



December 14, 2011

## FOUNDATION INVESTIGATION REPORT

**SUCKER CREEK NBL BRIDGE, SITE NO. 44-447/1  
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 5193-06-01**

**Submitted to:**

MMM Group  
100 Commerce Valley Drive West  
Thornhill, Ontario  
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**GEOCRES No.: 41H-80**

**Report Number:** 07-1191-0020-B6

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- 1 e-copy MMM Group, Thornhill, Ontario
- 1 Copy Golder Associates Ltd., Sudbury, Ontario

REPORT



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## Table of Contents

<b>1.0 INTRODUCTION.....</b>	<b>1</b>
<b>2.0 SITE DESCRIPTION.....</b>	<b>1</b>
<b>3.0 INVESTIGATION PROCEDURES .....</b>	<b>1</b>
<b>4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS .....</b>	<b>3</b>
4.1 Regional Geology .....	3
4.2 Subsurface Conditions.....	4
4.2.1 Organics/Topsoil .....	4
4.2.2 Sand and Silt.....	4
4.2.3 Clayey Silt .....	4
4.2.4 Sand.....	5
4.2.5 Gravelly Sand to Sand and Gravel.....	5
4.2.6 Refusal/Bedrock.....	6
4.2.7 Groundwater Conditions .....	7
<b>5.0 CLOSURE.....</b>	<b>7</b>

## APPENDICES

### APPENDIX A

Record of Boreholes and Drillholes

List of Symbols and Abbreviations

Lithological and Geotechnical Rock Description Terminology

Record of Borehole Nos. B6-1 to B6-6, B6-6a to B6-6d, B6-7, B6-10, B6-11, B6-13 and B6-14

Record of Drillhole B6-2 to B6-4, B6-6, B6-6b, B6-6c, B6-7, B6-10

Record of Penetration Test No. B6-DC1

### APPENDIX B

Laboratory Test Results

Table B-1	Refusal/Bedrock Elevations
Table B-2	Uniaxial Compressive Strength Test Results
Table B-3	Point Load Strength Test Results
Figure B-1	Grain Size Distribution – Sand and Silt
Figure B-2	Plasticity Chart – Clayey Silt
Figure B-3	Grain Size Distribution – Sand
Figure B-4	Consolidated Drained Direct Shear Test
Figure B-5	Grain Size Distribution – Gravelly Sand



## **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 northbound lane (NBL) 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 NBL bridge structure crossing Sucker Creek and the associated approach embankments. Separate reports detail the foundation investigations for the related SBL 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 NBL 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 about 7 m above the existing ground surface at the south approach and about 15 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 and situated in a valley about 60 m wide. Bedrock is exposed within or near the footprint of the proposed south abutment and south pier and to the north of the north abutment. The ground surface at the borehole locations within the limits of the proposed structure and approach embankment areas is between Elevation 183.4 m and Elevation 195.3 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:

- Between February 9 and March 3, 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 B6-1 to B6-5);
  - One (1) borehole at the north pier (Borehole B6-7);



- Two (2) boreholes and one (1) DCPT at the north abutment (Boreholes B6-10 and B6-11 and DCPT B6-DC1); and
- One (1) borehole for each of the south and north approach embankments (Boreholes B6-13 and B6-14, respectively). Borehole B6-14 was advanced by hand excavation.
- On March 14, 2009, five (5) boreholes (Boreholes B6-6 and B6-6a to B6-6d) 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. One borehole was advanced using hand auger methods. Soil samples were obtained, where possible, continuously or 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 21.1 m below existing ground surface, or snow surface at one location and included coring bedrock for lengths of between 3.0 m and 3.5 m in Boreholes B6-2 to B6-4, B6-6, B6-6b, B6-6c, B6-7 and B6-10.

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 sand from Borehole B5-7 for determination of the effective angle of internal friction. Strength testing (uniaxial compression and point load index) was also carried out on selected specimens of the rock core.

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		
B6-1	5051546.2	236870.1	195.3	0.4
B6-2	5051551.1	236869.0	194.9	3.3
B6-3	5051547.5	236864.7	194.6	3.6
B6-4	5051544.0	236860.4	194.5	3.9
B6-5	5051548.9	236859.3	193.7	0.7
B6-6	5051576.8	236858.1	185.5	3.5
B6-6a	5051573.3	236853.8	187.5	0.1
B6-6b	5051578.1	236852.7	184.9	3.4
B6-6c	5051575.5	236863.6	189.7	3.4
B6-6d	5051580.3	236862.5	185.9	0.2
B6-7	5051611.2	236851.4	183.4	21.1
B6-10	5051640.2	236843.9	188.3	7.8
B6-11	5051637.4	236839.4	188.5	4.0
B6-13	5051532.9	236868.0	195.3	1.7
B6-14	5051655.8	236840.4	193.2	0.1
B6-DC1	5051643.7	236848.2	188.0	3.7

## 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

### 4.1 Regional Geology

As delineated in The Physiography of Southern Ontario (Chapman and Putnam, 1984)<sup>1</sup>, 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.

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 4<sup>2</sup> (OGS, 1991). Deposition of Paleozoic strata initially covered the bedrock and later erosion during glaciation exposed these Precambrian rocks.

<sup>1</sup> 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.

<sup>2</sup> Geology of Ontario, 1991. Ontario Geological Society Special Volume 4, Part 2. Ministry of Northern Development and Mines, Ontario.





## **4.2 Subsurface Conditions**

The detailed subsurface soil and groundwater conditions, as encountered in the boreholes advanced 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 SPTs. 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, bedrock outcrops are present on the south side of the creek in places overlain with a surficial layer of topsoil and thin deposits of sand and silt. On the north side of the creek, bedrock outcrops are also present north of the proposed bridge footprint, similarly in places overlain with a surficial layer of topsoil and then deposits of sand and gravelly sand to sand and gravel. The total thickness of overburden is variable at the site, ranging from approximately 0.1 m to 0.7 m on the south side of the creek and from approximately 0.1 m to 17.6 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 Organics/Topsoil**

A deposit of moist, brown organics or topsoil was encountered at ground surface, or below the snow, at each of the boreholes. The top of the organics layers were encountered between Elevation 195.3 m and 183.4 m and the thickness of the deposit ranges between 0.1 m and 0.4 m.

### **4.2.2 Sand and Silt**

A deposit of moist, brown sand and silt was encountered below the organics or topsoil in Boreholes B6-3 to B6-5 and B6-13. The surface of the deposit was encountered between Elevation 195.0 m and 193.5 m and ranges in thickness from 0.3 m to 0.5 m. As discussed in Section 4.2.4, a layer of clayey silt was encountered within the deposit of sand and silt in Borehole B6-13.

A grain size distribution test was carried out on one sample of the sand and silt deposit and the results are shown on Figure B-1.

The natural moisture content of one sample of the sand and silt is 47 percent.

### **4.2.3 Clayey Silt**

Within the sand and silt deposit in Borehole B6-13, a layer of moist, brown, clayey silt was encountered. The surface of this layer was encountered at Elevation 194.5 m, and its thickness is 0.6 m.

One SPT 'N'-value measured within the clayey silt deposit is 36 blows per 0.3 m of penetration indicating a hard consistency.



An Atterberg limits test carried out on the sample of the clayey silt yielded a liquid limit of 25 percent, a plastic limit of 14 percent and a plasticity index of 11 percent. The results of the Atterberg limits testing are shown on the plasticity chart on Figure B-2 in Appendix B and indicate that the material is a clayey silt of low plasticity.

The natural moisture content of the sample is 16 percent.

#### **4.2.4 Sand**

A deposit of moist to wet, brown to grey sand, trace to some gravel and trace to some silt was encountered below the topsoil in Boreholes B6-7, B6-10 and B6-11 located on the north side of the creek. The deposit contained occasional cobbles in Boreholes B6-10 and B6-11. The surface of the deposit was encountered between Elevation 183.2 m and 188.1 m and the thickness of the deposit ranges between 2.7 m and 15.0 m.

SPT 'N'-values measured within the sand/gravelly sand deposit range between 0 blows (i.e. weight of hammer) and 64 blows per 0.3 m of penetration. Typically, the 'N'-values range between 5 and 25 blows per 0.3 m of penetration, indicating a loose to compact relative density, and the presence of very loose or very dense layers.

The grain size distributions of five samples of the sand deposit are shown on Figures B-3 in Appendix B.

The natural water content measured on samples of the deposit range between 5 percent and 28 percent.

