



December 14, 2011

FOUNDATION INVESTIGATION REPORT

**SUCKER CREEK SBL BRIDGE, SITE 44-447/2
HIGHWAY 69 FOUR-LANING FROM 0.4 KM NORTH OF HIGHWAY 7182
(SHEBESHEKONG ROAD) NORTHERLY 11 KM
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5005-08-00, WP 5194-06-01**

Submitted to:
MMM Group
100 Commerce Valley Drive West
Thornhill, Ontario
L3T 0A1



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Distribution:

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REPORT





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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by MMM Group (MMM) on behalf of Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the proposed Highway 69 southbound lane (SBL) bridge crossing Sucker Creek. This project is part of the detail design for the four-laning of Highway 69 from 0.4 km north of Highway 7182 (Shebeshekong Road) northerly for 11 km. The general location of this section of the Highway 69 four-laning alignment is shown on the Key Plan on the Contract Drawing.

This report addresses the investigation carried out for the Highway 69 SBL bridge structure crossing Sucker Creek and the associated approach embankments. Separate reports detail the foundation investigations for the related NBL bridge structure, swamp and pond crossings, culverts and other bridge structures for the project.

The purpose of this investigation is to establish the subsurface conditions at the proposed structure location, including the associated approach embankments, by borehole drilling, rock coring and laboratory testing on selected soil and rock core samples. The investigated areas are shown on the Contract Drawing.

2.0 SITE DESCRIPTION

The proposed SBL bridge crossing Sucker Creek is a 97 m long 3-span structure, located in the Township of Harrison along the new Highway 69 alignment, about 1.5 km south of Highway 529 and about 400 m east of the existing Highway 69 alignment. The proposed grade at the new Highway 69 south and north approach embankments will be at about Elevation 201 m and 203 m, respectively, which is up to about 9 m above the existing ground surface at the south approach and about 16 m above the existing ground surface at the north approach.

In general, the topography in the area of the overall project limits consists of rolling terrain including densely treed areas and numerous bedrock outcrops separated by low-lying swamps. At the crossing location, Sucker Creek is about 15 m wide, situated in a valley more than 100 m wide. The ground surface at the borehole locations within the limits of the proposed structure and approach embankment areas is between Elevation 183.6 m and Elevation 192.6 m.

3.0 INVESTIGATION PROCEDURES

The fieldwork for the investigation at the location of the proposed structure was carried out in two stages and included the drilling of a total of fifteen (15) boreholes and one (1) Dynamic Cone Penetration Test (DCPT) at approximately the locations shown on the Contract Drawing. The field investigation was carried out as follows:



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- Between February 10 and February 24, 2009, the following boreholes and DCPT were advanced using a track mounted CME-55 supplied and operated by Landcore Drilling Ltd. (Landcore) of Sudbury, Ontario:
 - Five (5) boreholes at the south abutment (Boreholes B5-1 to B5-5);
 - One (1) borehole at the south pier (Borehole B5-6);
 - One (1) borehole at the north pier (Borehole B5-7);
 - Two (2) boreholes and one (1) DCPT at the north abutment (Boreholes B5-10 and B5-11 and DCPT B5-DC1); and
 - One (1) borehole for each of the south and north approach embankments (Boreholes B5-13 and B5-14, respectively).
- On March 16 and March 17, 2009, four (4) boreholes (Boreholes B5-6a to B5-6d) were drilled at the south pier using portable equipment, supplied and operated by OGS Inc. (OGS) of Ottawa, Ontario.

The boreholes were advanced using 108 mm inside diameter (I.D.) continuous flight hollow stem augers, 'NW' casing and wash boring or portable equipment using 'BW' or 'NW' casing and wash boring. Soil samples were obtained, where possible, at intervals of depth of 0.75 m to 1.5 m, using a 50 mm outer diameter (O.D.) split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586). Rock core samples were obtained in 'NQ' size using either an 'NQ'-size core barrel or a thin-walled core barrel which fits inside 'BW' casing. The groundwater conditions in the open boreholes were observed during the drilling operations. All boreholes were backfilled with bentonite upon completion in accordance with Ontario Regulation (O.Reg.) 903 (as amended).

The boreholes were advanced to auger/split-spoon refusal or cored into the bedrock, to depths ranging from 0.1 m to 21.8 m below existing ground surface or casing and included coring bedrock for lengths of between 2.9 m and 3.9 m in Boreholes B5-1, B5-3, B5-5, B5-6, B5-6b, B5-6c, B5-7 and B5-10.

A piezometer was installed in Borehole B5-11 to permit monitoring of the groundwater level at this location. The piezometer consists of 51 mm diameter PVC pipe, with a 1.5 m long slotted screen sealed at a selected depth within the borehole. The borehole annulus surrounding the piezometer screen was backfilled to Elevation 186.2 m with sand and sand cuttings from the borehole and a bentonite seal was installed between Elevation 186.2 m and 187.1 m. The piezometer was abandoned in accordance with Ontario Regulation 903 on March 3, 2009. The piezometer installation details and water level readings are described on the Record of Borehole sheets in Appendix A. The fieldwork was supervised throughout by members of our engineering and technical staff who: located the boreholes based on the survey carried out by MMM; 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 rock 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 samples. A consolidated drained direct shear test was performed on a sample of the sand from Borehole B507 for determination of the effective angle of internal friction (ϕ'). Strength testing (uniaxial compression and point load index) was also carried out on selected specimens of the rock core.



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The centreline of Highway 69 was surveyed and staked in the field by MMM in September 2009, and the borehole locations were staked by MMM in December 2008, and February 2009. Where boreholes were relocated from the original staked locations, Golder resurveyed and located the new borehole relative to MMM's stakes. The borehole locations shown on the Contract Drawing and summarized below are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum.

Borehole	Location (m)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
B5-1	5051523.5	236836.8	192.2	4.7
B5-2	5051528.4	236835.7	191.5	0.7
B5-3	5051524.8	236831.4	191.5	5.0
B5-4	5051521.3	236827.0	190.4	1.1
B5-5	5051526.2	236825.9	190.5	5.2
B5-6	5051554.1	236824.8	185.2	3.8
B5-6a	5051550.6	236820.5	185.0	0
B5-6b	5051555.5	236819.4	183.6	3.4
B5-6c	5051552.8	236830.2	185.9	5.5
B5-6d	5051557.6	236829.1	184.9	2.1
B5-7	5051589.2	236816.9	184.0	21.8
B5-10	5051618.5	236810.3	187.3	20.1
B5-11	5051615.0	236806.0	186.9	14.0
B5-13	5051510.2	236834.7	192.6	0.7
B5-14	5051663.1	236807.1	188.8	2.1
B5-DC1	5051622.0	236814.7	187.8	9.6

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 69 lies within the physiographic region known as the Georgian Bay Fringe which extends along the east side of Georgian Bay through the Parry Sound and Muskoka areas, then eastward from Muskoka in patches into the area north of the Kawartha Lakes.

This part of the Georgian Bay Fringe physiographic region was never submerged during periods of glacial recession. As a result, the surficial soils in this area consist of very shallow deposits of sand, silt and clay overlying metamorphic bedrock and numerous bare knobs and ridges of bedrock are present throughout the area. Localised low-lying swampy areas, containing peat and/or organic soils overlying soft/loose native soils, are present in valleys between the bedrock knobs and ridges.

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.



The bedrock in the area consists typically of gneisses of the Britt Domain of the Central Gneiss Belt, a subdivision of the Grenville Structural Province, as described in Geology of Ontario, OGS Special Volume 4² (OGS, 1991). Deposition of Paleozoic strata initially covered the bedrock and later erosion during glaciation exposed these Precambrian rocks.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions, as encountered in the boreholes advanced during this investigation, together with the results of the laboratory tests carried out on selected soil and rock samples, are presented on the Record of Borehole and Drillhole sheets in Appendix A. The results of the laboratory tests carried out on selected soil and rock samples are presented in Appendix B. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling and observations of drilling progress and the results of SPT. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. It should be noted that the interpreted stratigraphy shown on the Contract Drawings is a simplification of the subsurface conditions. Variation in the stratigraphic boundaries between boreholes will exist and is to be expected.

In general, on the south side of the creek, a surficial layer of topsoil or fill materials is underlain by thin deposits of sandy silt to silty sand or silty clay, underlain by bedrock at shallow depths. On the north side of the creek, a surficial layer of topsoil is underlain by deposits of sand and sand and gravel. The total thickness of overburden is variable at the site, ranging from approximately 0 m to 2.1 m on the south side of the creek and from approximately 2.1 m to 18.7 m on the north side of the creek.

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

4.2.1 Fill

In Boreholes B5-5, B5-6c and B5-6d, a deposit of moist to wet, brown fill consisting of sandy organics and/or sand and gravel was encountered at ground surface. The surface of the fill was encountered between Elevation 190.5 m and 184.9 m and the thickness of the fill ranges between 0.5 m and 2.1 m.

