REPORT

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January 21, 2010

Foundation Investigation Report
Frederick House Bridge Replacement
Highway 11, Site No. 39E-045
Township of Clute, Ontario
Ministry of Transportation, Ontario
GWP 5541-05-00

Submitted to:
LEA Consulting Ltd.
625 Cochrane Drive, Suite 900
Markham, Ontario
L3R 9R9

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Distribution:

1 Copy - Ministry of Transportation, Ontario, North Bay, Ontario (Northeastern Region)
1 Copy - LEA Consulting Ltd., Markham, Ontario
1 Copy - Golder Associates Ltd., Sudbury, Ontario

Golder Associates

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by LEA Consulting Ltd. (LEA) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the detail design of the Frederick House River Bridge replacement on Highway 11 in the Township of Clute, Ontario.

The terms of reference for the scope of work are outlined in Golder's proposal P7-1191-0007, dated February 26, 2007, which forms part of the Consultant's Agreement (P.O. Number 5006-E-0015) for this project. The work was carried out in accordance with the Quality Control Plan for this project dated September 18, 2007. The General Arrangement drawing (GA) for the bridge structure was provided to Golder by LEA in April 2009 and revised in June 2009.

The purpose of this investigation is to establish the subsurface conditions at the proposed replacement structure locations by borehole drilling, 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 and offset stakes laid out at the site by LEA, which were based on the April 2009 GA. The location of the investigated area is shown in plan on the Contract Drawings.

The investigation was supplemented with information contained in the following report from MTO's GEOCRES system:

- Foundation Investigation Report, Highway 11, Frederickhouse River Bridge, Structure Rehabilitation, W.P. 647-90-01, GEOCRES No. 42H-32, by Shaheen & Peaker Limited, dated February 1, 2006.

2.0 SITE DESCRIPTION

The site is situated in the Township of Clute on Highway 11 crossing Frederick House River, approximately 11 km west of Highway 652. The surrounding land is mainly comprised of scattered residences, residential farms and businesses. Grass and tree cover extend beyond the limits of the site, while the banks adjacent to the river are vegetated with grass and small shrubs. The river is up to 5 m deep and is mainly used for recreation. The river banks are relatively steep in the immediate area of the bridge. The river channel is about 60 m wide at the existing bridge location.

We understand that the existing Frederick House River Bridge, a five-span steel truss structure, was constructed in 1948 while the proposed bridge will be a three-span structure. The existing bridge has an overall deck length of about 135 m and overall width of about 10 m. We understand from LEA that rehabilitations/repairs have been made over the years to the bridge superstructure and as recently as 2006 to the abutments. The water level of Frederick House River was measured at approximately Elevation 242.3 m in November 2007 by others.

3.0 INVESTIGATION PROCEDURES

A total of eight (8) boreholes were advanced at the site between April 16 and 28, 2009. Six boreholes (FR-1 to FR-6) were advanced for the proposed main bridge abutments, piers and approaches. Two additional boreholes (FR-7 and FR-8) were advanced to address the high embankment fill and culvert extension west of the proposed structure. Three additional boreholes were advanced between July 29 and 30, 2009. Two boreholes (FR-9 and FR-10) were advanced at the west approach toe and one borehole (FR-4A) was advanced at the east pier and taken to bedrock. The locations and elevations of the boreholes are shown on the Contract Drawings and presented on the Record of Borehole sheets in Appendix A.

Boreholes FR-1 to FR-3, FR-4A and FR-5 to FR-10 were drilled using a track mounted CME 45-C drill rig supplied and operated by George Downing Estate Drilling Ltd. of Grenville-Sur-La-Rouge, Quebec. Borehole FR-4 was drilled using portable equipment that was supplied and operated by OGS Inc. of Almonte, Ontario.

The boreholes were advanced to depths ranging from 5.6 m to 29.0 m below the existing ground surface. The machine drilled boreholes were advanced using 108 mm inside diameter (I.D.) continuous flight hollow stem augers, with NW casing with wash boring, where necessary. The borehole advanced using portable equipment was advanced using NW and BW casing with wash boring to 5.6 m depth where casing refusal was met probably on the surface of the very dense sand and gravel.

A combination of continuous and non-continuous (at intervals of depth of about 0.75 m to 2.5 m) sampling methods were used in obtaining soil samples. Samples were obtained using a 50 mm outside diameter (O.D.) split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586-99). Shelby tube samples were taken in cohesive deposits at select borehole depths. Field vane shear tests were conducted in cohesive soils for assessment of undrained shear strengths (ASTM D2573-01) using an MTO standard "N" size vane. Rock core samples were obtained using an 'NQ' size core barrel and the bedrock was cored for a minimum of 3 m.

The groundwater conditions in the open boreholes were observed during the drilling operations and piezometers were installed in two boreholes, FR-1 and FR-6, at the west and east approaches, respectively, to allow monitoring of the groundwater level at these locations. The piezometers consisted of 50 mm O.D. rigid PVC tubing with a 1.5 m long slotted screen, sealed within the silt to sand and silt stratum. The boreholes were backfilled with bentonite as per Ontario Regulation 903 (as amended by O. Reg. 372) upon completion of drilling. The two piezometers were decommissioned in a similar manner after the last water level reading was obtained in July 2009. The installation details and water level readings are presented on the Record of Borehole sheets that follow the text of this report.

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. One-dimensional consolidation (oedometer) tests were carried out on Shelby tube samples of the cohesive soil deposit from three boreholes. In addition, uniaxial compressive strength (UCS) testing was carried out on selected samples of the bedrock core recovered from the boreholes.

The proposed boreholes were laid out in the field by Golder relative to the proposed centreline alignment and offset stakes surveyed by LEA and based on the GA supplied by LEA in April 2009. The northings and eastings in MTM NAD 83 coordinate system were determined by plotting the station and offset of the boreholes (relative to the stakes) on the April 2009 GA and converting to the coordinate system. The ground surface elevations were measured relative to the stakes and are referenced to geodetic datum.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Published literature indicates that the site is located in the Western Abitibi Subprovince of the Superior Province (Geology of Ontario; OGS Special Volume 4)[1]. The bedrock of this domain consists of metavolcanic and minor metasedimentary rocks.

Based on terrain mapping by the Ontario Geological Survey[2], the subsurface soils in the vicinity of the site consist of glaciolacustrine plain deposits comprising of organic peat and clayey silts terrain overlying bedrock.

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 samples, are given on the Record of Borehole and Drillhole sheets attached in 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 generally consist of embankment fill or alluvium, underlain by silty clay to clay and silt to sand and silt. The silt to sand and silt deposit was encountered overlying a sand and gravel deposit or directly overlying bedrock. The groundwater level was generally consistent with the river water level. A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Organics/Fill/Alluvium

Between 0.1 m and 0.6 m of organics was encountered in Boreholes FR-1 to FR-4, FR-4A and FR-7 at the ground surface between Elevation 242.9 m and 252.0 m. Embankment fill was encountered at the ground surface or below the organics in all boreholes except FR-3. In Boreholes FR-3, FR-4 and FR-4A, alluvium was encountered below the organics and/or fill. The total thickness of organics/fill/alluvium in the boreholes varied from 1.4 m to 7.6 m.

In Boreholes FR-6 and FR-8, between 0.6 m to 3.8 m of sand and silt to sand and gravel fill containing some clay was encountered. The fill contained clayey silt layers in Borehole FR-6. The surface of the cohesionless fill was encountered between Elevation 257.5 m and 258.5 m. In Borehole FR-6, an obstruction was encountered at a 2.3 m depth within the fill and the borehole was moved as a result.

In Boreholes FR-1, FR-2, FR-4, FR-4A, FR-5, FR-7 and FR-8, 0.6 m to 7.0 m of silty clay to silt fill, containing trace sand, trace gravel and trace organics was encountered between Elevation 242.3 m and 257.9 m.

In Boreholes FR-3, FR-4 and FR-4A, grey, brown or black silty clay to clayey silt to silt alluvium was encountered below the fill or organics and contained some sand and gravel and trace organics.

SPT 'N' values measured within the cohesionless fill layer ranged from 12 blows to 33 blows per 0.3 m of penetration suggesting a very loose to dense relative density. SPT 'N' values measured with the cohesive fill layer varied from 2 to 19 blows per 0.3 m of penetration suggesting a soft to very stiff consistency.
SPT 'N' values measured within the alluvium ranged from 5 blows to 13 blows per 0.3 m of penetration suggesting a very loose to compact relative density. In Borehole FR-3, one 'N' value of 40 was measured near the base of the layer suggesting the alluvium becomes dense with depth.

[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] Northern Ontario Engineering Geology Terrain Study, OGS Electronic Map

One grain size distribution test from the alluvium is shown on Figure B-1 in Appendix B. Note that this sample is indicative of the layering within the alluvium as it is classified as a sand and silt.