A laboratory consolidated drained direct shear (DS) test was carried out on one selected sample of the sand deposit from Borehole B6-7. The detailed test results are shown on Figure B-4 in Appendix B and the results are summarized below.

<b>Borehole/Sample Number</b>	<b>Depth / Elevation (m)</b>	<b>Effective Cohesion Intercept, <math>c'</math> (kPa)</b>	<b>Effective Angle of Internal Friction, <math>\phi'</math> (degrees)</b>
B6-7/6	4.9/178.5	0	38

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 9.1 m depth.

#### **4.2.5 Gravelly Sand to Sand and Gravel**

In Boreholes B6-7 and B6-11, a deposit of wet, brown or grey, gravelly sand to sand and gravel was encountered below the sand deposit. The surface of the deposit was encountered at Elevations 168.2 m and 185.4 m in Boreholes B6-7 and B6-11, respectively, and the thickness of the deposit is 2.4 m and 0.9 m, respectively.



SPT 'N'-values measured within the sand and gravel to gravelly sand deposit are 18 blows per 0.3 m of penetration to 50 blows per 0.1 m of penetration, indicating a compact to very dense relative density, and essentially refusal to split-spoon advancement at one sample depth in Borehole B6-7.

A grain size distribution test was carried out on one sample of the gravelly sand deposit and the results are shown on Figure B-5.

The natural moisture content of one sample of the deposit is 11 percent.

#### **4.2.6 Refusal/Bedrock**

Bedrock was encountered and cored in Boreholes B6-2 to B6-4, B6-6, B6-6b, B6-6c, B6-7 and B6-10. The bedrock surface was inferred from hand excavation, auger, casing or split-spoon refusal in the remaining boreholes. The bedrock surface (inferred or actual) was encountered in the boreholes at depths ranging from 0.1 m to 17.6 m below ground surface, ranging from Elevation 194.9 m and 165.8 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 grey to pinkish grey, fine to coarse grained and fresh to slightly weathered, except in Borehole B6-7 where the bedrock is a mafic intrusive, and the core samples are greenish grey, fine to medium grained and moderately to slightly weathered.

The Total Core Recovery (TCR) is 100 percent for all core samples. The Rock Quality Designation (RQD) measured on the core samples typically ranges from about 75 percent to 100 percent, indicating a rock mass of good to excellent quality. The uppermost core sample in Boreholes B6-6 and B6-7 measured RQD values of 35 percent and 0 percent, respectively, indicating a rock mass of very poor to poor quality. The RQD typically increased with depth. The Solid Core Recovery (SCR) typically ranges from 75 percent to 100 percent, increasing with depth. The uppermost core samples in Boreholes B6-6 and B6-7 measured a SCR of 36 percent and 0 percent, respectively.

Laboratory Uniaxial Compressive Strength (UCS) testing was carried out on seven core samples of the bedrock. The UCS ranges from about 71 MPa to 136 MPa for the gneiss bedrock and is 109 MPa for the mafic intrusive bedrock as summarized in Table B-2, indicating strong to very strong rock.

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 3 MPa to 7 MPa for the gneiss bedrock and about 10 MPa for the mafic intrusive bedrock. These index values correspond to estimated UCS values ranging between 58 MPa and 142 MPa, based on a relationship between  $I_{s50}$  and UCS which is given by a correlation factor (K) in accordance with ASTM D5731-08, which 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 20 for the gneiss and 11 for the mafic intrusive bedrock, 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 test results, in accordance with Table 3.5 in CFEM (2006)<sup>3</sup>, the estimated intact strength of the gneiss and mafic intrusive bedrock ranges from strong (R4, 50 MPa < UCS < 100 MPa) to very strong (R5, 100 MPa < UCS < 250 MPa).

#### **4.2.7 Groundwater Conditions**

The water levels were noted immediately after the drilling operations in the boreholes. 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 B6-7, B6-10 and B6-11 is at depths ranging between 1.3 m to 3.7 m below ground surface, corresponding to Elevation 182.1 m to 185.0 m.

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.

<sup>3</sup> Canadian Geotechnical Society, 2006. Canadian Foundation Engineering Manual, 4<sup>th</sup> Edition.



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**FOUNDATION REPORT - SUCKER CREEK NBL BRIDGE  
HIGHWAY 69 GWP 5005-08-00, WP 5193-06-01**

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## Report Signature Page

**GOLDER ASSOCIATES LTD.**



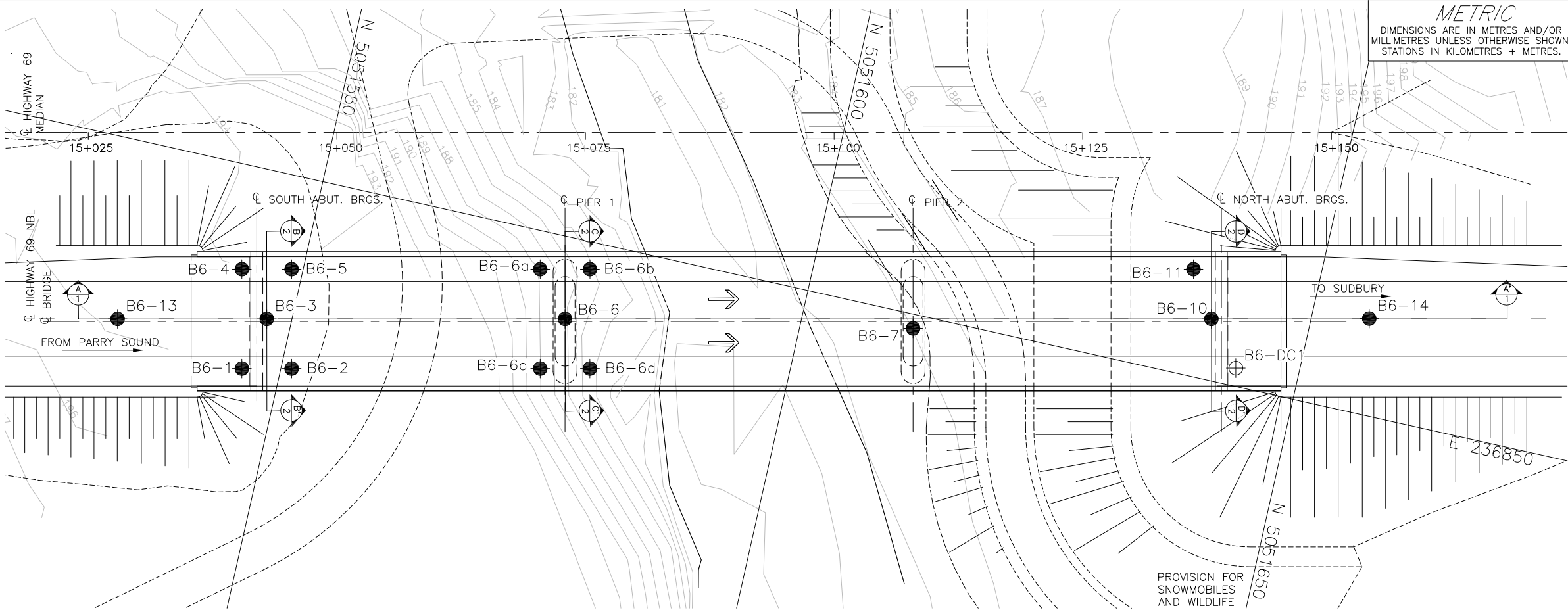
André Bom, P.Eng.  
Geotechnical Engineer



