



June 3, 2009

REPORT



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**Foundation Investigation Report
Shadow River Bridge Replacement
Highway 632, Site No. 44-160
Township of Seguin, Ontario
Ministry of Transportation, Ontario
G.W.P. 5408-02-00**

Submitted to:
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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by URS Canada Inc. (URS) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the detail design of the replacement of the structure carrying Highway 632 over Shadow River in the Township of Seguin, south of the village of Rosseau, Ontario.

The terms of reference for the scope of work are outlined in Golder's proposal P7-1191-0001, dated January 19, 2007, which forms part of the Consultant's Agreement (P.O. Number 5005 E 0077) for this project. The work was carried out in accordance with the Quality Control Plan for this project dated October 16, 2007. The General Arrangement drawing for the bridge structure was provided to Golder by URS in September 2008.

The purpose of this investigation is to establish the subsurface conditions at the proposed replacement structure location by borehole drilling, rock coring, in situ testing and laboratory testing on selected samples. The boreholes for the current investigation were located in the field by Golder relative to the centreline stakes laid out at the site by URS. The location of the investigated area is shown in plan on the Contract Drawings.

2.0 SITE DESCRIPTION

The site is situated in the Township of Seguin on Highway 632 crossing Shadow River, approximately 1 km south of the village of Rosseau, Ontario. The surrounding land is mainly used for residential development, with grass and tree cover extending beyond the limits of the site. The banks adjacent to the river are vegetated with grass and small shrubs. The river is up to 5 m deep, as indicated in the General Arrangement drawing provided to us, and mainly used for recreation. The river is generally about 30 m wide at the proposed crossing, but narrows to a width of about 15 m at the existing bridge location.

We understand that the existing Shadow River Bridge was constructed in 1930. The existing single lane bridge has three spans with an overall deck length of about 16.8 m and overall width of 5.6 m. We understand from URS that the substructure has been repaired three (3) times (1961, 1974 and 1998) and concrete-filled CSP casings were used in the most recent repair of the substructure.

The existing highway grade is about 2.5 m above the measured water level at the existing south and north bridge abutments. The water level in the river was measured at approximate Elevation 226.0 m in October 2008.

3.0 INVESTIGATION PROCEDURES

Between September 29 and November 6, 2008, four (4) boreholes (SR-1 to SR-4) were advanced for the proposed west and east abutments and approaches and one (1) borehole (SR-5) was advanced within the existing west approach embankment for potential temporary roadway protection. On November 27, 2008, Golder returned to the site to advance one (1) additional borehole (SR-2a) immediately adjacent to Borehole SR-2 to carry out additional field vane testing and to obtain Shelby Tube samples of the cohesive soil deposit.

The boreholes were drilled using a track mounted D-50 drill rig that was supplied and operated by Walker Drilling Ltd. (Walker) of Barrie, Ontario.

The boreholes were advanced using either 108 mm inside diameter (I.D.) continuous flight hollow stem augers or HW casing with wash boring. Soil samples were obtained at intervals of depth of about 0.75 m to 2.5 m, using a 50 mm outer diameter (O.D.) split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586-99). As indicated above, Shelby tube samples were taken in the cohesive deposit in



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Borehole SR-2a; an attempt was made in SR-2 to obtain a Shelby tube sample, but there was no sample recovery. Field vane shear tests were conducted in cohesive soils for assessment of undrained shear strengths (ASTM D2573-01). Rock core samples were obtained using an 'HQ' size core barrel at SR-2 and an 'NQ' size core barrel at SR-3.

The boreholes were advanced to depths ranging from 5.2 m to 38.8 m below the existing ground surface. Boreholes SR-1, SR-4 and SR-5 were terminated prior to reaching refusal in the sand and silt to silty sand to sand stratum. A Dynamic Cone Penetration Test (DCPT) was advanced from the bottom of Boreholes SR-1 and SR-4 to depths of about 15.2 m and 12.2 m below existing ground surface, respectively.

A minimum of 3 m of rock core was obtained from two of the boreholes drilled at this site within the two proposed abutment foundation units, namely Boreholes SR-2 and SR-3.

The groundwater conditions in the open boreholes were observed during the drilling operations and piezometers were installed in two boreholes, SR-1 and SR-4, at the west and east approaches, respectively, to allow monitoring of the groundwater level at these locations. The piezometers consisted of a 50 mm outside diameter rigid PVC tubing with a 1.5 m long slotted screen, sealed within the sand and silt to silty sand stratum. The boreholes were backfilled with bentonite as per Ontario Regulation 903 (as amended by O. Reg. 372) upon completion of drilling and the two piezometers were backfilled in a similar manner after the last water level reading was obtained on October 17, 2008. The installation details and water level readings are presented on the Record of Borehole sheets reporting Appendix A.

The fieldwork was supervised throughout by members of our engineering and technical staff, who located the boreholes, arranged for the clearance of underground service locations, supervised the drilling and sampling operations, logged the boreholes, and examined and cared for the soil and rock core samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Sudbury geotechnical laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing (water content, Atterberg limits and grain size distribution) was carried out on selected soil samples. A one-dimensional consolidation (oedometer) test was carried out on a Shelby tube sample of the cohesive soil deposit from SR-2a. In addition, uniaxial compressive strength (UCS) testing was carried out on selected specimens of the bedrock core recovered from the boreholes.

The locations of the proposed foundation elements were laid out in the field by Golder relative to the proposed centreline alignment staked in the field by URS, based on the dimensions shown on the General Arrangement drawing supplied by URS in September 2008. The ground surface and water surface elevations were surveyed by Golder relative to the centreline stakes and are referenced to geodetic datum.

The borehole locations and ground surface elevations are summarized below and the locations are shown on the Contract Drawings.

Borehole Number	Borehole Location	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)
SR-1	West Approach	5013054.4	292985.7	227.0
SR-2	West Abutment	5013064.4	293001.5	226.2
SR-2a	West Abutment	5013062.8	292999.9	226.2
SR-3	East Abutment	5013079.3	293038.8	227.0
SR-4	East Approach	5013083.6	293058.4	228.4
SR-5	Existing West Approach	5013065.4	292987.7	228.5



4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Published literature indicates that the site is located in the Rosseau Domain of the Algonquin Terrane, which is located in the Grenville Province (Geology of Ontario; OGS Special Volume 4)¹. The bedrock of this domain consists of gneiss to granitic gneiss with localized areas of metagabbro.

Based on terrain mapping by the Ontario Geological Survey², the subsurface soils in the vicinity of the site consist of glaciolacustrine plain and/or delta deposits comprising of silts and/or sands.

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 given on the attached Record of Borehole and Drillhole sheets reporting Appendix A. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling and observations of drilling progress and cuttings. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations.

The inferred soil stratigraphy based on the results of the boreholes at the bridge location is shown on the Contract Drawings.

In general, the subsoils at the structure site consist of topsoil or embankment fill of the existing Highway 632 underlain by deposits of clayey silt and clay over sand, sand and silt or silt. The upper deposits are underlain by a layer of gravelly sand and cobbles and boulders overlying gneiss bedrock. The thickness of overburden at the west and east abutment locations was 24.0 m and 35.3 m, respectively.

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

4.2.1 Topsoil

Moist, brown topsoil was encountered at ground surface in Boreholes SR-1, SR-3 and SR-4 with thicknesses between about 200 mm and 400 mm. The ground surface at these boreholes ranged from Elevation 227.0 m to 228.4 m. The natural water content measured on two samples of the topsoil were 34 percent and 39 percent.

4.2.2 Embankment Fill

Borehole SR-5 was advanced through the existing west approach embankment. From ground surface, approximately 130 mm of asphalt was encountered overlying a 270 mm thick layer of sand and gravel road base fill. The ground surface at the top of the embankment was 228.5 m.

From the ground surface in Borehole SR-2 and underlying the road base fill in Borehole SR-5, about 1.4 m of sandy silt fill and 1.9 m of sand and silt fill was encountered, respectively. The fill was noted to contain organics at both borehole locations. The ground surface elevation at Borehole SR-2 was 226.2 m and the top of the sand and silt fill in SR-5 was encountered at Elevation 228.1 m. The natural water content measured on the samples

¹ Geology of Ontario, 1991. Ontario Geological Survey, special Volume 4, Part 1. Eds P.C. Thurston, H.R. Williams, R.H. Sutcliffe and G.M. Stott, Ministry of Northern Development and Mines, Ontario.

² Southern Ontario Engineering Geology Terrain Study, OGS Map 5504.



of the fill from Boreholes SR-2 and SR-5 were approximately 50 percent (reflecting organic matter) and 15 percent, respectively.

SPT 'N' values measured within the fill ranged from 1 to 10 blows per 0.3 m of penetration (below the roadway) suggesting a very loose to compact relative density.

A grain size distribution test was carried out on a sample of the sand and silt fill from Borehole SR-5 and the result is shown on Figure B-1.

4.2.3 Clayey Silt

Below the existing fill in Borehole SR-5, a deposit of moist, brown to grey clayey silt was encountered. The top of this deposit was encountered at Elevation 226.2 m and the thickness was about 0.7 m.

One SPT 'N' value measured within the clayey silt was 4 blows per 0.3 m of penetration suggesting a soft to firm relative consistency.

Atterberg limits testing carried out on this sample of clayey silt indicate a liquid limit of about 30 percent and a plastic limit of about 18 percent, yielding a plasticity index of about 12 percent. The results of the Atterberg limits testing is shown on the plasticity chart on Figure B-2 and indicate that the stratum is a clayey silt of low plasticity. A grain size distribution test was carried out on a sample of this deposit and the result is shown on Figure B-3.

The natural water content measured on the sample was approximately 31 percent.

4.2.4 Clay

Beneath the topsoil in Boreholes SR-1, SR-3 and SR-4, beneath the fill in Boreholes SR-2 and SR-2a and beneath the clayey silt deposit in Borehole SR-5, a deposit of moist to wet, brown to grey clay was encountered. The top of the deposit was encountered from about Elevation 228.1 m to 224.8 m and the thickness ranged from about 1.2 m to 3.1 m.

At the proposed west approach, the SPT 'N' values measured within the clay ranged from 0 (i.e. weight of hammer) to 5 blows per 0.3 m of penetration suggesting a very soft to firm relative density. In situ field vane testing carried out at selected depths within this stratum measured undrained shear strengths ranging from about 18 kPa to 39 kPa, indicating a soft to firm consistency. In general, at the west side, based on the 'N' values together with the vanes, the clay is considered to have a very soft to firm consistency.

At the proposed east approach, the SPT 'N' values ranged from 3 to 5 blows per 0.3 m of penetration, and no field vanes were carried out. Therefore, at the east side, the clay is considered to have a soft to firm consistency.

Atterberg limits testing carried out on eight (8) samples of the clay deposit indicate liquid limits ranging from about 54 percent to 63 percent and plastic limits ranging from 23 percent to 27 percent, yielding plasticity indices ranging from about 28 percent to 37 percent. The results of the Atterberg limits testing are shown on the plasticity chart for the clay deposit on Figure B-4, and indicate that the stratum is a clay of high plasticity. Atterberg limits testing on one sample from the transitional base of this deposit from Borehole SR-2a gave a liquid limit of 42 percent, a plastic limit of 20 percent, resulting in a plasticity index of 22 percent, indicating that the sample is a silty clay of medium plasticity. However, the deposit is generally described as a clay.

Grain size distribution tests were carried out on two samples of the clay deposit and the results are shown on Figure B-5.



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The natural water content measured on samples of the clay deposit ranged from about 40 percent in the upper brown clay to 109 percent in the lower grey clay, well above the liquid limit in the grey clay.

