



March 14, 2012

## FOUNDATION INVESTIGATION REPORT

HIGHWAY 529 OVERPASS NBL STRUCTURE  
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 5191-06-01

**Submitted to:**

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**GEOCRES No.: 41H-85**

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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 Northbound Lane (NBL) structure crossing the future Highway 529 (i.e. Highway 529 Overpass NBL). 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 Drawings.

This report addresses the investigation carried out for the Highway 529 Overpass NBL structure, the associated approach embankments and the Retained Soil System (RSS) walls. Separate reports will be submitted detailing the foundation investigations for the SBL structure and other bridge structures, a pond crossing and culverts for the project.

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

## **2.0 SITE DESCRIPTION**

The proposed Highway 529 Overpass NBL structure is a 99.1 m long 3-span structure, located in the Township of Harrison, about 800 m south of South Shore Road. The proposed grade at the new Highway 69 NBL south and north approach embankments will be at about Elevation 200 m and 201.4 m, respectively, which is up to about 7 m above the existing ground surface at the south approach and up to about 4 m below 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. The existing Highway 69 (future Highway 529) at the crossing is located in a bedrock “cut”. The topography at the south approach area is generally flat, low-lying with tree cover. The ground surface at the borehole locations within the limits of the proposed structure and approach embankment areas ranges between Elevation 190.2 m and 205.2 m at the south and north ends of the site, respectively.

## **3.0 INVESTIGATION PROCEDURES**

The fieldwork for the investigation at the proposed structure was carried out between January 29 and April 15, 2009, and on April 7, 2010, during which time a total of twenty (20) boreholes (designated as Boreholes B4-1 to B4-6 and B4-10 to B4-23) were advanced at the locations shown on the Contract Drawings, following the text of this report. The locations of the boreholes are generally summarized as follows:

- Five boreholes were advanced for each of the south and north abutments and north pier;
- Two boreholes were advanced for the south pier;



- Two boreholes were advanced at the approach embankments (i.e. one borehole at each approach); and
- One borehole was advanced near the south end of the proposed RSS wall on the east side of the south abutment.

The boreholes were advanced using a track- or truck-mounted CME-55 supplied and operated by Landcore Drilling Ltd. (Landcore) of Sudbury, Ontario. The boreholes were advanced using 108 mm inside diameter (I.D.) continuous flight hollow stem augers or NW casing and wash boring. Soil samples were obtained, where possible, continuously or at intervals of depths of 0.75 m to 2 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 using an 'NQ' size core barrel. 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 by O.Reg. 372).

Bedrock was observed at ground surface in Boreholes B4-11, B4-12, B4-16, B4-17, B4-19, B4-20 and B4-22. The remaining boreholes were advanced to auger/split-spoon refusal or cored into the bedrock to depths ranging from 1.6 m to 14.6 m below existing ground surface. This included coring bedrock for lengths of between 2.9 m and 3.2 m in Boreholes B4-2, B4-3, B4-4, B4-10, B4-13 and B4-14 and 10.5 m in Borehole B4-18.

A piezometer was installed in Borehole B4-10 to permit monitoring of the groundwater level at this location. The piezometers consist of 51 mm diameter PVC pipe, with a 1.5 m long slotted screen sealed at a selected depth within the borehole. The non-instrumented borehole and the annulus surrounding the piezometer pipe above the sand pack were backfilled to the surface with bentonite pellets/grout. 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. Strength testing (uniaxial compression and point load index) was also carried out on selected specimens of the rock core.

MMM surveyed the location of the boreholes at the site in December 2008 prior to drilling, excluding Borehole B4-23, which was referenced to the staked highway alignment. Where boreholes were relocated from the original staked locations, Golder resurveyed and located the new boreholes relative to MMM's stakes. The borehole locations shown on the Contract Drawings are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole/drillhole locations and ground surface elevations are as follows:



Borehole	Location (m)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
B4-1	5050316.5	237115.6	191.8	4.2
B4-2	5050321.4	237114.8	190.7	7.1
B4-3	5050318.1	237110.3	192.3	8.5
B4-4	5050314.8	237105.8	191.9	5.8
B4-5	5050319.8	237104.9	192.1	4.1
B4-6	5050342.9	237109.9	193.2	9.9
B4-10	5050345.5	237098.3	190.2	14.6
B4-11	5050387.2	237101.2	197.6	0
B4-12	5050392.1	237100.4	199.3	0
B4-13	5050388.8	237095.8	192.2	4.1
B4-14	5050385.5	237091.3	192.8	5.7
B4-15	5050390.4	237090.5	192.7	1.6
B4-16	5050413.8	237096.6	203.8	0
B4-17	5050418.7	237095.7	205.0	0
B4-18	5050415.4	237091.2	203.9	10.7
B4-19	5050412.1	237086.7	202.9	0
B4-20	5050417.0	237085.9	203.2	0
B4-21	5050303.3	237112.8	192.0	3.2
B4-22	5050430.2	237088.7	205.2	0
B4-23	5050293.9	237135.8	193.5	2.3

## 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. Localized 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.

<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.



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 (OGS, 1991)<sup>2</sup>. 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 bedrock 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 bedrock 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 measurements. 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 and beyond the boreholes will exist and is to be expected.

In general, the subsoils in the area of the south approach/abutment/pier consist of organics/peat or fill materials underlain by cohesive deposits of silty clay to clay and/or cohesionless deposits of gravelly sand to sand and silt. Bedrock is exposed (i.e. along the existing Highway 69 rock cut) at the north approach/abutment and in the east half of the north pier. The total thickness of overburden is variable at the site, ranging from about 11.5 m in the south pier area to no overburden at the north abutment/approach where bedrock is exposed.

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

### **4.2.1 Fill**

Fill was encountered at ground surface in Boreholes B4-1 to B4-3, B4-6, B4-10, B4-13 to B4-15, B4-21 and B4-23. Boreholes B4-1 and B4-3 were advanced on the west side of the existing SBL ditch, Boreholes B4-2 and B4-10 were advanced in the existing SBL ditch and Boreholes B4-6 and B4-13 to B4-15 were advanced through the existing roadway. Borehole B4-23 advanced on the west side of the existing highway south of the south abutment.

#### **4.2.1.1 Roadway Fill**

In Boreholes B4-6, B4-14 and B4-15 (drilled from the roadway surface), between approximately 75 mm and 210 mm of asphalt was encountered. In Borehole B4-10, a 0.1 m thick layer of peat fill was encountered at ground surface. Underlying the asphalt and peat fill and from ground surface at Boreholes B4-13 and B4-23, the boreholes penetrated roadway fill which generally consists of sand to sand and gravel, trace silt. The ground surface/top of fill in Boreholes B4-6, B4-10, B4-13 to B4-15 and B4-23 ranges between Elevation 193.5 m and 190.2 m and the thickness of the embankment fill ranges from 0.2 m to 4.5 m.

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





SPT 'N'-values measured within the sand to sand and gravel fill range between 0 blows (weight of hammer) and 98 blows per 0.3 m of penetration indicating a very loose to very dense relative density, but are typically below 25 blows per 0.3 m of penetration, indicating a generally very loose to compact relative density.

The natural moisture content measured on samples of the fill layer ranged between about 15 percent and about 22 percent.

Grain size distribution tests were carried out on three samples of the sand fill and the results are shown on Figure B-1.

#### **4.2.1.2 Organics Fill**

In Boreholes B4-1, B4-2 and B4-3, fill consisting of peat containing sand, silt and clay or clayey silt to sand containing organics was encountered at ground surface. The ground surface/top of fill in these boreholes ranges from Elevation 192.3 m to 190.7 m and the thickness of the organic fill layer ranges between 0.6 m and 1.8 m.

