



November 17, 2011

FOUNDATION INVESTIGATION REPORT

HIGHWAY 11 NBL CULVERT REPLACEMENT AT STATION 11+873
TOWNSHIP OF NORTH HIMSWORTH, ONTARIO
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5416-06-00

Submitted to:
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REPORT





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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 rehabilitation of the Highway 11 Northbound Lanes (NBL), including the culvert replacement at Station 11+873. This project is part of the detail design for the rehabilitation of Highway 11 Northbound Lanes (NBL) and Southbound Lanes (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 Himsworth. The general location of this section of the Highway 11 alignment is shown on the Key Plan on Drawing 1 following the text of this report.

This report addresses the investigation carried out for the replacement of the culvert on Highway 11 NBL at Station 11+873 only. Separate reports will be submitted detailing the foundation investigations for other culverts for this project, as well as for the wildlife crossing. The drawing for the culvert alignment was provided to Golder by URS on June 4, 2010 and cross-sections showing invert information were provided on August 25, 2010.

Based on the information from URS, the culvert at Station 11+873 will be concrete and will have an opening of about 1.2 m. The inverts at the west and east ends of the culvert will be Elevation 259.3 m and 259.2 m, respectively. The embankment in the culvert area is about 2.5 m high and we understand that neither a grade raise nor embankment widening are required at this culvert location.

The purpose of this investigation is to establish the subsurface conditions at the location of the proposed culvert replacement 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 Drawing 1 following the text of this report.

2.0 SITE DESCRIPTION

The replacement culvert will be located on the same alignment as the existing culvert in the Township of North Himsworth on Highway 11 approximately 700 m 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 Preliminary Design Report (PDR) dated July 2009 indicates that the existing culvert at Station 11+873 is a 24 m long 910 mm concrete box culvert and that the condition of the culvert is poor to fair.

The ground surface of the shoulder of the embankment is at Elevation 262 m and the creek water surface at the time of the investigation was about Elevation 259.6 m.

3.0 INVESTIGATION PROCEDURES

The fieldwork for the investigation associated with culvert replacement at Station 11+873 was carried out on May 4, 6, and 17 2010, during which time a total of four (4) Boreholes (BH09-02, BH09-04, BH09-15 and BH09-16) and four (4) Dynamic Cone Penetration Tests (DCPTs) were advanced at the culvert location. The field



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investigation was carried out using a Track Mounted D-50 supplied and operated by Walker Drilling Ltd., of Utopia, Ontario. The location of the boreholes is shown on Drawing 1 following the text of this report.

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 and 1.5 m, using a 50 mm outer diameter (O.D.) split-spoon sampler, performed in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586-08a). The DCPTs were adjacent about 1 m north or south of each borehole to determine the depth to refusal. Samples of the bedrock were obtained using an 'NQ' size rock core barrel in one of the boreholes. All boreholes were backfilled with bentonite upon completion in accordance with Ontario Regulation 903 (as amended by Ontario Regulation 372).

The boreholes were advanced to depths ranging between 3.0 m and 5.5 m below existing ground surface. Three of the boreholes/DCPTs were terminated on refusal to further split-spoon and/or auger/casing advancement, or cone penetration. These depths to refusal do not confirm bedrock surface elevations, but may be inferred to indicate potential 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. It should be noted that groundwater elevations as encountered in the boreholes may not be representative of static groundwater levels since the groundwater levels in the boreholes may not have stabilized on completion of drilling. Furthermore, groundwater elevations will vary depending on seasonal fluctuations, precipitation and local soil permeability.

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 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 and grain size distribution) was carried out on selected soil samples. The results of the laboratory testing are included in Appendix B.

A sample of the creek water was obtained during the field investigation 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 B-1 in Appendix B.

Survey stakes were installed near the NBL embankment east toe 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 Drawing 1 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.



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Borehole	Location (m)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
09-02	5112418.1	315682.5	262.1	5.5
09-04	5112422.7	315673.0	262.0	4.2
09-15	5112420.0	315689.9	259.6	3.0
09-16	5112416.1	315662.7	259.6	3.0

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.

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 Drawing 1. The stratigraphic boundaries shown on the Record of Borehole sheets and in profile on Drawing 1 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.

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.



In general, the subsurface stratigraphy along the culvert alignment consists of a layer of fill at ground surface, underlain by a layer of organic silt or peat and deposits of sandy silt to silty sand, gravelly sand or sand and gravel, underlain by bedrock.

The bottom of the creek was probed using a steel bar from the edge of the creek and the depth to firm creek bottom measured on November 16, 2010 was 0.4 m and 0.6 m below water surface on the west and east side of the embankment, respectively.

4.2.1 Fill

Fill, consisting of brown sand to gravelly sand, some silt, was encountered at ground surface in Boreholes BH09-02, BH09-04 and BH09-15. The thickness of the fill deposit is between 0.2 m and 5.5 m and Borehole BH09-02 was terminated in the fill material upon casing refusal.

The SPT 'N'-values measured within the fill are between 3 blows and 35 blows per 0.3 m of penetration, indicating a very loose to dense relative density.

The grain size distribution of four samples of the deposit is shown on Figure B-1 in Appendix B.

The measured water content on samples of this deposit varies between about 7 percent and 11 percent.