4.2.2 Organics/Topsoil

A deposit of moist, brown organics or topsoil was encountered at ground surface at all the boreholes except B5-6b to B5-6d. The top of the organics layers were encountered between Elevation 192.6 m and 184.0 m and the thickness of the deposit ranges between 0.1 m and 0.8 m. The topsoil in Borehole B5-6 was noted to contain cobbles and boulders.

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



4.2.3 Sandy Silt to Silty Sand

A deposit of moist to wet, brown sandy silt to silty sand was encountered below the topsoil in Boreholes B5-1 to B5-5. The surface of the deposit was encountered between Elevation 192.0 m and 189.7 m and ranges in thickness from 0.5 m to 1.4 m. The deposit was noted to contain cobbles in Borehole B5-5 below a depth of 1.6 m.

The measured SPT 'N'-values within the sandy silt to silty sand range between 2 and 30 blows per 0.3 m of penetration, with a value of 19 blows per 0.1 m of penetration, indicating a very loose to compact relative density.

4.2.4 Silty Clay

A stratum of moist, brown silty clay was encountered below the topsoil in Borehole B5-13. The surface of this layer was encountered at Elevation 192.4 m, and its thickness is 0.5 m.

A measured SPT 'N'-value at the base of the stratum is 6 blows per 0.15 m of penetration, suggesting a stiff consistency.

An Atterberg limits test carried out on the sample of the silty clay yielded a liquid limit of 39 percent, a plastic limit of 24 percent and a plasticity index of 15 percent. The results of the Atterberg limits testing are shown on the plasticity chart on Figure B-1 in Appendix B and indicate that the material is a silty clay of intermediate plasticity.

The natural moisture content of the sample is 36 percent.

4.2.5 Sand to Gravelly Sand

On the south side of the creek, a deposit of moist, brown gravelly sand was encountered below the topsoil in Borehole B5-3. On the north side of the creek, a deposit of moist to wet, brown to grey sand, trace to some gravel, trace to some silt was encountered below the organics/topsoil in Boreholes B5-7, B5-10, B5-11 and B5-14. The deposit contained occasional cobbles in Borehole B5-7 and cobbles and boulders in Borehole B5-10. On the south side of the creek, the gravelly sand deposit was encountered at Elevation 190.5 m and the thickness is 1.1 m. On the north side of the creek, the surface of the deposit was encountered between Elevation 188.6 m and 183.8 m and the thickness of the deposit ranges between 1.9 m and 11.4 m.

The measured SPT 'N'-values within the sand/gravelly sand deposit range between 0 blows (i.e. weight of hammer) and greater than 100 blows per 0.3 m of penetration. Typically, the 'N'-values range between 11 and 26 blows per 0.3 m of penetration, indicating a compact relative density, and the presence of very loose or very dense layers.

The grain size distributions of eleven samples of the sand/gravelly sand deposit are shown on Figure B-2.

The natural water content measured on samples of the deposit range between 2 percent and 27 percent.



A laboratory consolidated drained direct shear (DS) test was carried out on one selected sample of the sand deposit from Borehole B5-7. The detailed test results are shown on Figure B-3 in Appendix B and the results are summarized below.

Borehole/Sample Number	Depth / Elevation (m)	Effective Cohesion Intercept, c' (kPa)	Effective Angle of Internal Friction, ϕ' (degrees)
B5-7/6	4.1/179.9	0	37

Note: The assessed shear strength parameters are only valid over the range of stress conditions employed in the direct shear test.

Heaving sands were noted in several boreholes despite a full head of water being maintained inside the augers/casing. Lower SPT 'N'-values were typically recorded below the elevation where heaving sands were encountered, typically between depths of about 3.6 m and 10.7 m.

Difficult casing/auger advancement was noted near the base of the deposit in Boreholes B5-7 and B5-10, inferred to be due to the presence of gravelly material or cobbles and boulders.

4.2.6 Sand and Gravel

In Boreholes B5-7, B5-10 and B5-11, a deposit of wet, brown or grey, sand and gravel, containing cobbles and boulders was encountered below the sand to gravelly sand deposit. The surface of the deposit was encountered between Elevations 176.4 m and 172.4 m and the thickness of the deposit ranges between 3.5 m and 7.1 m.

The measured SPT 'N'-values within the sand and gravel deposit range between 71 blows per 0.3 m of penetration and 20 blows per 0.3 m of penetration, indicating a very dense relative density, and essentially refusal to split-spoon advancement at several sample depths in Borehole B5-7.

A grain size distribution test was carried out on one sample of the sand and gravel deposit in Borehole B5-10 and the results are shown on Figure B-4.

The natural moisture content of one sample of the deposit is 15 percent.

4.2.7 Refusal/Bedrock

Bedrock was encountered and cored in Boreholes B5-1, B5-3, B5-5, B5-6, B5-6b, B5-6c, B5-7 and B5-10. The bedrock surface was inferred from refusal to further auger, casing or split-spoon advancement or dynamic cone penetration in Boreholes B5-2, B5-4, B5-6a, B5-6d, B5-11, B5-13, B5-14 and DCPT B5-DC1. The bedrock surface (inferred or actual) was encountered in the boreholes at depths ranging from ground surface to 18.7 m below ground surface, ranging from Elevation 191.9 m and 165.3 m, as presented in Table B-1.



Based on a review of the bedrock core samples, the bedrock at the site consists of gneiss and the core samples are described as reddish brown or pinkish grey to grey, fine to coarse grained and fresh to slightly weathered, except in Borehole B5 7 where the bedrock is a mafic intrusive, and the core samples are greenish grey, fine to medium grained and moderately weathered.

The Total Core Recovery (TCR) is 100 percent for all core samples, except for Run No. 2 in Borehole B5-10 which had a TCR of 91 percent. The Rock Quality Designation (RQD) measured on the core samples typically ranges from about 65 percent to 100 percent, indicating a rock mass of fair to excellent quality. The uppermost core sample in Borehole B5-6c measured a RQD value of 45 percent and the lowermost core sample in Boreholes B5-7 measured a RQD value of 24, indicating a rock mass of very poor to poor quality. The RQD typically increased with depth. The Solid Core Recovery (SCR) typically ranges from 50 percent to 100 percent, typically increasing with depth. The uppermost core samples in Boreholes B5-6b and B5 6c measured a SCR value of 48 percent and 45 percent, respectively. The lowermost core sample in Boreholes B5-7 measured a SCR value of 24 percent.

Laboratory Uniaxial Compressive Strength (UCS) testing was carried out on seven core samples of the bedrock. The UCS ranges from about 81 MPa to 123 MPa for the gneiss bedrock indicating strong to very strong rock, as summarized in Table B-2.

Point load strength tests were carried out on selected core samples of the bedrock. Diametral point load strength index values are shown on the Record of Drillhole sheets and are summarized in Table B-3 in Appendix B. The diametral point load index (I_{s50}) results from the laboratory tests carried out on core samples range from about 2 MPa to 8 MPa for the gneiss bedrock. These index values correspond to estimated UCS values between 48 MPa and 178 MPa, based on a relationship between I_{s50} and UCS which is given by a correlation factor (K) in accordance with ASTM D5731-08 and varies depending on the size of the core samples and the strength of the rock. For this site, these UCS values are based on an estimated average correlation factor (K) of 22 for the gneiss, which was calculated based on a comparison of the UCS test results and the point load strength test results. These values have been given for comparison only and should be interpreted together with the results of the UCS tests.

Based on the laboratory UCS tests and the point load strength test results, in accordance with Table 3.5 in CFEM (2006)³, the gneiss is medium strong (R3, 25 MPa < UCS < 50 MA) to very strong (R5, 100 MPa < UCS < 250 MPa).

4.2.8 Groundwater Conditions

The water levels in the boreholes were noted immediately after the drilling operations. In general, the soil samples taken in the boreholes were noted to be moist to wet. Where bedrock either was exposed or was encountered at shallow depth below ground surface, the open boreholes were dry. The water level measured in Borehole B5-5, B5-6d, B5 7, B5-10 and B5-11 is at depths ranging between 0.9 m to 5.5 m below ground surface, between Elevation 189.0 m and 181.8 m.

³ Canadian Geotechnical Society, 2006. Canadian Foundation Engineering Manual, 4th Edition.



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A standpipe piezometer was installed in Borehole B5-11 to permit monitoring of the water level at this site. Details of the piezometer installations are shown in the Record of Borehole sheets in Appendix A. The groundwater level measured in the piezometer installation is summarised below.

Foundation Element	Borehole No.	Ground Surface Elevation (m)	Groundwater Elevation (m)	Date of Measurement
North Abutment	B5-11	186.9	182.3	March 3, 2009

It should be noted that groundwater levels in the area are subject to seasonal fluctuations and precipitation events.

5.0 CLOSURE

The field personnel supervising the drilling program were Mr. Ed Savard and Mr. Trevor Moxam. This report was prepared by Mr. Adam Wissink, EIT and 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.

**FOUNDATION REPORT - SUCKER CREEK SBL BRIDGE
HIGHWAY 69, GWP 5005-08-00, WP 5194-06-01**

Report Signature Page

GOLDER ASSOCIATES LTD.