SPT 'N'-values measured within the peat fill layer range between 2 and 5 blows per 0.3 m of penetration suggesting a soft to firm consistency.

The natural moisture content measured on samples of the peat fill layer ranges between about 27 percent and about 58 percent.

#### **4.2.2 Peat**

A deposit of moist to wet, brown to black peat was encountered at ground surface or below the fill in Boreholes B4-3 to B4-5, B4-18 and B4-21. The top of the peat layer was encountered between Elevation 190.8 m and 192.1 m in the south approach area and Elevation 203.9 m in the north approach area and the thickness of the deposit ranges between 0.1 m and 2.2 m.

SPT 'N'-values measured within the peat deposit range between 1 and 4 blows per 0.3 m of penetration suggesting a very soft to soft consistency.

The natural moisture content measured on samples of this deposit ranges between about 24 percent and about 361 percent.

#### **4.2.3 Silty Clay to Clay**

A deposit of wet, brown to grey, silty clay to clay containing trace to some sand was encountered below the fill in Boreholes B4-1, B4-2, B4-6 and B4-10 and below the peat in Boreholes B4-3 to B4-5 and B4-21. In Borehole B4-21, a 0.3 m thick clayey silt seam was encountered at the top of the silty clay to clay deposit at a depth of 1.0 m (Elevation 191.0 m). The top of the silty clay to clay deposit was encountered between Elevation 186.8 m and 191.1 m and its thickness ranges between 1.2 m and 3.3 m. In Boreholes B4-2 and B4-4, the bottom of this deposit was confirmed by coring of the underlying bedrock and in Borehole B4-5 the bottom of this deposit was defined by refusal to further split-spoon and auger advancement.



SPT 'N'-values measured within the clayey silt to clay deposit range from 0 blows (weight of hammer) to 2 blows per 0.3 m of penetration. In situ field vane testing carried out within this stratum measured undrained shear strengths ranging from about 23 kPa to 48 kPa where the cohesive deposit was encountered below the fill (i.e. Boreholes B4-6 and B4-10) and ranging from 6 kPa to 18 kPa where fill was not generally encountered. The SPT 'N'-values together with the in situ field vane tests indicate the deposit has a very soft to firm consistency.

The natural moisture content measured on samples of this deposit ranges between about 40 percent and about 89 percent.

Atterberg limits testing carried out on eight (8) samples of the silty clay to clay deposit yielded liquid limits ranging from 49 percent to 60 percent, plastic limits ranging from 21 percent to 27 percent and plasticity indices ranging from 29 percent to 36 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 deposit consists of silty clay of medium plasticity to clay of high plasticity. An Atterberg limits test was also carried out on the clayey silt seam and yielded a liquid limit of 31 percent, a plastic limit of 18 percent and a plasticity index of 13 percent.

A grain size distribution test was carried out on one sample of the cohesive deposit and the results are shown on Figure B-3.

#### **4.2.4 Gravelly Sand to Sand and Silt**

A deposit of wet, brown to grey, gravelly sand to sand and silt containing trace to some clay was encountered below the silty clay to clay deposit in Boreholes B4-1, B4-3, B4-6, B4-10 and B4-21 and below the fill in Borehole B4-23. The top of the deposit was encountered between Elevation 189.3 m and 185.6 m in each of the boreholes except Borehole B4-23 where it was encountered at Elevation 193.3 m. The thickness of the deposit ranges from 0.2 m to 6.9 m. The bottom of this deposit was defined by either bedrock coring or refusal.

SPT 'N'-values measured within this deposit range from 2 blows to 51 blows per 0.3 m of penetration, indicating a very loose to very dense relative density.

The natural moisture content measured on samples of this deposit ranges between about 10 percent and about 21 percent.

Grain size distribution tests were carried out on four samples of the sand to sand and silt deposit and the results are shown on Figure B-4.

#### **4.2.5 Refusal/Bedrock**

Bedrock was encountered and cored in Boreholes B4-2 to B4-4, B4-10, B4-13, B4-14 and B4-18. Bedrock was also exposed in Boreholes B4-11, B4-12, B4-16, B4-17, B4-19, B4-20 and B4-22. The bedrock surface was inferred from spilt-spoon and/or auger refusal in the remaining holes. The bedrock surface (inferred or actual) was encountered at depths that ranged from 0.2 m to 11.5 m below ground surface, and ranges from Elevation 205.2 m to 178.7 m. Refusal and bedrock surface depths and elevations as encountered in the boreholes are summarized 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. In Borehole B4-10, the lower 1.5 m was heavily fractured with zones of broken core. In Borehole B4-18, the bedrock below a depth of 8.4 m (Elevation 195.5 m) is described as pegmatite.

The Total Core Recovery (TCR) is 100 percent for all core samples. The Rock Quality Designation (RQD) measured on the core samples ranges from about 70 percent to 100 percent, indicating a rock mass of fair to excellent quality. The lower core sample in Borehole B4-10 measured an RQD value of about 38 percent, indicating a rock mass of poor quality. The Solid Core Recovery (SCR) ranges from about 66 percent to 100 percent. The lower core sample in Borehole B4-10 measured a SCR of 38 percent.

Laboratory Uniaxial Compressive Strength (UCS) testing was carried out on six core samples of the bedrock. The UCS ranges from about 83 MPa to 154 MPa for the gneiss bedrock as summarized in Table B-2, indicating strong to very strong rock.

Point load strength tests were performed on selected 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. The diametral point load index ( $I_{s50}$ ) results from the laboratory tests carried out on core samples range from about 3 MPa to 6.5 MPa. These index values correspond to estimated UCS values ranging between 71 MPa and 150 MPa, as presented in Table B-3, based on a relationship between  $I_{s50}$  and UCS which is given by a correlation factor (K) in accordance with ASTM 5731-08, 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 23, 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), the gneiss bedrock is classified as strong (R4, 50 MPa < UCS < 100 MPa) to very strong (R5, 100 MPa < UCS < 250 MPa).

#### **4.2.6 Groundwater Conditions**

The water levels were noted in the boreholes 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 Boreholes B4-1 to B4-6, B4-14, B4-21 and B4-23 upon completion of drilling was at depths that ranged between 0.5 m and 2.3 m below ground surface, ranging between Elevation 191.3 m and 190.3 m.

A standpipe piezometer was installed in Borehole B4-10 to permit monitoring of the water level within the cohesionless stratum at this location. Details of the piezometer installation are shown on the Record of Borehole sheets in Appendix A. The groundwater level measured in the piezometer installation was 0.7 m above ground surface as summarized below.



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**GWP 5005-08-00**

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Foundation Element	Borehole No.	Ground Surface Elevation (m)	Groundwater Elevation (m)	Date of Measurement
South Pier	B4-10	190.2	190.9	March 31, 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. Indulis Dumpis. This report was prepared by Mr. Evan Childerhose, P.Eng. and Mr. André Bom, P.Eng. The technical aspects were reviewed by Mr. Jorge M. A. Costa, P.Eng., Golder's Designated MTO Contact for this project, who also carried out a quality control review of the report.