4.2.2 Peat/Organic Silt

A 0.6 m deposit of grey, organic silt was encountered below the fill in Borehole BH09-15 and a 0.2 m thick deposit of peat was encountered at ground surface in Borehole BH09-16. The top of this deposit was encountered at Elevation 259.4 m and 259.6 m in Boreholes BH09-15 and BH09-16, respectively.

An SPT N-value measured within the organic silt deposit is 3 blows per 0.3 m of penetration suggesting a soft consistency.

The natural water content measured on the sample of the peat in Borehole BH09-16 is about 65 percent.

4.2.3 Sandy Silt to Silty Sand

A deposit of brown and grey sandy silt to silty sand, some clay, trace to some gravel, was encountered below the fill in Borehole BH09-04. The top of this deposit was encountered at Elevation 259.3 m and the deposit has a thickness of 1.5 m. The bottom of this deposit was defined by spoon and auger refusal.

The SPT 'N'-values measured within this deposit are 9 and 14 blows per 0.3 m of penetration and a value of 15 blows per 0.25 m of penetration at the bottom of the deposit/borehole, indicating a loose to compact relative density.

The grain size distribution of two samples of the deposit is shown on Figure B-2 in Appendix B.

The natural water content measured on two samples of this deposit is about 12 percent and 18 percent.



4.2.4 Gravelly Sand to Sand and Gravel

A 2.2 m thick deposit of brown, gravelly sand, some silt, was encountered below the organic silt in Borehole BH09-15 and a 0.3 m thick deposit of grey sand and gravel, some organics, was encountered below the peat in Borehole BH09-16. The top of the deposit was encountered at Elevation 258.8 m and 259.4 m in Boreholes BH09-15 and BH09-16, respectively. The bottom of this deposit was defined by auger refusal in Borehole BH09-15 and the bedrock surface in Borehole BH09-16.

The SPT 'N'-values measured within this deposit range between 19 and 31 blows per 0.3 m of penetration, indicating a compact to dense relative density.

A grain size distribution of one sample of the gravelly sand portion of this deposit is shown on Figure B-3 in Appendix B.

The natural water content measured on two samples of this deposit is 11 percent and 12 percent.

4.2.5 Bedrock/ Refusal

In each of the boreholes and DCPTs, refusal to further split-spoon, casing and/or auger advancement or cone penetration was encountered at depths between 0.5 m and 5.5 m below ground surface, corresponding to Elevation 259.1 m and 256.6 m. In Borehole BH09-16, the bedrock was cored between Elevation 259.1 m and 256.6 m for a total length of 2.5 m. Where bedrock was not cored, while the depths to refusal do not confirm bedrock elevations, the depths of refusal may be inferred to indicate potential proximity to the bedrock interface. The depth to bedrock below ground surface and corresponding bedrock surface elevation is summarized below.

Borehole No.	Depth to Bedrock Surface (m)	Bedrock Surface Elevation (m)	Refusal Type
09-02	5.5	256.6	Casing Refusal
09-04	4.2	257.8	Spoon/Auger Refusal
09-15	3.0	256.6	Auger Refusal
09-16	0.5	259.1	Bedrock Cored

Based on the cored bedrock samples, the bedrock generally consists of gneiss, and may be described as slightly weathered to fresh, fine to medium grained, pinkish grey. The Rock Quality Designation (RQD) measured on the two core runs is 90 percent and 100 percent, indicating a rock mass of excellent quality. The Total Core Recovery (TCR) of the samples recovered is 100 percent.

4.2.6 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 0.2 m to 2.6 m below existing ground surface, ranging between Elevation 259.8 m and 259.1 m. Groundwater/surface water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.



5.0 CLOSURE

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



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Report Signature Page

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AB/JMAC/lb

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REFERENCES

Canadian Highway Bridge Design Code (CHBDC) and Commentary on CAN/CSA-S6-06. 2006. CSA Special Publication, S6.1-06. Canadian Standard Association.

Chapman, L.J., and Putnam, D.F., 1984. The Physiography of Southern Ontario. Ontario Geological Survey, Special Volume 2, 3rd Edition. Ontario Ministry of Natural Resources.

Geology of Ontario, 1991. Ontario Geological Society, Special Volume 4, Part 2. Eds. P.C. Thurston, H.R. Williams, R.H. Sutcliffe and G.M. Stott. Ministry of Northern Development and Mines, Ontario.

STANDARDS:

ASTM International:

ASTM D1586-08a	Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
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Contract Design Estimating and Documentation (CDED):

Special Provision 110S13	Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material. May 2010. Amendment to OPSS 1010.
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Ontario Occupational Health and Safety Act:

Ontario Regulation 213/91	Construction Projects
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Ontario Regulation 443/09	Amendment to Ontario Regulation 213
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Ontario Provincial Standard Drawing:

OPSD 203.010	Embankments Over Swamp – New Construction.
OPSD 802.031	Rigid Pipe Bedding, Cover and Backfill Type 3 Soil - Earth Excavation.
OPSD 803.010	Backfill and Cover for Concrete Culverts With Spans less than or equal to 3.0 m.
OPSD 810.010	Rip-Rap Treatment for Sewer and Culvert Outlets.