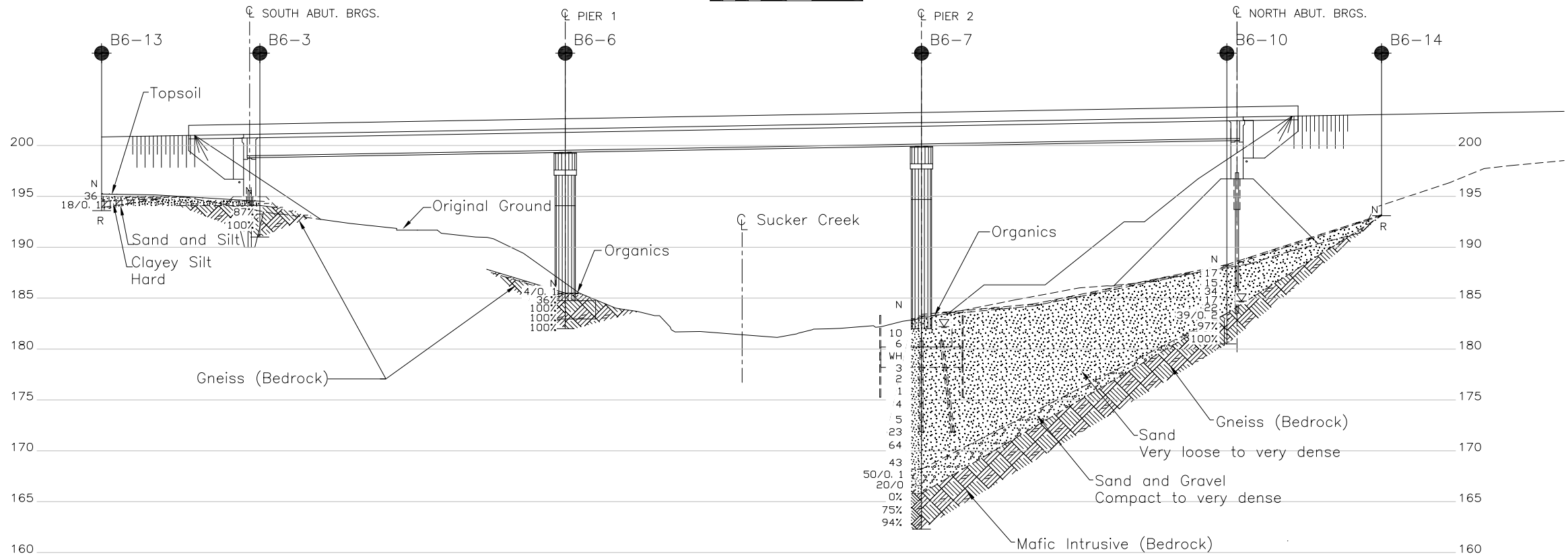
Jorge M. A. Costa, P.Eng.  
Designated MTO Contact, Principal

AW/AB/JMAC/lb/cl

N:\Active\2007\1190 Sudbury\1191\07-1191-0020 MMM Hwy 69 Twinning\7000 Reporting\Final\Sucker Creek\NBL\07-1191-0020-B6 RPT 11Dec14 Hwy 69 SC NBL.Docx



PLAN  
SCALE  
5 0 5 10 m



A-A'  
1  
CENTRELINE PROFILE  
HIGHWAY 69 NBL  
SCALE  
5 0 5 10 m

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

CONT No.  
WP No. 5193-06-01

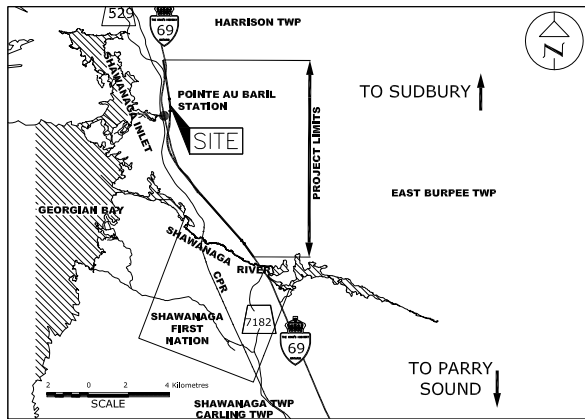
HIGHWAY 69  
SUCKER CREEK (NBL)  
BOREHOLE LOCATIONS  
AND SOIL STRATA



SHEET



Golder Associates Ltd.  
SUDBURY, ONTARIO, CANADA



KEY PLAN

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
B6-1	195.3	5051546.2	236870.1
B6-2	194.9	5051551.1	236869.0
B6-3	194.6	5051547.5	236864.7
B6-4	194.5	5051544.0	236860.4
B6-5	193.7	5051548.9	236859.3
B6-6	185.5	5051576.8	236858.1
B6-6a	187.5	5051573.3	236853.8
B6-6b	184.9	5051578.1	236852.7
B6-6c	189.7	5051575.5	236863.6
B6-6d	185.9	5051580.3	236862.5
B6-7	183.4	5051611.2	236851.4
B6-10	188.3	5051640.2	236843.9
B6-11	188.5	5051637.4	236839.4
B6-13	195.3	5051532.9	236868.0
B6-14	193.2	5051655.8	236840.4
B6-DC1	188.0	5051643.7	236848.2

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.

NO.	DATE	BY	REVISION
Geocres No. 41H-80			
HWY. 69		PROJECT NO. 07-1191-0020	
SUBM'D.		DIST.	
DRAWN: PL		SITE: 44-447/1	
CHKD. SEMC		DWG. 1	
APPD. JMAC			

REFERENCE  
Base plans provided in digital format by MMM, drawing file nos. 44\_447-1\_01-GENERAL ARRANGEMENT INTEGRAL (31m), received August 18, 2011



# **APPENDIX A**

## **Record of Boreholes and Drillholes**



## LIST OF SYMBOLS

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

### 1. GENERAL

$\pi$	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

$\gamma$	shear strain
$\Delta$	change in, e.g. stress: $\Delta\sigma$
$\epsilon$	linear strain
$\epsilon_v$	volumetric strain
$\eta$	coefficient of viscosity
$\nu$	Poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )
$\sigma_{vo}$	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
$\sigma_{oct}$	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
$\tau$	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
$\gamma'$	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  $\rho$ . Unit weight symbol is  $\gamma$  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
$\sigma'_p$	pre-consolidation pressure
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

#### (d) Shear Strength

$\tau_p, \tau_r$	peak and residual shear strength
$\phi'$	effective angle of internal friction
$\delta$	angle of interface friction
$\mu$	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.).

<b>PH:</b>	Sampler advanced by hydraulic pressure
<b>PM:</b>	Sampler advanced by manual pressure
<b>WH:</b>	Sampler advanced by static weight of hammer
<b>WR:</b>	Sampler advanced by weight of sampler and rod

#### Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm<sup>2</sup> 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 <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
$D_R$	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)
$\gamma$	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



+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3</sup>% STRAIN AT FAILURE

USUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT <u>07-1191-0020</u>			RECORD OF BOREHOLE <b>No B6- 2</b>			1 OF 1 <b>METRIC</b>																					
W.P. <u>5193-06-01</u>			LOCATION <u>N 5051551.1; E 236869.0</u>			ORIGINATED BY <u>EHS</u>																					
DIST <u>          </u> HWY <u>69</u>			BOREHOLE TYPE <u>108 I.D. Continuous Flight Hollow Stem Augers</u>			COMPILED BY <u>AMW</u>																					
DATUM <u>Geodetic</u>			DATE <u>February 9, 2009</u>			CHECKED BY <u>AB</u>																					
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			SHEAR STRENGTH kPa			WATER CONTENT (%)			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>	UNCONFINED	FIELD VANE	QUICK TRIAXIAL	REMOULDED	10	20	30	γ	GR	SA	SI	CL
194.9	GROUND SURFACE																										
0.0	Silty TOPSOIL																										
0.2	Brown Moist GNEISS (BEDROCK)																										
	Bedrock cored from 0.2 m depth to 3.3 m depth.		1	RC	REC 100%		194																				RQD = 100%
	For coring details refer to Record of Drillhole B6-2.		2	RC	REC 100%		193																				RQD = 97%
							192																				
191.6	End of Borehole																										
3.3	Note: 1. Borehole dry upon completion of drilling.																										

PROJECT: 07-1191-0020

## RECORD OF DRILLHOLE: B6- 2

SHEET 1 OF 1

LOCATION: N 5051551.1 ;E 236869.0

DRILLING DATE: February 9, 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		194.7 0.2																						
1	02/09/09 NQ Coring	GNEISS Fine to medium grained Fresh Strong to very strong Grey			1																	UCS = 100 MPa				
2					2																					
3																										
		End of Drillhole		191.6 3.3																						
4																										
5																										
6																										
7																										
8																										
9																										
10																										

DEPTH SCALE

1 : 50



LOGGED: EHS

CHECKED: AB

MTO-RCK 001: 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT <u>07-1191-0020</u>			RECORD OF BOREHOLE <b>No B6- 3</b>			1 OF 1 <b>METRIC</b>											
W.P. <u>5193-06-01</u>			LOCATION <u>N 5051547.5; E 236864.7</u>			ORIGINATED BY <u>EHS</u>											
DIST <u>          </u> HWY <u>69</u>			BOREHOLE TYPE <u>108 I.D. Continuous Flight Hollow Stem Augers</u>			COMPILED BY <u>AMW</u>											
DATUM <u>Geodetic</u>			DATE <u>February 9, 2009</u>			CHECKED BY <u>AB</u>											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
194.6	GROUND SURFACE							20	40	60	80	100					
0.0	Silty TOPSOIL																
194.1	Brown Moist		1	AS	-		194										0 42 38 20
0.5	SAND and SILT, some clay																
	Brown Moist																
	GNEISS (BEDROCK)		1	RC	REC 100%		193										RQD = 87%
	Bedrock cored from 0.5 m depth to 3.6 m depth.																
	For coring details refer to Record of Drillhole B6-3.																
			2	RC	REC 100%		192										RQD = 100%
191.0	End of Borehole						191										
3.6	Note:  1. Borehole dry upon completion of drilling.																