One laboratory consolidation (oedometer) test was carried out on a specimen of the clay obtained from Borehole SR-2a and the test results are shown on Figure B-6. The pre-consolidation pressures were estimated from the Void Ratio versus logarithmic Pressure plots using the Casagrande method as well as from the Total Work versus Pressure plots. The relevant consolidation test results are summarized below.

Borehole / Sample Number	Elevation (m)	σ_{vo}' (kPa)	σ_p' (kPa)	$\sigma_p' - \sigma_{vo}'$ (kPa)	OCR	e_o	C_r	C_c	c_v^* (cm ² /s)
SR-2A/1	223.7	22	115	93	5.2	2.63	0.097	1.33	0.018

Note: * For approximate stress range of $10 \leq \sigma_v' \leq 200$ kPa

where: σ_{vo}' effective overburden pressure in kPa

σ_p' preconsolidation pressure in kPa

OCR overconsolidation ratio

e_o initial void ratio

C_c compression index (based on void ratio)

C_r recompression index (based on void ratio)

c_v coefficient of consolidation in cm²/s in the normally consolidated range

4.2.5 Silt to Sandy Silt

A deposit of wet, brown to grey, silt to sandy silt was encountered beneath the clay stratum in each of the boreholes. The silt contained trace to some sand and clay and the sandy silt contained trace clay. The top of the deposit ranged from about Elevation 226.9 m to 222.4 m and the thickness of the deposit ranged from about 0.5 m to greater than 2.1 m. Boreholes SR-2a and SR 5 were terminated within this stratum at an Elevation 221.0 m and 220.3 m, respectively.

SPT 'N' values measured within the silt to sandy silt deposits ranged from 0 (i.e. weight of rods) to 9 blows per 0.3 m of penetration indicating a very loose to loose relative density.

Grain size distribution tests were carried out on ten (10) samples of the silt to sandy silt deposit and the results are shown on Figures B-7a and B-7b.

The natural water content measured on samples of the silt to sandy silt deposit range from about 26 percent to 32 percent.

4.2.6 Sand and Silt to Silty Sand to Sand

Beneath the silt to sandy silt stratum in Boreholes SR-1 to SR-4, a deposit of wet, brown to grey, sand and silt to silty sand to sand deposit was encountered. The sand contained trace to some silt and trace gravel. Trace clay was contained within the silty sand. The top of this deposit was encountered from about Elevation 226.1 m to 220.6 m and the thickness of the deposit was 14.5 m and 31.2 m in Boreholes SR-2 and SR-3, respectively. Boreholes SR-1 and SR-4 were terminated within this stratum.



Heaving in the augers was noted within this deposit in Boreholes SR-1 and SR-4 at depths of about 4.6 m (Elevation 222.4 m) and 9.1 m (Elevation 219.2 m), respectively. Heaving in the casing was noted in SR-3 at a depth of about 32.0 m (Elevation 195.0 m).

SPT 'N' values measured within the sand and silt to silty sand to sand deposit ranged from 0 (i.e. weight of hammer) to 50 blows per 0.3 m of penetration suggesting a very loose to very dense relative density, typically becoming more dense with depth.

Grain size distribution tests were carried out on fifteen (15) samples of the sand and silt to silty sand to sand deposit and the results are shown on Figures B-8a (sand and silt), B-8b (silty sand) and A-8c (sand), respectively. The natural water content measured on samples of the sand and silt to silty sand to sand deposit ranged from 19 percent to 28 percent.

Within the sand and silt to sand stratum in Borehole SR-2, a clayey silt seam was encountered at a depth of 12.5 m below ground surface corresponding to Elevation of 213.7 m. A grain size distribution test was carried out on this clayey silt seam and the result is shown on Figure B-3.

4.2.7 Sand to Gravelly Sand

Beneath the sand and silt to sand stratum in Borehole SR-2, a deposit of wet, grey sand to gravelly sand containing trace to some silt, trace clay was encountered. The deposit was noted to contain occasional cobbles. The top of this deposit was at an Elevation of 206.1 m and the thickness of the deposit was 3.1 m.

SPT 'N' values measured within the sand to gravelly sand deposit ranged from 36 to 123 blows per 0.3 m of penetration suggesting a dense to very dense relative density.

A grain size distribution test was carried out on one (1) sample of the sand to sand and gravel deposit and the result is shown on Figure B-9. The natural water content measured on samples of the sand to gravelly sand deposit ranged from 14 percent to 19 percent.

Heaving in the casing was noted in this deposit in Borehole SR-2 at a depth of about 21.3 m (Elevation 204.9 m).

4.2.8 Cobbles and Boulders

Beneath the sand to gravelly sand stratum in Borehole SR-2 and beneath the sand and silt to sand deposit in SR-3, a deposit of cobbles and boulders containing sand and gravel was encountered. At Boreholes SR-2 and SR-3, the top of this deposit was encountered at 23.2 m and 35.3 m of depth, respectively, corresponding to Elevations 203.0 m and 193.5 m, respectively. The thickness of the deposit was about 0.8 m and 1.8 m in Boreholes SR-2 and SR-3, respectively.

4.2.9 Bedrock

Bedrock was encountered and cored for a minimum of 3 m in Boreholes SR-2 and SR-3. The top of the bedrock surface was encountered at Borehole SR-2 and SR-3 at Elevations 202.2 m and 191.7 m, respectively, corresponding to depths of about 24.0 m and 35.3 m below ground surface, respectively.

Based on a review of the bedrock core samples, the bedrock at the site generally consists of fine grained, slightly weathered, pinkish grey gneiss.



The Rock Quality Designation (RQD) measured on the core samples ranges from 59 percent to 100 percent. This indicates rock mass of variable quality, ranging from fair to excellent. The Total Core Recovery (TCR) during bedrock coring was generally 100 percent.

Laboratory UCS testing was carried out on four core samples of the gneiss bedrock from Boreholes SR-2 and SR-3. The UCS results range between 50 MPa and 141 MPa, indicating strong to very strong rock, using the "Intact Rock Strength Classification" table. The depths and corresponding elevations of the tested samples and results of the UCS testing are presented in Table B-1, in Appendix B.

4.2.10 Groundwater Conditions

The water levels were noted during and after the drilling and coring operations in the boreholes. Piezometers were installed with screened sections sealed within the sand and silt to silty sand to sand deposit in Boreholes SR-1 and SR-4, respectively. Details of the piezometer installations are shown on the Record of Borehole Sheets reporting Appendix A. In general, the soil samples taken in the boreholes were noted to be moist to wet with free water evident within most of the non-cohesive materials.

The water level of Shadow River was measured at Elevation 226.0 m in October 2008. The water levels in the piezometers and open holes during drilling and upon completion of drilling are summarized below and they are generally at about river level. It should be noted that groundwater levels in the area are subject to seasonal fluctuations and after precipitation events.

Borehole	Installation	Groundwater Level Depth (m)	Groundwater Level Elevation (m)	Date
SR-1	Piezometer	1.0	226.0	October 17, 2008
SR-2	Open Borehole	0.2	226.0	October 3, 2008
SR-2a	Open Borehole	0.5	225.7	November 27, 2008
SR-3	Open Borehole	0.5	226.5	November 6, 2008
SR-4	Piezometer	2.4	226.0	October 17, 2008
SR-5	Open Borehole	4.7	223.8	October 21, 2008

5.0 CLOSURE

The field personnel supervising the drilling program was Mr. Ed Savard. This report was prepared by Mr. Evan Childerhose, EIT and Mr. André Bom, P.Eng., of the Sudbury office and the technical aspects were reviewed by Mrs. Sarah Coyne, P.Eng., an Associate with Golder Sudbury. A quality control review of the report was provided by Mr. Fintan J. Heffernan, P.Eng., Golder's Designated MTO Contact for this project.



Report Signature Page

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EC/AB/SEMC/FJH/lb

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APPENDIX A

RECORD OF BOREHOLES AND DRILLHOLES

LIST OF SYMBOLS

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

I. GENERAL

π	3.1416
$\ln x$,	natural logarithm of x
\log_{10}	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
F	factor of safety
V	volume
W	weight

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. stress: $\Delta\sigma$
ϵ	linear strain
ϵ_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s/\rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

* Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity).

(a) Index Properties (continued)

w	water content
w_L	liquid limit
w_p	plastic limit
I_p	plasticity index $= (w_L - w_p)$
w_s	shrinkage limit
I_L	liquidity index $= (w - w_p)/I_p$
I_c	consistency index $= (w_L - w)/I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_a	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction $= \tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 + \sigma_3)/2$ or $(\sigma'_1 + \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 + \sigma_3)$
S_t	sensitivity

Notes: 1 $\tau = c' + \sigma' \tan \phi'$
2 Shear strength = (Compressive strength)/2

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.).

Dynamic Cone Penetration Resistance, N_d :

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezcone Penetration Test (CPT)

An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	N Blows/300 mm or Blows/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

Consistency

	C_u, S_u kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO ₄	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERING STATE

Fresh: no visible sign of weathering

Faintly weathered: weathering limited to the surface of Major discontinuities

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock Mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock texture and structure are preserved.

BEDDING THICKNESS

<u>Description</u>	<u>Bedding Plane Spacing</u>
Very thickly bedded	> 2 m
Thickly bedded	0.6 m to 2 m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	< 6 mm

JOINT OR FOLIATION SPACING

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

GRAIN SIZE

<u>Terms</u>	<u>Size*</u>
Very Coarse Grained	> 60 mm
Coarse Grained	2 – 60 mm
Medium Grained	60 microns – 2 mm
Fine Grained	2 – 60 microns
Very Fine Grained	< 2 microns

* Note: Grains > 60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varies from 0% for completely broken core to 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separation) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to (W.R.T.) Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole, a discontinuity with a 90° angle is horizontal.

Description and Notes

An abbreviated description of the discontinuities, whether naturally occurring separation such as fractures, bedding planes and foliation planes or mechanically induced fractures caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

B - Bedding	P - Polished
FO - Foliation / Schistosity	S - Slickensided
CL - Cleavage	SM - Smooth
SH - Shear Plane / Zone	R - Ridged / Rough
VN - Vein	ST - Stepped
F - Fault	PL - Planar
CO - Contact	FL - Flexured
J - Joint	UE - Uneven
FR - Fracture	W - Wavy
MF - Mechanical Fracture	C - Curved
- Parallel To	⊥ - Perpendicular To

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

PROJECT <u>07-1191-0001</u>		RECORD OF BOREHOLE No SR - 1		2 OF 2 METRIC	
W.P. <u>5408-02-00</u>		LOCATION <u>N 5013054.4 ;E 292985.7</u>		ORIGINATED BY <u>EHS</u>	
DIST <u> </u> HWY <u>632</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers</u>		COMPILED BY <u>MM</u>	
DATUM <u>Geodetic</u>		DATE <u>September 29 and 30, 2008</u>		CHECKED BY <u>AB</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIMIT CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20	40	60	80	100	W _p	W	W _L		
	--- CONTINUED FROM PREVIOUS PAGE ---																
211.8	Start of DCPT																
15.2	End of Borehole End of DCPT Note: 1. Water level measured in piezometer at a depth of 1.0 m below ground surface (Elev. 226.0 m) on October 17, 2008.																