Ontario Provincial Standard Specification:

OPSS 209	Construction Specification for Embankments Over Swamps and Compressible Soils.
OPSS 421	Construction Specification For Pipe Culvert Installation In Open Cut.
OPSS 422	Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut.
OPSS 501	Construction Specification for Compacting.

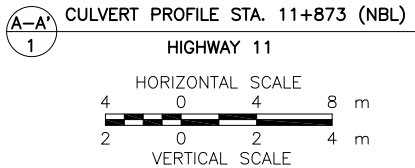
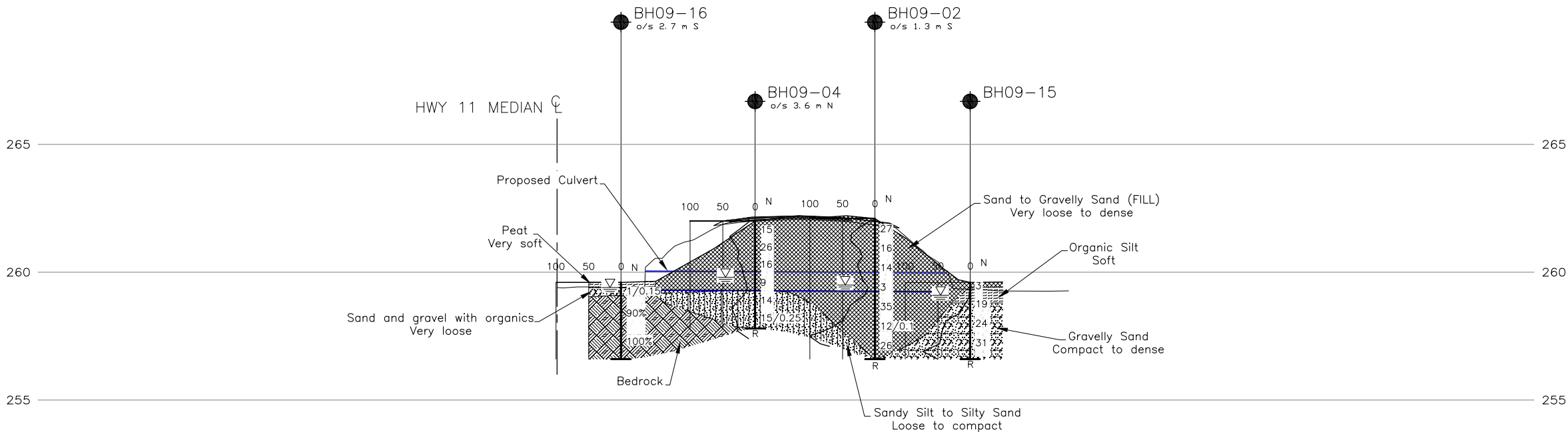
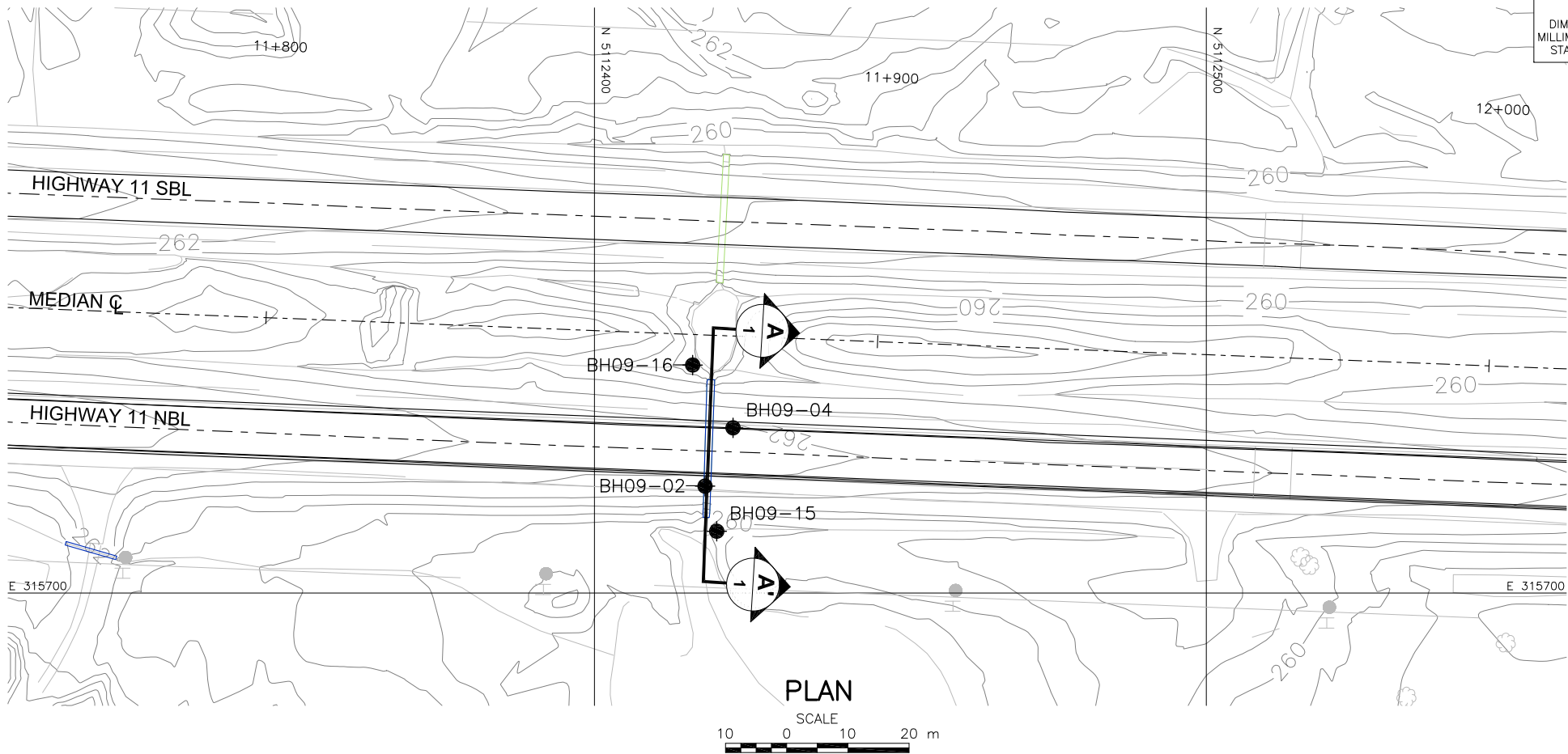