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: Landcore Drilling

CHECKED: AB



PROJECT 07-1191-0020			RECORD OF BOREHOLE No B6- 4			1 OF 1 METRIC											
W.P. 5193-06-01			LOCATION N 5051544.0; E 236860.4			ORIGINATED BY EHS											
DIST _____ HWY 69			BOREHOLE TYPE 108 I.D. Continuous Flight Hollow Stem Augers			COMPILED BY AMW											
DATUM Geodetic			DATE February 10, 2009			CHECKED BY AB											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
194.5	GROUND SURFACE							20	40	60	80	100					
0.0	Silty TOPSOIL																
0.2	Brown Moist		1	AS	-		194										
193.8	SAND and SILT, some clay																
0.7	Brown Moist GNEISS (BEDROCK)		1	RC	REC 100%		193										RQD = 100%
	Bedrock cored from 0.7 m depth to 3.9 m depth.																
	For coring details refer to Record of Drillhole B6-4.		2	RC	REC 100%		192										RQD = 100%
190.6			3	RC	REC 100%		191										RQD = 100%
3.9	End of Borehole																
	Note: 1. Borehole dry upon completion of drilling.																

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT: 07-1191-0020

**RECORD OF DRILLHOLE: B6- 4**

SHEET 1 OF 1

LOCATION: N 5051544.0 ;E 236860.4

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 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 0				10 0
								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.														
1	02/10/09 NQ Coring	Refer to Previous Page  GNEISS Fine to medium grained Fresh Strong Grey  Healed vertical joint from 0.9 to 2.0 m.		193.8 0.7	1			100	100	100												
2																						
3					2																	
4		End of Drillhole		190.6 3.9	3																	
5																						
6																						
7																						
8																						
9																						
10																						

DEPTH SCALE

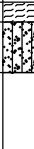
1 : 50



LOGGED: EHS

CHECKED: AB

MTO-RCK 001: 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT <u>07-1191-0020</u>				<b>RECORD OF BOREHOLE No B6- 5</b>				1 OF 1 <b>METRIC</b>														
W.P. <u>5193-06-01</u>		LOCATION <u>N 5051548.9; E 236859.3</u>				ORIGINATED BY <u>EHS</u>																
DIST <u>          </u> HWY <u>69</u>		BOREHOLE TYPE <u>108 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 <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa														
193.7	GROUND SURFACE																					
0.0	Silty TOPSOIL		1	AS	-		193															
0.2	Brown Moist																					
193.0	SAND and SILT, some clay																					
0.7	Brown Moist End of Borehole Auger Refusal																					
Note: 1. Borehole dry upon completion of drilling.																						

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT <u>07-1191-0020</u>				<b>RECORD OF BOREHOLE No B6- 6</b>				1 OF 1 <b>METRIC</b>									
W.P. <u>5193-06-01</u>				LOCATION <u>N 5051576.8; E 236858.1</u>				ORIGINATED BY <u>TDM</u>									
DIST <u>          </u> HWY <u>69</u>				BOREHOLE TYPE <u>Portable Equipment</u>				COMPILED BY <u>AMW</u>									
DATUM <u>Geodetic</u>				DATE <u>March 14, 2009</u>				CHECKED BY <u>AB</u>									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
185.5	GROUND SURFACE							20	40	60	80	100					
0.0	ORGANICS		1	SS	4/0.1												
0.2	Brown Moist GNEISS (BEDROCK)		1	RC	REC 100%		185										RQD = 36%
	Bedrock cored from 0.2 m depth to 3.5 m depth.		2	RC	REC 100%		184										RQD = 100%
	For coring details refer to Record of Drillhole B6-6.		3	RC	REC 100%		183										RQD = 100%
			4	RC	REC 100%												RQD = 100%
182.0	End of Borehole						182										
3.5	Note:  1. Borehole dry upon completion of drilling.																

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: OGS Inc.

1 : 50






+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

USUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:



PROJECT <u>07-1191-0020</u>			<b>RECORD OF BOREHOLE No B6- 6b</b>			1 OF 1 <b>METRIC</b>											
W.P. <u>5193-06-01</u>			LOCATION <u>N 5051578.1; E 236852.7</u>			ORIGINATED BY <u>TDM</u>											
DIST <u>          </u> HWY <u>69</u>			BOREHOLE TYPE <u>Portable Equipment</u>			COMPILED BY <u>AMW</u>											
DATUM <u>Geodetic</u>			DATE <u>March 14, 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					W <sub>p</sub> W W <sub>L</sub> WATER CONTENT (%)			γ kN/m <sup>3</sup>	GR SA SI CL
							20 40 60 80 100	20 40 60 80 100	10 20 30								
184.9	GROUND SURFACE																
0.0 184.6 0.3	ORGANICS, gravel Brown Moist  GNEISS (BEDROCK)  Bedrock cored from 0.3 m depth to 3.4 m depth.  For coring details refer to Record of Drillhole B6-6b.		1	SS	34/0.1		184										RQD = 82%
			1	RC	REC 100%												RQD = 91%
			2	RC	REC 100%		183										RQD = 100%
			3	RC	REC 100%												
			4	RC	REC 100%		182										RQD = 85%
181.5	End of Borehole																
3.4	Note:  1. Borehole dry upon completion of drilling.																

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: OGS Inc.

CHECKED: AB

PROJECT <u>07-1191-0020</u>		<b>RECORD OF BOREHOLE No B6- 6c</b>				1 OF 1 <b>METRIC</b>	
W.P. <u>5193-06-01</u>		LOCATION <u>N 5051575.5; E 236863.6</u>				ORIGINATED BY <u>TDM</u>	
DIST <u>          </u> HWY <u>69</u>		BOREHOLE TYPE <u>Portable Equipment</u>				COMPILED BY <u>AMW</u>	
DATUM <u>Geodetic</u>		DATE <u>March 14, 2009</u>				CHECKED BY <u>AB</u>	

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 <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED   + FIELD VANE ● QUICK TRIAXIAL   × REMOULDED					W <sub>p</sub>	W	W <sub>L</sub>					
						20	40	60	80	100	20	40	60	80	100	10	20	30		
189.7	GROUND SURFACE																			
0.0	ORGANICS		1	SS	2/0.15															
189.4	Brown		1	RC	REC															
0.3	Moist				100%															
	GNEISS (BEDROCK)																			
	Bedrock cored from 0.3 m depth to 3.4 m depth.		2	RC	REC															
	For coring details refer to Record of Drillhole B6-6c.				100%															
			3	RC	REC															
					100%															
			4	RC	REC															
					100%															
186.3	End of Borehole																			
3.4	Note:  1. Borehole dry upon completion of drilling.																			

PROJECT: 07-1191-0020

## RECORD OF DRILLHOLE: B6- 6c

SHEET 1 OF 1

LOCATION: N 5051575.5 ;E 236863.6

DRILLING DATE: March 14, 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			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		189.4 0.3	1																		
1	03/14/09 Thin-Wall N Coring	GNEISS Fine to coarse grained Slightly weathered Strong Pinkish grey			2																		
2				3																			
				4																			
3		End of Drillhole		186.3 3.4																			
4																							
5																							
6																							
7																							
8																							
9																							
10																							

DEPTH SCALE


1 : 50



LOGGED: TDM

CHECKED: AB

MTO-RCK 001: 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT <u>07-1191-0020</u>		<b>RECORD OF BOREHOLE No B6- 6d</b>				1 OF 1 <b>METRIC</b>										
W.P. <u>5193-06-01</u>		LOCATION <u>N 5051580.3; E 236862.5</u>				ORIGINATED BY <u>TDM</u>										
DIST <u>          </u> HWY <u>69</u>		BOREHOLE TYPE <u>Portable Equipment</u>				COMPILED BY <u>AMW</u>										
DATUM <u>Geodetic</u>		DATE <u>March 14, 2009</u>				CHECKED BY <u>AB</u>										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	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	ORGANICS		1	SS	4/0.15											
0.2	Brown Moist  End of Borehole Refusal to Further Penetration (Hammer Bouncing)  Note:  1. Borehole dry upon completion of drilling.															