## Report Signature Page

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N:\Active\2007\1190 Sudbury\1191\07-1191-0020 MMM Hwy 69 Twinning\7000 Reporting\Final\Hwy 529 Overpass\NBL\07-1191-0020-B4 RPT 12Mar14 Hwy 529 OP NBL.Docx



# **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.

### 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.

### 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





## 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 B4- 1			1 OF 1 METRIC															
W.P. 5191-06-01			LOCATION N 5050316.5; E 237115.6			ORIGINATED BY EHS															
DIST _____ HWY 69			BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers			COMPILED BY MR															
DATUM Geodetic			DATE February 3, 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 (%)			γ					
191.8	GROUND SURFACE							20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>	10 20 30								
0.0	Peat containing sand, silt and clay layers (FILL) Very soft Brown Moist to wet		1	SS	2		191														
190.0	CLAY Very soft Brown to grey Wet		2	SS	WH		190														
1.8			3	SS	WR		189														
187.8	SAND and SILT, some sand Loose Grey Wet		4	SS	3/0.05		188														
4.2	End of Borehole Spoon and Auger Refusal  Note: 1. Water level at a depth of 1.5 m below ground surface (Elev. 190.3 m) upon completion of drilling.																				

SUD-MTO 001 07-1191-0020 B4 BH LOGS METRIC.GPJ GAL-MISS.GDT 21/02/12 DATA INPUT:

PROJECT 07-1191-0020				<b>RECORD OF BOREHOLE No B4- 2</b>				1 OF 1 <b>METRIC</b>									
W.P. 5191-06-01				LOCATION N 5050321.4; E 237114.8				ORIGINATED BY EHS									
DIST _____ HWY 69				BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers				COMPILED BY MR									
DATUM Geodetic				DATE February 4, 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 $\gamma$ 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									
191.1	SNOW SURFACE							20	40	60	80	100					
0.0	SNOW						191										
190.7																	
0.4	Peat containing sand and silt (FILL) Brown Wet																
190.1																	
1.0	SILTY CLAY Very soft to soft Brown to grey Wet		1	SS	WH		190										
							189	5									
								+	5								
			2	SS	WH		188										
								3									
								+	4								
								+									
186.8	GNEISS (BEDROCK)		3	SS	17		187										
4.3	Bedrock cored from 4.3 m depth to 7.5 m depth.  For coring details refer to Record of Drillhole B4-2.		1	RC	REC 100%		186										RQD = 98%
							185										
			2	RC	REC 100%		184										RQD = 100%
183.6	End of Borehole																
7.5	Note:  1. Water level at a depth of 0.5 m below ground surface (Elev. 190.6 m) upon completion of drilling.																

SUD-MTO 001 07-1191-0020 B4 BH LOGS METRIC.GPJ GAL-MISS.GDT 21/02/12 DATA INPUT:

PROJECT: 07-1191-0020

RECORD OF DRILLHOLE: **B4- 2**

SHEET 1 OF 1

LOCATION: N 5050321.4 ;E 237114.8

DRILLING DATE: February 4, 2009

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Landcore Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.	RUN No.	COLOUR % RETURN	JN - Joint FLT - Fault SHR - Shear VN - Vein CJ - Conjugate	BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage	PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular	PO - Polished K - Slickensided SM - Smooth Ro - Rough MB - Mechanical Break	BR - Broken Rock	NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
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RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY				Diameter Point Load Index (MPa)	RMC -Q AVG.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	10 <sup>-6</sup>	10 <sup>-5</sup>			10 <sup>-4</sup>	10 <sup>-3</sup>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							

DEPTH SCALE

1 : 50



LOGGED: EHS

CHECKED: AB

SUD-RCK 07-1191-0020 B4 BH LOGS METRIC.GPJ GAL-MISS.GDT 21/02/12 DATA INPUT:

PROJECT 07-1191-0020			RECORD OF BOREHOLE No B4- 3			1 OF 1 METRIC											
W.P. 5191-06-01			LOCATION N 5050318.1; E 237110.3			ORIGINATED BY EHS											
DIST HWY 69			BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers			COMPILED BY DA											
DATUM Geodetic			DATE February 5, 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									
192.3	GROUND SURFACE							20	40	60	80	100					
0.0	Clayey silt to sand, containing organics (FILL) Loose Brown Moist to wet		1	AS	-		192										
			2	SS	5												
190.8							191										
1.5	PEAT (Fibrous) Soft Black Wet		3	SS	3												
190.0							190										
2.3	CLAY Very soft Brown to grey Wet		4	SS	WH												
			5	SS	WH		189										
							188										
187.5			6A														
4.8	Gravelly SAND, trace to some silt Very loose Grey Wet		6B	SS	WH												
187.0							187										
5.3	GNEISS (BEDROCK)  Bedrock cored from 5.3 m depth to 8.5 m depth.  For coring details refer to Record of Drillhole B4-3.		1	RC	REC 100%		186										
			2	RC	REC 100%		185										
183.8							184										
8.5	End of Borehole  Notes: 1. Moved 1.0 m north and obtained Shelby tube at 3.8 m depth. 2. Water level at a depth of 1.4 m below ground surface (Elev. 190.9 m) upon completion of drilling.																

SUD-MTO 001 07-1191-0020 B4 BH LOGS METRIC.GPJ GAL-MISS.GDT 21/02/12 DATA INPUT:

PROJECT: 07-1191-0020

**RECORD OF DRILLHOLE: B4- 3**

SHEET 1 OF 1

LOCATION: N 5050318.1 ;E 237110.3

DRILLING DATE: February 5, 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.	FLUSH	COLOUR % RETURN	JN - Joint FLT - Fault SHR - Shear VN - Vein CJ - Conjugate	BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage	PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular	PO - Polished K - Slickensided SM - Smooth Ro - Rough MB - Mechanical Break	BR - Broken Rock  NOTE: For additional abbreviations refer to list of abbreviations & symbols.	RECOVERY TOTAL CORE % SOLID CORE %	R.Q.D. %	FRACT. INDEX METRES	B Angle	DIP w.r.t. CORE AXIS	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY k, cm/s	Diametral Point Load Index (MPa)	RMC -Q AVG.	NOTES WATER LEVELS INSTRUMENTATION
		Refer to Previous Page		187.0																					
6	NQ Coring 02/05/09	GNEISS Fine to medium grained Fresh Very strong Pinkish grey		5.3	1																				
7																									
8					2																				
		End of Drillhole		183.8																					
9				8.5																					
10																									
11																									
12																									
13																									
14																									
15																									

DEPTH SCALE

1 : 50



LOGGED: EHS

CHECKED: AB

SUD-RCK 07-1191-0020 B4 BH LOGS METRIC.GPJ GAL-MISS.GDT 21/02/12 DATA INPUT:



PROJECT		7-1191-0020		<b>RECORD OF BOREHOLE No B4- 4</b>		1 OF 1 <b>METRIC</b>													
W.P.		5191-06-01		LOCATION		N 5050314.8; E 237105.8													
DIST		HWY 69		BOREHOLE TYPE		108 mm I.D. Continuous Flight Hollow Stem Augers													
DATUM		Geodetic		DATE		February 3, 2009													
				ORIGINATED BY		EHS													
				COMPILED BY		MR													
				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	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40						60	80	100	20	40
192.2	SNOW SURFACE																		
0.0	SNOW																		
191.9																			
0.3	PEAT, trace to some sand, trace silt (Fibrous) Very soft to firm Black Moist to wet		1	AS	-														
			2	SS	4														
190.3			3	SS	1														
1.9	CLAY Very soft Grey Wet																		
			4	TO	PH														
189.0			5	SS	20/0														
3.2	GNEISS (BEDROCK)																		
	Bedrock cored from 3.2 m depth to 6.1 m depth.  For coring details refer to Record of Drillhole B4-4.		1	RC	REC 100%														
			2	RC	REC 100%														
187																			
186.1																			
6.1	End of Borehole																		
	Note:  1. Water level at a depth of 0.8 m below ground surface (Elev. 191.1 m) upon completion of drilling.																		