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OPSS 539	Construction Specification for Temporary Protection Systems.
OPSS 1002	Material Specification for Aggregates – Concrete.
OPSS 1205	Material Specification for Clay Seal.

Ontario Water Resources Act:

Ontario Regulation 372/97 Amendment to Ontario Regulation 903



CONT No.
WP No. 5416-06-00

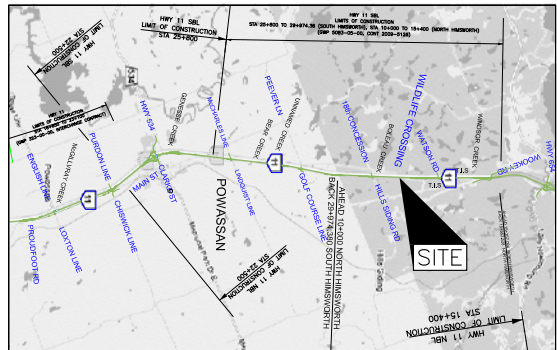
HIGHWAY 11
CULVERT AT STA 11+873 NBL
BOREHOLE LOCATIONS AND
SOIL STRATA



SHEET



Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA



KEY PLAN
SCALE
2.5 0 2.5 km

LEGEND

- Borehole - Current Investigation
- 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

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
BH09-02	262.1	5112418.1	315682.5
BH09-04	262.0	5112422.7	315673.0
BH09-15	259.6	5112420.0	315689.9
BH09-16	259.6	5112416.1	315662.7

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 received June 04, 2010, Keyplan received June 03, 2011.

NO.	DATE	BY	REVISION
Geores No. 31L-148			
HWY. 11	PROJECT NO. 09-1191-0042		DIST.
SUBM'D. LG	CHKD. AB	DATE: NOV 2011	SITE:
DRAWN: JJJ	CHKD.	APPD. JMAC	DWG. 1



APPENDIX A

Record of Boreholes and Drillhole



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 BH09-02		1 OF 1 METRIC											
W.P.		5416-06-00		LOCATION		N 5112418.1; E 315682.5											
DIST		HWY 11		BOREHOLE TYPE		108 mm I.D. Continuous Flight, Hollow Stem Augers, NW Casing, Wash Boring											
DATUM		Geodetic		DATE		May 4, 2010											
				ORIGINATED BY		EHS											
				COMPILED BY		AMW											
				CHECKED BY		AB											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ kN/m ³	GR SA SI CL
							20 40 60 80 100	20 40 60 80 100	W _p	W	W _L	20 40 60					
262.1	GROUND SURFACE						262	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED									
0.0	Sand to gravelly sand, some silt (FILL) Very loose to dense Brown Moist		1	SS	27	▽	262										
			2	SS	16		261										
			3	SS	14		260						○			16	69 (15)
	Becoming wet below 2.6 m depth.		4	SS	3		259						○			24	55 (21)
			5	SS	35		258						○				
	Boulder at 3.9 m depth, switched to NW Casing.		6	SS	12/0.1		257						○			35	56 (9)
			7	SS	26												
256.6	END OF BOREHOLE CASING REFUSAL																
5.5	Note: 1. Water level at a depth of 2.6 m below ground surface (Elev. 259.5 m) upon completion of drilling. 2. Advanced DCPT 4.2 m north of Borehole BH09-02 (located on other side of culvert, Elev. 262.0 m). Refusal at a depth of 5.0 m (hammer bouncing) (Elev. 257.0 m).																