André Bom, P.Eng.
Geotechnical Engineer

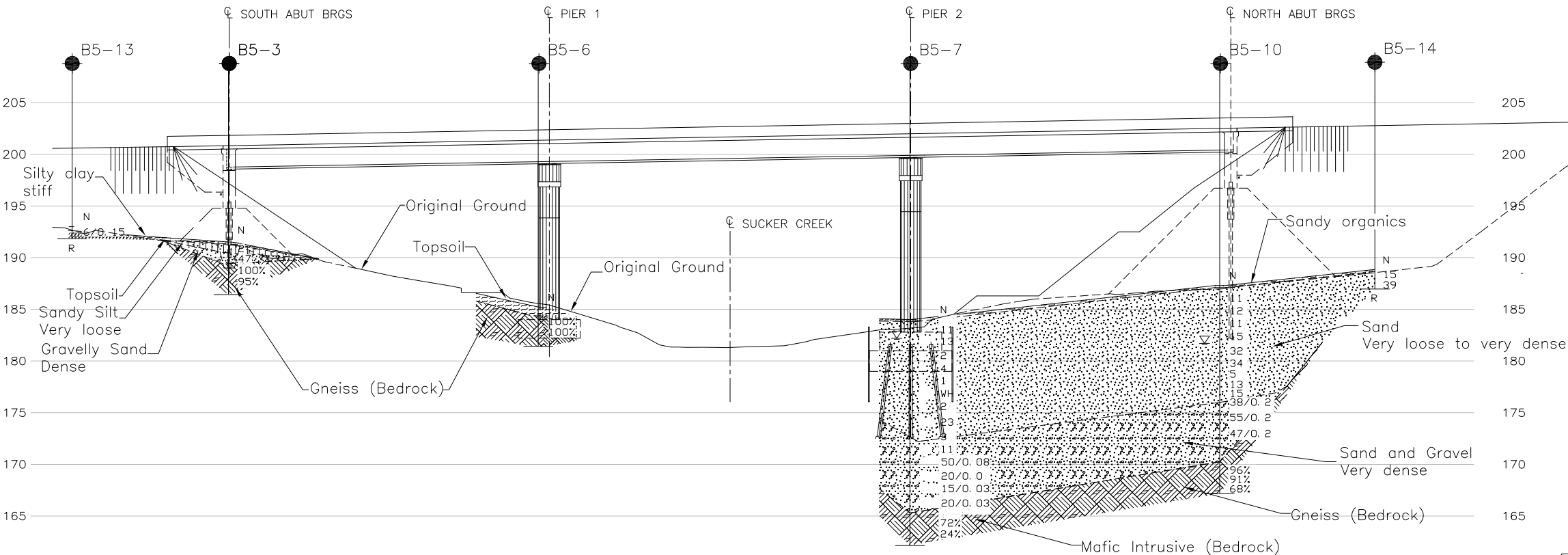
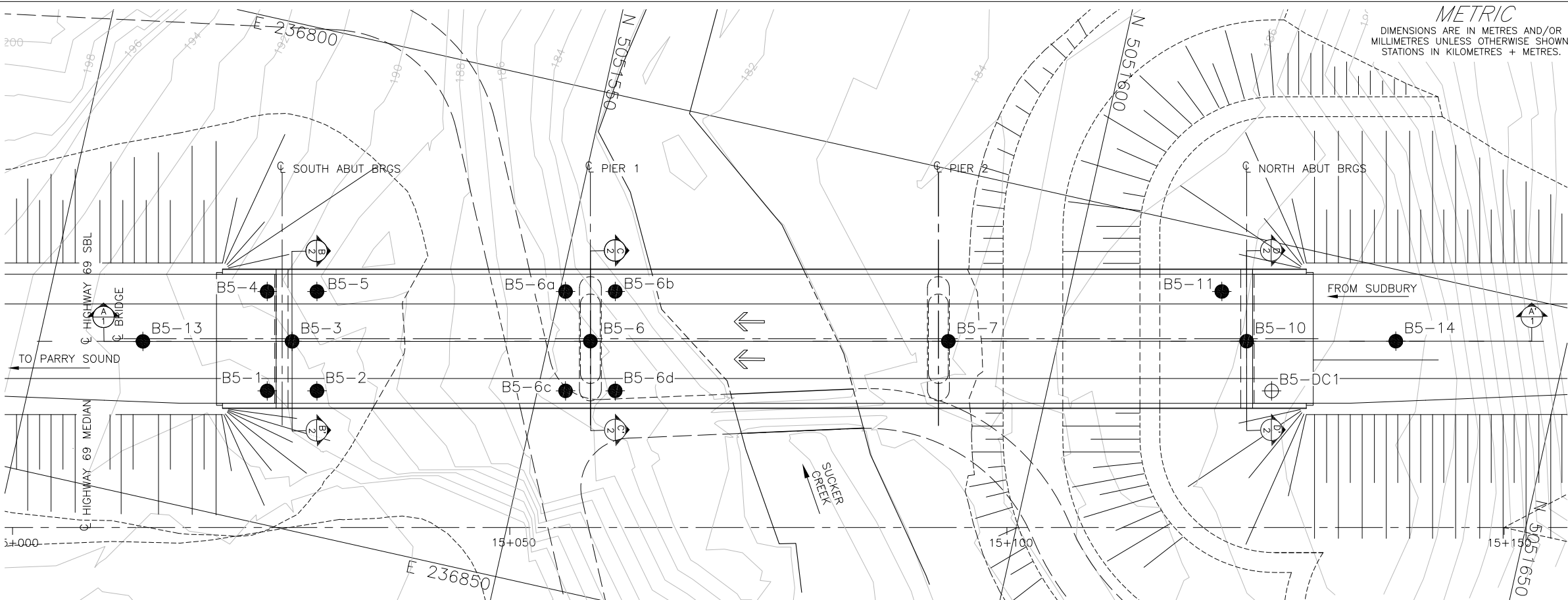


Jorge M. A. Costa, P.Eng.
Designated MTO Contact, Principal

AW/AB/JMAC/lb/cl

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

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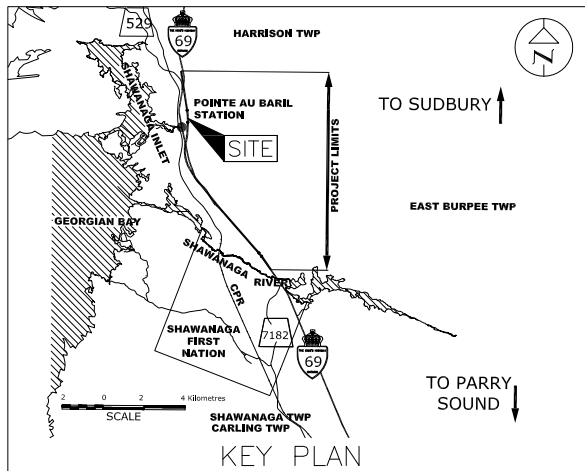


HIGHWAY 69
SUCKER CREEK (SBL)
BOREHOLE LOCATIONS
AND SOIL STRATA

SHEET



Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA



LEGEND

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

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
B5-1	192.2	5051523.5	236836.8
B5-2	191.5	5051528.4	236835.7
B5-3	191.5	5051524.8	236831.4
B5-4	190.4	5051521.3	236827.0
B5-5	190.5	5051526.2	236825.9
B5-6	185.2	5051554.1	236824.8
B5-6a	185.0	5051550.6	236820.5
B5-6b	183.6	5051555.5	236819.4
B5-6c	185.9	5051552.8	236830.2
B5-6d	184.9	5051557.6	236829.1
B5-7	184.0	5051589.2	236816.9
B5-10	187.3	5051618.5	236810.3
B5-11	186.9	5051615.0	236806.0
B5-13	192.6	5051510.2	236834.7
B5-14	188.8	5051633.1	236807.1
B5-DC1	187.8	5051622.0	236814.7

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 MMM, drawing file nos. 44_447-2_01-GENERAL ARRANGEMENT INTEGRAL (31m), received August 18, 2011



CENTRELINE PROFILE

HIGHWAY 69 SBL

SCALE

5 0 5 10 m



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 07-1191-0020			RECORD OF BOREHOLE No B5- 1			1 OF 1 METRIC											
W.P. 5194-06-01			LOCATION N 5051523.5; E 236836.8			ORIGINATED BY EHS											
DIST _____ HWY 69			BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers			COMPILED BY AMW											
DATUM Geodetic			DATE February 11, 2009			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 (%)			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
							20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100			
192.2	GROUND SURFACE																
0.0	Silty TOPSOIL																
0.2	Brown Moist																
	Sandy SILT to Silty SAND																
	Compact to dense																
	Brown																
	Moist																
190.6			1	SS	30												
1.6	GNEISS (BEDROCK)																
	Bedrock cored from 1.6 m depth to 4.7 m depth.																
	For coring details refer to Record of Drillhole B5-1.																
			1	RC	REC 100%												RQD = 75%
			2	RC	REC 100%												RQD = 99%
187.5	End of Borehole																
4.7	Note: 1. Borehole dry upon completion of drilling.																

