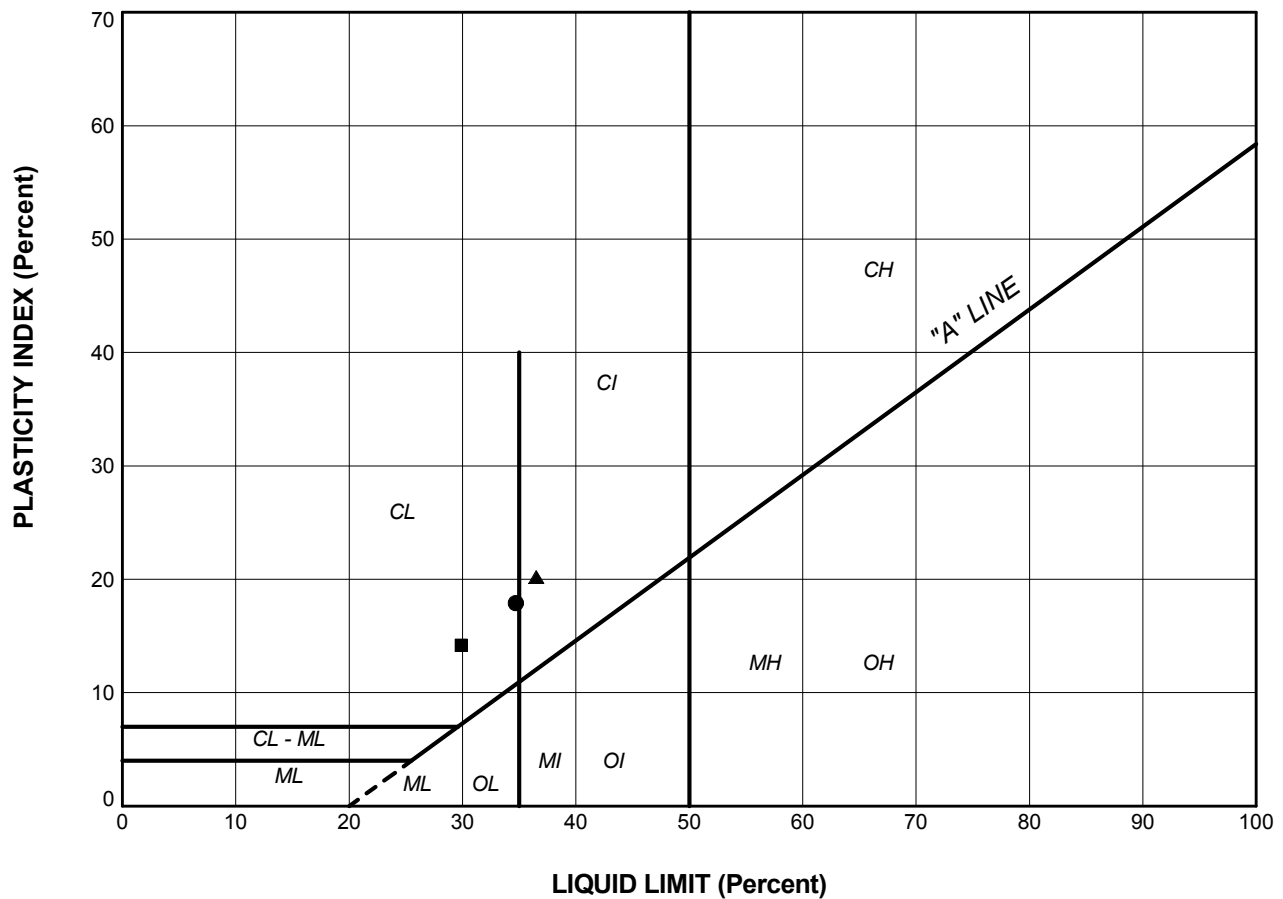
GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	WL-1	3	258.5
■	WL-5	2	258.8

PROJECT					
HIGHWAY 11 WILDLIFE CROSSING 12+169 NBL & 12+181 SBL					
TITLE					
GRAIN SIZE DISTRIBUTION SILT TO SAND AND SILT					
PROJECT No.		09-1191-0042		FILE No 09-1191-0042-4000.GPJ	
DRAWN	JJL	Jan 2012	SCALE	N/A	REV.
CHECK	AB	Jan 2012			
APPR	JMAC	Jan 2012			
			FIGURE B3		