PROJECT		09-1191-0042		RECORD OF BOREHOLE No BH09-04		1 OF 1 METRIC										
W.P.		5416-06-00		LOCATION		N 5112422.7; E 315673.0										
DIST		HWY 11		BOREHOLE TYPE		108 mm I.D. Continuous Flight, Hollow Stem Augers										
DATUM		Geodetic		DATE		May 6, 2010										
						ORIGINATED BY EHS										
						COMPILED BY AMW										
						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			W _p	W
262.0	GROUND SURFACE															
0.0	Sand to gravelly sand, some silt (FILL) Compact Brown Moist		1	SS	15											
			2	SS	26											
			3	SS	16											
	Becoming wet below 2.2 m depth.		4a	SS	9											
259.3			4b													
2.7	Sandy SILT to Silty SAND, some clay, trace to some gravel Loose to compact Grey Wet		5	SS	14											
			6	SS	15/0.25											
257.8																
4.2	END OF BOREHOLE SPOON AND AUGER REFUSAL Note: 1. Water level at a depth of 2.2 m below ground surface (Elev. 259.8 m) upon completion of drilling. 2. Advanced DCPT 1 m north of Borehole BH09-04. Refusal at a depth of 4.6 m (hammer bouncing).															

PROJECT 09-1191-0042				RECORD OF BOREHOLE No BH09-15				1 OF 1 METRIC						
W.P. 5416-06-00				LOCATION N 5112420.0; E 315689.9				ORIGINATED BY ID						
DIST HWY 11				BOREHOLE TYPE 108 mm I.D. Continuous Flight, Hollow Stem Augers				COMPILED BY AMW						
DATUM Geodetic				DATE May 17, 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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
259.6	GROUND SURFACE													
0.0	Gravelly sand (FILL)													
0.2	Brown Moist		1	SS	3									
258.8	ORGANIC SILT													
0.8	Soft Grey Moist		2	SS	19									
	Gravelly SAND, some silt													
	Compact to dense													
	Brown Wet		3	SS	24									
			4	SS	31									
256.6	END OF BOREHOLE AUGER REFUSAL													
3.0	<p>Note:</p> <p>1. Water level at a depth of 0.5 m below ground surface (Elev. 259.1 m) upon completion of drilling.</p> <p>2. Advanced DCPT 1 m south of Borehole BH09-15. Refusal at a depth of 3.0 m (hammer bouncing).</p> <p>3. Borehole advanced on north side of creek on May 17, 2010; water surface at Elev. 259.6 m. On November 16, 2010 returned to site to probe bottom of creek (water surface elevation was not surveyed on return visit). Creek bed measured at about 0.2 m below water surface and probed to firm bottom at about 0.6 m below water surface.</p>													

PROJECT		RECORD OF BOREHOLE				No BH09-16		1 OF 1		METRIC																																																																																																																																																																																																																						
W.P.		LOCATION				ORIGINATED BY		ID																																																																																																																																																																																																																								
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DATUM		DATE				CHECKED BY		AB																																																																																																																																																																																																																								
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Geodetic		May 17, 2010																																																																																																																																																																																																																														
<table border="1" style="width:100%; border-collapse: collapse;"> <thead> <tr> <th colspan="3">SOIL PROFILE</th> <th colspan="3">SAMPLES</th> <th rowspan="2">GROUND WATER CONDITIONS</th> <th rowspan="2">ELEVATION SCALE</th> <th colspan="5">DYNAMIC CONE PENETRATION RESISTANCE PLOT</th> <th colspan="3">PLASTIC LIMIT NATURAL MOISTURE CONTENT</th> <th rowspan="2">LIQUID LIMIT</th> <th rowspan="2">UNIT WEIGHT γ kN/m³</th> <th rowspan="2">REMARKS & GRAIN SIZE DISTRIBUTION (%)</th> </tr> <tr> <th>ELEV DEPTH</th> <th>DESCRIPTION</th> <th>STRAT PLOT</th> <th>NUMBER</th> <th>TYPE</th> <th>"N" VALUES</th> <th>20</th> <th>40</th> <th>60</th> <th>80</th> <th>100</th> <th>W_p</th> <th>W</th> <th>W_L</th> </tr> </thead> <tbody> <tr> <td>259.6</td> <td>GROUND SURFACE</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>0.0</td> <td>PEAT Very soft Black Wet</td> <td></td> <td>1a</td> <td>SS</td> <td>1</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>259.1</td> <td></td> <td></td> <td>1b</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>0.5</td> <td>SAND and GRAVEL, with organics Very loose Grey Wet</td> <td></td> <td>1</td> <td>RC</td> <td>REC 100%</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>RQD = 90%</td> </tr> <tr> <td></td> <td>GNEISS (BEDROCK)</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td>Bedrock cored from 0.5 m depth to 3.0 m depth.</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td>For coring details see Record of Drillhole BH09-16.</td> <td></td> <td>2</td> <td>RC</td> <td>REC 100%</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>RQD = 100%</td> </tr> <tr> <td>256.6</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>3.0</td> <td>END OF BOREHOLE</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td colspan="18"> <p>Note:</p> <p>1. Water level at a depth of 0.2 m below ground surface (Elev. 259.4 m) upon completion of drilling.</p> <p>2. Advanced DCPT 1 m north of Borehole BH09-16. Refusal at a depth of 0.5 m (hammer bouncing).</p> <p>3. Borehole advanced on south side of creek on May 17, 2010; water surface at Elev. 259.6 m. On November 16, 2010 returned to site to probe bottom of creek (water surface elevation was not surveyed on return visit). Creek bed measured at about 0.2 m below water surface and probed to firm bottom at about 0.4 m below water surface.</p> </td> </tr> </tbody> </table>												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	20	40	60	80	100	W _p	W	W _L	259.6	GROUND SURFACE																	0.0	PEAT Very soft Black Wet		1a	SS	1													259.1			1b															0.5	SAND and GRAVEL, with organics Very loose Grey Wet		1	RC	REC 100%												RQD = 90%		GNEISS (BEDROCK)																		Bedrock cored from 0.5 m depth to 3.0 m depth.																		For coring details see Record of Drillhole BH09-16.		2	RC	REC 100%												RQD = 100%	256.6																		3.0	END OF BOREHOLE																	<p>Note:</p> <p>1. Water level at a depth of 0.2 m below ground surface (Elev. 259.4 m) upon completion of drilling.</p> <p>2. Advanced DCPT 1 m north of Borehole BH09-16. Refusal at a depth of 0.5 m (hammer bouncing).</p> <p>3. Borehole advanced on south side of creek on May 17, 2010; water surface at Elev. 259.6 m. On November 16, 2010 returned to site to probe bottom of creek (water surface elevation was not surveyed on return visit). Creek bed measured at about 0.2 m below water surface and probed to firm bottom at about 0.4 m below water surface.</p>																	
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PROJECT: 09-1191-0042