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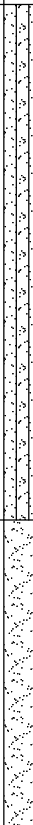
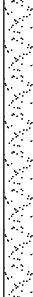


PROJECT <u>07-1191-0001</u>		RECORD OF BOREHOLE No SR - 2		1 OF 2 METRIC	
W.P. <u>5408-02-00</u>	LOCATION <u>N 5013064.4 ; E 293001.5</u>	ORIGINATED BY <u>EHS</u>			
DIST <u> </u> HWY <u>632</u>	BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers, HW Casing, Wash Boring</u>	COMPILED BY <u>MM</u>			
DATUM <u>Geodetic</u>	DATE <u>September 30 to October 3, 2008</u>	CHECKED BY <u>AB</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W _p	W	W _L		
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × REMOULDED					
226.2	GROUND SURFACE													
0.0	Sandy silt, containing organics (FILL) Very loose Brown Wet		1	SS	1									
224.8			2	SS	2									
1.4	CLAY Very soft to firm Brown to grey Wet No recovery in sample No.4 .		3	SS	1									
			4	TO	PM									
222.4														
3.8	Sandy SILT Very loose to loose Brown to grey Wet		5	SS	9									
			6	SS	4									
220.6														
5.6	SAND and SILT to SAND, trace gravel Very loose to dense Brown to grey Wet		7	SS	2									
			8	SS	12									
			9	SS	8									
			10	SS	8									
			11	SS	27									
			12	SS	28									

Continued Next Page

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

PROJECT <u>07-1191-0001</u>		RECORD OF BOREHOLE No SR - 2		2 OF 2 METRIC	
W.P. <u>5408-02-00</u>	LOCATION <u>N 5013064.4 ; E 293001.5</u>	ORIGINATED BY <u>EHS</u>			
DIST <u> </u> HWY <u>632</u>	BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers, HW Casing, Wash Boring</u>	COMPILED BY <u>MM</u>			
DATUM <u>Geodetic</u>	DATE <u>September 30 to October 3, 2008</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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)					
								<div><div></div><div>20 40 60 80 100</div></div> <div>○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED</div>					<div><div></div><div>W_p W W_L</div><div>20 40 60</div></div>					
--- CONTINUED FROM PREVIOUS PAGE ---																		
206.1	SAND and SILT to SAND, trace gravel Very loose to dense Brown to grey Wet		13	SS	32		211											
							210											
							209											1 85 (14)
							208											
							207											
							206											1 48 51 0
20.1	SAND to Gravelly SAND, trace to some silt, trace clay, occasional cobbles Dense to very dense Grey Wet		16	SS	36		206											
					205													
					204													
203.0			18	SS	123		203										26 50 (24)	
23.2	COBBLES and BOULDERS, containing sand and gravel						202											
202.2	GNEISS (BEDROCK) Bedrock cored from 24.0m to 27.4m depth. For coring details refer to Record of Drillhole SR-2.						201											
24.0							200											
198.8							199											
27.4	End of Borehole																	
	Notes: 1. Switched to HW Casing at 2.3 m depth. 2. Prior to the start of drilling on October 1, 2008, casing tip at 21.3 m depth (Elev. 204.9 m) and approximately 6.1 m of heave was measured above casing tip. 3. Water level in																	

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PROJECT: 07-1191-0001

RECORD OF DRILLHOLE: SR - 2

SHEET 1 OF 1

LOCATION:

DRILLING DATE: September 30 to October 3, 2008

DATUM: Geodetic

INCLINATION: -90°

AZIMUTH: ---

DRILL RIG: D - 50

DRILLING CONTRACTOR: Walker

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm/min)	FLUSH COLOUR % RETURN	FR/FX-FRACTURE-F-FAULT												SM-SMOOTH				FL-FLEXURED				BC-BROKEN CORE				DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
								CL-CLEAVAGE				SH-SHEAR				VN-VEIN				J-JOINT				P-POLISHED				S-SLICKENSIDED						R-ROUGH				ST-STEPPED				PL-PLANAR				C-CURVED				UE-UNEVEN				W-WAVY				B-BEDDING																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
								RECOVERY		R.Q.D. %		FRACT. INDEX PER 0.3		DIP w.r.t. CORE AXIS		TYPE AND SURFACE DESCRIPTION		HYDRAULIC CONDUCTIVITY K _f cm/sec		2		4		6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
								TOTAL CORE %	SOLID CORE %																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				

DEPTH SCALE

1 : 50



LOGGED: EHS

CHECKED: AB

MIS-RCK 001 0711910001SR.GPJ GAL-MISS.GDT 2/6/09

PROJECT		RECORD OF BOREHOLE				No SR - 2a		1 OF 1		METRIC	
W.P.		LOCATION		ORIGINATED BY		DIST		BOREHOLE TYPE		COMPILED BY	
DATUM		DATE		CHECKED BY							
07-1191-0001		N 5013062.8 ; E 292999.9		EHS		HWY 632		108 mm I.D. Continuous Flight Hollow Stem Augers		MM	
Geodetic		November 27, 2008		AB							

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20	40	60	80	100	20	40	60			
226.2 0.0	GROUND SURFACE Sandy silt (FILL) Brown Wet					▽	226										
224.8 1.4	CLAY Soft to firm Brown to grey Wet						225										
			1	TO	PM		224										
	Becoming Silty Clay at 3.0m depth.		2	TO	PM		223										
222.9 3.4	SILT to Sandy SILT, trace clay Very loose Brown to grey Wet						222										
			3	SS	3												
221.0 5.2	End of Borehole Note: 1. Water level in open borehole at a depth of 0.5 m below ground surface (Elev. 225.7 m) upon completion of drilling.																

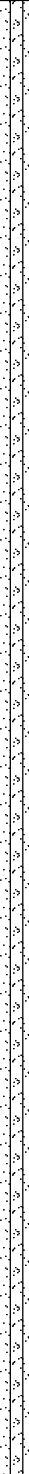
PROJECT <u>07-1191-0001</u>		RECORD OF BOREHOLE No SR - 3		1 OF 3 METRIC	
W.P. <u>5408-02-00</u>		LOCATION <u>N 5013079.3 ; E 293038.8</u>		ORIGINATED BY <u>EHS</u>	
DIST <u> </u> HWY <u>632</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers, HW Casing, Wash Boring</u>		COMPILED BY <u>MM</u>	
DATUM <u>Geodetic</u>		DATE <u>October 7 to 10, 16 and November 6, 2008</u>		CHECKED BY <u>AB</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100	20 40 60 80 100					
227.0	GROUND SURFACE													
0.0	TOPSOIL													
226.6	Brown Moist		1	SS	3									
0.4	CLAY													
	Soft Brown to grey Moist to wet		2	SS	3									
225.2														
1.8	SILT, trace to some clay, trace sand		3	SS	1									0 1 61 38
224.7	Very loose Grey Wet													0 3 88 9
2.3	SAND and SILT to SAND, trace clay		4	SS	WH									
	Very loose to dense Grey Wet		5	SS	3									
			6	SS	5									0 53 46 1
			7	SS	5									
			8	SS	7									
			9	SS	5									0 77 23 0
			10	SS	11									
			11	SS	7									0 37 63 0
			12	SS	7									
			13	SS	16									

Continued Next Page

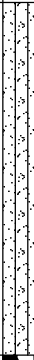


+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>07-1191-0001</u>		RECORD OF BOREHOLE No SR - 3		2 OF 3 METRIC	
W.P. <u>5408-02-00</u>		LOCATION <u>N 5013079.3 ; E 293038.8</u>		ORIGINATED BY <u>EHS</u>	
DIST <u> </u> HWY <u>632</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers, HW Casing, Wash Boring</u>		COMPILED BY <u>MM</u>	
DATUM <u>Geodetic</u>		DATE <u>October 7 to 10, 16 and November 6, 2008</u>		CHECKED BY <u>AB</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE LIMIT CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)					
	--- CONTINUED FROM PREVIOUS PAGE ---																
	SAND and SILT to SAND, trace clay Very loose to dense Grey Wet		14	SS	12		211									0 89 (11)	
			15	SS	18		210										
							209										
			16	SS	10		208										
							207										
			17	SS	12		206										
							205										
			18	SS	11		204										
							203										
			19	SS	42		202										
							201										
			20	SS	14		200										
							199										
21	SS	22	198														

Continued Next Page

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

PROJECT <u>07-1191-0001</u>		RECORD OF BOREHOLE No SR - 3				3 OF 3 METRIC						
W.P. <u>5408-02-00</u>		LOCATION <u>N 5013079.3 ; E 293038.8</u>				ORIGINATED BY <u>EHS</u>						
DIST <u> </u> HWY <u>632</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers, HW Casing, Wash Boring</u>				COMPILED BY <u>MM</u>						
DATUM <u>Geodetic</u>		DATE <u>October 7 to 10, 16 and November 6, 2008</u>				CHECKED BY <u>AB</u>						
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	W _p W W _L			
--- CONTINUED FROM PREVIOUS PAGE ---												
	SAND and SILT to SAND, trace clay Very loose to dense Grey Wet						196					
			22	SS	50		195					
							194					
193.5 33.5	COBBLES and BOULDERS, containing sand and gravel						193					
							192					
							191					
191.7 35.3	GNEISS (BEDROCK) Bedrock cored from 35.3m to 38.8m depth. For coring details refer to Record of Drillhole SR-3.						190					
							189					
188.2 38.8	End of Borehole Notes: 1. Switched to HW Casing at 3.0 m depth. 2. Prior to the start of drilling on October 10, 2008, casing tip at 32.0 m depth (Elev. 195.0 m) and approximately 1.5 m of heave was measured above casing tip. 3. Water level in open borehole at a depth of 0.5 m below ground surface (Elev. 226.5 m) upon completion of drilling.											

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PROJECT: 07-1191-0001

RECORD OF DRILLHOLE: SR - 3

SHEET 1 OF 1

LOCATION:

DRILLING DATE: October 7 to 10, 16 and November 6, 2008

DATUM: Geodetic

INCLINATION: -90°

AZIMUTH: ---

DRILL RIG: D - 50

DRILLING CONTRACTOR: Walker

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	PENETRATION RATE RUN No. (mm/min)	FLUSH COLOUR % RETURN	FR/FX-FRACTURE F-FAULT												SM-SMOOTH		FL-FLEXURED		BC-BROKEN CORE		DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
							CL-CLEAVAGE				J-JOINT				R-ROUGH				UE-UNEVEN		MB-MECH. BREAK																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
							SH-SHEAR				P-POLISHED				ST-STEPPED				W-WAVY		B-BEDDING																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
							VN-VEIN				S-SLICKENSIDED				PL-PLANAR				C-CURVED																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
RECOVERY		R.Q.D. %		FRACT. INDEX PER 0.3		DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY K, cm/sec																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
TOTAL CORE %	SOLID CORE %					DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	10 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³	2	4	6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
80	60	40	20	80	60	40	20	80	60	40	20	5	10	15	20	0	30	60	90																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									

DEPTH SCALE

1 : 50



LOGGED: EHS

CHECKED: AB

MIS-RCK 001 0711910001SR.GPJ GAL-MISS.GDT 2/6/09

PROJECT <u>07-1191-0001</u>			RECORD OF BOREHOLE No SR - 4			1 OF 1 METRIC												
W.P. <u>5408-02-00</u>			LOCATION <u>N 5013083.6 ; E 293058.4</u>			ORIGINATED BY <u>EHS</u>												
DIST <u> </u> HWY <u>632</u>			BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers</u>			COMPILED BY <u>MM</u>												
DATUM <u>Geodetic</u>			DATE <u>October 7, 2008</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 _p	W	W _L	γ	GR	SA	SI	CL
228.4	GROUND SURFACE							20 40 60 80 100										
0.0	TOPSOIL																	
228.1	Brown Moist		1	SS	7		228											
0.3	CLAY Firm Brown to grey Moist		2	SS	5		227											
226.9	SILT, trace to some sand, trace clay Loose Grey Wet		3	SS	4		226											
226.1	Silty SAND, trace clay Very loose to loose Grey Wet		4	SS	5		225											
2.3			5	SS	8		224											
			6	SS	3		223											
			7	SS	4		222											
			8	SS	9		221											
			9	SS	5		220											
	Heaving in augers noted below 9.1m depth.		10	SS	4		219											
218.6	Start of DCPT						218											
9.8							217											
216.2	End of Borehole End of DCPT																	
12.2	Note: 1. Water level measured in piezometer at a depth of 2.4 m below ground surface (Elev. 226.0 m) on October 17, 2008.																	