SUD-MTO 001 07-1191-0020 B4 BH LOGS METRIC.GPJ GAL-MISS.GDT 21/02/12 DATA INPUT:

PROJECT: 07-1191-0020

**RECORD OF DRILLHOLE: B4- 4**

SHEET 1 OF 1

LOCATION: N 5050314.8 ;E 237105.8

DRILLING DATE: February 3, 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	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.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
							FLUSH	TOTAL CORE %	SOLID CORE %	TYPE AND SURFACE DESCRIPTION			Jr	Ja	Jn	k, cm/s	10 <sup>-6</sup>	10 <sup>-5</sup>	10 <sup>-4</sup>	10 <sup>-3</sup>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
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PROJECT <u>07-1191-0020</u>				<b>RECORD OF BOREHOLE No B4- 5</b>				1 OF 1 <b>METRIC</b>										
W.P. <u>5191-06-01</u>				LOCATION <u>N 5050319.8; E 237104.9</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</u>				COMPILED BY <u>DA</u>										
DATUM <u>Geodetic</u>				DATE <u>January 29, 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										
192.1	GROUND SURFACE							20	40	60	80	100						
0.0	PEAT (Fibrous) Very soft Black Moist		1	AS	-		192										52.6	
			2	SS	2		191										52.5	
			3	SS	1		190										62.1	
189.9	CLAY Very Soft Grey to brown Wet	4	SS	WR	189		+5									50.2		
2.2	Approximately 1.5 m of heave at 3.8 m depth.				189		+5											
188.0	End of Borehole Spoon and Auger Refusal		5	SS	8/0.15		188											
4.1	Note:  1. Augers dipping to the southeast upon refusal. Advanced spoon to a depth of 4.4 m, bending the spoon.  2. Water level at a depth of 1.8 m below ground surface (Elev. 190.3 m) upon completion of drilling.																	

SUD-MTO 001 07-1191-0020 B4 BH LOGS METRIC.GPJ GAL-MISS.GDT 21/02/12 DATA INPUT:

PROJECT 07-1191-0020			RECORD OF BOREHOLE No B4- 6			1 OF 1 METRIC														
W.P. 5191-06-01			LOCATION N 5050342.9; E 237109.9			ORIGINATED BY ID														
DIST HWY 69			BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers			COMPILED BY DA														
DATUM Geodetic			DATE March 31, 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					W <sub>p</sub>	W	W <sub>L</sub>	γ	GR	SA	SI	CL
193.2	GROUND SURFACE							20 40 60 80 100												
0.1	ASPHALT Sand, trace to some silt (FILL) Very loose to compact Brown to grey Moist to wet		1	SS	25		193													
			2	SS	20		192													
			3	SS	2		191													
			4	SS	1		190													
			5	SS	1		189													
188.7	CLAY Soft Grey Wet		6	SS	WH		188													
4.5			7	TO	WH		187													
186.0	SAND and SILT, trace gravel, cobbles and boulders inferred / encountered at 9.1 m depth Compact to very dense Grey Wet		8	SS	15		186													
7.2			9	SS	45/0.15		185													
183.3	End of Borehole Auger Refusal  Notes: 1. Spoon refusal at a depth of 9.4 m below ground surface (Elev. 183.8 m) 2. Water level at a depth of 2.2 m below ground surface (Elev. 191.0 m) upon completion of drilling.						184													
9.9																				

SUD-MTO 001 07-1191-0020 B4 BH LOGS METRIC.GPJ GAL-MISS.GDT 13/03/12 DATA INPUT:

**RECORD OF BOREHOLE No B4-10**

1 OF 2 **METRIC**


PROJECT 07-1191-0020  
 W.P. 5191-06-01 LOCATION N 5050345.5; E 237098.3 ORIGINATED BY EHS  
 DIST            HWY 69 BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring COMPILED BY DA  
 DATUM Geodetic DATE January 30 and February 2, 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								
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× REMOULDED					
190.9	SNOW SURFACE						20	40	60	80	100	10	20	30		
0.0	SNOW															
190.2																
0.8	Peat (FILL)															
	Sand, trace gravel, trace silt (FILL)		1	SS	7								○			
	Very loose to loose															
	Brown		2	SS	2											2 93 (5)
	Wet															
			3	SS	WH											
			4	SS	WH											
186.8			5A	SS	2											
4.1	CLAY		5B	SS	2											
	Firm															
	Brown															
	Wet															
185.6																
5.3	SAND and SILT, some clay		6	SS	WH								○			0 53 34 13
	Very loose															
	Brown															
184.9	Wet															
6.0	SAND, some gravel, some silt, cobbles and boulders inferred / encountered at 9.3 m depth		7	SS	5											
	Loose to very dense															
	Grey															
	Wet															
	Approximately 2.1 m of heave at 7.6 m depth.		8	SS	11									○		15 72 (13)
	Switched to NW Casing at 9.3 m depth.		9	SS	13/0.01											
	Approximately 1.2 m of heave at 9.7 m depth.															
	Approximately 3.0 m of heave at 11.3 m depth. Bi-cone was used to clear casing.		10	SS	51											
178.7																
12.2	GNEISS (BEDROCK)															
	Bedrock cored from 12.2 m depth to 15.3 m depth.		1	RC	REC 100%											RQD = 92%
	For coring details refer to Record of Drillhole B4-10.		2	RC	REC 100%											RQD = 38%

Continued Next Page

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

SUD-MTO 001 07-1191-0020 B4-BH LOGS METRIC.GPJ GAL-MISS.GDT 21/02/12 DATA INPUT:

PROJECT <u>07-1191-0020</u>		<b>RECORD OF BOREHOLE No B4-10</b>				2 OF 2 <b>METRIC</b>											
W.P. <u>5191-06-01</u>		LOCATION <u>N 5050345.5; E 237098.3</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>DA</u>											
DATUM <u>Geodetic</u>		DATE <u>January 30 and February 2, 2009</u>				CHECKED BY <u>AB</u>											
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			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					WATER CONTENT (%)				
	--- CONTINUED FROM PREVIOUS PAGE ---																
175.6 15.3	End of Borehole  Notes:  1. Water level at 0.1 m below ground surface (Elev. 190.1 m) upon completion of drilling.  2. Water level measured in piezometer at 0.7 m above ground surface (Elev. 190.9 m) on March 31, 2009.		2	RC													RQD = 38%

SUD-MTO 001 07-1191-0020 B4 BH LOGS METRIC.GPJ GAL-MISS.GDT 21/02/12 DATA INPUT:



SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: Landcore Drilling

CHECKED: AB



SUD-MTO 001 07-1191-0020 B4 BH LOGS METRIC.GPJ GAL-MISS.GDT 21/02/12 DATA INPUT:

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



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

PROJECT		RECORD OF BOREHOLE No B4-13				1 OF 1 METRIC											
W.P. 07-1191-0020		LOCATION N 5050388.8; E 237095.8				ORIGINATED BY ID											
DIST HWY 69		BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers				COMPILED BY DA											
DATUM Geodetic		DATE April 15, 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									
192.2	GROUND SURFACE							20	40	60	80	100					
0.0	Sand and gravel (FILL) Compact Brown Moist		1	AS	-		192										
191.3			2	SS	9/0.15												
0.9	GNEISS (BEDROCK)  Bedrock cored from 0.9 m depth to 4.1 m depth.  For coring details refer to Record of Drillhole B4-13.		1	RC	REC 100%		191										RQD = 70%
			2	RC	REC 100%		190										RQD = 97%
			3	RC	REC 100%		189										RQD = 100%
188.1	End of Borehole  Note:  1. Borehole dry upon completion of drilling.																
4.1																	

SUD-MTO 001 07-1191-0020 B4 BH LOGS METRIC.GPJ GAL-MISS.GDT 21/02/12 DATA INPUT:

PROJECT: 07-1191-0020

**RECORD OF DRILLHOLE: B4-13**

SHEET 1 OF 1

LOCATION: N 5050388.8 ; E 237095.8

DRILLING DATE: April 15, 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.	FLUSH	COLOUR % RETURN		JN - Joint FLT - Fault SHR- Shear VN - Vein CJ - Conjugate		BD- Bedding FO- Foliation CO- Contact OR- Orthogonal CL - Cleavage		PL - Planar CU- Curved UN- Undulating ST - Stepped IR - Irregular		PO- Polished K - Slickensided SM- Smooth Ro - Rough MB- Mechanical Break		BR - Broken Rock		NOTES WATER LEVELS INSTRUMENTATION		
							TOTAL CORE %	SOLID CORE %	R.Q.D. %	FRACT. INDEX METRES	B Angle	DIP w.r.t. CORE AXIS	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY k, cm/s	Diametral Point Load Index (MPa)	RMC -Q AVG.				
													TYPE AND SURFACE DESCRIPTION	Jr				Ja		Jn	
1	NQ Coring 04/05/09	Refer to Previous Page		191.3																	
		GNEISS Fine to medium grained Slightly weathered Grey  Numerous joints from 0.9 m to 1.2 m depth.		0.9	1																
2					2																
3					3																
4		End of Drillhole		188.1	4.1																
5																					
6																					
7																					
8																					
9																					
10																					

DEPTH SCALE

1 : 50



LOGGED: ID

CHECKED: AB

SUD-RCK 07-1191-0020 B4 BH LOGS METRIC.GPJ GAL-MISS.GDT 13/03/12 DATA INPUT:

PROJECT <u>07-1191-0020</u>				<b>RECORD OF BOREHOLE No B4-14</b>				1 OF 1 <b>METRIC</b>									
W.P. <u>5191-06-01</u>		LOCATION <u>N 5050385.5; E 237091.3</u>				ORIGINATED BY <u>ID</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>DA</u>											
DATUM <u>Geodetic</u>		DATE <u>March 31, 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  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
192.8	GROUND SURFACE							20	40	60	80	100					
0.0	ASPHALT																
0.2	Sand and gravel to sand (FILL) Dense to very dense Brown Moist to wet		1	SS	98		192										
			2	SS	46		191										
190.2	GNEISS (BEDROCK)		3	SS	10/0.08		190										
2.6	Bedrock was cored from 2.6 m to 5.7 m depth.  For coring details refer to Record of Drillhole B4-14.		1	RC	REC 100%		189										RQD = 89%
			2	RC	REC 100%		188										RQD = 94%
187.1	End of Borehole																
5.7	Notes:  1. Water level at a depth of 2.3 m below ground surface (Elev. 190.5 m) upon completion of drilling.																

SUD-MTO 001 07-1191-0020 B4 BH LOGS METRIC.GPJ GAL-MISS.GDT 21/02/12 DATA INPUT:



PROJECT: 07-1191-0020

**RECORD OF DRILLHOLE: B4-14**

SHEET 1 OF 1

LOCATION: N 5050385.5 ; E 237091.3

DRILLING DATE: March 31, 2009

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Landcore Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.	RUN No.	COLOUR % RETURN	FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY				Diameter Point Load Index (MPa)	RMC -Q AVG.	NOTES WATER LEVELS INSTRUMENTATION		
				DEPTH (m)				TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	k, cm/s	T				T2	T3
		Refer to Previous Page		190.2																				
3	NO Coring 03/31/09	GNEISS Fine to coarse grained Slightly weathered Strong Grey		2.6																				
4																								
5																								
6		End of Drillhole		187.1																				
7																								
8																								
9																								
10																								
11																								
12																								

DEPTH SCALE

1 : 50



LOGGED: ID

CHECKED: AB

SUD-RCK 07-1191-0020 B4 BH LOGS METRIC.GPJ GAL-MISS.GDT 21/02/12 DATA INPUT:

PROJECT <u>07-1191-0020</u>				<b>RECORD OF BOREHOLE No B4-15</b>				1 OF 1 <b>METRIC</b>									
W.P. <u>5191-06-01</u>				LOCATION <u>N 5050390.4; E 237090.5</u>				ORIGINATED BY <u>ID</u>									
DIST <u>          </u> HWY <u>69</u>				BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers</u>				COMPILED BY <u>DA</u>									
DATUM <u>Geodetic</u>				DATE <u>April 14, 2009</u>				CHECKED BY <u>AB</u>									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			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					WATER CONTENT (%)				
192.7	GROUND SURFACE							20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
0.0	ASPHALT					192											
	Sand and gravel to sand (FILL) Dense Brown Moist		1	SS	39												
191.1	End of Borehole Auger Refusal		2	SS	15/0.08												
1.6	Note:  1. Borehole dry upon completion of drilling.																

SUD-MTO 001 07-1191-0020 B4 BH LOGS METRIC.GPJ GAL-MISS.GDT 21/02/12 DATA INPUT:



## 1 OF 1 METRIC

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



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

PROJECT 07-1191-0020				RECORD OF BOREHOLE No B4-18				1 OF 1 METRIC									
W.P. 5191-06-01		LOCATION N 5050415.4; E 237091.2		ORIGINATED BY EHS													
DIST _____ HWY 69		BOREHOLE TYPE NQ Coring		COMPILED BY DA													
DATUM Geodetic		DATE March 9 and 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					WATER CONTENT (%)			γ kN/m³	GR SA SI CL
							20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>	10 20 30					
203.9	GROUND SURFACE																
0.0	ORGANICS																
0.2	Brown Moist GNEISS (BEDROCK)																
	Bedrock cored from 0.2 m to 10.7 m depth.		1	RC	REC 100%		203										RQD = 95%
	For coring details refer to Record of Drillhole B4-18.		2	RC	REC 100%		202										RQD = 96%
			3	RC	REC 100%		201										RQD = 100%
			4	RC	REC 100%		200										RQD = 100%
			5	RC	REC 100%		199										RQD = 100%
			6	RC	REC 100%		198										RQD = 100%
			7	RC	REC 100%		197										RQD = 100%
195.5	PEGMATITE (BEDROCK)						196										RQD = 100%
8.4							195										RQD = 100%
193.2	End of Borehole						194										RQD = 100%
10.7	Note: 1. Borehole dry upon completion of drilling.																

SUD-MTO 001 07-1191-0020 B4 BH LOGS METRIC.GPJ GAL-MISS.GDT 13/03/12 DATA INPUT:

PROJECT: 07-1191-0020

**RECORD OF DRILLHOLE: B4-18**

SHEET 1 OF 2

LOCATION: N 5050415.4 ; E 237091.2

DRILLING DATE: March 9 and 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	RECOVERY		FRACT. INDEX METRES	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY				Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
							FLUSH	TOTAL CORE %		SOLID CORE %	R.Q.D. %	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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									

DEPTH SCALE

1 : 50



LOGGED: EHS

CHECKED: AB

SUD-RCK 07-1191-0020 B4 BH LOGS METRIC.GPJ GAL-MISS.GDT 13/03/12 DATA INPUT:

NQ Coring  
03/09/09 and 04/09/09

UCS = 101 MPa

PROJECT: 07-1191-0020

RECORD OF DRILLHOLE: **B4-18**

SHEET 2 OF 2

LOCATION: N 5050415.4 ;E 237091.2

DRILLING DATE: March 9 and 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.	FLUSH	COLOUR % RETURN	JN - Joint FLT - Fault SHR - Shear VN - Vein CJ - Conjugate BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular PO - Polished K - Slickensided SM - Smooth Ro - Rough MB - Mechanical Break BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.										NOTES WATER LEVELS INSTRUMENTATION			
								RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY k, cm/s		Diametral Point Load Index (MPa)	RMC -Q AVG.		
								TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Ur	Ja	Un				
		--- CONTINUED FROM PREVIOUS PAGE ---																			
	No Coring	PEGMATITE Fine to coarse grained Sound		193.2 10.7	7																
		End of Drillhole																			
11																					
12																					
13																					
14																					
15																					
16																					
17																					
18																					
19																					
20																					

DEPTH SCALE

1 : 50



LOGGED: EHS

CHECKED: AB

SUD-RCK 07-1191-0020 B4 BH LOGS METRIC.GPJ GAL-MISS.GDT 13/03/12 DATA INPUT:



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





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

PROJECT 07-1191-0020				<b>RECORD OF BOREHOLE No B4-21</b>				1 OF 1 <b>METRIC</b>									
W.P. 5191-06-01		LOCATION N 5050303.3; E 237112.8				ORIGINATED BY EHS											
DIST _____ HWY 69		BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers				COMPILED BY DA											
DATUM Geodetic		DATE January 29, 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 $\gamma$ 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									
192.0	GROUND SURFACE																
0.0	ORGANICS (FILL)																
0.2	Brown Moist																
191.2	Silty sand, trace gravel, trace clay (FILL)																
0.9	Brown Wet		1	AS	-												
	PEAT Black Wet		2	SS	WH												
	SILTY CLAY to CLAY, clayey silt seam at top of the deposit																
	Very soft Grey to brown Wet		3	SS	WH												
189.3																	
2.7	SAND, trace to some gravel, trace to some silt																
188.8	Very loose Grey Wet		4	SS	40/0.08												
3.2																	
	End of Borehole Spoon and Auger Refusal																
Notes: 1. Water level at a depth of 1.1 m below ground surface (Elev. 190.9 m) upon completion of drilling.																	

SUD-MTO 001 07-1191-0020 B4 BH LOGS METRIC.GPJ GAL-MISS.GDT 21/02/12 DATA INPUT:



PROJECT		RECORD OF BOREHOLE No B4-23				1 OF 1 METRIC											
W.P. 07-1191-0020		LOCATION N 5050293.9; E 237135.8				ORIGINATED BY ID											
DIST HWY 69		BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers				COMPILED BY JJL											
DATUM Geodetic		DATE April 7, 2010				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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
193.5	GROUND SURFACE																
0.0	Sand and gravel to sand (FILL)																
0.2	Very loose Grey Moist		1	SS	2												
	SAND Loose Brown Moist		2	SS	5												1 89 (10)
			3	SS	5												
191.2																	
2.3	End of Borehole Auger Refusal																
	Notes:  1. Water level at a depth of 2.2 m below ground surface (Elev. 191.3 m) upon completion of drilling.  2. Moved 1.5 m south and encountered auger refusal at 2.3 m depth.																

SUD-MTO 001 07-1191-0020 B4 BH LOGS METRIC.GPJ GAL-MISS.GDT 21/02/12 DATA INPUT:



# **APPENDIX B**

## **Laboratory Test Results**

**TABLE B-1  
REFUSAL/BEDROCK ELEVATIONS  
HIGHWAY 529 OVERPASS NBL  
GWP 5005-08-00**

<b>Borehole</b>	<b>Depth to Refusal/Bedrock Surface* (m)</b>	<b>Refusal/Bedrock Surface Elevation (m)</b>	<b>Comments</b>
B4-1	4.2	187.6	Spoon and Auger Refusal
B4-2	3.9	186.8	Bedrock Surface
B4-3	5.3	187.0	Bedrock Surface
B4-4	3.2	189.0	Bedrock Surface
B4-5	4.1	188.0	Spoon and Auger Refusal
B4-6	9.9	183.3	Auger Refusal
B4-10	12.2	178.7	Bedrock Surface
B4-11	G.S.**	197.6	Exposed Bedrock
B4-12	G.S.**	199.3	Exposed Bedrock
B4-13	0.9	191.3	Bedrock Surface
B4-14	2.6	190.2	Bedrock Surface
B4-15	1.6	191.1	Auger Refusal
B4-16	G.S.**	203.8	Exposed Bedrock
B4-17	G.S.**	205.0	Exposed Bedrock
B4-18	0.2	203.7	Bedrock Surface
B4-19	G.S.**	202.9	Exposed Bedrock
B4-20	G.S.**	203.2	Exposed Bedrock
B4-21	3.2	188.8	Spoon and Auger Refusal
B4-22	G.S.**	205.2	Exposed Bedrock
B4-23	2.3	191.2	Auger Refusal

\* Below bottom of snow where encountered.

\*\* G.S. denotes bedrock was encountered at ground surface.

Compiled by: EC  
Checked by: AB  
Reviewed by: JMAC

**TABLE B-2**  
**UNIAXIAL COMPRESSIVE STRENGTH TEST RESULTS**  
**HIGHWAY 529 OVERPASS NBL**  
**GWP 5005-08-00**

<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>
B4-2	5.4	184.9	Gneiss	48	138
B4-3	6.0	186.3	Gneiss	48	154
B4-4	3.1	188.5	Gneiss	48	118
B4-10	11.4	178.1	Gneiss	48	112
B4-14	4.7	188.1	Gneiss	48	83
B4-18	10.0	193.9	Gneiss	48	101

\* Below bottom of snow where encountered

Compiled by: EC  
Checked by: AB  
Reviewed by: JMAC

**TABLE B-3  
POINT LOAD STRENGTH TEST RESULTS  
HIGHWAY 529 OVERPASS NBL  
GWP 5005-08-00**

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)
B4-2	4.5	186.2	Gneiss	D	48	11.1	0.010	4.64	4.53	104
B4-2	4.8	185.9	Gneiss	D	48	7.5	0.007	3.15	3.08	71
B4-2	6.2	184.5	Gneiss	D	48	11.6	0.011	4.87	4.76	109
B4-3	5.6	186.7	Gneiss	D	48	13.9	0.013	5.84	5.71	131
B4-3	8.2	184.1	Gneiss	D	48	14.6	0.014	6.14	6.00	138
B4-4	3.0	188.9	Gneiss	D	48	12.8	0.012	5.41	5.28	122
B4-4	4.6	187.3	Gneiss	D	48	15.9	0.015	6.65	6.50	150
B4-4	5.3	186.6	Gneiss	D	48	15.0	0.014	6.28	6.14	141
B4-10	12.7	177.5	Gneiss	D	48	9.2	0.009	3.88	3.79	87
B4-10	14.5	175.7	Gneiss	D	48	10.2	0.010	4.28	4.18	96
B4-14	3.4	189.4	Gneiss	D	48	13.7	0.013	5.76	5.63	130
B4-14	4.2	188.6	Gneiss	D	48	12.6	0.012	5.29	5.16	119
B4-14	5.2	187.6	Gneiss	D	48	12.1	0.011	5.07	4.95	114
B4-18	8.6	195.3	Gneiss	D	48	11.5	0.011	4.83	4.72	109

- NOTES:**
1. Depths are given below the ground surface at the borehole location (bottom of snow where encountered).
  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. A K value of 23 has been used, 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.  
K = Conversion factor uniaxial compressive strength and corrected point load strength.