RECORD OF DRILLHOLE: BH09-16

SHEET 1 OF 1

LOCATION: N 5112416.1 ;E 315662.7

DRILLING DATE: May 17, 2010

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: D-50 Turbo

DRILLING CONTRACTOR: Walker Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	COLOUR % RETURN	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY				Diametral Point Load Index (MPa)	RMC -Q AVG	NOTES WATER LEVELS INSTRUMENTATION
								TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	k, cm/s				
		Refer to Previous Page		259.1 0.5																		
1	NQ Coring May 17, 2010	GNEISS Fine to medium grained Pinkish grey Slightly weathered to fresh Joints are undulating and rough			1																	
2					2																	
3		END OF DRILLHOLE		256.6 3.0																		
4																						
5																						
6																						
7																						
8																						
9																						
10																						

DEPTH SCALE

1 : 50



LOGGED: ID

CHECKED: AB

SUD-RCK 09-1191-0042-4000.GPJ GAL-MISS.GDT 16/11/11 DATA INPUT:



APPENDIX B

Laboratory Test Results



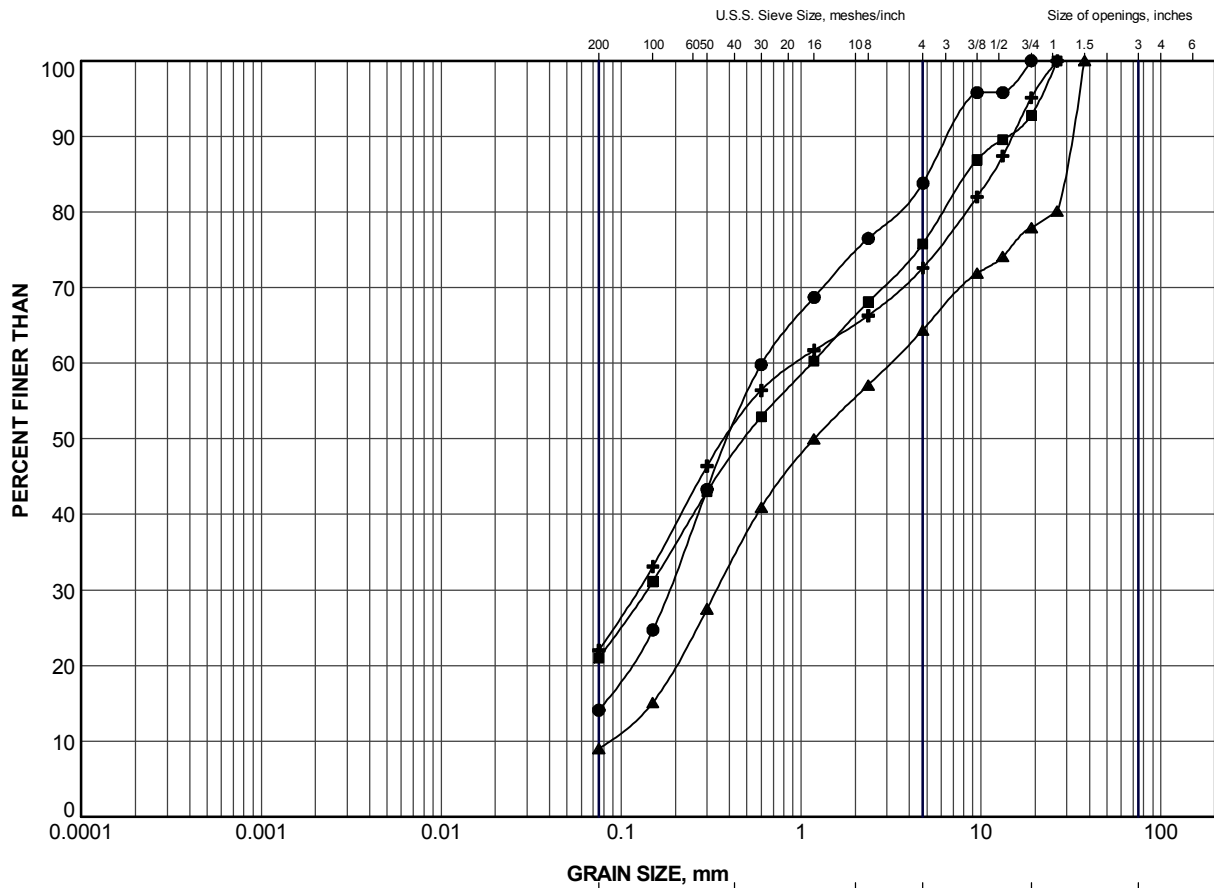
FOUNDATION REPORT - HIGHWAY 11 NBL STA 11+873 CULVERT REPLACEMENT

Table B-1 - Summary of Analytical Testing of Creek Water

Parameter	Units	Method Detection Limit	Result
Chloride	mg/L	0.2	439
Sulphate	mg/L	1	6
Conductivity	$\mu\text{S/cm}$	1	1650
Resistivity	Mohm-cm	n/a	0.0006
pH	n/a	n/a	7.53

Notes: 1. Samples obtained May 17, 2010.
2. Analytical testing carried out by Testmark Laboratory Ltd.


Compiled by: AB
Checked by: LG

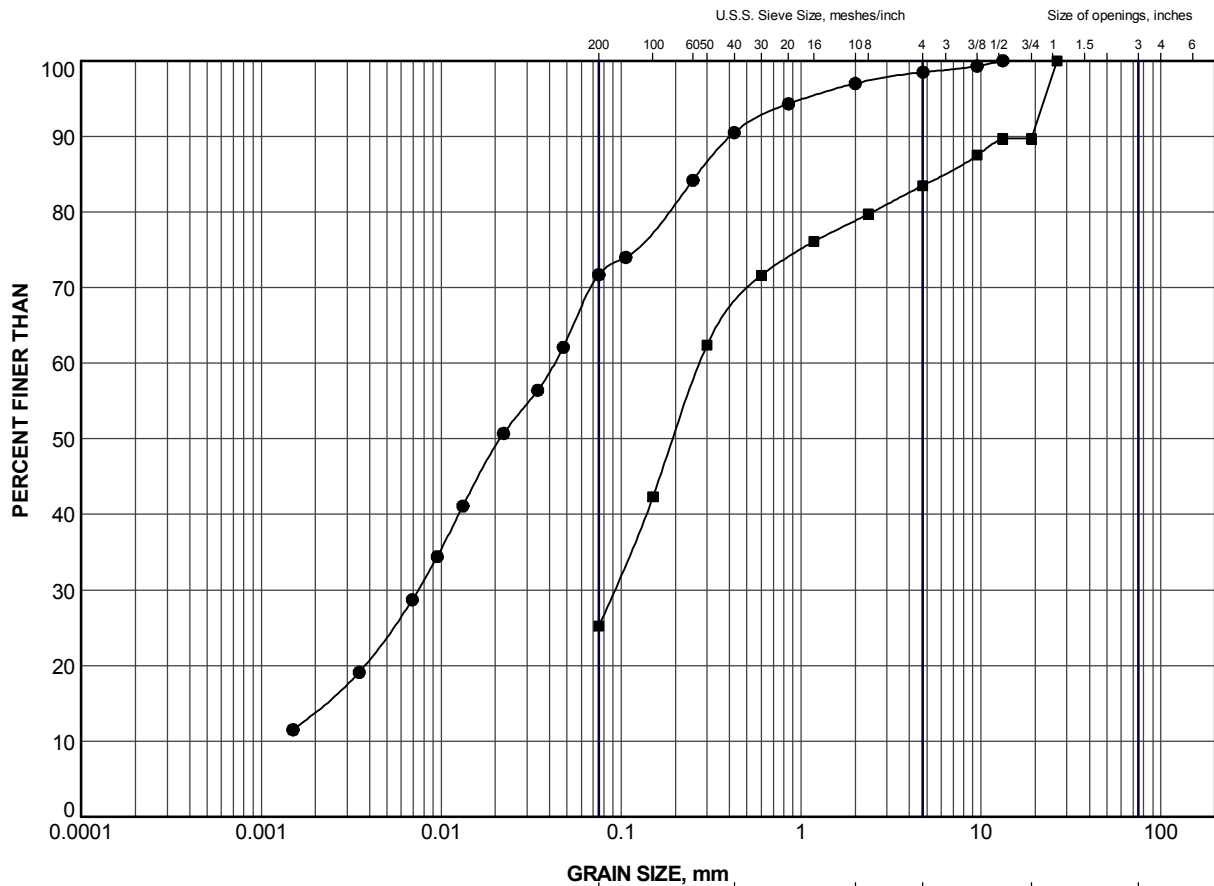


CLAY AND SILT	SAND SIZE, mm						Cobble Size
	fine	medium	coarse	fine	coarse		
	SAND SIZE			GRAVEL SIZE			

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BH09-02	3	260.3
■	BH09-02	5	258.7
▲	BH09-02	7	257.2
+	BH09-04	4a	259.5