MIS-MTO 001 0711910001SR.GPJ GAL-MISS.GDT 2/6/09

PROJECT		RECORD OF BOREHOLE				No SR - 5		1 OF 1		METRIC	
W.P.		LOCATION		ORIGINATED BY		DIST		BOREHOLE TYPE		COMPILED BY	
DATUM		DATE		CHECKED BY							
07-1191-0001		N 5013065.4 ; E 292987.7		EHS		HWY 632		108 mm I.D. Continuous Flight Hollow Stem Augers		MM	
Geodetic		October 21, 2008		AB							

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W _p	W	W _L		
							20	40	60	80	100						
228.5	GROUND SURFACE																
0.0	ASPHALT																
228.1	Sand and gravel (FILL)																
0.4	Brown		1	AS	-												
	Sand and silt, some clay, trace gravel, containing organics (FILL)																
	Very loose to compact		1a	SS	10												
	Brown																
	Moist		2	SS	3												
226.2																	
2.3	CLAYEY SILT		3	SS	4												
	Soft to firm																
	Brown to grey																
	Moist																
225.5																	
3.0	CLAY		4	SS	5												
	Very soft to firm																
	Brown to grey		5	SS	2												
	Moist																
			6	SS	WH												
222.4																	
6.1	SILT to Sandy SILT, trace clay		7	SS	1												
	Very loose																
	Brown																
	Wet																
			8	SS	WR												
220.3																	
8.2	End of Borehole																
	Note:																
	1. Water level in open borehole at a depth of 4.7 m below ground surface (Elev. 223.8 m) upon completion of drilling.																



APPENDIX B

LABORATORY TEST RESULTS

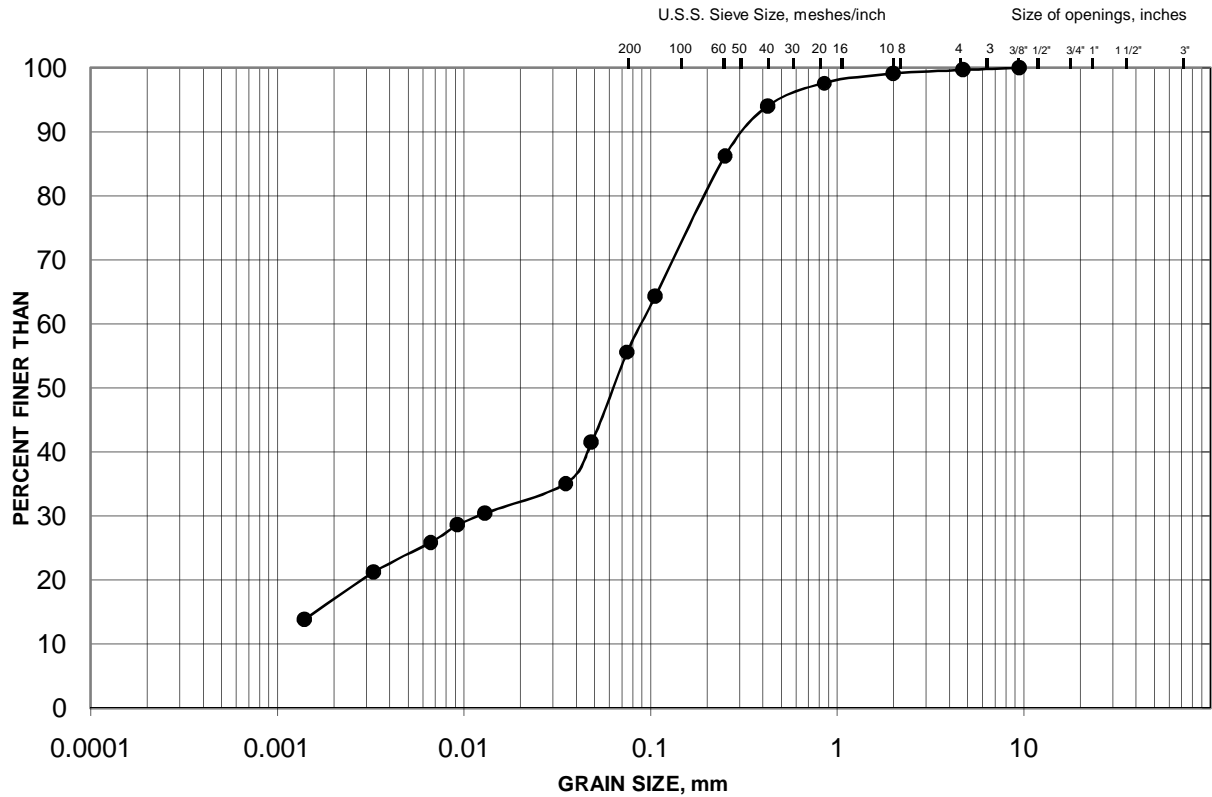
TABLE B-1
UNIAXIAL COMPRESSIVE STRENGTH TEST RESULTS
HIGHWAY 632 STRUCTURE AT SHADOW RIVER
W.P 5408-02-00, Site no. 44-160

Borehole Number	Sample Depth (m)	Sample Elevation (m)	Rock Type	Core Diameter (mm)	Uniaxial Compressive Strength (MPa)
SR-2	25.2	201.0	Gneiss	63.0	132
SR-2	26.4	199.8	Gneiss	63.0	138
SR-3	36.3	190.7	Gneiss	47.5	50
SR-3	38.3	188.7	Gneiss	47.5	141

Compiled by: EC
Checked by: AB
Reviewed By: FJH

GRAIN SIZE DISTRIBUTION Sand and Silt (Fill)

**FIGURE
B-1**



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

LEGEND

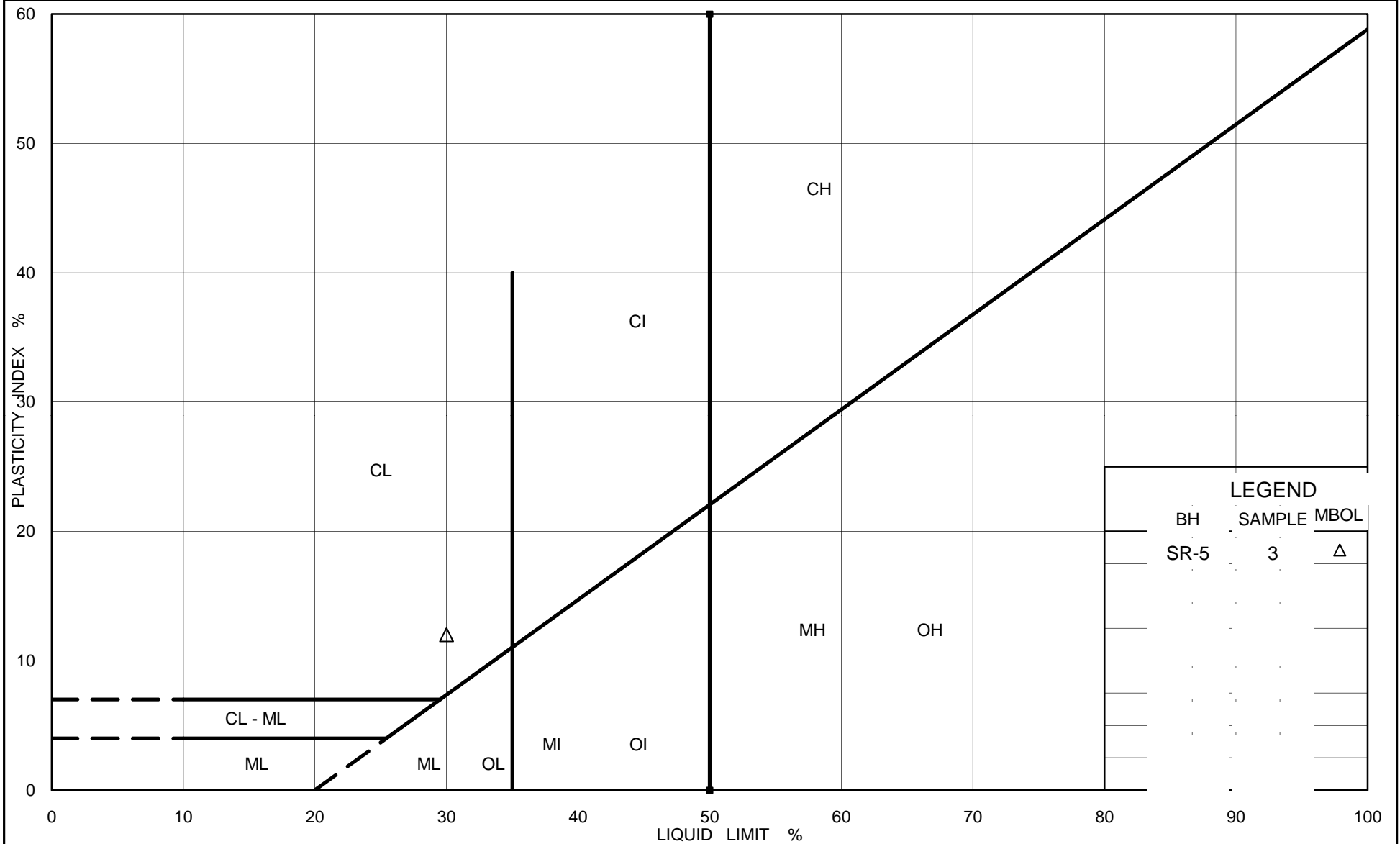
SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
—●—	SR-5	1a	227.4