SUD-MTO 001 07-1191-0020 B5 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT: 07-1191-0020

RECORD OF DRILLHOLE: B5- 1

SHEET 1 OF 1

LOCATION: N 5051523.5 ;E 236836.8

DRILLING DATE: February 11, 2009

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	FLUSH	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								
																			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
		Refer to Previous Page		190.6																						
2	02/11/09 NQ Coring	GNEISS Fine to coarse grained Slightly weathered to 2.5 m, fresh below 2.5 m Very strong Pinkish grey		1.6	1																					
3		Numerous joints to 2.5 m depth.																								
4																										
5		End of Drillhole				187.5	4.7																			
6																										
7																										
8																										
9																										
10																										
11																										

DEPTH SCALE

1 : 50



LOGGED: EHS

CHECKED: AB

SUD-RCK 07-1191-0020 B5 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT <u>07-1191-0020</u>		RECORD OF BOREHOLE No B5- 2		1 OF 1 METRIC	
W.P. <u>5194-06-01</u>		LOCATION <u>N 5051528.4; E 236835.7</u>		ORIGINATED BY <u>EHS</u>	
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers</u>		COMPILED BY <u>AMW</u>	
DATUM <u>Geodetic</u>		DATE <u>February 11, 2009</u>		CHECKED BY <u>AB</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%) w _p w w _L				
191.5	GROUND SURFACE							20	40	60	80	100					
0.0	Silty TOPSOIL																
0.2	Brown Moist		1	AS	-												
190.8	Sandy SILT, some clay with rootlets																
0.7	Brown Moist																
	End of Borehole Auger Refusal																
	Note: 1. Borehole dry upon completion of drilling.																

SUD-MTO 001 07-1191-0020 B5 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT <u>07-1191-0020</u>				RECORD OF BOREHOLE No B5- 3				1 OF 1 METRIC									
W.P. <u>5194-06-01</u>				LOCATION <u>N 5051524.8; E 236831.4</u>				ORIGINATED BY <u>EHS</u>									
DIST <u> </u> HWY <u>69</u>				BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers</u>				COMPILED BY <u>AMW</u>									
DATUM <u>Geodetic</u>				DATE <u>February 10, 2009</u>				CHECKED BY <u>AB</u>									
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									
191.5	GROUND SURFACE																
0.0	Silty TOPSOIL																
191.2	Brown																
0.3	Moist																
190.5	Sandy SILT, some clay with rootlets		1	SS	2												
1.0	Very loose																
	Brown																
	Moist																
	Gravelly SAND, some silt		2	SS	47												
	Dense																
	Brown																
	Moist																
189.4	GNEISS (BEDROCK)																
2.1	Bedrock cored from 2.3 m depth to 5.2 m depth.		1	RC	REC 100%												
	For coring details refer to Record of Drillhole B5-3.																
			2	RC	REC 100%												
187																	
186.5	End of Borehole																
5.0	Note: 1. Borehole dry upon completion of drilling. 2. About 0.2 m of snow at BH location.																

SUD-MTO 001 07-1191-0020 B5 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT: 07-1191-0020

RECORD OF DRILLHOLE: B5- 3

SHEET 1 OF 1

LOCATION: N 5051524.8 ;E 236831.4

DRILLING DATE: February 10, 2009

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	FLUSH	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								
																			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
3	02/10/09 NQ Coring	Refer to Previous Page		189.4 2.1	1																	UCS = 111 MPa				
		GNEISS Fine to coarse grained Fresh Very strong Pinkish grey																								
4					2																					
5		End of Drillhole		186.5 5.0																						
6																										
7																										
8																										
9																										
10																										
11																										
12																										

DEPTH SCALE


1 : 50



LOGGED: EHS

CHECKED: AB

SUD-RCK 07-1191-0020 B5 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT <u>07-1191-0020</u>				RECORD OF BOREHOLE No B5- 4				1 OF 1 METRIC									
W.P. <u>5194-06-01</u>				LOCATION <u>N 5051521.3; E 236827.0</u>				ORIGINATED BY <u>EHS</u>									
DIST <u> </u> HWY <u>69</u>				BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers</u>				COMPILED BY <u>AMW</u>									
DATUM <u>Geodetic</u>				DATE <u>February 10, 2009</u>				CHECKED BY <u>AB</u>									
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									
190.4	GROUND SURFACE							20	40	60	80	100					
0.0	Silty TOPSOIL																
0.2	Brown Moist		1	SS	9	190											
	Sandy SILT, some clay, trace gravel																
189.3	Loose Brown Moist		2	SS	19/0.1												
1.1	End of Borehole Spoon and Auger Refusal																
Note: 1. Borehole dry upon completion of drilling. 2. About 0.6 m of snow at BH location.																	

SUD-MTO 001 07-1191-0020 B5 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT 07-1191-0020			RECORD OF BOREHOLE No B5- 5			1 OF 1 METRIC														
W.P. 5194-06-01			LOCATION N 5051526.2; E 236825.9			ORIGINATED BY EHS														
DIST HWY 69			BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers			COMPILED BY AMW														
DATUM Geodetic			DATE February 10, 2009			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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%) W _p — W — W _L			γ	GR	SA	SI	CL
190.5	GROUND SURFACE							20 40 60 80 100												
0.0	Sand and gravel mixed with snow (FILL)																			
190.0							190													
189.7	Silty TOPSOIL																			
0.8	Brown Moist																			
	Sandy SILT to Silty SAND, trace to some clay, trace gravel, containing cobbles below 1.6 m depth		1	SS	4															
	Very loose to loose		2	SS	18/0.18		189													
	Brown Moist to wet																			
188.3	GNEISS (BEDROCK)																			
2.2	Bedrock cored from 2.2 m depth to 5.2 m depth.		1	RC	REC 100%		188													
	For coring details refer to Record of Drillhole B5-5.																			
			2	RC	REC 100%		187													
185.3	End of Borehole																			
5.2																				
	Note: 1. Water level measured at a depth of 1.5 m below ground surface (Elev. 189.0 m) upon completion of drilling.																			

PROJECT: 07-1191-0020

RECORD OF DRILLHOLE: B5- 5

SHEET 1 OF 1

LOCATION: N 5051526.2 ;E 236825.9

DRILLING DATE: February 10, 2009

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	FLUSH												DISCONTINUITY DATA										HYDRAULIC CONDUCTIVITY				Diameter Point Load Index (MPa)	RMC -Q AVG	NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
							RECOVERY		R.Q.D. %	FRACT. INDEX METRES	TYPE AND SURFACE DESCRIPTION				Jr	Ja	Jn	k, cm/s	10 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³	10 ⁻²	10 ⁻¹																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
							TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t CORE AXIS	J, I, R	J, FO, R											J, I, R	J, FO, R	J, I, R	J, FO, R																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
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DEPTH SCALE





1 : 50



LOGGED: EHS

CHECKED: AB

SUD-RCK 07-1191-0020 B5 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT <u>07-1191-0020</u>				RECORD OF BOREHOLE No B5- 6				1 OF 1 METRIC									
W.P. <u>5194-06-01</u>				LOCATION <u>N 5051554.1; E 236824.8</u>				ORIGINATED BY <u>EHS</u>									
DIST <u> </u> HWY <u>69</u>				BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers</u>				COMPILED BY <u>AMW</u>									
DATUM <u>Geodetic</u>				DATE <u>February 11, 2009</u>				CHECKED BY <u>AB</u>									
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									
185.2	GROUND SURFACE							20	40	60	80	100					
0.0	Silty TOPSOIL, containing cobbles and boulders Brown Moist						185										
184.4	GNEISS (BEDROCK)						184										
0.8	Bedrock cored from 0.8 m depth to 3.8 m depth. For coring details refer to Record of Drillhole B5-6.		1	RC	REC 100%		183										RQD = 100%
			2	RC	REC 100%		182										RQD = 100%
181.4	End of Borehole																
3.8	Note: 1. Borehole dry upon completion of drilling.																

SUD-MTO 001 07-1191-0020 B5 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: Landcore Drilling

CHECKED: AB



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

USUD-MTO 001 07-1191-0020 B5 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:



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

USUD-MTO 001 07-1191-0020 B5 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: OGS Inc.

CHECKED: AB

SUD-RCK 07-1191-0020 B5 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT		RECORD OF BOREHOLE				No B5- 6c		1 OF 1		METRIC							
W.P. 07-1191-0020		LOCATION				N 5051552.8; E 236830.2		ORIGINATED BY TDM									
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment, BW Casing, Wash Boring		COMPILED BY AMW									
DATUM Geodetic		DATE		March 17, 2009		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									
185.9	GROUND SURFACE																
0.0	Sandy organics (FILL) Loose Brown Moist		1	SS	7												
185.1																	
0.8	Sand and gravel, trace to some silt (FILL) Dense Brown Moist		2	SS	39												
184.3																	
1.6	GNEISS (BEDROCK)																
	Bedrock cored from 1.6 m depth to 5.5 m depth.		1	RC	REC 100%												RQD = 45%
	For coring details refer to Record of Drillhole B5-6c.		2	RC	REC 100%												RQD = 100%
			3	RC	REC 100%												RQD = 100%
			4	RC	REC 100%												RQD = 100%
180.4	End of Borehole																
5.5	Notes: 1. Borehole dry upon completion of drilling. 2. Borehole located on existing snowmobile trail.																