Atterberg limits testing carried out on samples of the cohesive fill and alluvium as well as a clayey silt seam within the cohesionless fill indicate liquid limits ranging from about 25 percent to 42 percent and plastic limits ranging from about 13 percent to 19 percent, yielding plasticity indices ranging from about 12 percent to 24 percent. The results of the Atterberg limits testing are shown on the plasticity chart on Figure B-2, and indicate that the fill material is classified as a clayey silt of low plasticity to a silty clay of intermediate plasticity.

The natural water content measured on samples of the cohesionless fill ranged between about 6 percent and 19 percent. In the cohesive fill and alluvium, the measured water content ranged between 17 percent and 42 percent.

4.2.2 Sand

A 1.3 m thick layer of sand containing trace gravel and clay pockets was encountered at the ground surface at Elevation 244.7 m and 246.7 m in Boreholes FR-9 and FR-10, respectively.

SPT 'N' values measured within the sand ranged from 4 blows to 8 blows per 0.3 m of penetration suggesting a very loose to loose relative density.

4.2.3 Silty Clay to Clay

A deposit of moist to wet, brown to grey, silty clay to clay was encountered beneath the fill in Boreholes FR-1, FR-2 and FR-5 to FR-10. This deposit was not encountered in the boreholes immediately adjacent to the river. The deposit was distinctly varved in Boreholes FR-1 and FR-5 to FR-10 and somewhat varved in Borehole FR-2. The top of the deposit was encountered at Elevation 243.4 m to 253.7 m and the thickness ranged from 0.8 m to 8.1 m.

SPT 'N' values measured within this deposit ranged from 0 blows (weight of hammer) to 15 blows per 0.3 m of penetration being greatest near the top of the deposit and in Boreholes FR-9 and FR-10. In situ field vane testing carried out within this stratum measured undrained shear strengths that ranged from about 27 kPa to 86 kPa. The SPT 'N' values combined with the undrained shear strengths indicate that the material had a soft to stiff consistency, typically firm to stiff.

Atterberg limits testing carried out on several samples of the silty clay to clay deposit indicate liquid limits that ranged from about 38 to 68 percent and plastic limits that ranged from about 18 to 25 percent, yielding plasticity indices that ranged from about 19 to 43 percent. The results of the Atterberg limits testing are shown on the plasticity chart on Figure B-3 in Appendix B, and indicate that the deposit ranged from a silty clay of intermediate plasticity to a clay of high plasticity. In two samples, the clay and clayey silt varves were tested separately. The clayey silt varves had liquid limits that ranged from about 27 to 30 percent, plastic limits that ranged from about 16 to 17 percent, yielding plasticity indices that ranged from about 11 to 13 percent. The clay varves had liquid limits that ranged from about 51 to 57 percent, plastic limits that ranged from about 20 to 22 percent, yielding plasticity indices that ranged from about 31 to 35 percent. The results indicate that the varves were a clayey silt of low plasticity as shown on Figure B-3.

The results of Atterberg limits testing in Borehole FR-9 and FR-10, located at the northwest portion of the site, indicated liquid limits of about 28 and 32 percent, plastic limits of about 14 and 18 percent, yielding plasticity indices of about 13 and 14 percent. These results suggest that the deposit could be classified as more of a clayey silt of low plasticity in this area. Further, the SPT 'N' values were the highest in Borehole FR-10 with the lowest liquid limit.

One grain size distribution test of the clayey silt varve is shown on Figure B-4 in Appendix B.

The natural water content measured on samples this deposit ranged from about 24 percent to 59 percent.

Three laboratory consolidation tests were carried out on specimens of the silty clay to clay obtained from Boreholes FR-5, FR-6 and FR-7 and the test results are shown on Figures B-5, B-6 and B-7, respectively. The preconsolidation pressure was 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)
FR-5/9	247.1	133	200	67	1.5	0.707	0.030	0.121	0.0040
FR-6/8	251.1	122	240	118	2.0	1.071	0.084	0.473	0.0038
FR-7/8	245.7	109	230	121	2.1	1.150	0.089	0.360	0.0061

Note: *For approximate stress range of $18 \leq \sigma_v' \leq 285$ 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 cm^2/s in the normally consolidated range

4.2.4 Silt to Sand and Silt

A deposit of wet, grey, silt to sand and silt containing trace to some gravel and clay was encountered beneath the silty clay to clay deposit in Boreholes FR-1, FR-2 and FR-5 to FR-10 and beneath the alluvium in Borehole FR-3. The top of the deposit ranged from Elevation 241.1 m to 246.5 m and the thickness of the deposit ranged from 1.8 m to 9.9 m. Boreholes FR-1 and FR-7 to FR-10 were terminated within this deposit.

SPT 'N' values measured within this deposit ranged from 3 blows to 27 blows per 0.3 m of penetration indicating a very loose to compact relative density.

Grain size distribution tests were carried out on several samples of the silt to sand and silt and the results are shown on Figure B-8a. One test result from Borehole FR-3 indicates that a gravel size piece was retained on the 26.5 mm sieve causing the results to portray a more gravelly material than was actually the case. This test result is shown on Figure B-8b.

The natural water content measured on samples of the deposit were between about 24 percent and 29 percent.

4.2.5 Sand and Gravel/Cobbles and Boulders

A deposit of wet, grey sand and gravel containing trace to some silt and cobbles and boulders was encountered underlying the silt to sand and silt deposit in Boreholes FR-2, FR-4, FR-4A, FR-5 and FR-6. In Borehole FR-4, this deposit is classified more as a sand to silty sand containing some gravel and cobbles. The top of this deposit was encountered between Elevation 232.7 m and 242.3 m and the thickness of the deposit varied from 3.4 m to 12.1 m. Borehole FR-6 was terminated within this deposit and Borehole FR-4 was also terminated within this deposit due to casing refusal of the portable equipment.

SPT 'N' values measured within this deposit ranged from 12 blows per 0.3 m of penetration to greater than 100, suggesting a compact to very dense relative density. The higher 'N' values are also indicative of the presence of cobbles and boulders. Difficult auger and/or casing advance was observed during drilling through the sand and gravel deposit and, in Boreholes FR-2, FR-4A and FR-5, coring using an NQ core barrel had to be used to advance the borehole through the deposit to reach the bedrock.

Grain size distribution tests were carried out on three samples of this deposit and the results are shown on Figure B-9.

The natural water content measured on samples of the deposit were between about 10 and 13 percent.

In Borehole FR-3, a 0.4 m thick layer of cobbles and boulders was encountered below the silty to sand and silt deposit at Elevation 231.3 m.

4.2.6 Bedrock

Bedrock was encountered and cored for a minimum of 3 m in Boreholes FR-2, FR-3, FR-4A and FR-5. The depth to bedrock below ground surface and corresponding bedrock surface elevation encountered at each borehole is summarized below.

Borehole	Depth to Bedrock Surface (m)	Bedrock Surface Elevation (m)
FR-2	17.9	229.3
FR-3	13.5	231.4
FR-4A	18.3	230.7
FR-5	25.5	229.5

Based on a review of the rock core samples, a grey, fine grained, slightly weathered metasediment bedrock was encountered. In Boreholes FR-2, FR-3, FR-4A and FR-5, silt seams, up to 0.4 m thick, were observed within the bedrock. The Rock Quality Designation (RQD) measured on the core samples typically ranged from 57 percent to 100 percent, with one core sample having an RQD of 9 percent on a 1.2 m core run. This indicates a rock mass quality that generally ranged from fair to excellent. The Total Core Recovery (TCR) during bedrock coring ranged from 65 percent to 100 percent with the lower values indicative of the presence and thickness of silt seams within the bedrock.

Laboratory UCS testing was performed on three samples of the bedrock and the results gave strengths ranging from 89 MPa to 175 MPa. The results of this testing can be found in Table B-1 in Appendix B. Based on the laboratory UCS test results, the estimated intact strength of the bedrock ranges from strong (R4, 50 MPa < UCS < 100 MPa) to very strong (R5, 100 MPa < UCS < 250 MPa).

4.2.7 Groundwater Conditions

The water levels were noted during and after the drilling operations in the boreholes. In general, the soil samples taken in the boreholes were noted to be moist to wet. The water levels were noted during and after the drilling and coring operations in the boreholes, and these levels may not have stabilized prior to reading. Piezometers were installed in Boreholes FR-1 and FR-6, with screened sections sealed within the silt to sand and silt deposit. Details of the piezometer installations are shown on the Record of Borehole sheets in Appendix A.

The groundwater level ranged from 1.0 m to 15.9 m below the ground surface in the boreholes. The groundwater level ranged from Elevation 240.7 m to 247.4 m. The water level in Frederick House River was surveyed by others in November 2007 at Elevation 242.3 m. The water levels in the piezometers and open boreholes during and upon completion of drilling are summarized below.