Project Number: 07-1191-0001

Checked By: AB

Golder Associates

Date: June 2009



Ministry of Transportation

Ontario

PLASTICITY CHART

Clayey Silt

Figure B-2

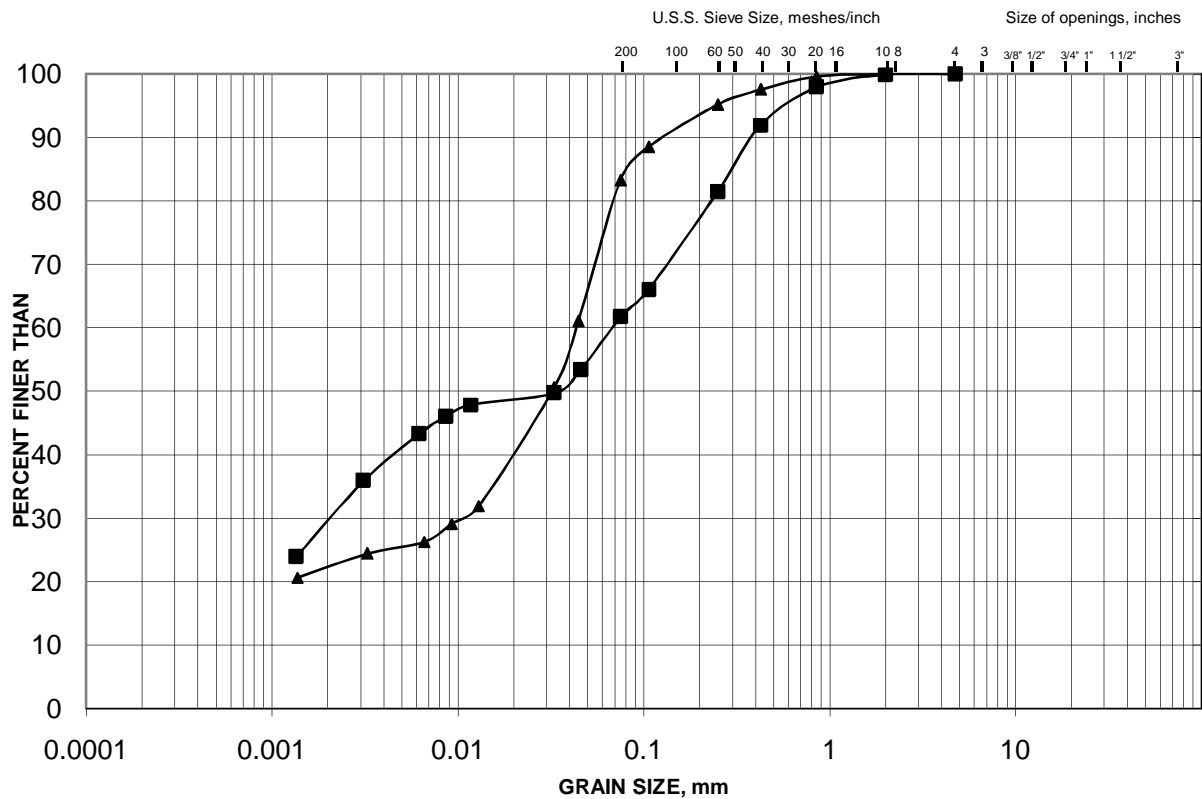
Project No. 07-1191-0001

Checked By: AB / Reviewed By: SEMC

GRAIN SIZE DISTRIBUTION

Clayey Silt

FIGURE
B-3



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

LEGEND

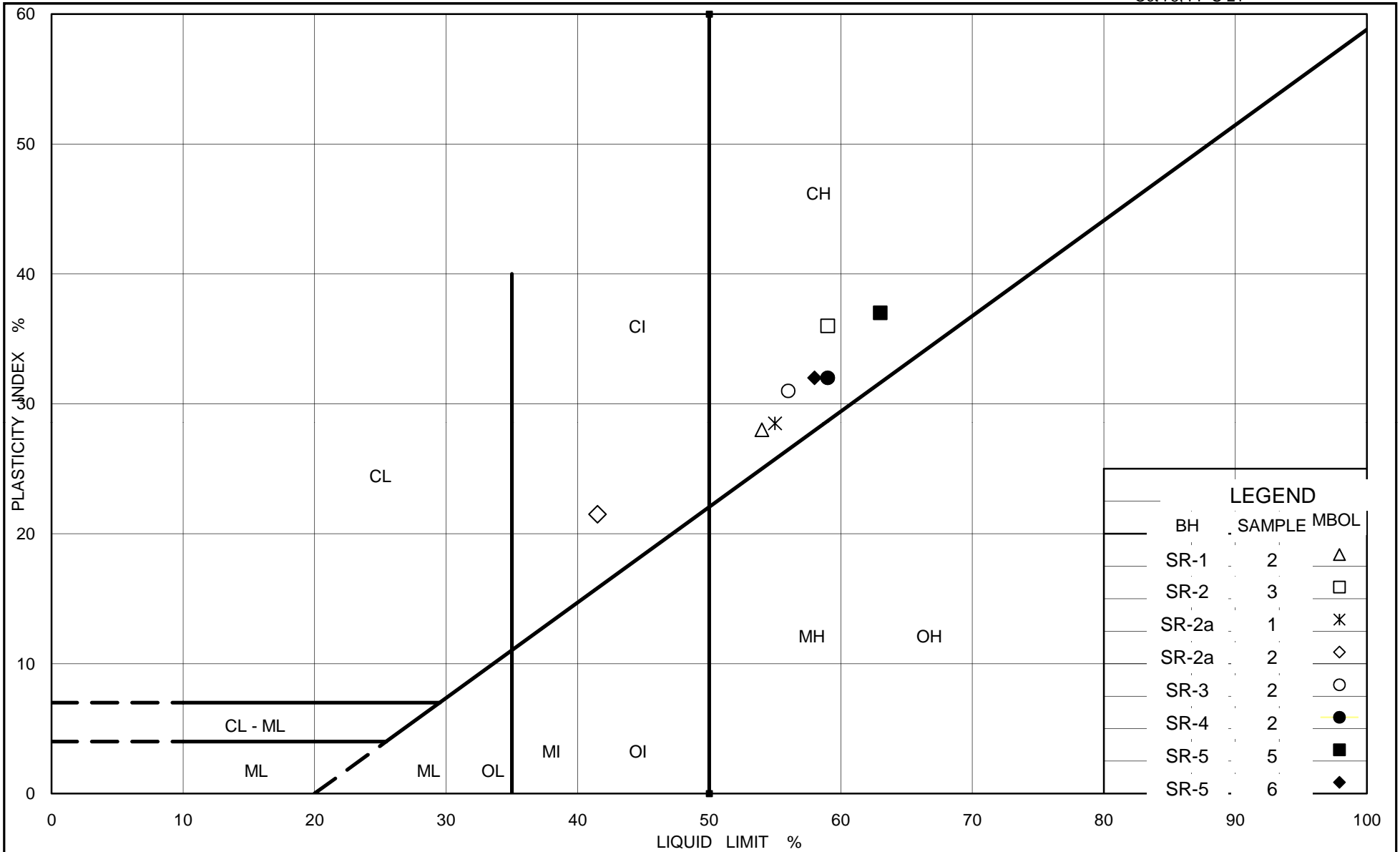
SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
▲	SR-2	11	213.7
■	SR-5	3	225.9

Project Number: 07-1191-0001

Checked By: AB

Golder Associates

Date: June 2009



Ministry of Transportation

Ontario

PLASTICITY CHART Clay

Figure B-4

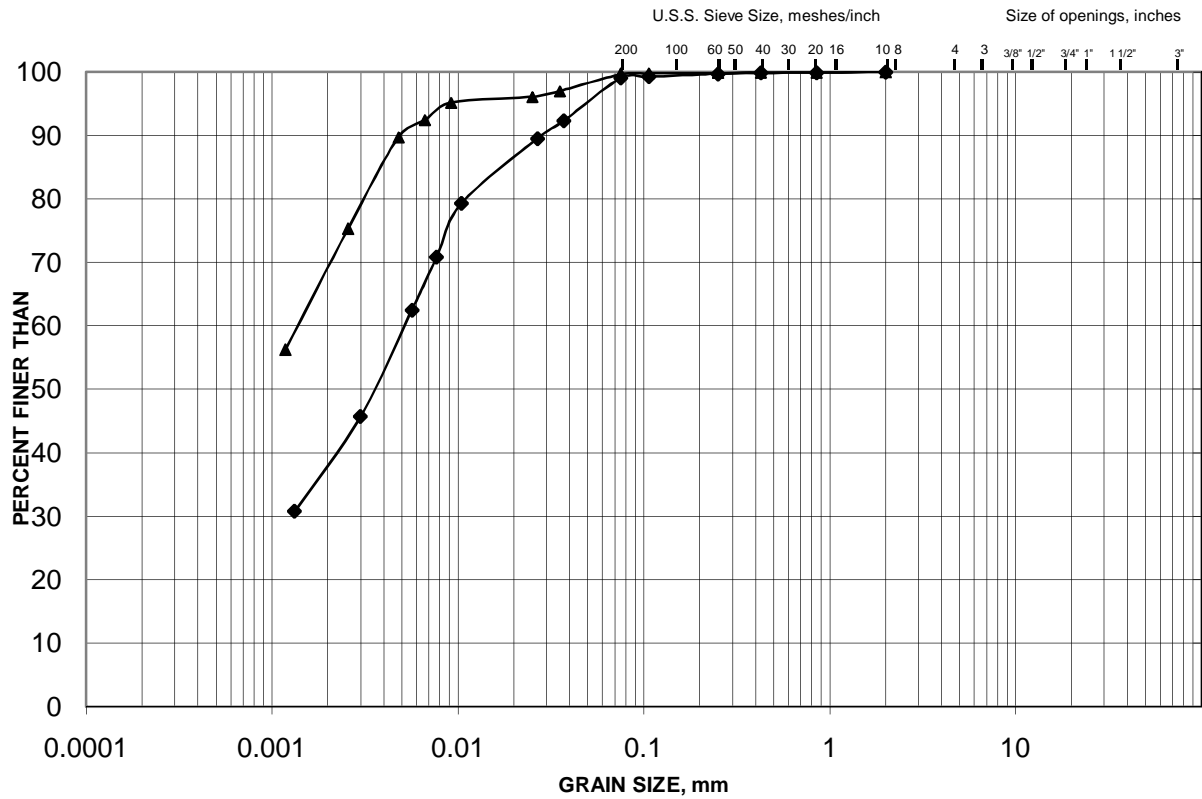
Project No. 07-1191-0001

Checked By: AB / Reviewed By: SEMC

GRAIN SIZE DISTRIBUTION

Clay

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)
▲	SR-2	3	224.4
◆	SR-3	3a	225.3