PROJECT: 07-1191-0020

RECORD OF DRILLHOLE: **B5- 6c**

SHEET 1 OF 1

LOCATION: N 5051552.8 ;E 236830.2

DRILLING DATE: March 17, 2009

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: Portable Equipment

DRILLING CONTRACTOR: OGS Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY k, cm/s				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	10	10				10					
																								JN - Joint	BD - Bedding	PL - Planar	PO - Polished	BR - Broken Rock
																								FLT - Fault	FO - Foliation	CU - Curved	K - Slickensided	
SHR - Shear	CO - Contact	UN - Undulating	SM - Smooth																									
VN - Vein	OR - Orthogonal	ST - Stepped	Ro - Rough																									
CJ - Conjugate	CL - Cleavage	IR - Irregular	MB - Mechanical Break																									
NOTE: For additional abbreviations refer to list of abbreviations & symbols.																												

03/17/09 Thin-Wall N Coring	Refer to Previous Page		184.3																				
	GNEISS Fine to coarse grained Slightly weathered to 2.4 m depth, fresh below 2.4 m Very strong Pinkish grey Broken core between 1.8 and 2.4 m depths.		1.6	1																			
			2	2																			
			3																				
			4	3																			
			5	4																			
End of Drillhole		180.4	5.5																				
6																							
7																							
8																							
9																							
10																							
11																							

DEPTH SCALE

1 : 50



LOGGED: TDM

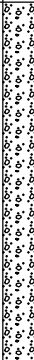

CHECKED: AB

SUD-RCK 07-1191-0020 B5 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT <u>07-1191-0020</u>		RECORD OF BOREHOLE No B5- 6d				1 OF 1 METRIC											
W.P. <u>5194-06-01</u>		LOCATION <u>N 5051557.6; E 236829.1</u>				ORIGINATED BY <u>TDM</u>											
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>Portable Equipment, BW Casing, Wash Boring</u>				COMPILED BY <u>AMW</u>											
DATUM <u>Geodetic</u>		DATE <u>March 17, 2009</u>				CHECKED BY <u>AB</u>											
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)
184.9	GROUND SURFACE						20	40	60	80	100						
0.0	Sand and gravel (FILL), trace silt Compact Brown Moist to wet		1	SS	20	▽											
			2	SS	16												
			3	SS	20												
182.8	End of Borehole Refusal to Further Penetration (Hammer Bouncing)																
2.1	Notes: 1. Water level measured at a depth of 0.9 m below ground surface (Elev. 184.0 m) upon completion of drilling. 2. Borehole located on existing snowmobile trail.																

SUD-MTO 001 07-1191-0020 B5 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

[illegible]

PROJECT <u>07-1191-0020</u>		RECORD OF BOREHOLE No B5- 7				2 OF 2 METRIC											
W.P. <u>5194-06-01</u>		LOCATION <u>N 5051589.2; E 236816.9</u>				ORIGINATED BY <u>EHS</u>											
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring</u>				COMPILED BY <u>AMW</u>											
DATUM <u>Geodetic</u>		DATE <u>February 12, 2009</u>				CHECKED BY <u>AB</u>											
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)
	--- CONTINUED FROM PREVIOUS PAGE ---						<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> ○ UNCONFINED + FIELD VANE </div> <div style="display: flex; justify-content: space-between;"> ● QUICK TRIAXIAL × REMOULDED </div>					<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 10 20 30 </div>					
165.3	SAND and GRAVEL, containing cobbles and boulders Very dense Brown to grey Wet			SS	20/0.03												
				SS	15/0.03												
			13	SS	20/0.03												
18.7	MAFIC INTRUSIVE (BEDROCK) Bedrock cored from 18.7 m depth to 21.8 m depth. For coring details refer to Record of Drillhole B5-7.			1	RC	REC 100%											RQD = 72%
			2	RC	REC 100%												RQD = 24%
162.2 21.8	End of Borehole Note: 1. Water level measured at a depth of 1.8 m below ground surface (Elev. 182.2 m) upon completion of drilling.																

SUD-MTO 001 07-1191-0020 B5 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT: 07-1191-0020

RECORD OF DRILLHOLE: B5- 7

SHEET 1 OF 1

LOCATION: N 5051589.2 ;E 236816.9

DRILLING DATE: February 12, 2009

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	FLUSH	JN - Joint FLT - Fault SHR - Shear VN - Vein CJ - Conjugate										BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage										PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular										PO - Polished K - Slickensided SM - Smooth Ro - Rough MB - Mechanical Break										BR - Broken Rock	NOTE: For additional abbreviations refer to list of abbreviations & symbols.	NOTES WATER LEVELS INSTRUMENTATION
								RECOVERY		R.Q.D. %	FRACT. INDEX 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	k, cm/s	10 ⁻⁵	10 ⁻⁴	10 ⁻³																													
								88 																																										

DEPTH SCALE

1 : 50



LOGGED: EHS

CHECKED: AB

SUD-RCK 07-1191-0020 B5 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT 07-1191-0020			RECORD OF BOREHOLE No B5-10			1 OF 2 METRIC														
W.P. 5194-06-01			LOCATION N 5051618.5; E 236810.3			ORIGINATED BY EHS														
DIST _____ HWY 69			BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring			COMPILED BY AMW														
DATUM Geodetic			DATE February 20, 2009			CHECKED BY AB														
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			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		ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ kN/m³	GR SA SI CL			
							20 40 60 80 100	○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × REMOULDED	W _p	W	W _L	20 40 60 80 100	10 20 30						
187.3	GROUND SURFACE																			
0.0	Silty TOPSOIL																			
0.2	Brown Moist		1	AS	-		187													
	SAND, some silt, trace to some gravel		2	SS	11		186										0 81 19 0			
	Loose to very dense		3	SS	12															
	Brown Moist		4	SS	11		185													
			5	SS	15		184													
			6	SS	32		183										11 80 (9)			
			7	SS	34		182													
	Becoming wet below 5.2 m depth		8	SS	5		181													
			9	SS	13		180													
	Containing cobbles and boulders below 8.2 m depth		10	SS	15		179													
	Approximately 3.0 m of heaving sands at 9.1 m depth. Switched to NW Casing Wash Boring. Tricone used to clean out casing at 9.1 m depth.		11	SS	38/0.2		178										12 77 (11)			
176.0							177													
11.3	SAND and GRAVEL, trace silt, containing cobbles and boulders		12	SS	55/0.2		176													
	Very dense						175													
	Grey						174													
	Wet		13	SS	47/0.2		173													
	Difficulty advancing casing below 12.2 m depth.																			

Continued Next Page

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

SUD-MTO 001 07-1191-0020 B5 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT <u>07-1191-0020</u>		RECORD OF BOREHOLE No B5-10				2 OF 2 METRIC											
W.P. <u>5194-06-01</u>		LOCATION <u>N 5051618.5; E 236810.3</u>				ORIGINATED BY <u>EHS</u>											
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring</u>				COMPILED BY <u>AMW</u>											
DATUM <u>Geodetic</u>		DATE <u>February 20, 2009</u>				CHECKED BY <u>AB</u>											
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)
	--- CONTINUED FROM PREVIOUS PAGE ---																
	SAND and GRAVEL, trace silt, containing cobbles and boulders Very dense Grey Wet		14	RC	-		172										33 64 (3)
170.2							171										
17.1	GNEISS (BEDROCK) Bedrock cored from 17.1 m depth to 20.1 m depth. For coring details refer to Record of Drillhole B5-10.		1	RC	REC 100%		170									RQD = 96%	
			2	RC	REC 91%		169									RQD = 91%	
			3	RC	REC 100%		168									RQD = 68%	
167.2 20.1	End of Borehole Note: 1. Water level measured at a depth of 5.5 m below ground surface (Elev. 181.8 m) upon completion of drilling.																