Borehole	Installation	Depth to Groundwater below Existing Ground Surface (m)	Groundwater Elevation (m)	Date
FR-1	Piezometer	4.4	245.4	April 23/09 (after installation)
		5.6	244.2	April 28/09
		6.9	242.9	July 31/09
FR-2	Open Borehole	3.7	244.1	April 23/09
FR-3	Open Borehole	3.8	240.7	April 22/09
FR-4	Open Borehole	1.0	241.9	April 21/09
FR-4A	Open Borehole	10.7 and rising	238.3	July 30/09
FR-5	Open Borehole	7.6	247.4	April 19/09
FR-6	Piezometer	11.6	245.9	April 19/09 (after installation)
		13.9	243.6	April 28/09
		11.9	245.6	July 31/09
FR-7	Open Borehole	8.3	243.7	April 27/09
FR-8	Open Borehole	15.9	242.6	April 28/09
FR-9	Open Borehole	1.5	243.7	July 30/09
FR-10	Open Borehole	4.4 and rising	242.5	July 30/09

It should be noted that groundwater levels in the area are subject to seasonal fluctuations. Although not observed in the boreholes during this investigation, the previous report (Shaheen & Peaker 2006) measured perched water within the embankment fill.

5.0 CLOSURE

The field personnel supervising the drilling program was Mr. Ed Savard, Mr. Trevor Moxam and Mr. Mat Riopelle. This report was prepared by Mr. Evan Childerhose, E.I.T. and the technical aspects were reviewed by Ms. Sarah E. M. Coyne, P.Eng., an Associate with Golder in 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

GOLDER ASSOCIATES LTD.

Evan Childerhose
Geotechnical E.I.T.

LICENSED PROFESSIONAL ENGINEER
S.E.M. COYNE
90471921
PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER
F. J. HEFFERNAN
PROVINCE OF ONTARIO

Sarah E. M. Coyne, P.Eng.
Associate, Senior Geotechnical Engineer

Fintan J. Heffernan, P.Eng.
Designated MTO Contact

EC/SEMC/FJH/lb

APPENDIX A

RECORD OF BOREHOLE AND DRILLHOLE SHEETS

LIST OF SYMBOLS

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

1. GENERAL

π	3.1416
in 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 = σ'_p / σ'_{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 δ
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:

1. 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

Piezocone Penetration Test (CPT)

An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 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

Description	Bedding Plane Spacing
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

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

GRAIN SIZE

Terms	Size*
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
II - Parallel To	⊾ - Perpendicular To

Golder Associates

RECORD OF BOREHOLE No FR- 1

1 OF 1 **METRIC**

PROJECT 07-1191-0007
W.P. 5541-05-01
DIST HWY 11
DATUM Geodetic
LOCATION N 5435620.5 ;E 294567.2
BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers
DATE April 23, 2009
ORIGINATED BY TDM
COMPILED BY MM
CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
249.8	GROUND SURFACE										
0.0	Organics (FILL)										
0.2	Brown Wet Silty clay, trace sand, trace gravel (FILL) Soft to stiff Brown Moist to wet		1	AS	-						
			2	SS	6		249		42		
			3	SS	13		248				
			4	SS	11		247		41.6		
			5	SS	9						
			6	SS	2		246		42		
245.2											
4.6	SILTY CLAY, varved Soft to firm Grey Wet		7	SS	3		245	4			
	Dark grey clay laminae 5 mm to 20 mm thick. Light grey clayey silt laminae 25 mm to 50 mm thick.		8	TO	PH		244		51		
243.2											0 1 76 23
6.6	SILT, some sand, trace to some clay Compact Grey Wet						243				
			9	SS	10		242				0 18 75 7
							241				
240.0			10	SS	14						
9.8	End of Borehole Note: 1. Water level at a depth of 4.4 m below ground surface (Elev. 245.4 m) upon completion of drilling. 2. Water level measured in piezometer at a depth of 5.6 m below ground surface (Elev. 244.2 m) on April 28, 2009 and at 6.9 m depth (Elev. 242.9 m) on July 31, 2009.										

$+^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No FR- 2

1 OF 2 **METRIC**

PROJECT 07-1191-0007 | W.P. 5541-05-01 | LOCATION N 5435620.8 ;E 294587.5 | ORIGINATED BY TDM

DIST | HWY 11 | BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring | COMPILED BY MM

DATUM Geodetic | DATE April 22 to 24, 2009 | CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
247.2	GROUND SURFACE						247				
0.0	Organics (FILL)										
0.2	Brown Moist Clayey silt to silty clay, trace sand, trace gravel (FILL) Soft to stiff Brown Moist		1	AS	-						
			2	SS	4		246				
			3	SS	2						
			4	SS	9		245				
			5	SS	7		244		41		
243.4						▽					
3.8	SILTY CLAY Soft Brown Wet		6	SS	3		243				
242.6											
4.6	SILT to Sandy SILT, trace to some clay Loose to compact Grey Wet		7	SS	11		242				0 5 88 7
			8	SS	11		241				
	Difficulty advancing augers at 7.5 m depth. Switch to NW Casing.		9	SS	6		240				
			10	SS	5		239				
			11	SS	10		238				0 27 69 4
			12	SS	22		237				
			13	SS	24		236				
232.7							235				
14.5							234				
							233				

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No FR- 2

2 OF 2 **METRIC**

PROJECT 07-1191-0007 | W.P. 5541-05-01 | LOCATION N 5435620.8 ;E 294587.5 | ORIGINATED BY TDM

DIST | HWY 11 | BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring | COMPILED BY MM

DATUM Geodetic | DATE April 22 to 24, 2009 | CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) / PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---									
	SAND and GRAVEL, trace silt Compact Grey Wet Difficult casing advance at 14.5 m depth.		14	RC	-		232			
							231			
			15	SS	16		230			
229.3										
17.9	METASEDIMENT (BEDROCK) Bedrock cored from 17.9 m to 21.1 m depth. For coring details refer to Record of Drillhole FR- 2.		1	RC	REC 100%		229			RQD = 87%
			2	RC	REC 100%		228			RQD = 88%
			3	RC	REC 100%		227			RQD = 91%
226.1										
21.1	End of Borehole Note: 1. Water level at a depth of 3.7 m below ground surface (Elev. 243.5 m) upon completion of drilling.									

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 07-1191-0007

RECORD OF DRILLHOLE: FR- 2

SHEET 1 OF 1

LOCATION: N 5435620.8 ;E 294587.5

DRILLING DATE: April 22 to 24, 2009

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 45

DRILLING CONTRACTOR: Downing Drilling Ltd.

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.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	PENETRATION RATE min/(m)	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA: B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -'Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		Refer to Previous Page		229.30																		
18	04/24/2009 NQ Coring	METASEDIMENT, containing occasional silt seams Fine grained Slightly weathered Very strong Grey		17.90	1										J, I, R							
															FO, I, R							
19					2										FO, I, R FO, I, R FO, I, R							UCS = 143 MPa
															FO, I, R							
															FO, I, R FO, I, R							
20															FO, I, R FO, I, R J, PL, R J, PL, SM							
					3										J, I, R							
21				226.10																		
		End of Drillhole		21.10																		
22																						
23																						
24																						
25																						
26																						
27																						

DEPTH SCALE
1 : 50

LOGGED: TDM
CHECKED: AB

Golder Associates

MIS-RCK 004 FREDERICK_HOUSE_0711910007_METRIC.GPJ GAL-MISS.GDT 20/1/10

Golder Associates

RECORD OF BOREHOLE No FR- 3

1 OF 2 **METRIC**

PROJECT 07-1191-0007
W.P. 5541-05-01
DIST HWY 11
DATUM Geodetic
LOCATION N 5435622.4 ;E 294624.8
BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers
DATE April 22, 2009
ORIGINATED BY TDM
COMPILED BY MM
CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
244.9	GROUND SURFACE										
0.0	Organics (FILL)										
0.2	Brown Wet		1	AS	-						
	Silty clay, some sand and gravel, trace organics (ALLUVIUM) Soft to hard Brown Wet		2	SS	7		244		○		0 46 38 16
			3	SS	3		243				
			4	SS	13		242				
241.2			5	SS	40						
3.7	SILT to SAND and SILT, trace to some clay, trace gravel Very loose to compact Grey Wet Sample 7: One large gravel piece was retained on 26.5 mm sieve.		6	SS	8	▽	241		○		0 12 79 9
			7	SS	6		240				32 54 12 2
			8	SS	8		239				
			9	SS	3		238				
			10	SS	7		237		○		0 35 62 3
			11	SS	8		236				
	Cobble encountered at 12.0 m depth.		12	SS	27		235				
231.8							234				
231.4	COBBLES and BOULDERS		13	RC	-		233				
13.5	METASEDIMENT (BEDROCK) Bedrock cored from 13.5 m to 16.5 m depth. For coring details refer to Record of Drillhole FR- 3.		1	RC	REC 90%		232				RQD = 57%
			2	RC	REC 100%		231				RQD = 80%
							230				

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No FR- 3

2 OF 2 **METRIC**

PROJECT 07-1191-0007 | W.P. 5541-05-01 | LOCATION N 5435622.4 ;E 294624.8 | ORIGINATED BY TDM

DIST | HWY 11 | BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers | COMPILED BY MM

DATUM Geodetic | DATE April 22, 2009 | CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	METASEDIMENT (BEDROCK) Bedrock cored from 13.5 m to 16.5 m depth. For coring details refer to Record of Drillhole FR- 3.		2	RC							RQD = 80%
228.4			3	RC	REC 65%		229				RQD = 9%
16.5	End of Borehole										
	Note: 1. Water level at a depth of 3.8 m below ground surface (Elev. 241.1 m) upon completion of drilling.										