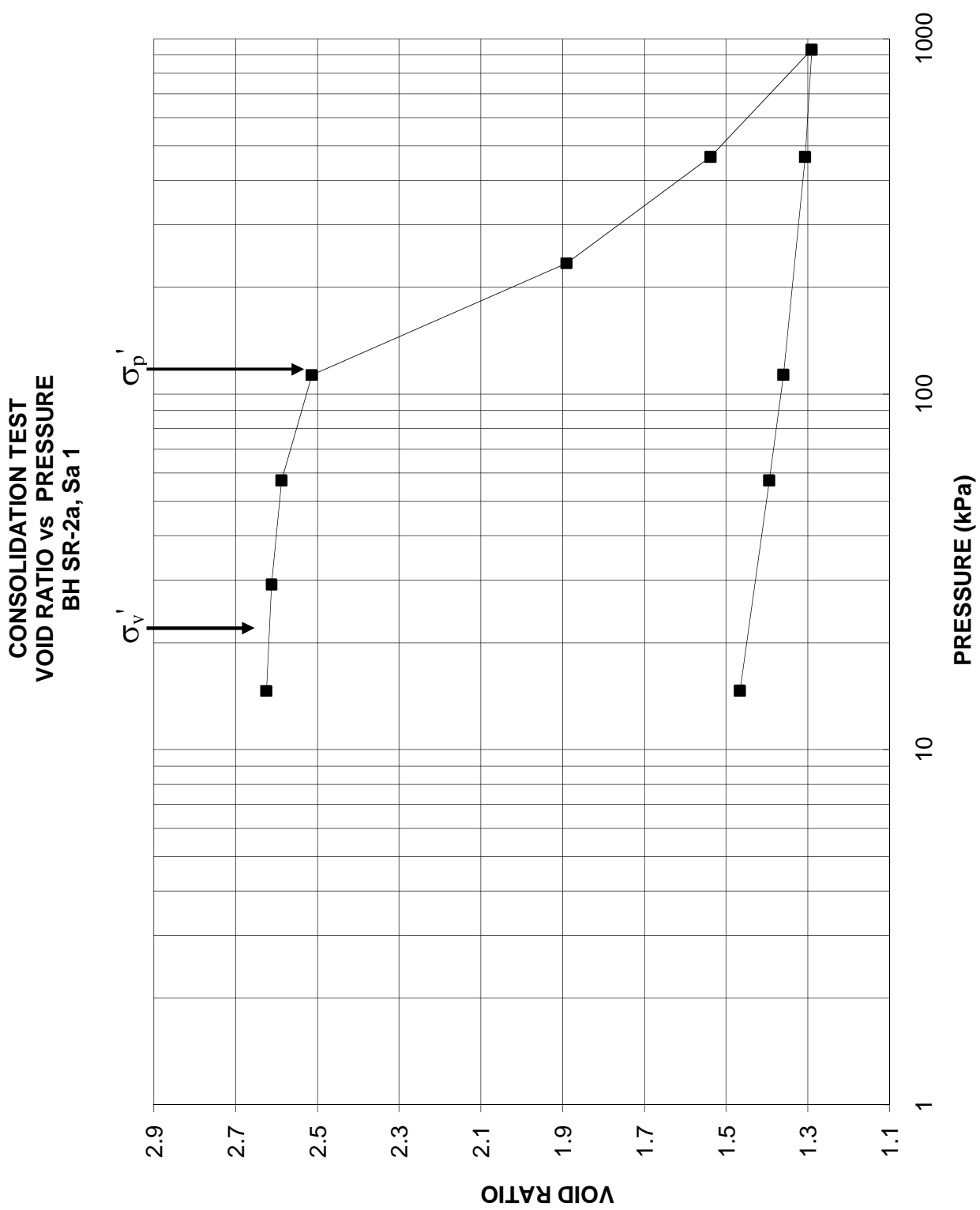
Project Number: 07-1191-0001

Checked By: AB

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Date: June 2009

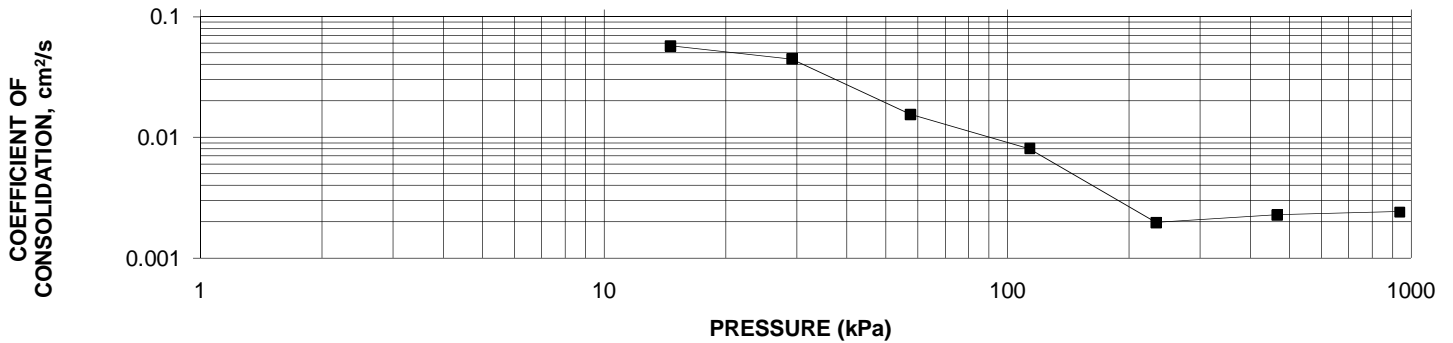
OEDOMETER CONSOLIDATION SUMMARY					FIGURE B-6 Page 1 of 4			
SAMPLE IDENTIFICATION								
Project Number		07-1191-0001			Sample Number		1	
Borehole Number		SR-2a			Sample Depth, (m)		2.6	
TEST CONDITIONS								
Test Type		Standard			Load Duration, hr		24	
Oedometer Number		1						
Date Started		28-Nov-08						
Date Completed		11-Dec-08						
SAMPLE DIMENSIONS AND PROPERTIES - INITIAL								
Sample Height, cm		2.538			Unit Weight, kN/m ³		14.6	
Sample Diameter, cm		6.342			Dry Unit Weight, kN/m ³		7.3	
Area, cm ²		31.59			Specific Gravity, assumed		2.7	
Volume, cm ³		80.17			Solids Height, cm		0.699	
Water Content, %		99.4			Volume of Solids, cm ³		22.09	
Wet Mass, g		118.95			Volume of Voids, cm ³		58.09	
Dry Mass, g		59.64			Degree of Saturation, %		102.1	
TEST COMPUTATIONS								
Pressure	Primary Consolidation	Corr. Height	Void Ratio	Average Height	t ₅₀	cv.	m _v	k
kPa	mm	cm	Ratio	cm	s	cm ² /s	m ² /MN	cm/s
0	0.00	2.538	2.630	2.538				
14.6	0.04	2.534	2.624	2.536	22	0.05730	0.102	5.761E-07
29.2	0.08	2.526	2.613	2.530	28	0.04481	0.216	9.492E-07
57.4	0.18	2.508	2.587	2.517	80	0.01553	0.250	3.812E-07
113.1	0.52	2.457	2.514	2.483	150	0.00805	0.368	2.910E-07
233.3	4.36	2.021	1.890	2.239	500	0.00196	1.477	2.847E-07
466.1	2.46	1.775	1.538	1.898	310	0.00228	0.523	1.168E-07
933.2	1.73	1.602	1.291	1.688	230	0.00243	0.209	4.973E-08
466.5	-0.11	1.613	1.306	1.607				
113.7	-0.38	1.651	1.360	1.632				
57.4	-0.24	1.675	1.395	1.663				
14.7	-0.50	1.724	1.466	1.700				
Notes: k calculated using cv based on t ₅₀ values.								
SAMPLE DIMENSIONS AND PROPERTIES - FINAL								
Sample Height, cm		1.724			Unit Weight, kN/m ³		16.4	
Sample Diameter, cm		6.342			Dry Unit Weight, kN/m ³		10.7	
Area, cm ²		31.59			Specific Gravity, assumed		2.7	
Volume, cm ³		54.47			Solids Height, cm		0.699	
Water Content, %		52.6			Volume of Solids, cm ³		22.09	
Wet Mass, g		91.04			Volume of Voids, cm ³		32.38	
Dry Mass, g		59.64			Degree of Saturation, %		101.9	
Prepared By: SL					Golder Associates		Checked By: AB	



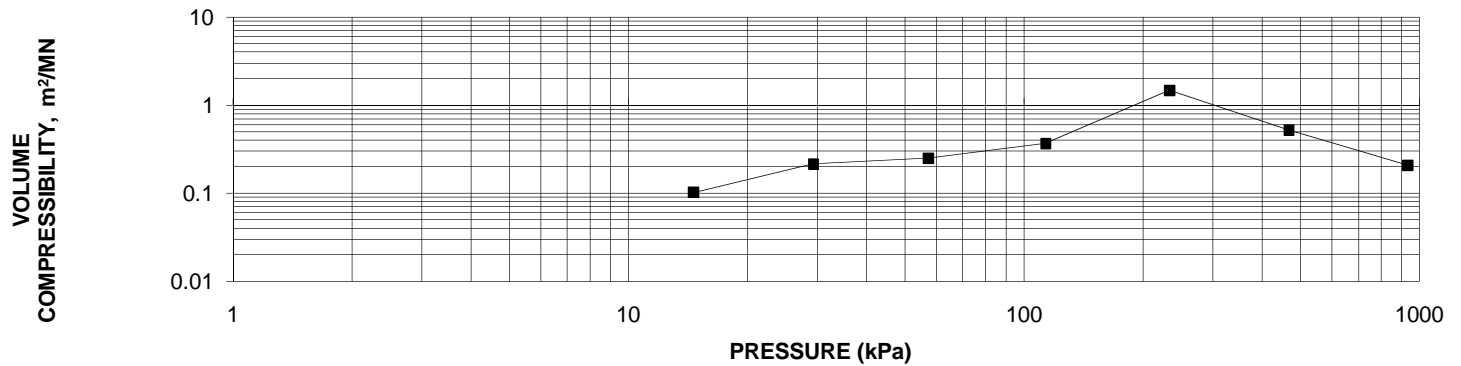
OEDOMETER CONSOLIDATION SUMMARY

FIGURE B-6
Page 3 of 4

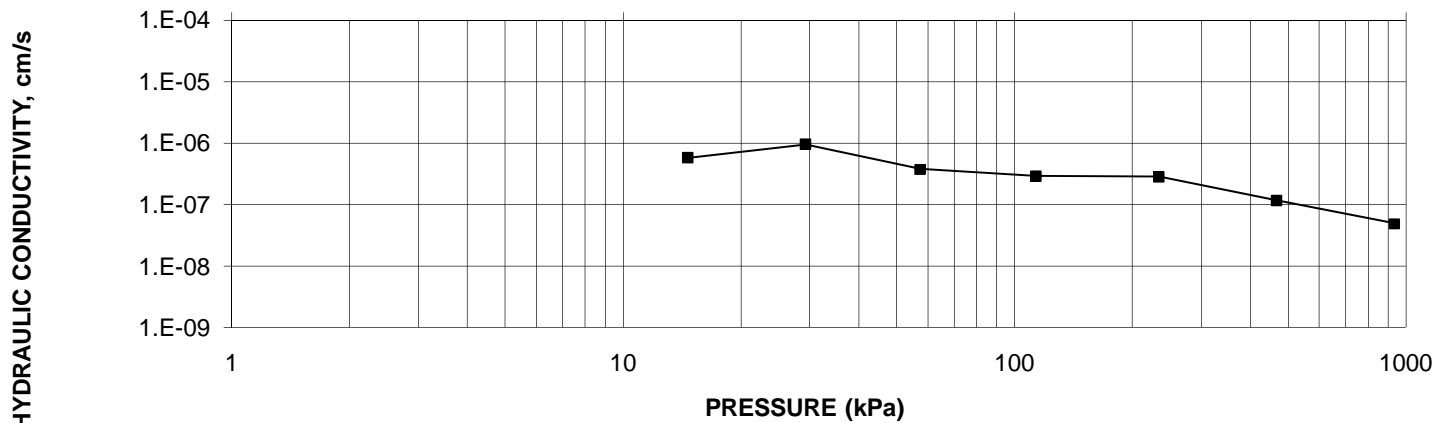
CONSOLIDATION TEST
CV cm²/s VS PRESSURE (kPa)
BH SR-2a, Sa 1