SUD-MTO 001 07-1191-0020 B5 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT: 07-1191-0020

RECORD OF DRILLHOLE: B5-10

SHEET 1 OF 1

LOCATION: N 5051618.5 ;E 236810.3

DRILLING DATE: February 20, 2009

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	FLUSH	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		170.2 17.1																	
18	02/20/09 NQ Coring	GNEISS Fine to coarse grained Slightly weathered Very strong Reddish Brown			1									J, I, R J, FO, R							
		Broken core from 17.1 to 17.3 m											J, I, R J, ST, R J, I, R J, I, R								
19		Silt seam 75 mm thick at 18.1 m depth			2									J, I, R J, I, R							
											J, I, R J, I, R J, FO, R J, I, R J, FO, R J, I, R J, FO, R J, I, R										
20		Broken core between 19.9 and 20.0 m depths		167.2 20.1										J, FO, R							
		End of Drillhole																			
21																					
22																					
23																					
24																					
25																					
26																					
27																					

DEPTH SCALE

1 : 50



LOGGED: EHS

CHECKED: AB

SUD-RCK 07-1191-0020 B5 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT <u>07-1191-0020</u>			RECORD OF BOREHOLE No B5-11			1 OF 2 METRIC											
W.P. <u>5194-06-01</u>			LOCATION <u>N 5051615.0; E 236806.0</u>			ORIGINATED BY <u>EHS</u>											
DIST <u> </u> HWY <u>69</u>			BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring</u>			COMPILED BY <u>AMW</u>											
DATUM <u>Geodetic</u>			DATE <u>February 23 and 24, 2009</u>			CHECKED BY <u>AB</u>											
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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%) W _p — W — W _L			γ kN/m ³	GR SA SI CL
							20 40 60 80 100	20 40 60 80 100	10 20 30								
186.9	GROUND SURFACE																
0.0	Sandy ORGANICS																
186.6	Brown																
0.3	Moist																
	SAND, trace to some gravel, trace to some silt		1	SS	19		186										6 89 (5)
	Loose to compact		2	SS	18		185										
	Brown		3	SS	26		184										
	Moist		4	SS	20		183										
			5	SS	20		182										
	Becoming wet below 5.1 m depth		6	SS	19		181										
			7	SS	17		180										
			8	SS	8		179										
			9	SS	9		178										
	Approximately 0.6 m heaving sands in augers at 9.1 m and 10.7 m depths						177										
176.4	SAND and GRAVEL, trace to some silt		10	SS	71		176										
10.5	Very dense						175										
	Brown to grey		11	SS	77/0.2		174										
	Wet						173										
	Containing cobbles and boulders below 11.6 m depth.		12	SS	50/0.25												
172.9	Switched to NW Casing, Wash Boring at 13.7 m depth																
14.0																	

SUD-MTO 001 07-1191-0020 B5 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

Continued Next Page

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



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

USUD-MTO 001 07-1191-0020 B5 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT		RECORD OF BOREHOLE No B5-13				1 OF 1 METRIC										
W.P. 07-1191-0020		LOCATION N 5051510.2; E 236834.7				ORIGINATED BY EHS										
DIST _____ HWY 69		BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers				COMPILED BY AMW										
DATUM Geodetic		DATE February 11, 2009				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								
192.6	GROUND SURFACE						20	40	60	80	100					
0.0	Silty TOPSOIL															
0.2	Brown Moist															
191.9	SILTY CLAY		1	SS	6/0.15	192										
0.7	Brown Moist															
	End of Borehole Spoon and Auger Refusal															
Note:																
1. Borehole dry upon completion of drilling.																
2. About 0.4 m of snow at BH location.																

SUD-MTO 001 07-1191-0020 B5 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:



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

USUD-MTO 001 07-1191-0020 B5 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:



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



APPENDIX B

Laboratory Test Results

**TABLE B-1
REFUSAL/BEDROCK ELEVATIONS
HIGHWAY 69 SUCKER CREEK SBL
GWP 5005-08-00, WP 5194-06-01**

Borehole	Depth to Refusal/Bedrock Surface (m)	Refusal/Bedrock Surface Elevation (m)	Comments
B5-1	1.6	190.6	Bedrock Surface
B5-2	0.7	190.8	Auger Refusal
B5-3	2.1	189.4	Bedrock Surface
B5-4	1.1	189.3	Spoon and Auger Refusal
B5-5	2.2	188.3	Bedrock Surface
B5-6	0.8	184.4	Bedrock Surface
B5-6a	0.1	185.0	Spoon Refusal
B5-6b	0	183.6	Bedrock Surface
B5-6c	1.6	184.3	Bedrock Surface
B5-6d	2.1	182.8	Spoon Refusal
B5-7	18.7	165.3	Bedrock Surface
B5-10	17.1	170.2	Bedrock Surface
B5-11	14.0	172.9	Casing Refusal
B5-13	0.7	191.9	Spoon and Auger Refusal
B5-14	2.1	186.7	Auger Refusal
B5-DC1	9.6	178.2	DCPT Refusal

Compiled by: AMW
Checked by: AB
Reviewed by: JMAC

TABLE B-2
UNIAXIAL COMPRESSION STRENGTH TEST RESULTS
HIGHWAY 69 SUCKER CREEK SBL
GWP 5005-08-00, WP 5194-06-01

Borehole Number	Sample Depth (m)	Sample Elevation (m)	Rock Type	Core Diameter (mm)	Uniaxial Compressive Strength (MPa)
B5-1	3.4	188.8	Gneiss	48	123
B5-3	3.1	188.4	Gneiss	48	111
B5-5	3.7	186.8	Gneiss	48	103
B5-6	1.6	183.6	Gneiss	48	123
B5-6b	1.2	182.4	Gneiss	51	81
B5-6c	3.3	182.6	Gneiss	51	119
B5-10	19.0	168.3	Gneiss	48	107

Compiled by: AMW
Checked by: AB
Reviewed by: JMAC

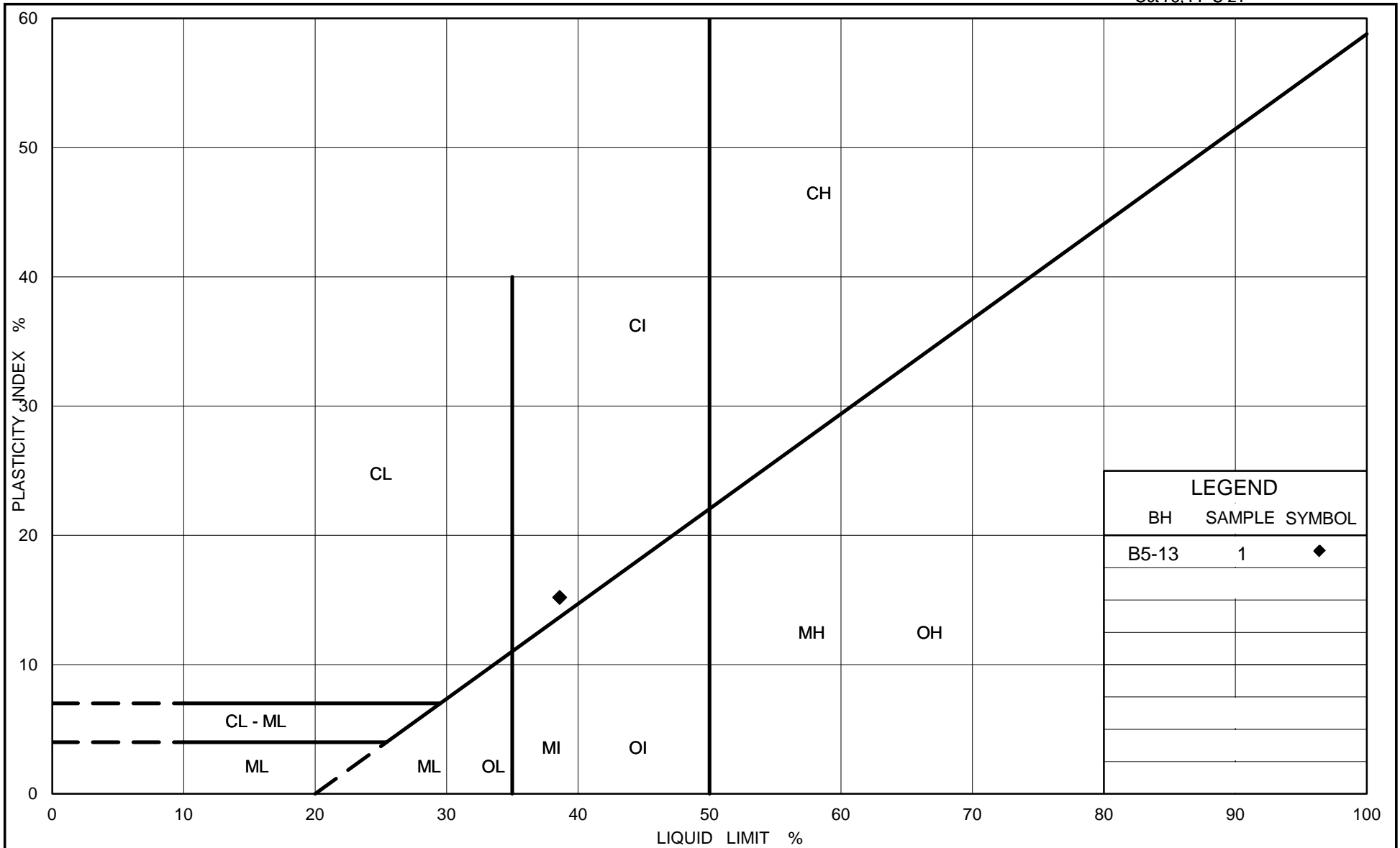
TABLE B-3
POINT LOAD STRENGTH TEST RESULTS
HIGHWAY 69 SUCKER CREEK SBL
GWP 5005-08-00, WP 5194-06-01