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

## RECORD OF BOREHOLE No B6-7

1 OF 2 METRIC

PROJECT 07-1191-0020

W.P. 5193-06-01

LOCATION N 5051611.2; E 236851.4

ORIGINATED BY EHS

DIST \_\_\_\_\_ HWY 69

BOREHOLE TYPE 108 I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring

COMPILED BY AMW

DATUM Geodetic

DATE February 26 and March 3, 2009

CHECKED BY AB

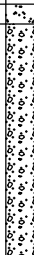

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Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3</sup>% STRAIN AT FAILURE

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

<b>PROJECT</b> 07-1191-0020		<b>RECORD OF BOREHOLE No B6- 7</b>		2 OF 2 <b>METRIC</b>	
W.P. 5193-06-01		LOCATION N 5051611.2; E 236851.4		ORIGINATED BY EHS	
DIST _____ HWY 69		BOREHOLE TYPE 108 I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring		COMPILED BY AMW	
DATUM Geodetic		DATE February 26 and March 3, 2009		CHECKED BY AB	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT			LIQUID LIMIT	UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)					
								20	40	60	80	100	W <sub>P</sub>	W	W <sub>L</sub>			
168.2																		
15.2	SAND and GRAVEL Very dense Grey Wet  Difficulty advancing casing below 15.2 m depth.		12	SS	50/0.1													
				SS	20/0													
165.8	MAFIC INTRUSIVE (BEDROCK)  Bedrock cored from 17.6 m depth to 21.1 m depth.  For coring details refer to Record of Drillhole B6-7.																	
17.6																		
			1	RC	REC 100%											RQD = 0%		
			2	RC	REC 100%											RQD = 75%		
			3	RC	REC 100%											RQD = 94%		
162.3																		
21.1	End of Borehole  Note:  1. Water level measured at a depth of 1.3 m below ground surface (Elev. 182.1 m) upon completion of drilling.																	

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: Landcore Drilling

CHECKED: AB

MTO-RCK 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:



PROJECT 07-1191-0020			RECORD OF BOREHOLE No B6-10			1 OF 1 METRIC														
W.P. 5193-06-01			LOCATION N 5051640.2; E 236843.9			ORIGINATED BY EHS														
DIST _____ HWY 69			BOREHOLE TYPE 108 I.D. Continuous Flight Hollow Stem Augers			COMPILED BY AMW														
DATUM Geodetic			DATE February 25, 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 <sub>p</sub> W W <sub>L</sub>			γ	GR	SA	SI	CL
188.3 0.0	GROUND SURFACE							20 40 60 80 100												
0.2	Sandy ORGANICS Brown Moist		1	AS	-		188													
	SAND, trace to some gravel, trace to some silt, occasional cobbles Compact to dense Brown Moist		2	SS	17		187											0	79	(21)
			3	SS	15		186													
			4	SS	34		185													
	Becoming wet below 3.7 m depth.		5	SS	17		184													
			6	SS	22		183													
183.5 4.8	GNEISS (BEDROCK)		7	SS	39/0.2		182													
	Bedrock cored from 4.8 m depth to 7.8 m depth.  For coring details refer to Record of Drillhole B6-10.		1	RC	REC 100%		181													
			2	RC	REC 100%															
180.5 7.8	End of Borehole																			
	Note:  1. Water level measured at a depth of 3.7 m below ground surface (Elev. 184.6 m) upon completion of drilling.																			

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT: 07-1191-0020

**RECORD OF DRILLHOLE: B6-10**

SHEET 1 OF 1

LOCATION: N 5051640.2 ;E 236843.9

DRILLING DATE: February 25, 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	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.																													

5		Refer to Previous Page		183.5																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														</
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DEPTH SCALE

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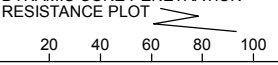
LOGGED: EHS

CHECKED: AB

MTO-RCK 001: 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT		07-1191-0020		<b>RECORD OF BOREHOLE No B6-11</b>		1 OF 1 <b>METRIC</b>											
W.P.		5193-06-01		LOCATION		N 5051637.4; E 236839.4											
DIST		HWY 69		BOREHOLE TYPE		108 I.D. Continuous Flight Hollow Stem Augers											
DATUM		Geodetic		DATE		February 25, 2009											
						ORIGINATED BY EHS											
						COMPILED BY AMW											
						CHECKED BY AB											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
188.5	SNOW SURFACE																
0.0	SNOW																
0.4	Sandy ORGANICS Brown Moist																
	SAND, trace to some silt, trace to some gravel, occasional cobbles		1	SS	24												
	Compact Brown Moist		2	SS	27												
			3	SS	16												
185.4																	
3.1	Gravelly SAND Compact Brown Wet		4	SS	18												26 68 (6)
184.5			5	SS	9/0.1												
4.0	End of Borehole Refusal to Further Penetration Auger Penetration																
Note: 1. Water level measured at a depth of 3.5 m below ground surface (Elev. 185.0 m) upon completion of drilling. 2. Borehole moved 0.7 m north due to boulder at ground surface at original borehole location.																	

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT <u>07-1191-0020</u>			RECORD OF BOREHOLE <b>No B6-13</b>			1 OF 1 <b>METRIC</b>					
W.P. <u>5193-06-01</u>			LOCATION <u>N 5051532.9; E 236868.0</u>			ORIGINATED BY <u>EHS</u>					
DIST <u>          </u> HWY <u>69</u>			BOREHOLE TYPE <u>108 I.D. Continuous Flight Hollow Stem Augers</u>			COMPILED BY <u>AMW</u>					
DATUM <u>Geodetic</u>			DATE <u>February 9, 2009</u>			CHECKED BY <u>AB</u>					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT  SHEAR STRENGTH kPa ○ UNCONFINED    + FIELD VANE ● QUICK TRIAXIAL    × REMOULDED	PLASTIC LIMIT W <sub>p</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub> WATER CONTENT (%)	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
195.3	GROUND SURFACE										
0.0	Silty TOPSOIL										
195.0	Brown										
0.3	Moist										
194.5	SAND and SILT										
0.8	Brown										
	Moist										
193.9	CLAYEY SILT, some fine sand		1	SS	36						
	Hard										
193.6	Brown		2	SS	18/0.1						
	Moist										
1.7	SAND and SILT, trace gravel										
	Compact										
	Brown										
	Moist										
	End of Borehole										
	Refusal to Further Penetration										
	Note:										
	1. Borehole dry upon completion of drilling.										

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:



+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3</sup>% STRAIN AT FAILURE

USUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:



# **APPENDIX B**

## **Laboratory Test Results**

**TABLE B-1  
REFUSAL/BEDROCK ELEVATIONS  
HIGHWAY 69 SUCKER CREEK NBL – STA 15+025 TO 15+150  
GWP 5005-08-00, WP 5193-06-01**

<b>Borehole</b>	<b>Depth to Refusal/Bedrock Surface (m)</b>	<b>Refusal/Bedrock Surface Elevation (m)</b>	<b>Comments</b>
B6-1	0.4	194.9	Auger Refusal
B6-2	0.2	194.7	Bedrock Surface
B6-3	0.5	194.1	Bedrock Surface
B6-4	0.7	193.8	Bedrock Surface
B6-5	0.7	193.0	Auger Refusal
B6-6	0.2	185.3	Bedrock Surface
B6-6a	0.1	187.4	Split-Spoon Refusal
B6-6b	0.3	184.6	Bedrock Surface
B6-6c	0.3	189.4	Bedrock Surface
B6-6d	0.2	185.7	Split-Spoon Refusal
B6-7	17.6	165.8	Bedrock Surface
B6-10	4.8	183.5	Bedrock Surface
B6-11	4.0	184.5	Auger/Split-Spoon Refusal
B6-13	1.7	193.6	Split-Spoon Refusal
B6-14	0.1	193.1	Bedrock Exposed by Hand Excavation
B6-DC1	3.7	184.3	DCPT Refusal

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



**TABLE B-2**  
**UNIAXIAL COMPRESSION STRENGTH TEST RESULTS**  
**HIGHWAY 69 SUCKER CREEK NBL – STA 15+025 TO 15+150**  
**GWP 5005-08-00, WP 5193-06-01**