PROJECT				
HIGHWAY 11 NBL CULVERT 11+873				
TITLE				
GRAIN SIZE DISTRIBUTION				
SAND TO GRAVELLY SAND (FILL)				
PROJECT No.		09-1191-0042		FILE No. 09-1191-0042-4000.GPJ
DRAWN	JJL	Nov 2011	SCALE	N/A
CHECK	AB	Nov 2011	REV.	
APPR	JMAC	Nov 2011		
				FIGURE B-1

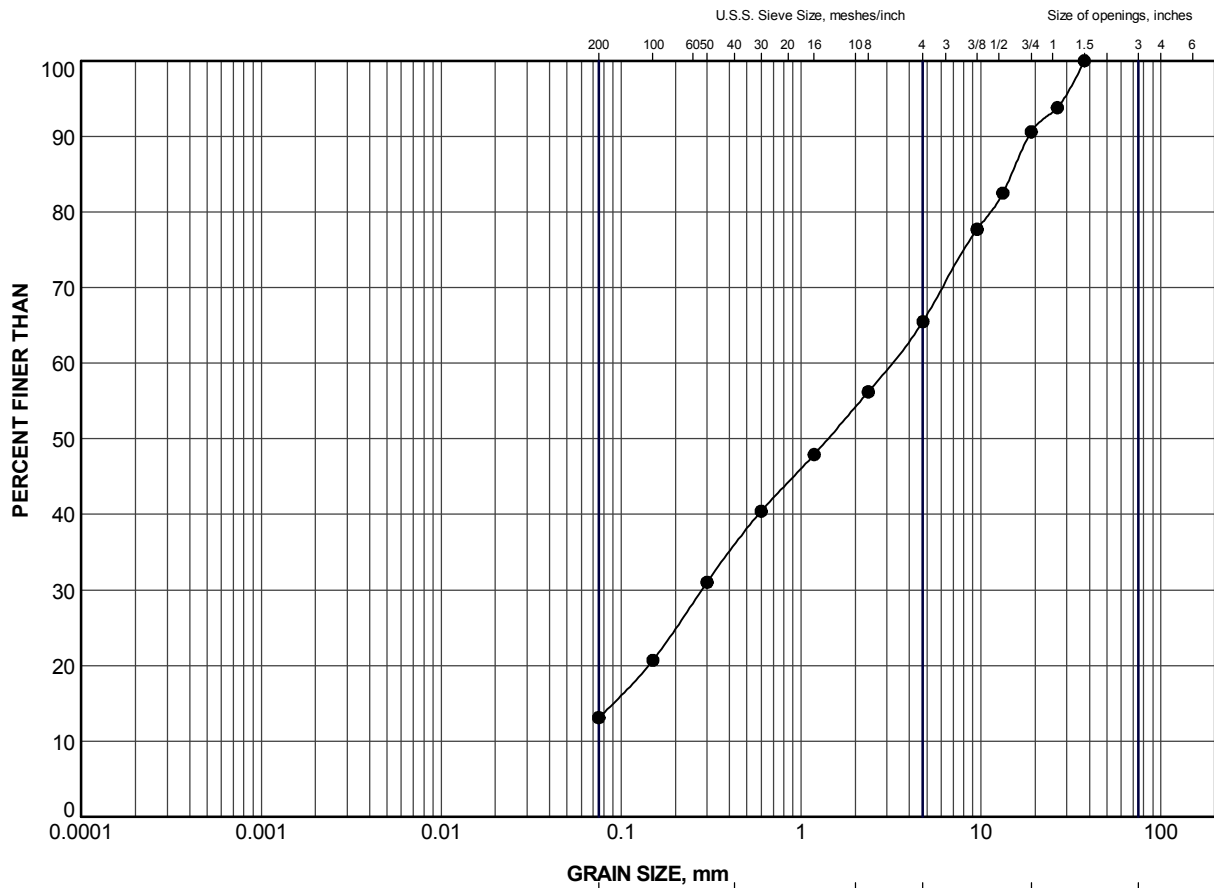


CLAY AND SILT		SAND SIZE, mm			GRAVEL SIZE, mm		Cobble Size
		fine	medium	coarse	fine	coarse	
		SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BH09-04	4b	259.2
■	BH09-04	5	258.6


PROJECT				
HIGHWAY 11 NBL CULVERT 11+873				
TITLE				
GRAIN SIZE DISTRIBUTION				
SANDY SILT TO SILTY SAND				
PROJECT No.		09-1191-0042		FILE No. 09-1191-0042-4000.GPJ
DRAWN	JJL	Nov 2011	SCALE	N/A
CHECK	AB	Nov 2011	REV.	
APPR	JMAC	Nov 2011		
				FIGURE B-2



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BH09-15	4	257.0

PROJECT				
HIGHWAY 11 NBL CULVERT 11+873				
TITLE				
GRAIN SIZE DISTRIBUTION				
GRAVELLY SAND				
		PROJECT No. 09-1191-0042		FILE No. 09-1191-0042-4000.GPJ
		DRAWN	JJL	Nov 2011
		CHECK	AB	Nov 2011
		APPR	JMAC	Nov 2011
		SCALE		N/A
		REV.		
FIGURE B-3				

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.

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Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

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