Borehole Number	Sample Depth ¹ (m)	Sample Elevation (m)	Rock Type	Test Type ²	Core Diameter (mm)	Ram Pressure (MPa)	Load (kN)	I _s Diametral ² (MPa)	I _s 50 mm ² (MPa)	Approximate UCS ² (MPa)
B5-1	2.3	189.9	Gneiss	D	48	9.7	0.00916	4.0	4.0	88
B5-1	2.8	189.4	Gneiss	D	48	12.8	0.01217	5.4	5.3	117
B5-1	4.1	188.2	Gneiss	D	48	15.0	0.01418	6.3	6.1	134
B5-3	2.5	189.0	Gneiss	D	48	9.8	0.00927	4.1	4.0	88
B5-3	4.6	186.9	Gneiss	D	48	17.6	0.01672	7.4	7.2	158
B5-3	4.9	185.7	Gneiss	D	48	17.4	0.01646	7.3	7.1	156
B5-5	4.1	186.4	Gneiss	D	48	11.7	0.01113	4.9	4.8	106
B5-5	5.0	185.5	Gneiss	D	48	12.1	0.01149	5.1	5.0	110
B5-6	1.0	184.2	Gneiss	D	48	11.0	0.01047	4.6	4.5	97
B5-6	2.4	182.8	Gneiss	D	48	7.1	0.00669	3.0	2.9	64
B5-6	3.7	181.5	Gneiss	D	48	16.7	0.01583	7.0	6.8	194
B5-6b	1.0	182.6	Gneiss	D	51	11.7	0.01111	4.2	4.3	95
B5-6b	1.7	181.9	Gneiss	D	51	11.6	0.01100	4.2	4.2	92
B5-6b	2.9	180.7	Gneiss	D	51	10.4	0.00988	3.8	3.8	84
B5-6c	2.6	183.3	Gneiss	D	51	6.1	0.00574	2.2	2.2	48
B5-6c	4.3	182.6	Gneiss	D	51	8.7	0.00821	3.1	3.2	70
B5-6c	5.2	181.7	Gneiss	D	51	15.6	0.01481	5.6	5.7	125
B5-10	17.4	169.9	Gneiss	D	48	17.9	0.01695	7.5	7.3	161
B5-10	19.2	168.1	Gneiss	D	48	17.6	0.01665	7.4	7.2	158
B5-10	19.8	167.5	Gneiss	D	48	19.6	0.01856	8.2	8.1	178

NOTES:

1. Depths are given below the ground surface at the borehole location.
2. Where: D = Diametral test;
I_s Diametral = Uncorrected point load strength;
I_s 50 mm = Corrected point load strength; and
UCS = Uniaxial compressive strength = I_s 50 mm X K Values of 22 has been used for the Gneiss, based on correlation with UCS for this site ("Suggested Methods for Determining Point Load Strength", International Society for Rock Mechanics Commission on Testing Methods, Int. J. Rock Mech. Sci. and Geomechanical Abst., Vol 22, No. 2, 1985, pp. 53-60, in ASTM D5731.

Compiled by: AMW
Checked by: AB
Reviewed by: JMAC



Ministry of Transportation
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PLASTICITY CHART Silty Clay

Figure B-1

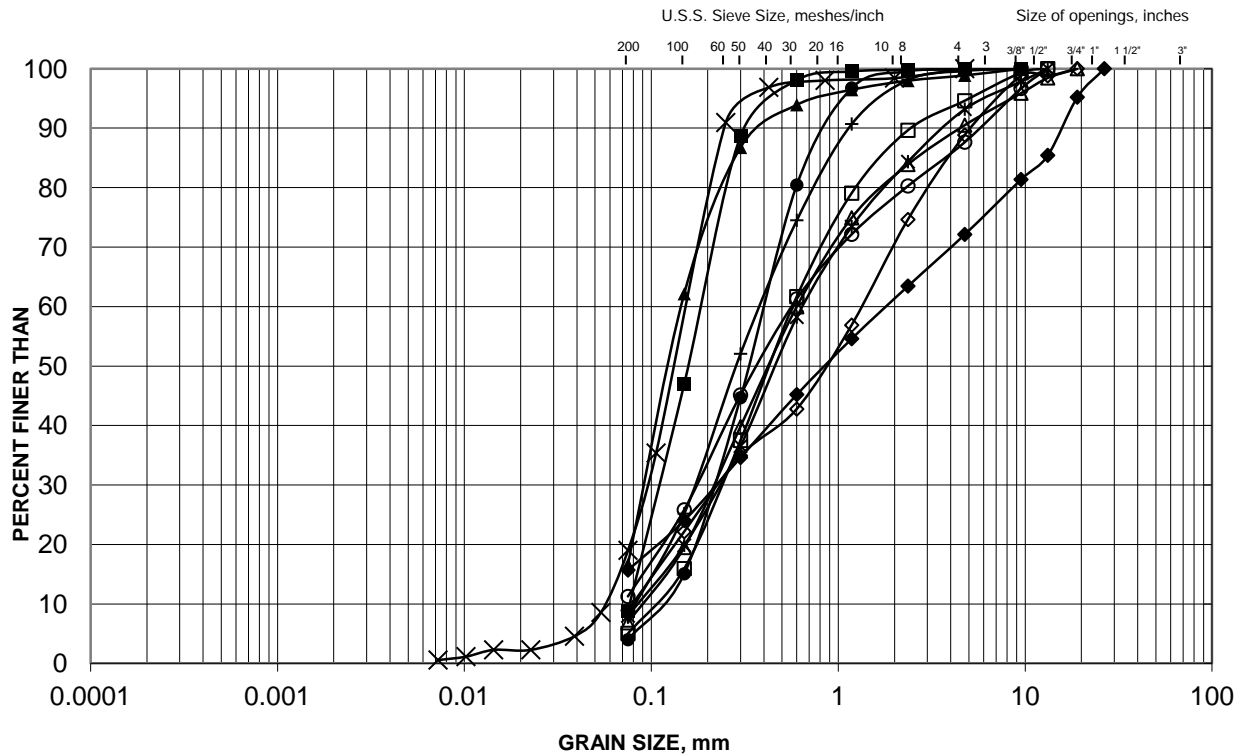
Project No. 07-1191-0020-B5

Checked By: AB

GRAIN SIZE DISTRIBUTION

Sand to Gravelly Sand

FIGURE
B-2



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
◆	B5-3	2	189.9
●	B5-7	3	182.2
■	B5-7	7	179.1
▲	B5-7	10	174.6
×	B5-10	2	186.2
◇	B5-10	6	183.2
○	B5-10	10	177.9
□	B5-11	1	186.0
△	B5-11	5	183.0
+	B5-11	9	177.7
*	B5-14	2	187.1

Project Number: 07-1191-0020-B5
Checked By: AB

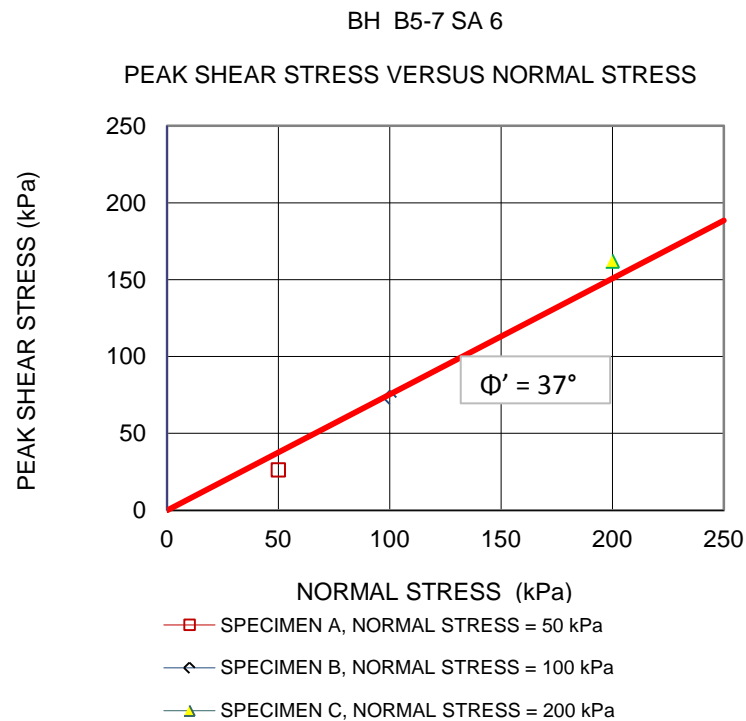
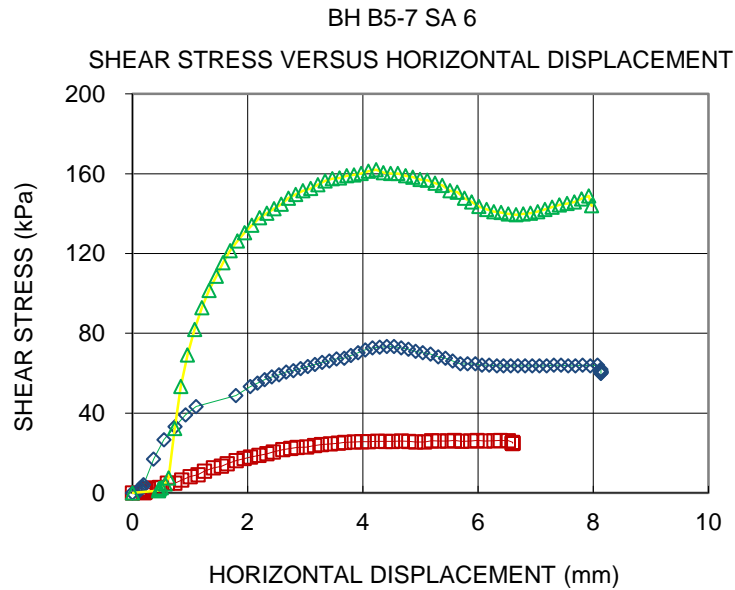
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Date: December 2011