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

PROJECT: 07-1191-0007

RECORD OF DRILLHOLE: FR- 3

SHEET 1 OF 1

LOCATION: N 5435622.4 ;E 294624.8

DRILLING DATE: April 22, 2009

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 45

DRILLING CONTRACTOR: Downing Drilling Ltd.

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.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	PENETRATION RATE min/(m)	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -'Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		Refer to Previous Page		231.40																		
14	04/22/2009 NQ Coring	METASEDIMENT, containing occasional silt seams Fine grained Slightly weathered Very strong Grey		13.50	1										J, I, R							
															J, I, R							
															J, PL, R							UCS = 175 MPa
15					2										J, I, R							
															J, I, R							
															FO, I, R							
															FO, I, R							
															FO, I, R							
															FO, I, R							
															FO, I, R							
		Silt layer encountered between 15.8 m and 16.0 m depth.			3										FO, I, R							
16															FO, I, R							
															FO, I, R							
															FO, I, R							
															J, I, R							
															J, I, R							
				228.40											FO, I, R							
		End of Drillhole		16.50																		
17																						
18																						
19																						
20																						
21																						
22																						
23																						

MIS-RCK 004 FREDERICK_HOUSE_0711910007_METRIC.GPJ GAL-MISS.GDT 20/1/10

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: TDM
CHECKED: AB

Golder Associates

RECORD OF BOREHOLE No FR- 4

1 OF 1 **METRIC**

PROJECT 07-1191-0007
W.P. 5541-05-01
LOCATION N 5435608.2 ;E 294700.4
ORIGINATED BY MR
DIST HWY 11
BOREHOLE TYPE Portable Equipment, NW and BW Casing, Wash Boring
COMPILED BY MM
DATUM Geodetic
DATE April 21, 2009
CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
242.9	GROUND SURFACE										
0.0	Organics, some sand (FILL) Stiff Brown Wet		1	SS	10						
242.3											
0.6	Clayey silt to silt, trace sand (FILL) Firm Grey Wet		2	SS	4	▽	242				
241.7											
1.2	Clayey silt to silt, trace sand, organic seams (ALLUVIUM) Firm to stiff Grey Wet		3	SS	5						
			4	SS	12		241				
240.5											
2.4	SAND to Silty SAND, some gravel, some clay, containing cobbles Compact to dense Grey Wet		5	SS	31		240				29 20 31 20
			6	SS	33						
			7	SS	40		239				
			8	SS	12		238				
237.3											
5.6	End of Borehole Casing Refusal										

Notes:

1. Could not advance casing with portable equipment below 5.6 m depth.
2. No recovery in sample 4.
3. Small trickle of water coming over top of casing at 3.2 m depth.
4. Water level at a depth of 1.0 m below ground surface (Elev. 241.9 m) upon completion of drilling.

$+^3, \times^3$: Numbers refer to Sensitivity
$\circ^{3\%}$ STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No FR- 4a

1 OF 2 **METRIC**

PROJECT 07-1191-0007 | W.P. 5541-05-01 | LOCATION N 5435615.4 ;E 294706.7 | ORIGINATED BY ID

DIST | HWY 11 | BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers/ NW Casing Wash Boring | COMPILED BY DA

DATUM Geodetic | DATE July 29 and 30, 2009 | CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
249.0	GROUND SURFACE										
0.0	Silty clay to clay, trace organics (FILL) Loose Brown Moist		1	SS	9		248				
			2	SS	9		247				
			3	SS	8		246				
			4	SS	10		245				
244.9											
4.1	Silty clay with organics, fine sand seams (ALLUVIUM) Firm to stiff Grey to black Wet		5	SS	7		244				
			6	SS	11		243				
242.0											
7.0	SAND and GRAVEL, containing cobbles Compact to very dense Grey Wet		7	SS	14		242				
	Hard augering and spoon bouncing at 8.4 m depth. Switched to NW casing.		8	SS	50/0.08		241				
			9	SS	33	▽	240				
			10	SS	47		239				58 39 (3)
			11	SS	16		238				
							237				
							236				
							235				

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

PROJECT 07-1191-0007

RECORD OF BOREHOLE No FR- 4a

2 OF 2 **METRIC**

W.P. 5541-05-01 LOCATION N 5435615.4 ;E 294706.7 ORIGINATED BY ID

DIST HWY 11 BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers/ NW Casing Wash Boring COMPILED BY DA

DATUM Geodetic DATE July 29 and 30, 2009 CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	SAND and GRAVEL, containing cobbles Compact to very dense Grey Wet		12	SS	15/0.08		233				
			13	SS	55		232		○		
			14	SS	20/0.15		231				
230.7											
18.3	METASEDIMENT (BEDROCK) Bedrock cored from 18.3 to 21.7 m depth. For coring details refer to Record of Drillhole FR-4a		1	RC	REC 100%		230				RQD = 79%
			2	RC	REC 100%		229				RQD = 100%
			3	RC	REC 100%		228				RQD = 93%
227.3											
21.7	End of Borehole Notes: 1. Sand and gravel and cobbles (up to 150 mm dimension) recovered from core runs 1 to 4. 2. Water level at a depth of 10.7 m (Elev. 238.3 m) and rising upon completion of drililng.										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 07-1191-0007

RECORD OF DRILLHOLE: FR- 4a

SHEET 1 OF 1

LOCATION: N 5435615.4 ;E 294706.7

DRILLING DATE: July 29 and 30, 2009

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 45

DRILLING CONTRACTOR: Downing Drilling Ltd.

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.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	PENETRATION RATE min/(m)	FLUSH / COLOUR % RETURN	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -'Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		Refer to Previous Page		230.70																	
19	NQ RC 07/29/09 and 07/30/09	METASEDIMENT, containing occasional silt seams Fine grained Slightly weathered Very strong Grey		18.30	1									J, I, R J, I, R J, I, R J, I, R Broken Core J, I, R							
20					2																UCS= 99 MPa
21		Weathered zone between 20.7 m and 20.8 m depth		227.30	3									J, I, R J, I, R							
22		End of Drillhole		21.70																	
23																					
24																					
25																					
26																					
27																					
28																					

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: ID
CHECKED: AB

MIS-RCK 004 FREDERICK_HOUSE_0711910007_METRIC.GPJ GAL-MISS.GDT 20/1/10

Golder Associates

RECORD OF BOREHOLE No FR- 5

1 OF 2 **METRIC**

PROJECT 07-1191-0007 | W.P. 5541-05-01 | LOCATION N 5435611.9 ;E 294739.3 | ORIGINATED BY EHS

DIST | HWY 11 | BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring | COMPILED BY MM

DATUM Geodetic | DATE April 19 to 21, 2009 | CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
255.0	GROUND SURFACE										
0.0	Clayey silt to silty clay, containing gravelly sand layers (FILL) Soft to stiff Grey to brown Moist		1	AS	-						
			2	SS	7		254				
			3	SS	7		253				
			4	SS	2		252				
	Gravelly sand layers 0.2 m thick at 3.2 m and 3.8 m depth.		5	SS	15						
251.0											
4.0	SILTY CLAY, varved Firm to stiff Grey to brown Moist to wet		6	SS	9		251				
			7	SS	5		250		42		
								+ 4			
			8	SS	WH		249				
							248	+ 4			
	Dark grey clay laminae 5 mm to 20 mm thick. Light grey silt laminae 10 mm to 50 mm thick.		9	TO	PH	▽	247		57 / 44.2	20.0	
246.5								+ >96			
8.5	SILT to Silty SAND, some gravel, trace to some clay Loose to compact Grey Wet		10	SS	9		246				0 8 80 12
			11	SS	7		245				
			12	SS	7		244				
	Switched to NW Casing at 13.4 m depth.						243				
241.6							242				
13.4	SAND and GRAVEL, trace to some silt, containing cobbles and boulders Very dense Grey Wet Contains silty sand above 14.1 m depth		13	SS	28		241				13 62 22 3

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No FR- 5

2 OF 2 **METRIC**

PROJECT 07-1191-0007 | W.P. 5541-05-01 | LOCATION N 5435611.9 ;E 294739.3 | ORIGINATED BY EHS
DIST | HWY 11 | BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring | COMPILED BY MM
DATUM Geodetic | DATE April 19 to 21, 2009 | CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- *CONTINUED FROM PREVIOUS PAGE* ---										
	SAND and GRAVEL, trace to some silt, containing cobbles and boulders Very dense Grey Wet		14	SS	23/0.08		239				
			15	SS	76/0.23		238				
							237				
			16	SS	60/0.15		236				
							235				
	Split spoon attempted at 21.0 m depth and recorded 50 blows for 0 m advance (Hammer Bouncing).						234				
229.5							233				
							232				
							231				
							230				
25.5	METASEDIMENT (BEDROCK) Bedrock cored from 25.5 m to 29.0 m depth. For coring details refer to Record of Drillhole FR- 5.		1	RC	REC 100%		229				RQD = 100%
			2	RC	REC 73%		228				RQD = 60%
			3	RC	REC 84%		227				RQD = 67%
226.0							226				
29.0	End of Borehole Note: 1. Water level at a depth of 7.6 m below ground surface (Elev. 247.4 m) upon completion of drilling.										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MIS-MTO 001 FREDERICK_HOUSE_0711910007_METRIC.GPJ GAL-MISS.GDT 20/1/10

PROJECT: 07-1191-0007

RECORD OF DRILLHOLE: FR- 5

SHEET 1 OF 1

LOCATION: N 5435611.9 ;E 294739.3

DRILLING DATE: April 19 to 21, 2009

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 45

DRILLING CONTRACTOR: Downing Drilling Ltd.