CONSOLIDATION TEST
MV m²/MN vs PRESSURE (kPa)
BH SR-2a, Sa 1



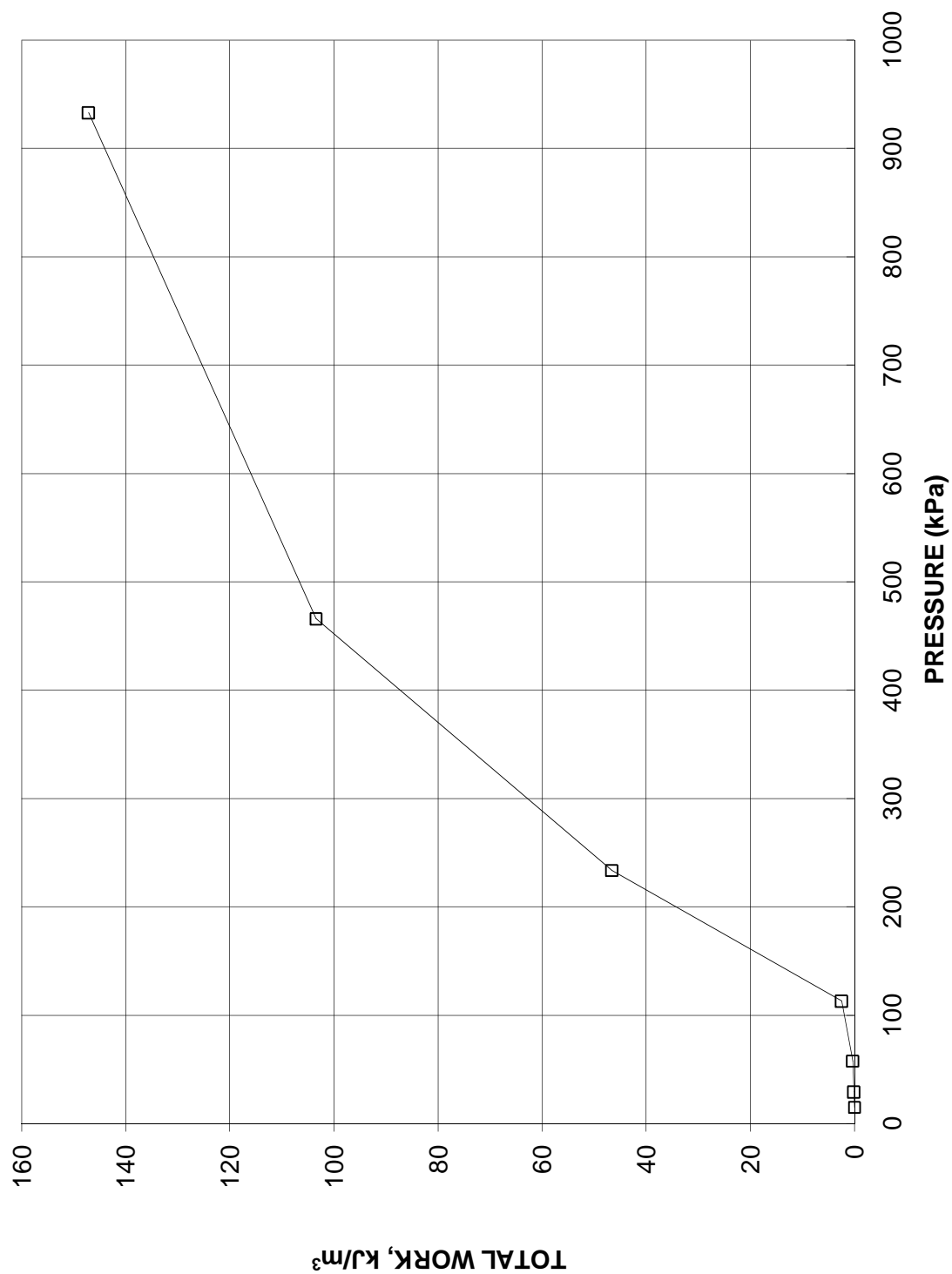
CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs PRESSURE
BH SR-2a, Sa 1



**PRIMARY CONSOLIDATION TEST
TOTAL WORK VS. PRESSURE**

**FIGURE B-6
Page 4 of 4**

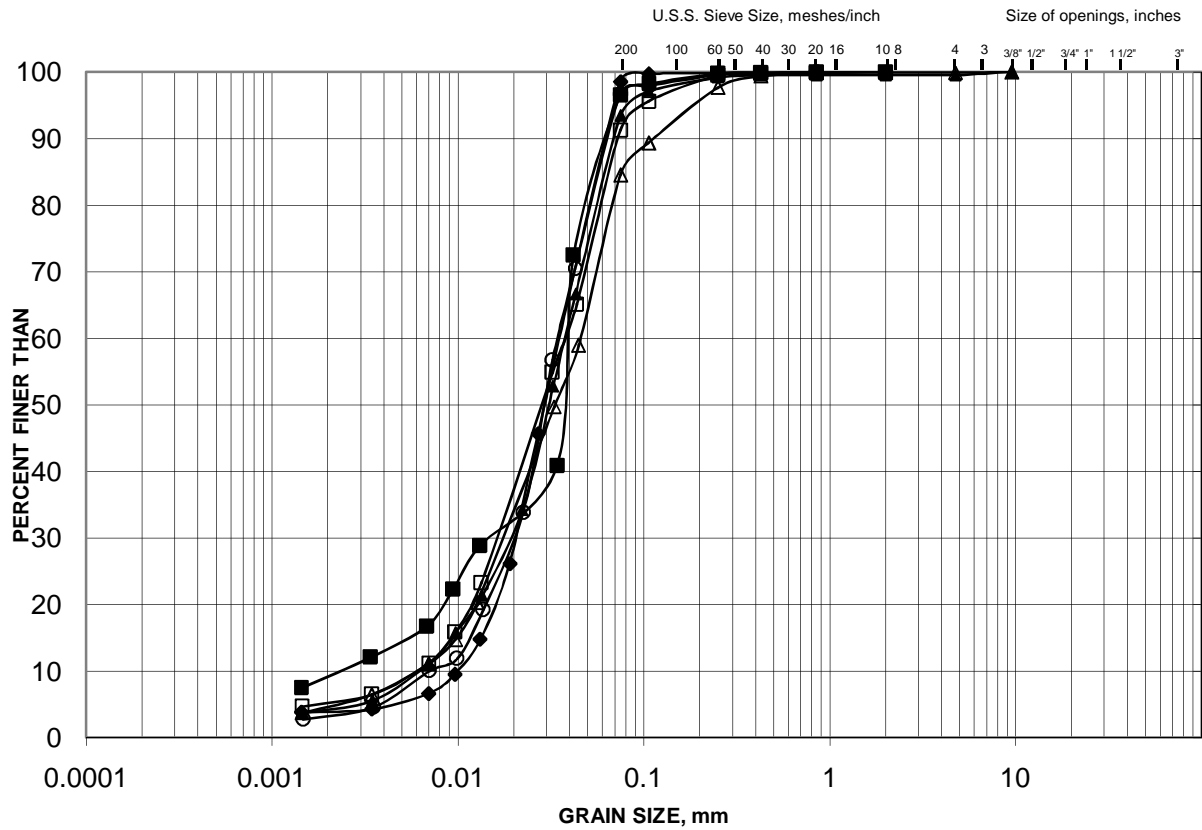
**CONSOLIDATION TEST
TOTAL WORK, kJ/m^3 vs PRESSURE
BH SR-2a, Sa 1**



GRAIN SIZE DISTRIBUTION

Silt

FIGURE
B-7a



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
—▲—	SR-1	3	225.2
—◆—	SR-2a	2b	222.8
—■—	SR-3	3b	225.0
—□—	SR-4	3	226.6
—○—	SR-5	7a	222.2
—△—	SR-5	7b	221.9

Project Number: 07-1191-0001

Checked By: AB

Golder Associates

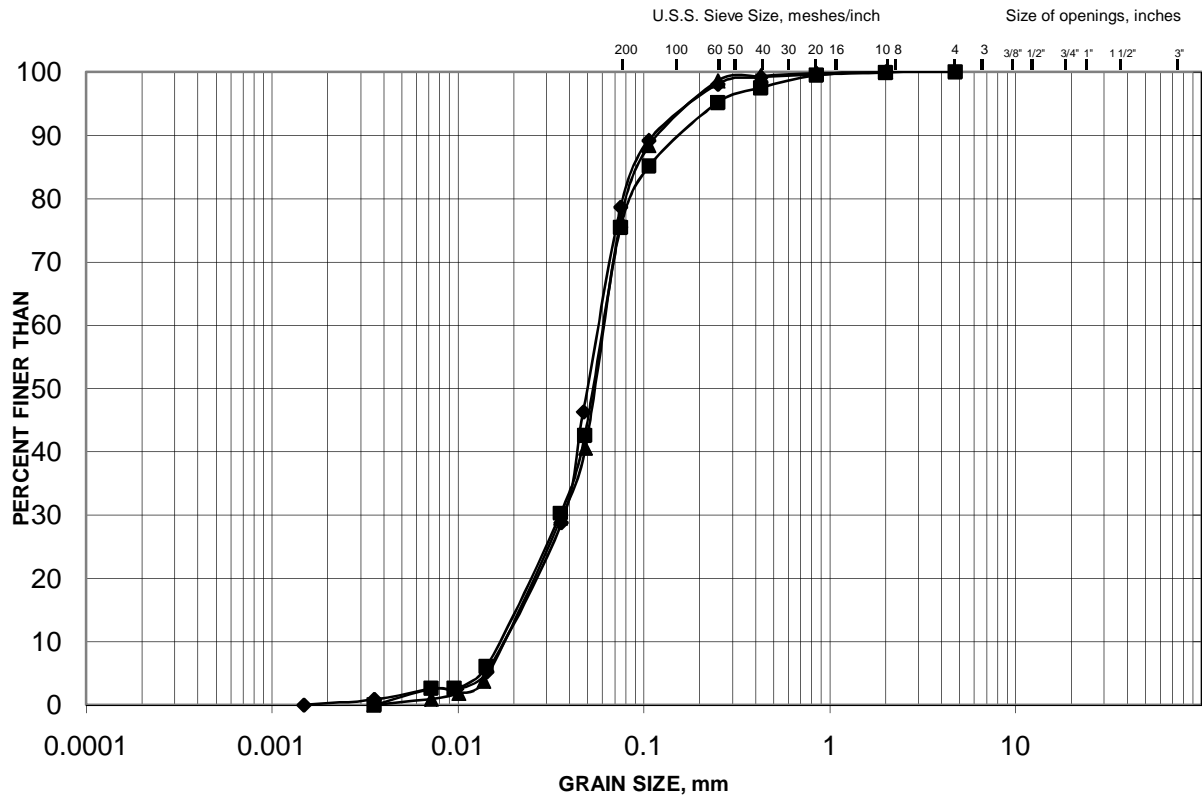
Date: June 2009

GRAIN SIZE DISTRIBUTION

Sandy Silt

FIGURE

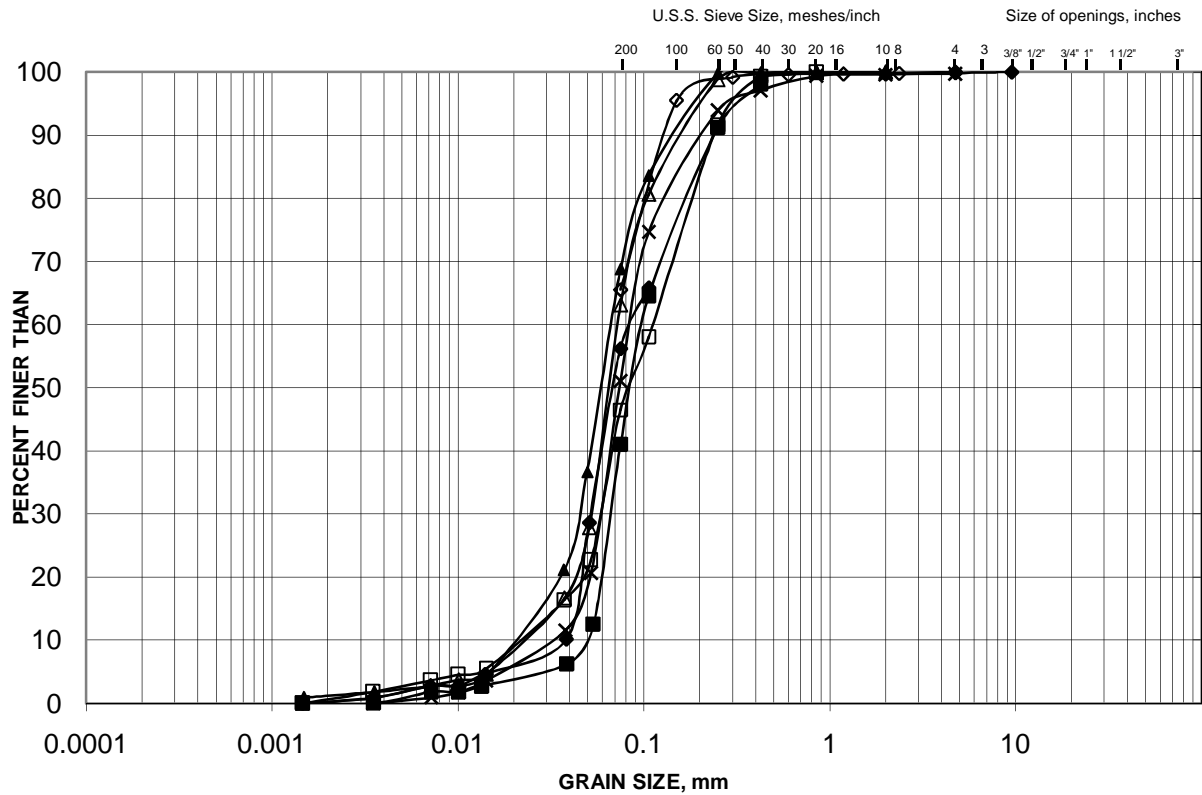
B-7b



GRAIN SIZE DISTRIBUTION

Sand and Silt

FIGURE
B-8a



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
▲	SR-1	7	222.1
◆	SR-1	10	217.6
■	SR-2	8	218.3
×	SR-2	16a	206.3
□	SR-3	6	222.9
△	SR-3	11	216.0
◇	SR-3	20	200.8