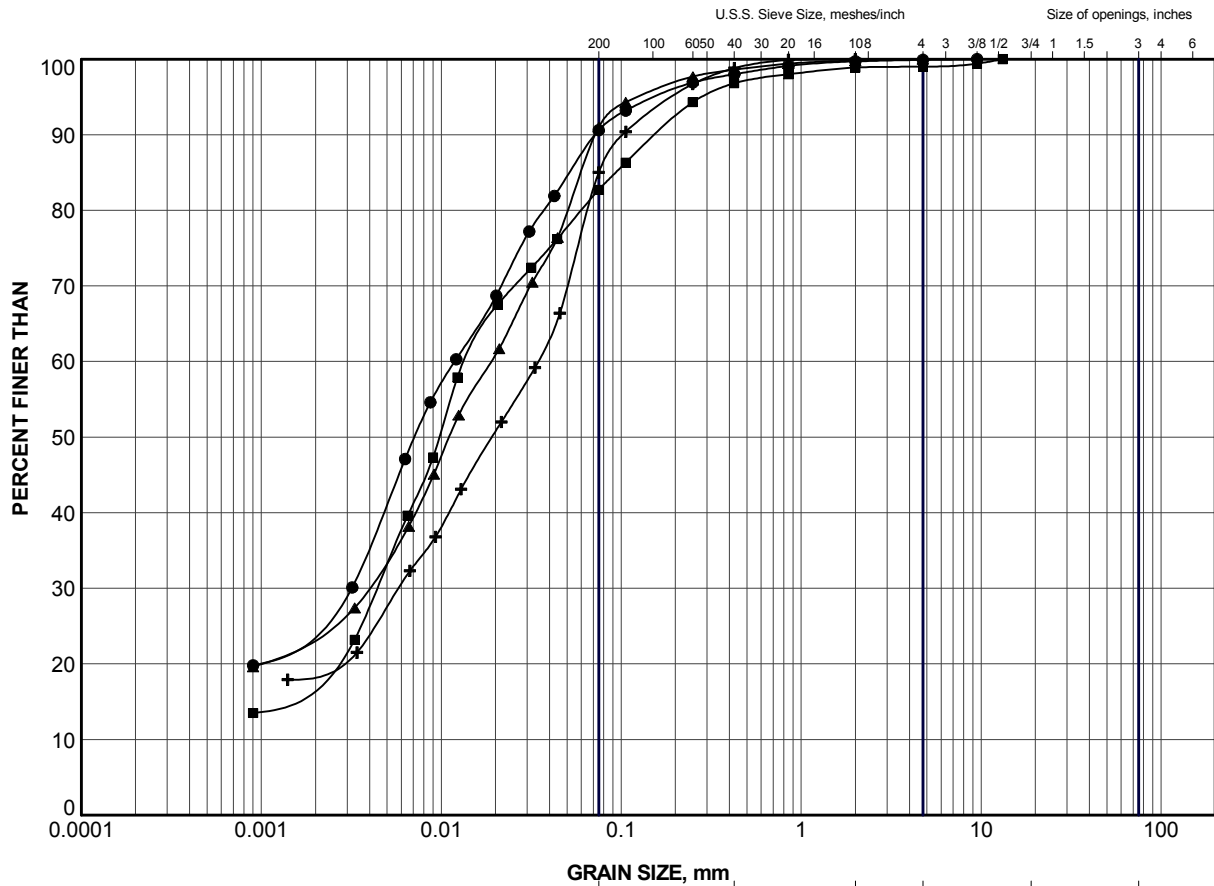


LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	WL-2	7	34.7	16.8	17.9
■	WL-3	7	29.9	15.7	14.2
▲	WL-4	3	36.5	16.3	20.2

PROJECT					
HIGHWAY 11 WILDLIFE CROSSING 12+169 NBL & 12+181 SBL					
TITLE					
PLASTICITY CHART CLAYEY SILT TO SILTY CLAY					
PROJECT No.		09-1191-0042		FILE No. 09-1191-0042-4000.GPJ	
DRAWN	JJL	Jan 2012	SCALE	N/A	REV.
CHECK	AB	Jan 2012			
APPR	JMAC	Jan 2012			
			FIGURE B4		