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.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	PENETRATION RATE min/(m)	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -'Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		Refer to Previous Page		229.50																		
	04/21/2009 NQ Coring	METASEDIMENT, containing occasional silt seams Fine grained Slightly weathered Strong Grey		25.50	1										J, FO, R							
26					2										J, FO, R							UCS = 89 MPa
		Sandy silt layer between 26.4 m and 26.8 m depth.													J, FO, R J, I, R							
27															J, FO, R							
															J, FO, R							
					3										J, FO, R							
28															J, FO, R							
															J, FO, R							
															J, I, R							
		Highly weathered and silt filled between 28.3 m and 28.6 m depth.													J, FO, R							
				226.00											J, FO, R							
29		End of Drillhole		29.00																		
30																						
31																						
32																						
33																						
34																						
35																						

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: EHS
CHECKED: AB

MIS-RCK 004 FREDERICK_HOUSE_0711910007_METRIC.GPJ GAL-MISS.GDT 20/1/10

RECORD OF BOREHOLE No FR- 6

 METRIC

PROJECT 07-1191-0007			
W.P. 5541-05-01	LOCATION N 5435607.6 ;E 294757.8		ORIGINATED BY EHS
DIST	HWY 11	BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring	COMPILED BY MM
DATUM Geodetic	DATE April 18, 2009		CHECKED BY AB

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
257.5	GROUND SURFACE
0.0	Gravelly sand, containing clayey silt to silty clay layers (FILL) Compact to dense Brown Moist Obstruction encountered at 2.3 m depth.
253.7 / 3.8	SILTY CLAY to CLAY, varved Firm to stiff Grey Moist to wet Dark grey clay laminae 5 mm to 10 mm thick. Light grey silty clay laminae 25 mm thick.
245.6 / 11.9	SILT, some clay, trace sand Loose Grey Wet

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS
1	AS	-	
2	SS	33	
3	SS	12	
4	SS	10/0.15	
5	SS	31	
6	SS	6	
7	SS	WH	
8	TO	PH	Unit weight 17.6 kN/m³
9	SS	WH	
10	SS	WH	
11	SS	2	
12	SS	9	GR 0, SA 4, SI 82, CL 14
13	SS	9	

Elevation scale: 257 to 243

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED — 20 40 60 80 100

Field vane results (sensitivity): approx. El. 251.9 – 5; El. 250.5 – 5; El. 249.0 – 3; El. 247.6 – 4; El. 245.8 – 5

PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L — WATER CONTENT (%): 10 20 30

Water content annotations: 65 / 47.6 (sample 6); 63 / 41 (sample 8)

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

PROJECT 07-1191-0007

RECORD OF BOREHOLE No FR- 6

2 OF 2 **METRIC**

W.P. 5541-05-01 LOCATION N 5435607.6 ;E 294757.8 ORIGINATED BY EHS

DIST HWY 11 BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring COMPILED BY MM

DATUM Geodetic DATE April 18, 2009 CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- *CONTINUED FROM PREVIOUS PAGE* ---										
242.3											
15.2	SAND and GRAVEL Compact Grey Wet		14	SS	14		242				
241.7											
15.8	End of Borehole										

Notes:

1. Obstruction encountered at 2.3 m depth. Moved borehole 2.5 m N.

2. Water level measured in piezometer at a depth of 11.4 m below ground surface (Elev. 246.1 m) on April 19, 2009.

3. Water level measured in piezometer at a depth of 13.9 m below ground surface (Elev. 243.6 m) on April 28, 2009 and at a depth of 11.9 m depth (Elev. 245.6 m) on July 31, 2009.

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No FR- 7

1 OF 1 **METRIC**

PROJECT 07-1191-0007 | W.P. 5541-05-01 | LOCATION N 5435627.1 ;E 294533.0 | ORIGINATED BY MR

DIST | HWY 11 | BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers | COMPILED BY MM

DATUM Geodetic | DATE April 27, 2009 | CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
252.0	GROUND SURFACE										
0.0 / 251.4	Organics, some sand (FILL) Brown Moist		1	AS	-						
0.6 / 250.6	Silty clay, trace sand, trace organics (FILL) Firm Brown		2	SS	7		251				
1.4	SILTY CLAY to CLAY, varved Soft to firm Grey Moist to wet		3	SS	5		250				
			4	SS	4				60 (47.2)		
			5	SS	4		249				
			6	SS	2		248				
			7	SS	3		247	4, 3			
	Less than 5 mm thick silt to clayey silt varves.		8	TO	PH		246			17.9	
244.4							245	3			
7.6	SILT, some sand, trace to some clay Loose to compact Grey Wet		9	SS	7	▽	244				
			10	SS	16		243				0 14 78 8
			11	SS	12		242				
			12	SS	12		241				
239.2							240				
12.8	End of Borehole										

Note:

1. Water level at a depth of 8.3 m below ground surface (Elev. 243.7 m) upon completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No FR- 8

1 OF 2 **METRIC**

PROJECT 07-1191-0007
W.P. 5541-05-01
DIST HWY 11
DATUM Geodetic
LOCATION N 5435599.3 ;E 294545.4
BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers
DATE April 28, 2009
ORIGINATED BY MR
COMPILED BY MM
CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS
258.5	GROUND SURFACE					
0.0	Sand and gravel (FILL) Brown Moist		1	AS	-	
257.9						
0.6	Clayey silt, trace sand (FILL) Firm to very stiff Grey to brown Moist		2	SS	10	
			3	SS	19	
			4	SS	12	
			5	SS	10	
			6	SS	12	
			7	SS	8	
			8	SS	16	
250.9						
7.6	SILTY CLAY to CLAY, varved Firm to stiff Grey Wet		9	SS	4	
			10	TO	PH	
			11	SS	WH	
			12	SS	WH	
			13	SS	1	

ELEVATION SCALE: 258, 257, 256, 255, 254, 253, 252, 251, 250, 249, 248, 247, 246, 245, 244

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × REMOULDED
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30

UNIT WEIGHT γ kN/m^3

REMARKS & GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No FR- 8

2 OF 2 **METRIC**

PROJECT 07-1191-0007 | W.P. 5541-05-01 | DIST | HWY 11 | DATUM Geodetic

LOCATION N 5435599.3 ;E 294545.4 | BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers | DATE April 28, 2009

ORIGINATED BY MR | COMPILED BY MM | CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
243.3	--- *CONTINUED FROM PREVIOUS PAGE* ---										
15.2	SILT, some clay, some sand Loose to compact Grey Wet		14	SS	6	▽	243				
			15	SS	12		242		○		0 10 77 13
							241				
239.6			16	SS	26		240				
18.9	End of Borehole Note: 1. Water level at a depth of 15.9 m below ground surface (Elev. 242.6 m) upon completion of drilling.										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No FR- 9

1 OF 1 **METRIC**

PROJECT 07-1191-0007 | W.P. 5541-05-01 | LOCATION N 5435641.9 ;E 294587.4 | ORIGINATED BY ID
DIST | HWY 11 | BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers | COMPILED BY DA
DATUM Geodetic | DATE July 30, 2009 | CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
245.2	GROUND SURFACE										
0.0 / 244.7	TOPSOIL		1	SS	6		245				
0.5 / 243.4	SAND, trace gravel Loose Brown Wet		2	SS	7		244				
			3	SS	8						
1.8 / 241.1	SILTY CLAY to CLAYEY SILT, varved Soft to stiff Grey Wet		4	SS	6		243				
			5	SS	3		242	+ 4			
4.1 / 238.5	SILT to Sandy SILT Loose Grey Wet		6	SS	8		241				
			7	SS	9		240				
6.7	End of Borehole						239				

Notes:

1. Harder augering below 4.1 m depth.

2. Water level at a depth of 1.5 m (Elev. 243.7 m) upon completion of drilling

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

Golder Associates

RECORD OF BOREHOLE No FR- 10

1 OF 1 **METRIC**

PROJECT 07-1191-0007
W.P. 5541-05-01
DIST HWY 11
DATUM Geodetic
LOCATION N 5435641.5 ;E 294567.5
BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers
DATE July 31, 2009
ORIGINATED BY ID
COMPILED BY DA
CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
246.9	GROUND SURFACE										
0.0	TOPSOIL										
0.2	Silty SAND with clay pockets Loose Brown Wet		1	SS	4		246				
245.4											
1.5	SILTY CLAY to CLAYEY SILT, trace sand, trace gravel Stiff Grey Wet		2	SS	11		245				
			3	SS	14		244				
			4	SS	15						
						▽	243				
242.0			5	SS	10		242				
4.9	SILT, trace sand Compact Grey Wet										
							241				
240.2			6	SS	19						
6.7	End of Borehole Note: 1. Water level at a depth of 4.4 m (Elev. 242.5 m) and rising, upon completion of drilling.										