<b>Borehole Number</b>	<b>Sample Depth (m)</b>	<b>Sample Elevation (m)</b>	<b>Rock Type</b>	<b>Core Diameter (mm)</b>	<b>Uniaxial Compressive Strength (MPa)</b>
B6-2	0.7	194.2	Gneiss	47	100
B6-4	2.1	192.4	Gneiss	48	71
B6-6	1.2	184.3	Gneiss	51	136
B6-6b	2.4	182.5	Gneiss	51	82
B6-6c	2.9	186.8	Gneiss	51	92
B6-7	20.6	162.8	Mafic Intrusive	48	109
B6-10	5.6	182.7	Gneiss	48	114

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

**TABLE B-3**  
**POINT LOAD STRENGTH TEST RESULTS**  
**HIGHWAY 69 SUCKER CREEK NBL – STA 15+025 TO 15+150**  
**GWP 5005-08-00, WP 5193-06-01**

Borehole Number	Sample Depth <sup>1</sup> (m)	Sample Elevation (m)	Rock Type	Test Type <sup>2</sup>	Core Diameter (mm)	Ram Pressure (MPa)	Load (kN)	I <sub>s</sub> Diametral <sup>2</sup> (MPa)	I <sub>s</sub> 50 mm <sup>2</sup> (MPa)	Approximate UCS <sup>2</sup> (MPa)
B6-2	1.9	193.0	Gneiss	D	47	10.6	0.01007	4.5	4.4	88
B6-2	2.8	192.1	Gneiss	D	48	9.3	0.00885	3.9	3.8	76
B6-2	3.1	191.9	Gneiss	D	47	10.3	0.00973	4.3	4.2	84
B6-4	2.7	191.8	Gneiss	D	48	15.4	0.01460	6.5	6.3	126
B6-4	3.1	191.4	Gneiss	D	47	11.7	0.01111	4.9	4.8	98
B6-4	3.7	190.8	Gneiss	D	48	12.0	0.01138	5.1	4.9	99
B6-6	1.5	184.0	Gneiss	D	51	14.0	0.01325	5.1	5.1	102
B6-6	2.4	183.1	Gneiss	D	51	14.7	0.01394	5.3	5.4	108
B6-6	3.0	182.5	Gneiss	D	51	19.4	0.01839	7.1	7.1	142
B6-6b	1.2	183.7	Gneiss	D	51	17.0	0.01615	6.3	6.3	126
B6-6b	2.7	182.2	Gneiss	D	51	14.2	0.01344	5.1	5.2	104
B6-6b	3.4	181.5	Gneiss	D	51	13.4	0.01270	4.9	4.9	98
B6-6c	0.9	188.8	Gneiss	D	51	7.8	0.00736	2.8	2.9	58
B6-6c	2.4	187.3	Gneiss	D	51	12.7	0.01206	4.6	4.7	94
B6-7	18.8	164.6	Mafic Intrusive	D	48	23.8	0.02260	10.0	9.8	108
B6-10	5.4	182.9	Gneiss	D	48	11.3	0.01073	4.8	4.6	92
B6-10	6.2	182.1	Gneiss	D	48	11.5	0.01092	4.8	4.7	94
B6-10	6.9	181.4	Gneiss	D	47	15.8	0.01496	6.7	6.5	130

**NOTES:** 1. Depths are given below the ground surface at the borehole location.

2. Where: D = Diametral test;  
I<sub>s</sub> Diametral = Uncorrected point load strength;  
I<sub>s</sub> 50 mm = Corrected point load strength; and  
UCS = Uniaxial compressive strength = I<sub>s</sub> 50 mm X K. Values of 20 and 11 have been used for the Gneiss and Mafic Intrusive, respectively, 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.

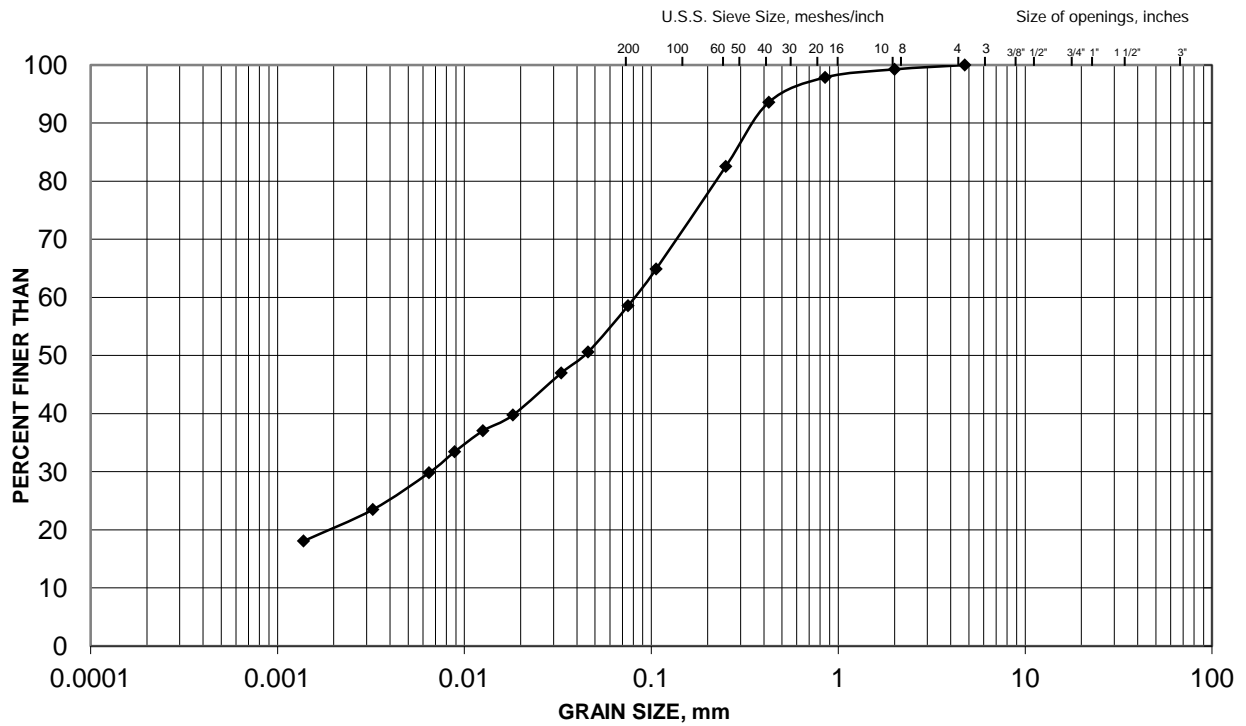
Compiled by: AMW

Checked by: AB

Reviewed by: JMAC

# GRAIN SIZE DISTRIBUTION Sand and Silt

FIGURE  
B-1



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

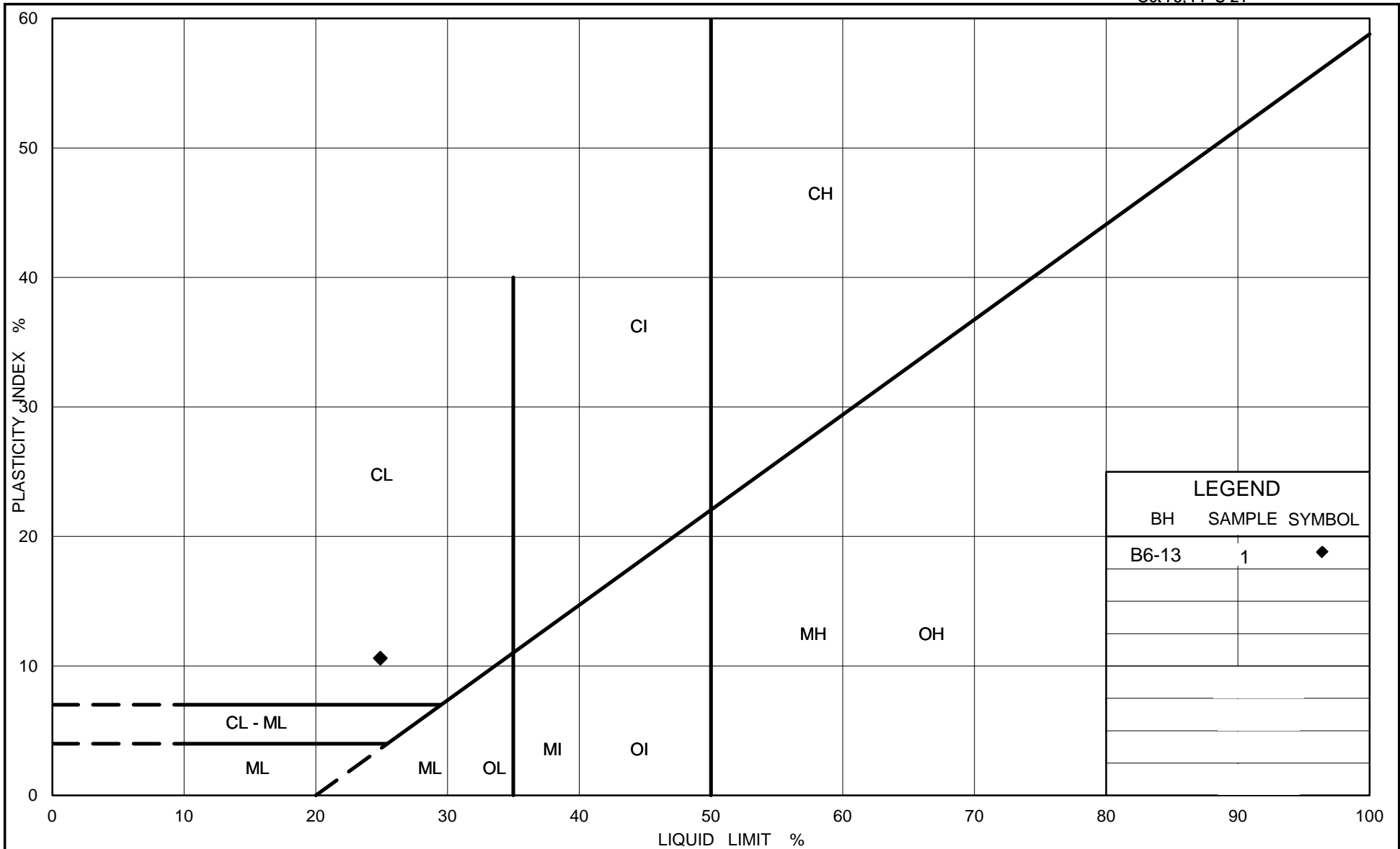
## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
—◆—	B6-3	1	194.2