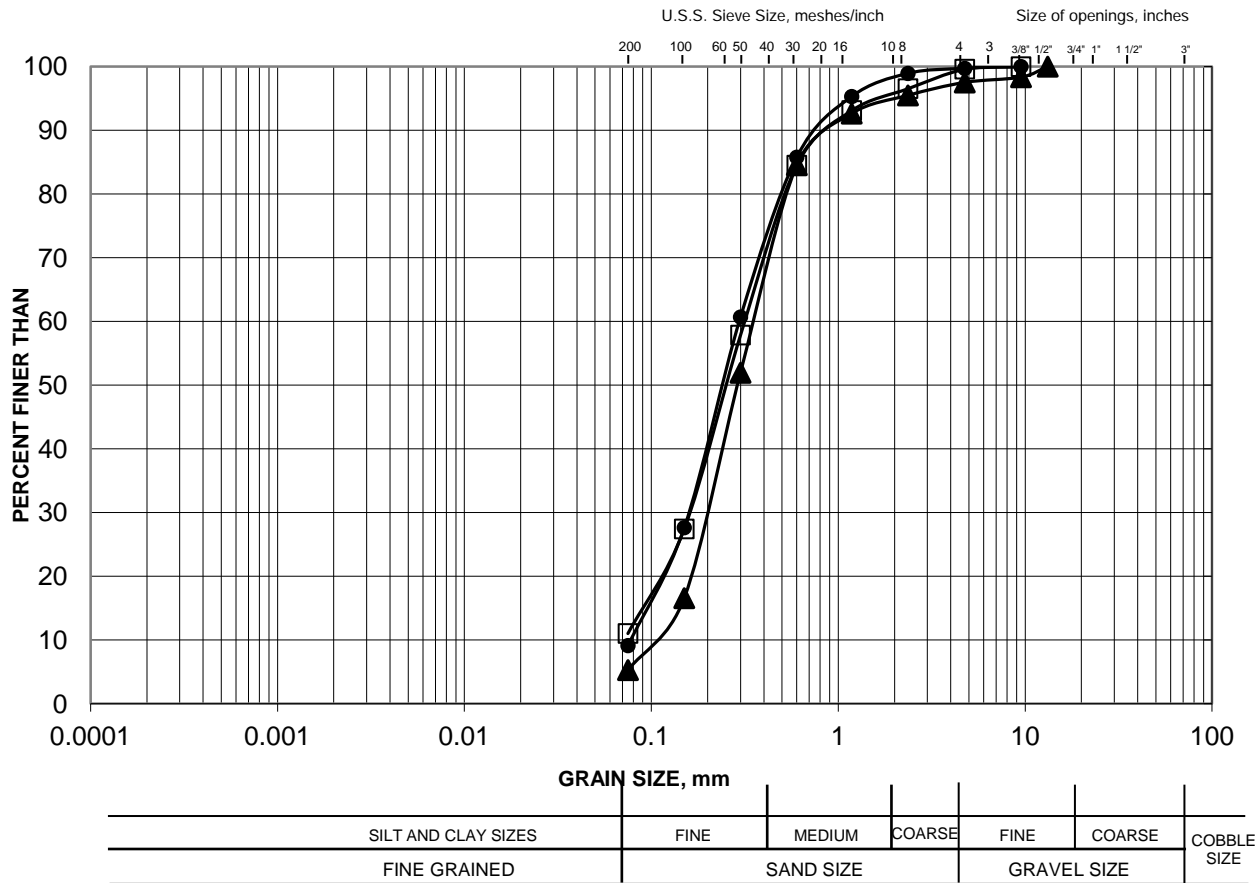
Compiled by: EC  
Checked by: AB  
Reviewed by: JMAC



# GRAIN SIZE DISTRIBUTION

Sand (FILL)

FIGURE  
B-1



## LEGEND

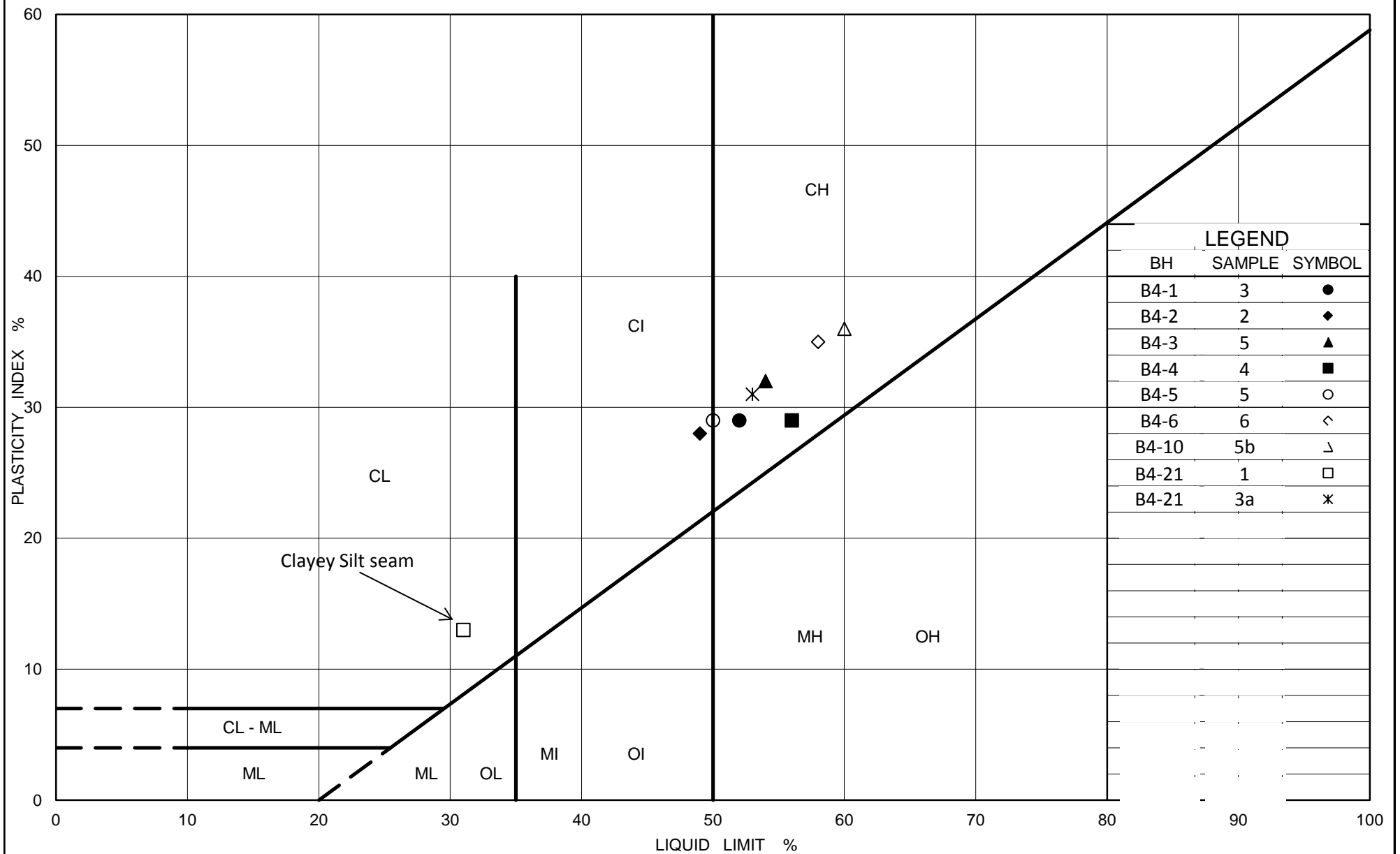
SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
—●—	B4-6	2	191.4
—□—	B4-6	5	189.1
—▲—	B4-10	2	189.1

Project Number: 07-1191-0020-B4

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## PLASTICITY CHART Silty Clay to Clay