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

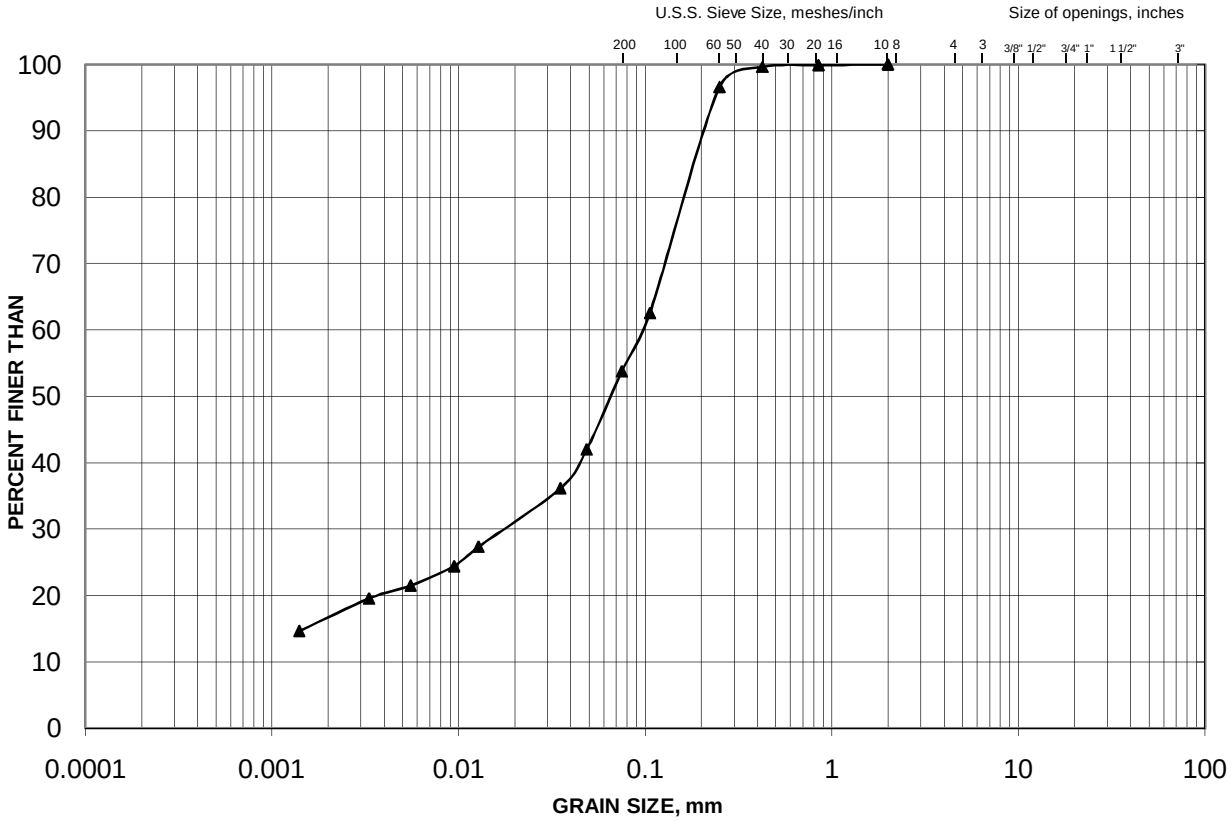
APPENDIX B

LABORATORY TEST RESULTS

GRAIN SIZE DISTRIBUTION

Alluvium

FIGURE B-1



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
—▲—	FR-3	2	243.4

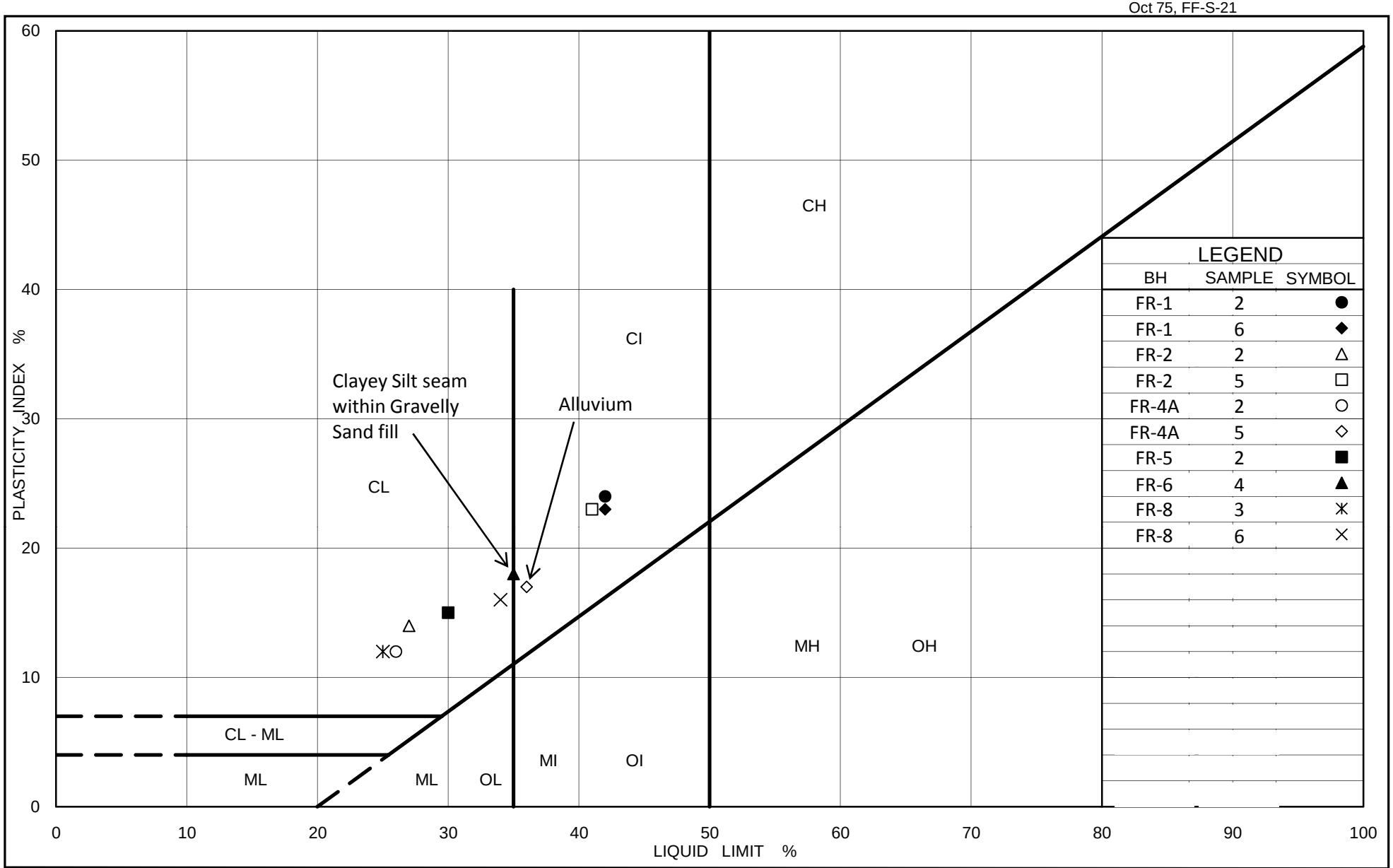
Project Number: 07-1191-0007-FR

Checked By: SEMC

Golder Associates

Date: January 2010

Oct 75, FF-S-21



Ministry of Transportation

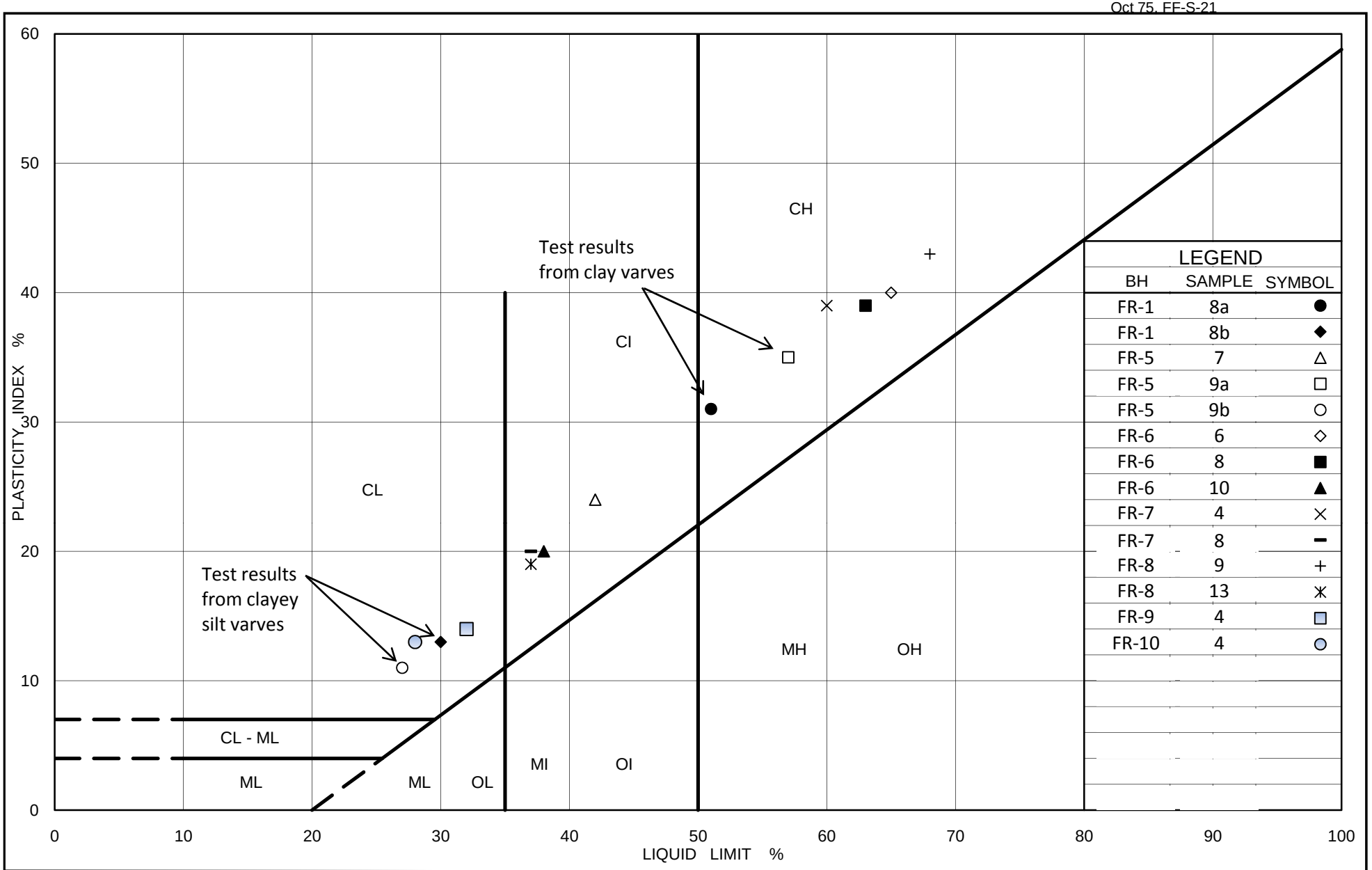
Ontario

PLASTICITY CHART
Clayey Silt to Silty Clay (Fill/Alluvium)

FIG No. B-2

Project No. 07-1191-0007-FR

Checked By: SEMC



Ministry of Transportation

Ontario

PLASTICITY CHART
Silty Clay to Clay

FIG No. B-3

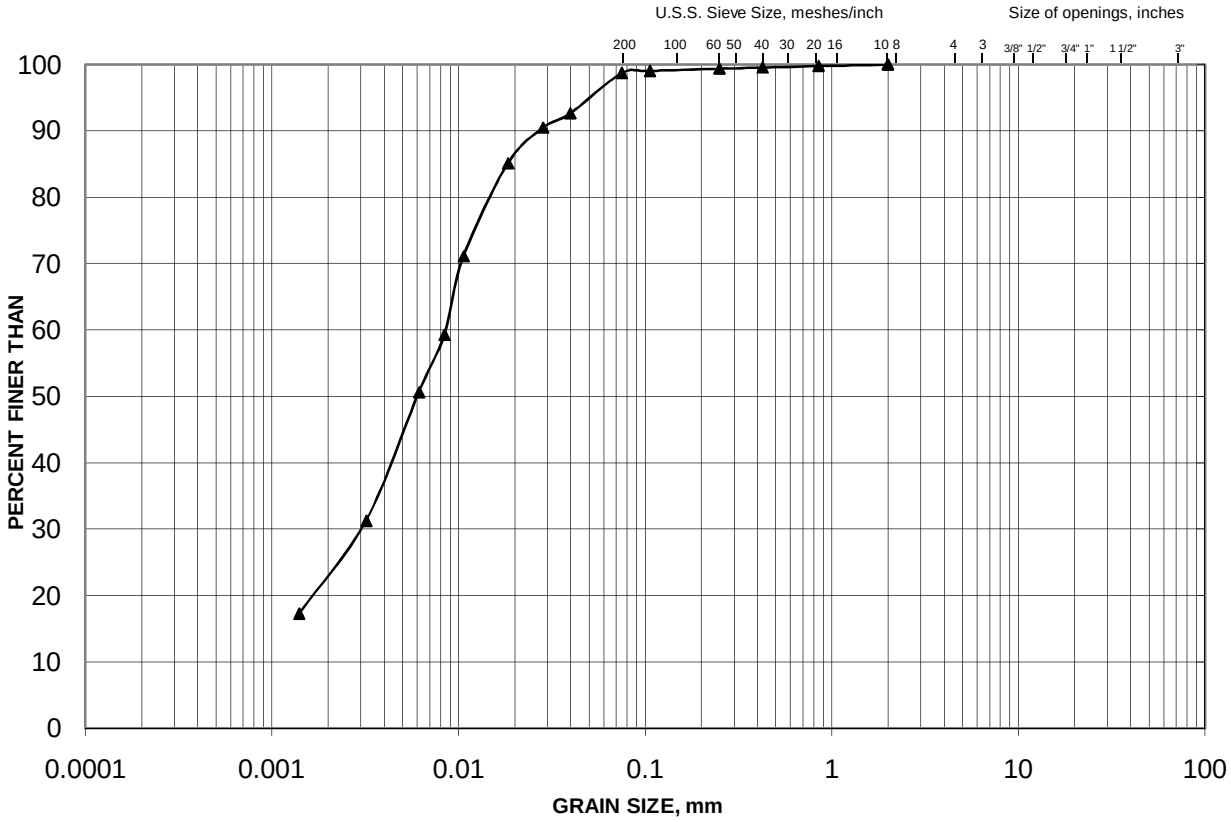
Project No. 07-1191-0007-FR

Checked By: SEMC

GRAIN SIZE DISTRIBUTION

Clayey Silt

FIGURE B-4



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
—▲—	FR-1	8	243.5

Project Number: 07-1191-0007-FR

Checked By: SEMC

Golder Associates

Date: January 2010

OEDOMETER CONSOLIDATION SUMMARY

FIGURE B-5

SAMPLE IDENTIFICATION

Project Number	07-1191-0007-FR	Borehole, Sample	FR-5, 9
		Sample Depth, (m)	7.9

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	1		
Date Started	April 29/09		
Date Completed	May 14/09		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.538	Unit Weight, kN/m^3	20.0
Sample Diameter, cm	6.342	Dry Unit Weight, kN/m^3	15.5
Area, cm^2	31.59	Specific Gravity, assumed	2.7
Volume, cm^3	80.17	Solids Height, cm	1.486
Water Content, %	28.9	Volume of Solids, cm^3	46.96
Wet Mass, g	163.48	Volume of Voids, cm^3	33.22
Dry Mass, g	126.78	Degree of Saturation, %	110.5