CONSOLIDATED DRAINED DIRECT SHEAR TEST Sand		FIGURE B-3 (Sheet 1 of 3)	
TEST STAGE	A	B	C
BOREHOLE NUMBER	B5-7	B5-7	B5-7
SAMPLE NUMBER	6	6	6
SAMPLE DEPTH, (m)	3.8-4.4	3.8-4.4	3.8-4.4
SAMPLE HEIGHT, (mm)	24.80	25.10	26.10
SAMPLE LENGTH, (mm)	59.80	59.90	59.70
WATER CONTENT, BEFORE TEST, (%)	-	-	-
NORMAL (CONSOLIDATION) STRESS, (kPa)	50.00	100.00	200.00
WATER CONTENT, AFTER TEST, (%)	23.85	25.50	24.44
DISPLACEMENT RATE, mm/min	0.12	0.12	0.12
TIME TO FAILURE, HOURS	0.8	0.6	0.6
PEAK SHEAR STRESS, (kPa)	26.29	73.41	162.02
HORIZONTAL DISPLACEMENT AT PEAK, (mm)	5.59	4.42	4.23
DRY DENSITY, initial, Mg/m ³	1.50	1.53	1.51
WET DENSITY, initial, Mg/m ³	-	-	-
TEST NOTES:			
Each specimen was prepared dry with low compaction, normal stresses applied and then submerged in the shear box.			
Date: December 2011		Prepared By: LH	
Project No. 07-1191-0020-B5		Checked By: MM	
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CONSOLIDATED DRAINED DIRECT SHEAR TEST
Sand

FIGURE B-3
(Sheet 2 of 3)



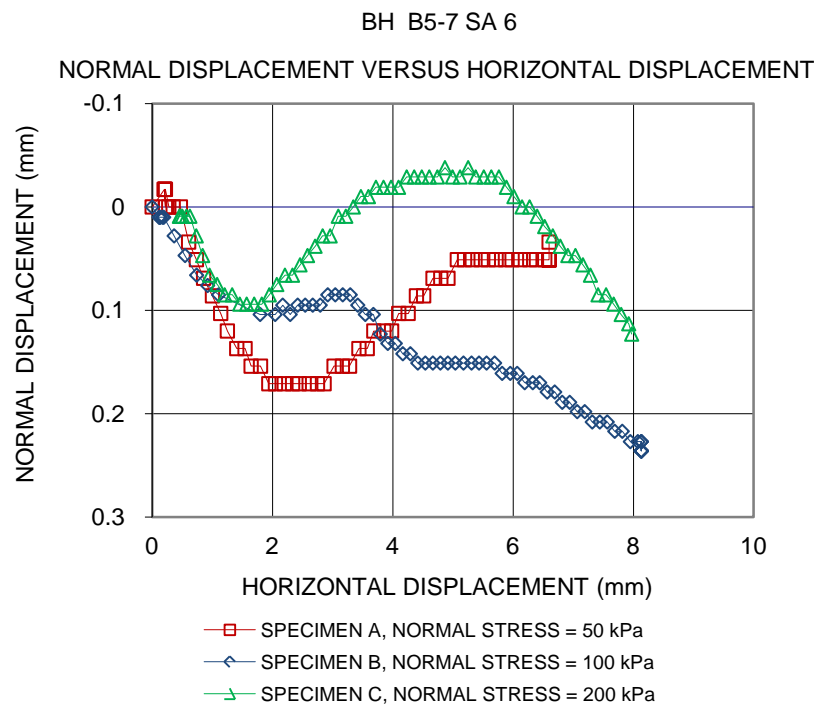
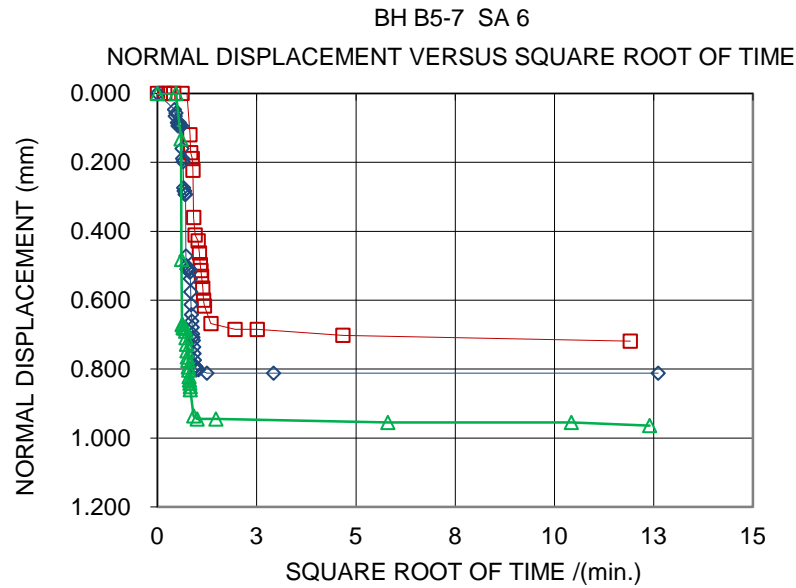
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Checked By: MM

CONSOLIDATED DRAINED DIRECT SHEAR TEST
Sand

FIGURE B-3
(Sheet 3 of 3)



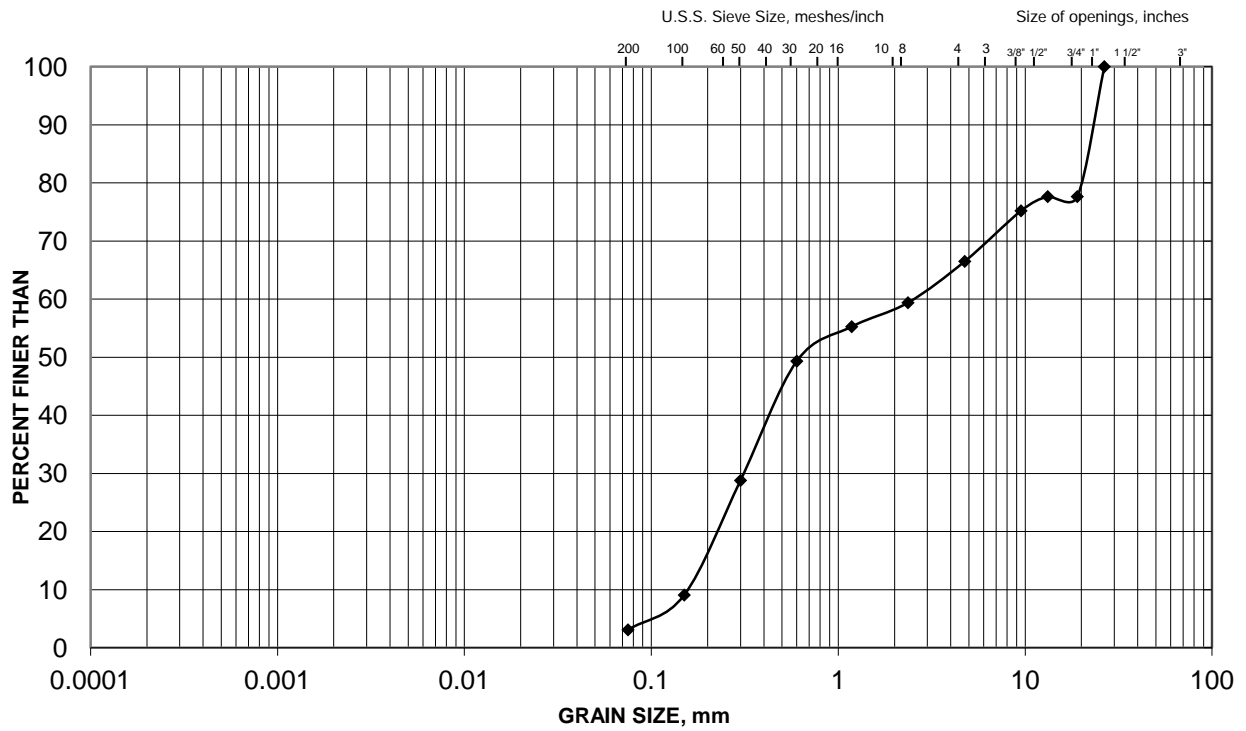
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Checked By: MM

GRAIN SIZE DISTRIBUTION Sand and Gravel

FIGURE
B-4



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
—◆—	B5-10	14	171.8

Project Number: 07-1191-0020-B5
Checked By: AB

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Date: December 2011

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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