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Figure B-2

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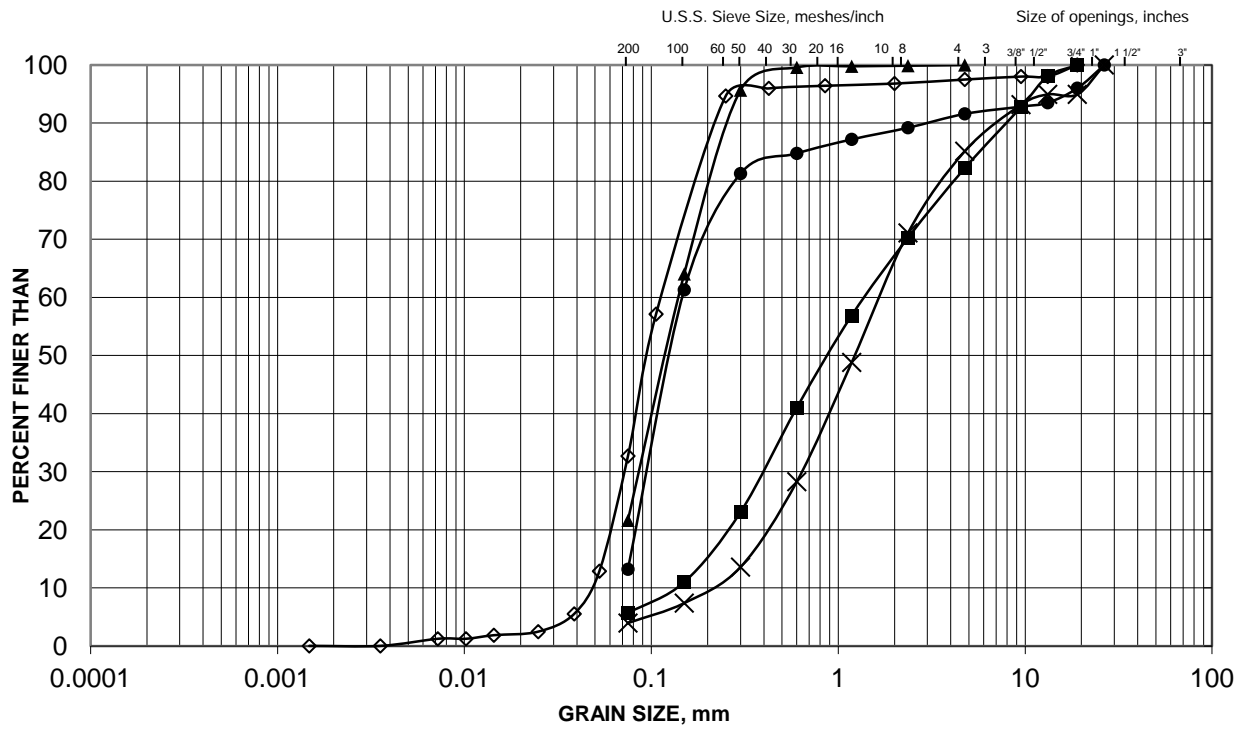
Checked By: AB

# GRAIN SIZE DISTRIBUTION

Sand

FIGURE

B-3



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
◇	B6-7	3	180.9
●	B6-7	7	177.0
■	B6-7	11	169.4
▲	B6-10	2	187.2
×	B6-10	5	184.9

Project Number: 07-1191-0020-B6

Checked By: AB

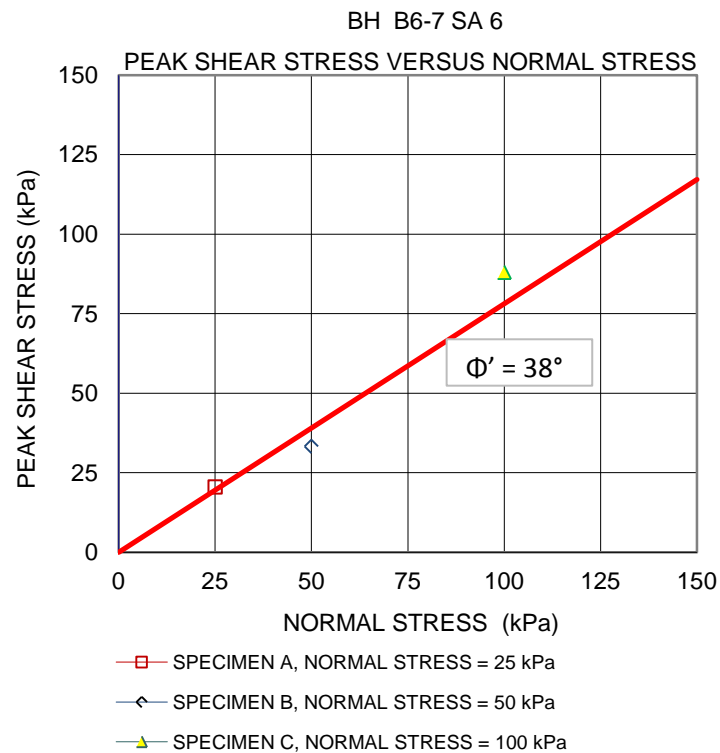
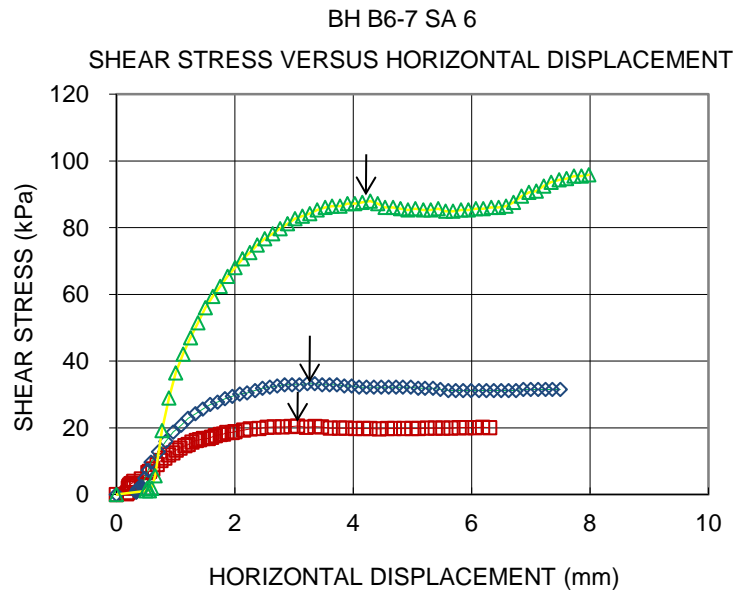
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CONSOLIDATED DRAINED DIRECT SHEAR TEST Sand		FIGURE B-4 (Sheet 1 of 3)	
TEST STAGE	A	B	C
BOREHOLE NUMBER	B6-7	B6-7	B6-7
SAMPLE NUMBER	6	6	6
SAMPLE DEPTH, (m)	4.6-5.2	4.6-5.2	4.6-5.2
SAMPLE HEIGHT, (mm)	26.70	26.00	26.30
SAMPLE LENGTH, (mm)	59.60	59.60	59.90
WATER CONTENT, BEFORE TEST, (%)	-	-	-
NORMAL (CONSOLIDATION) STRESS, (kPa)	25.00	50.00	100.00
WATER CONTENT, AFTER TEST, (%)	21.89	21.84	22.13
DISPLACEMENT RATE, mm/min	0.12	0.12	0.12
TIME TO FAILURE, HOURS	0.4	0.4	0.6
PEAK SHEAR STRESS, (kPa)	20.53	33.24	87.97
HORIZONTAL DISPLACEMENT AT PEAK, (mm)	3.06	3.23	4.29
DRY DENSITY, initial, Mg/m <sup>3</sup>	1.53	1.59	1.52
WET DENSITY, initial, Mg/m <sup>3</sup>	-	-	-
TEST NOTES:  Tested sample was screened through #4 (4.75 mm) sieve (9.8% retained on #4). Each specimen was prepared dry with low compaction, normal stresses applied and then submerged in the shear box.			
Date: December 2011 Project No. 07-1191-0020-B6		Prepared By: LH Checked By: MM	
Golder Associates			