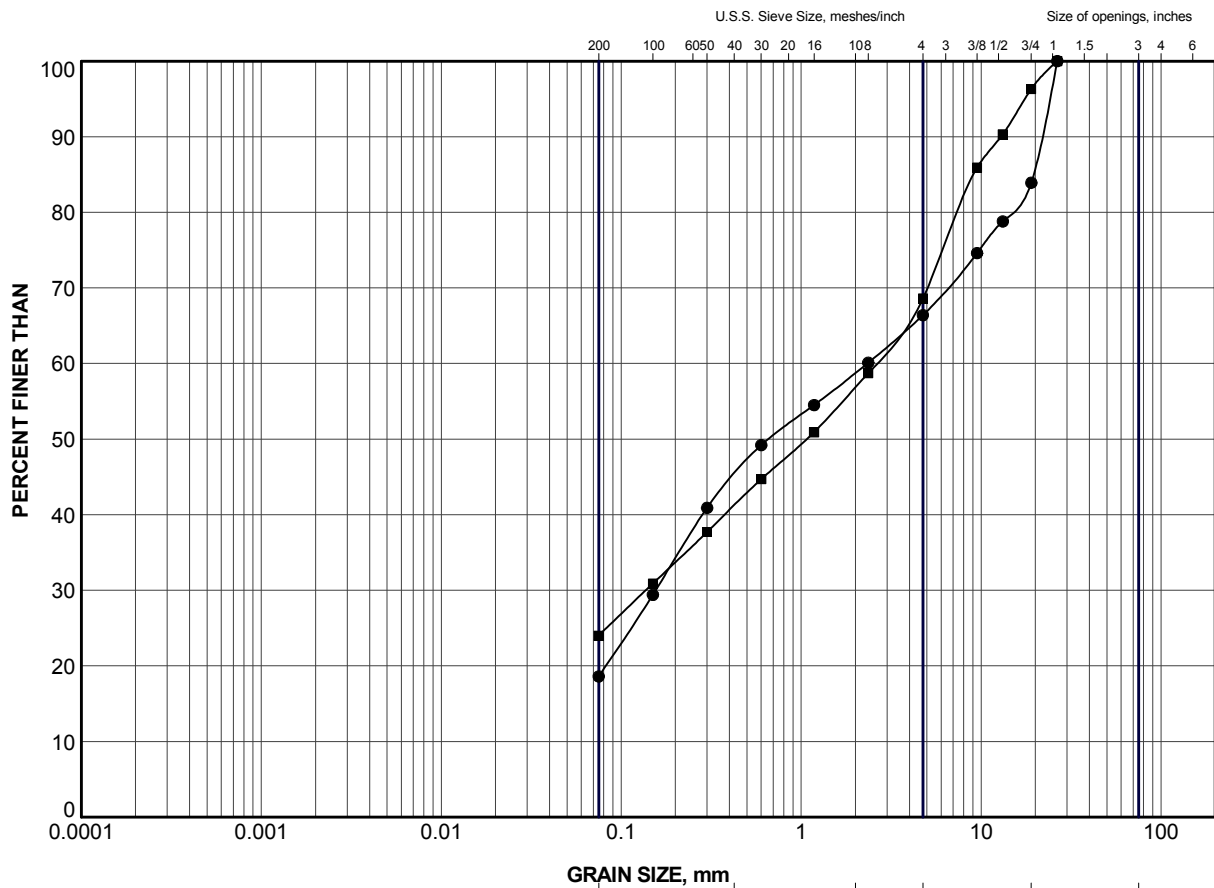
GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	WL-2	7	258.1
■	WL-3	7	258.2
▲	WL-4	3	258.0
+	WL-5	3	258.1

PROJECT					
HIGHWAY 11 WILDLIFE CROSSING 12+169 NBL & 12+181 SBL					
TITLE					
GRAIN SIZE DISTRIBUTION CLAYEY SILT TO SILTY CLAY					
PROJECT No.		09-1191-0042		FILE No 09-1191-0042-4000.GPJ	
DRAWN	JJL	Jan 2012	SCALE	N/A	REV.
CHECK	AB	Jan 2012			
APPR	JMAC	Jan 2012			
			FIGURE B5		






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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	WL-4	5	256.4
■	WL-6	3	257.0

PROJECT				
HIGHWAY 11 WILDLIFE CROSSING 12+169 NBL & 12+181 SBL				
TITLE				
GRAIN SIZE DISTRIBUTION SAND AND GRAVEL				
PROJECT No.		09-1191-0042		FILE No 09-1191-0042-4000.GPJ
DRAWN	JJL	Jan 2012	SCALE	N/A
CHECK	AB	Jan 2012	REV.	
APPR	JMAC	Jan 2012		
				FIGURE B6

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. 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 who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
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.
1010 Lorne Street
Sudbury, Ontario, P3C 4R9
Canada
T: +1 (705) 524 6861