FIG No. B-2

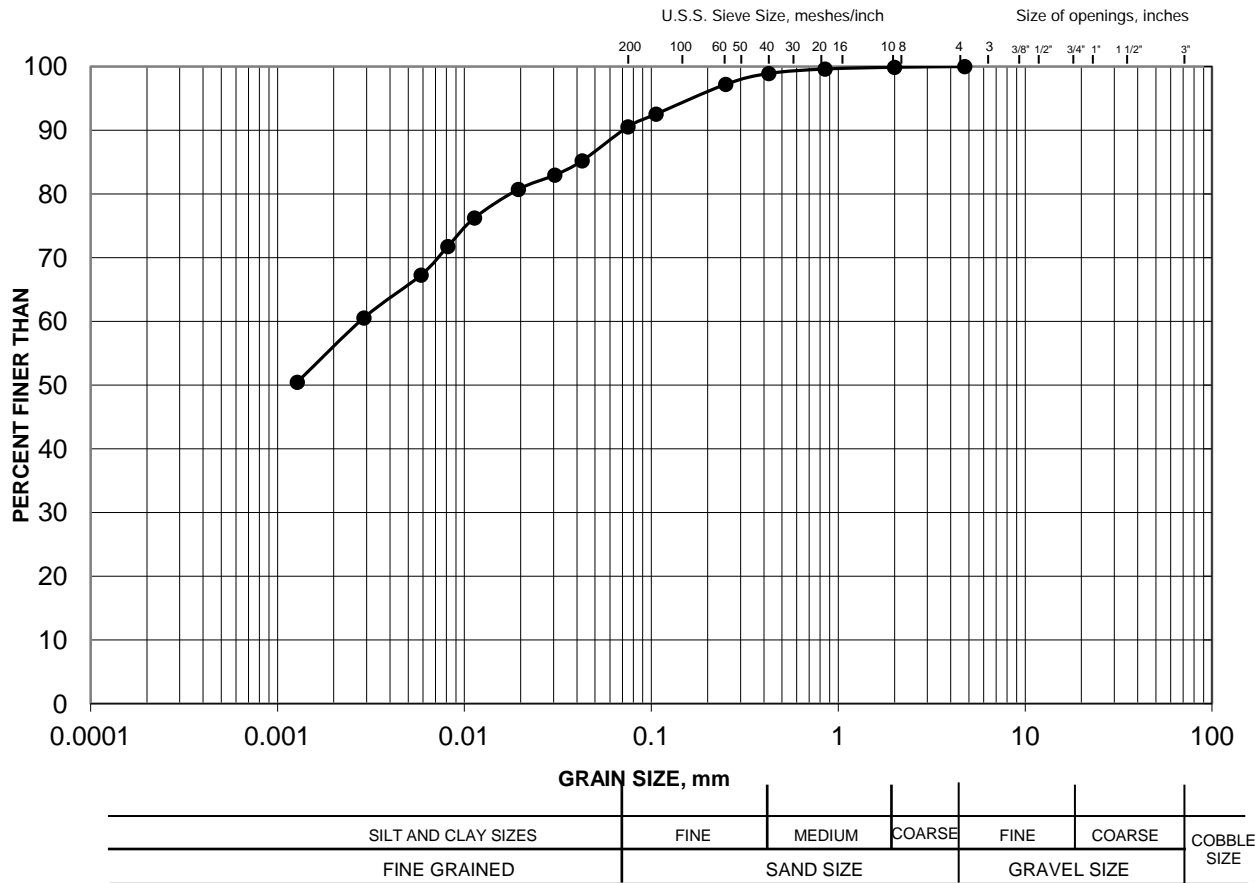
Project No. 07-1191-0020-B4

Checked By: AB

# GRAIN SIZE DISTRIBUTION

Clay

FIGURE  
B-3



## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
—●—	B4-3	6a	187.5

Project Number: 07-1191-0020-B4

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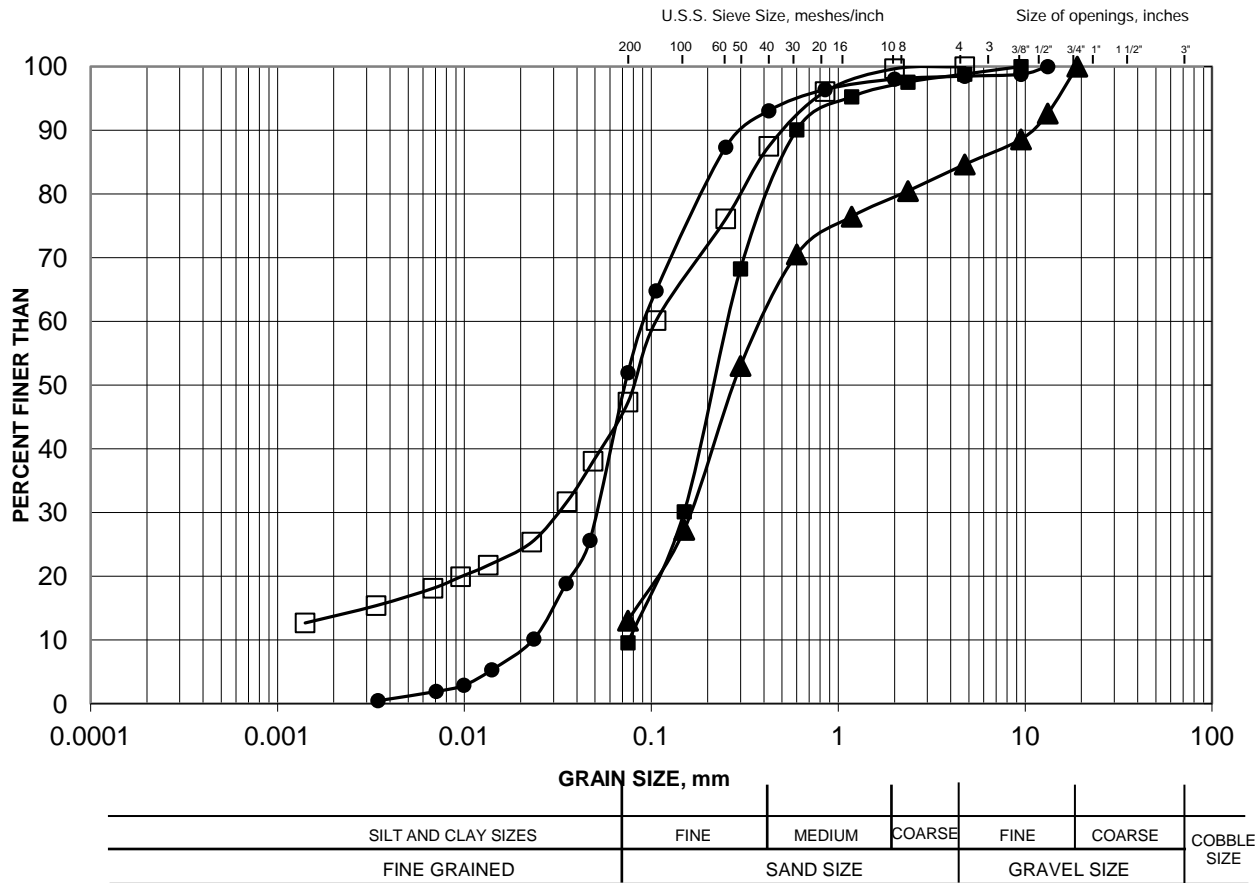
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# GRAIN SIZE DISTRIBUTION

Sand to Sand and Silt

FIGURE  
B-4



## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	B4-6	9	183.9
□	B4-10	6	185.3
▲	B4-10	8	183.0
■	B4-23	2	192.4

Project Number: 07-1191-0020-B4

Checked By: AB

Golder Associates

Date: March 2012

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