**CONSOLIDATED DRAINED DIRECT SHEAR TEST**  
**Sand**

**FIGURE B-4**  
**(Sheet 2 of 3)**



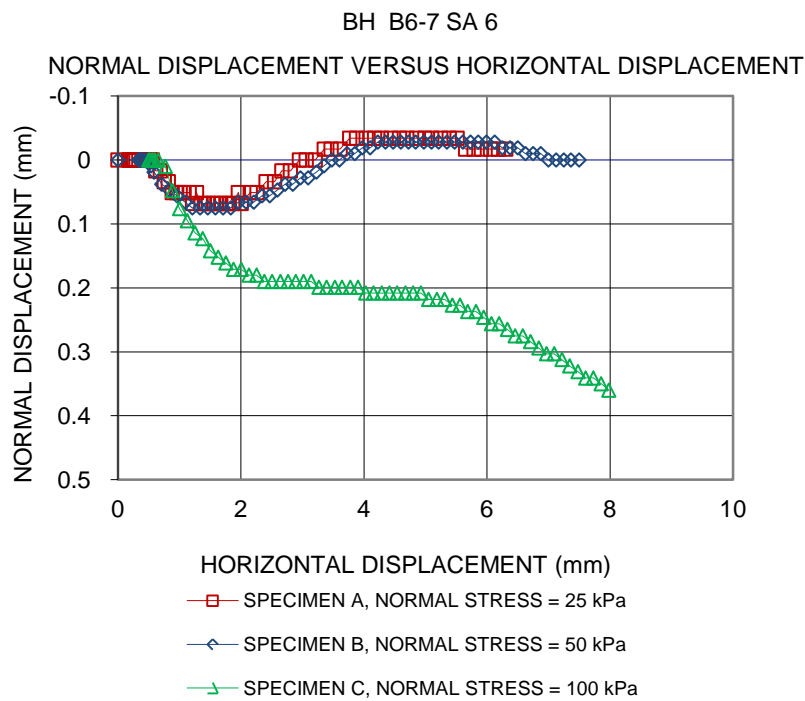
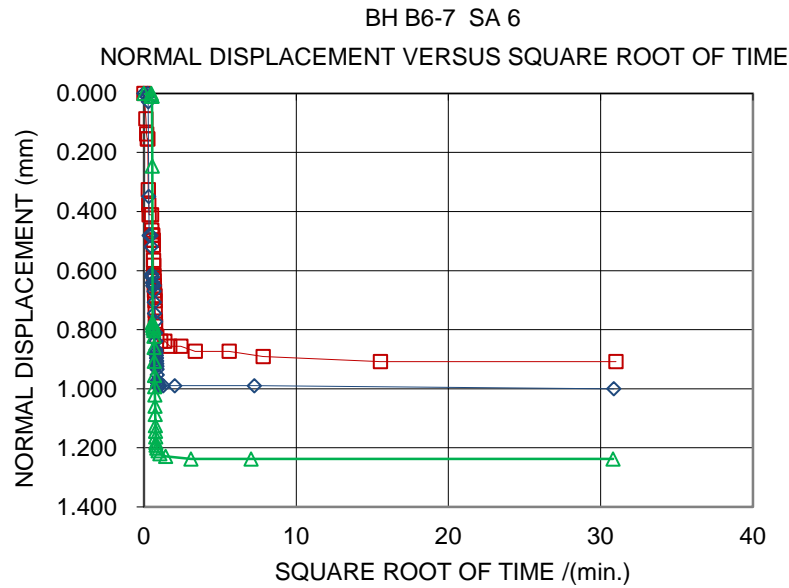
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Prepared By: LH  
Checked By: MM

# **CONSOLIDATED DRAINED DIRECT SHEAR TEST** **Sand**

**FIGURE B-4**  
(Sheet 3 of 3)



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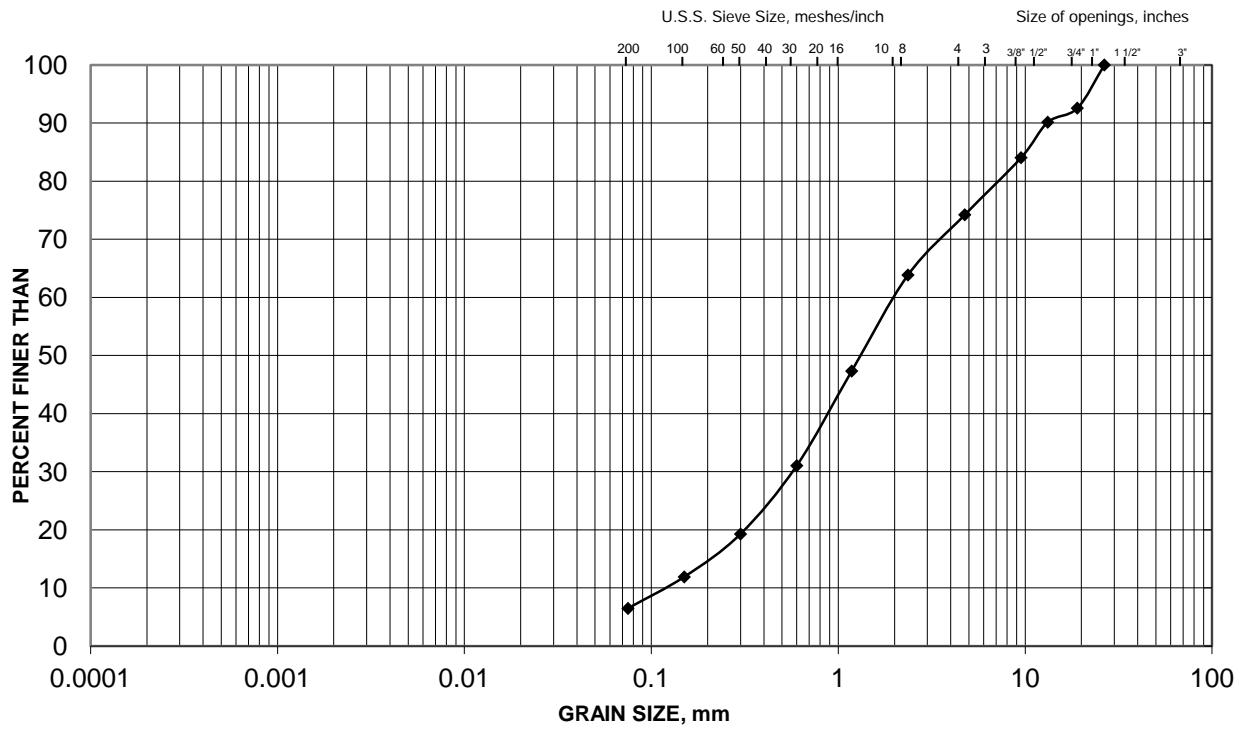


# GRAIN SIZE DISTRIBUTION

Gravelly Sand

FIGURE

B-5



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
—◆—	B6-11	4	185.1

Project Number: 07-1191-0020-B6

Checked By: AB

Golder Associates

Date: December 2011

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