Project Number: 07-1191-0001

Checked By: AB

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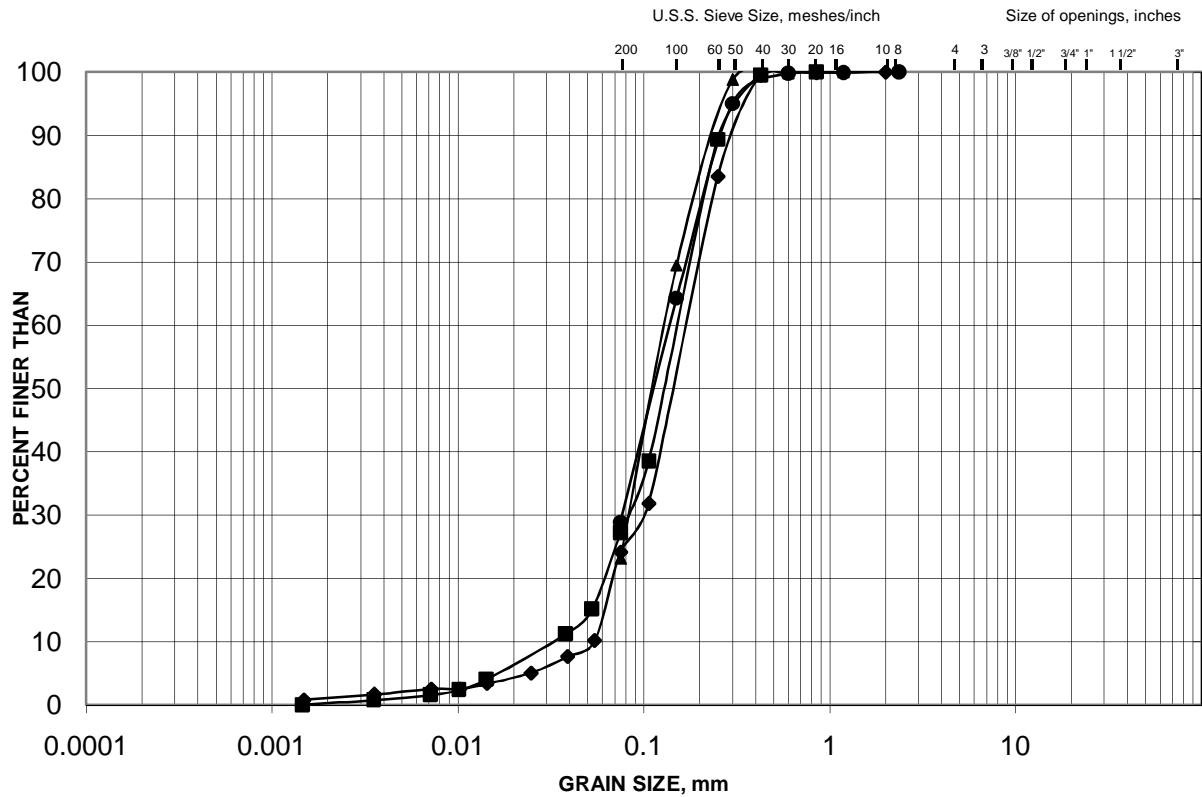
Date: June 2009

GRAIN SIZE DISTRIBUTION

Silty Sand

FIGURE

B-8b



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
—▲—	SR-3	9	219.1
—◆—	SR-4	5	225.0
—■—	SR-4	7	223.5
—●—	SR-4	10	219.0

Project Number: 07-1191-0001

Checked By: AB

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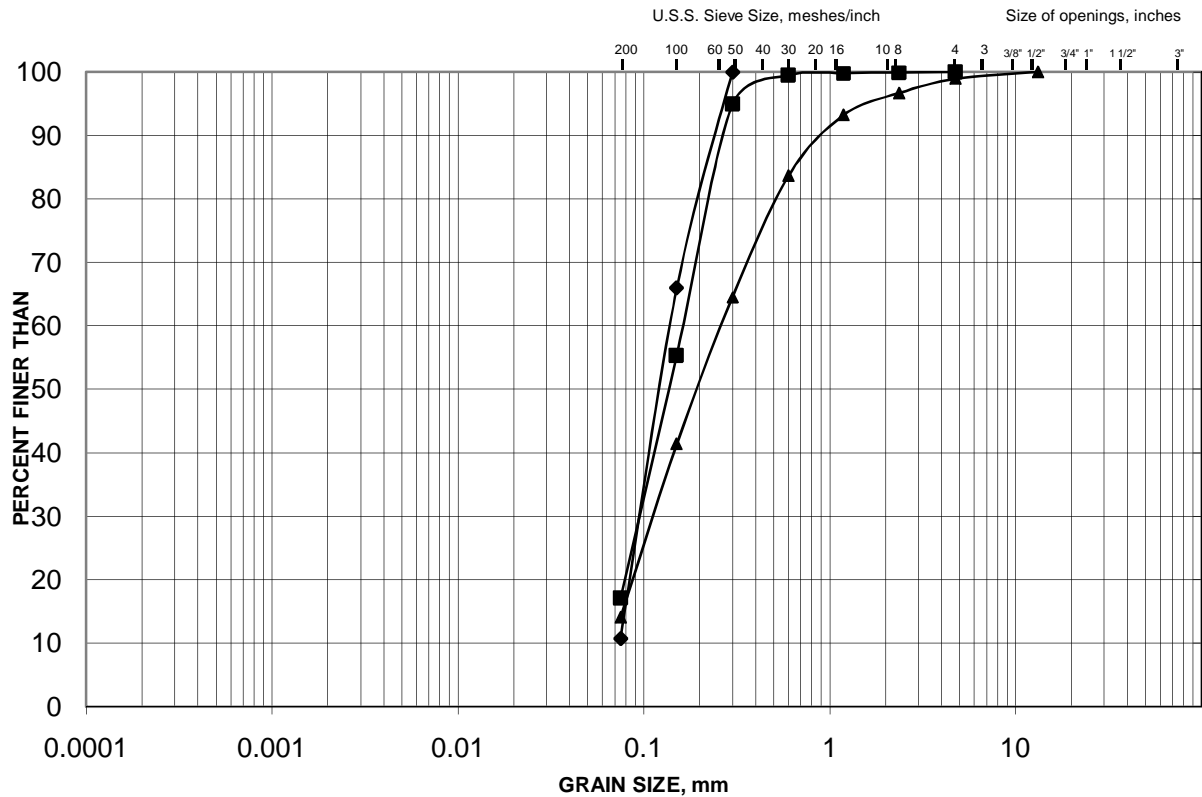
Date: June 2009

GRAIN SIZE DISTRIBUTION

Sand

FIGURE

B-8c



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
—▲—	SR-2	14	209.1
—◆—	SR-3	14	211.5
—■—	SR-3	17	206.9

Project Number: 07-1191-0001

Checked By: AB

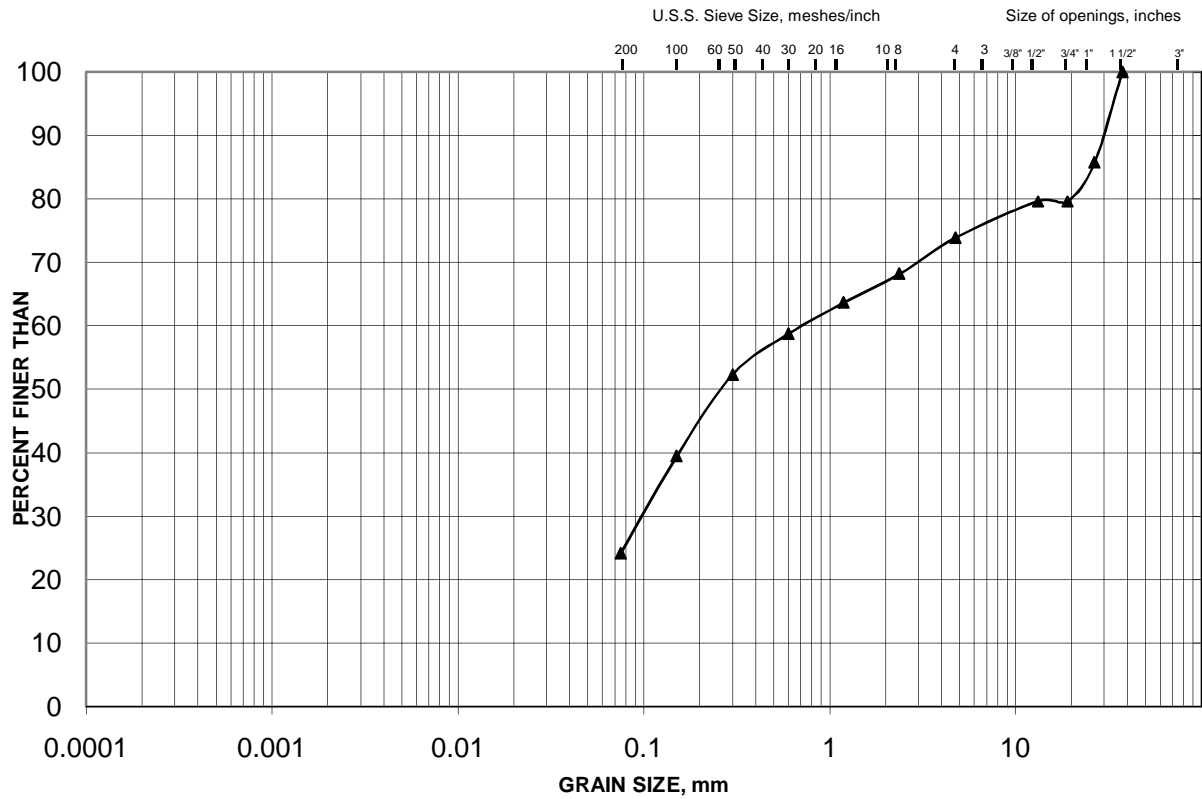
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Date: June 2009

GRAIN SIZE DISTRIBUTION

Gravelly Sand

**FIGURE
B-9**



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
—▲—	SR-2	18	203.2

Project Number: 07-1191-0001

Checked By: AB

Golder Associates

Date: June 2009

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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