TEST COMPUTATIONS

Pressure	Primary Consolidation	Corr. Height	Void	Average Height	t_{50}	cv.	m_v	k
kPa	mm	cm	Ratio	cm	s	cm^2/s	m^2/MN	cm/s
0.0	0	2.538	0.707	2.538				
8.9	0.10	2.528	0.701	2.533	180	0.00699	0.437	2.992E-07
17.9	0.10	2.518	0.694	2.523	400	0.00312	0.452	1.382E-07
35.1	0.16	2.502	0.683	2.510	300	0.00412	0.376	1.519E-07
69.2	0.18	2.483	0.671	2.493	400	0.00304	0.213	6.374E-08
142.6	0.24	2.460	0.655	2.472	250	0.00479	0.129	6.078E-08
284.9	0.35	2.425	0.631	2.442	230	0.00508	0.100	4.986E-08
570.5	0.50	2.375	0.598	2.400	250	0.00452	0.071	3.167E-08
1139.6	0.61	2.314	0.557	2.345	140	0.00770	0.045	3.407E-08
2300.0	0.54	2.260	0.521	2.287	80	0.01282	0.020	2.529E-08
1139.6	-0.08	2.268	0.526	2.264				
284.9	-0.22	2.290	0.541	2.279				
69.2	-0.29	2.319	0.560	2.305				
17.9	-0.29	2.348	0.580	2.334				
8.9	-0.12	2.360	0.587	2.354				

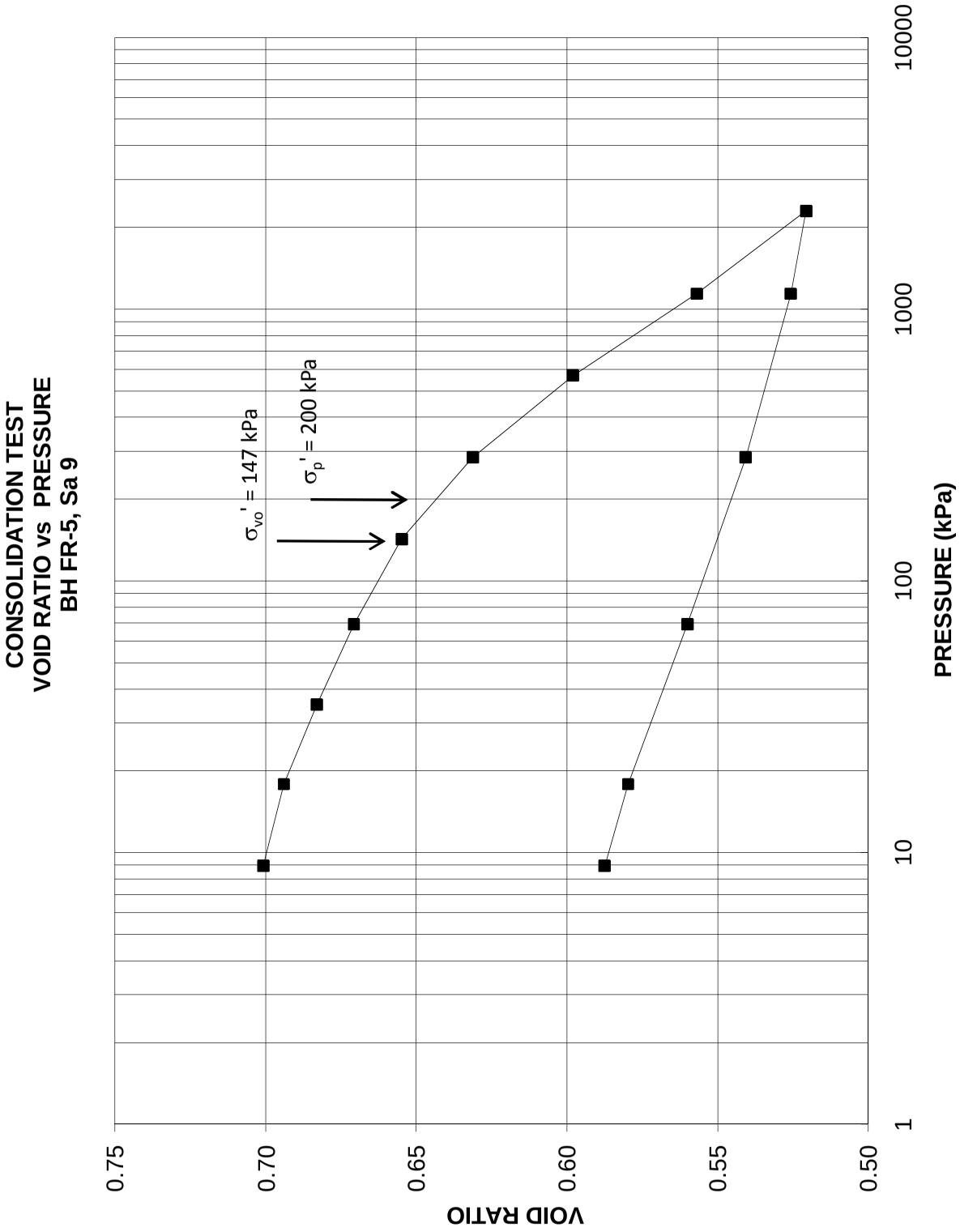
Notes:
k calculated using cv based on t_{50} values.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	2.360	Unit Weight, kN/m^3	20.6
Sample Diameter, cm	6.342	Dry Unit Weight, kN/m^3	16.7
Area, cm^2	31.59	Specific Gravity, assumed	2.7
Volume, cm^3	74.54	Solids Height, cm	1.486
Water Content, %	23.8	Volume of Solids, cm^3	46.96
Wet Mass, g	156.90	Volume of Voids, cm^3	27.59
Dry Mass, g	126.78	Degree of Saturation, %	110.7

PRIMARY CONSOLIDATION TEST
VOID RATIO VS. LOG PRESSURE

FIGURE B-5
Page 2 of 4



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Checked by: AB

Project No. 07-1191-0007-FR

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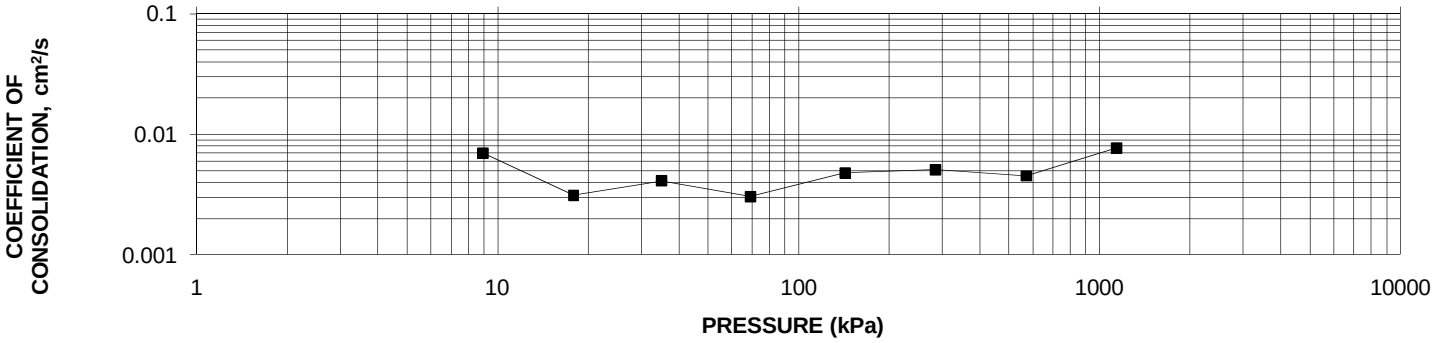
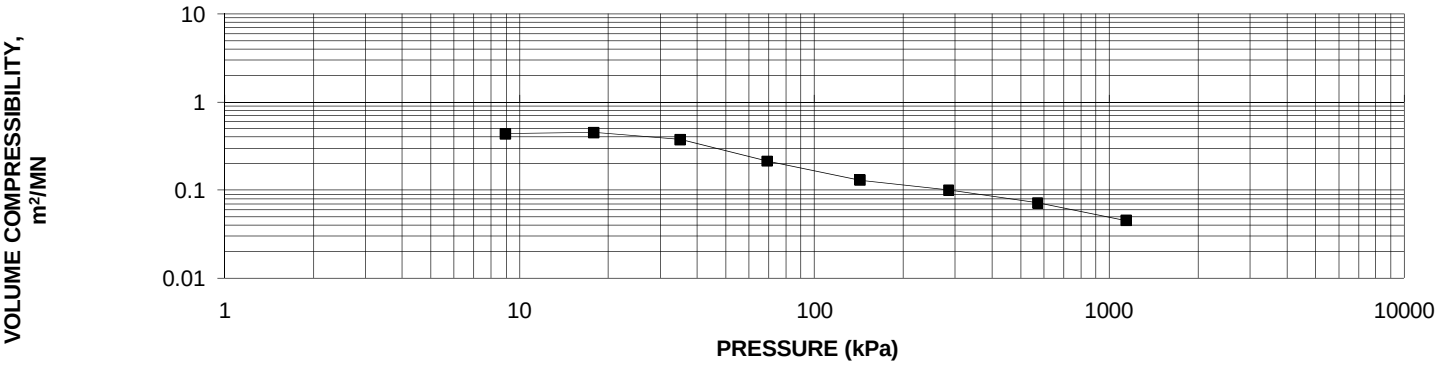
OEDOMETER CONSOLIDATION SUMMARY

FIGURE B-5

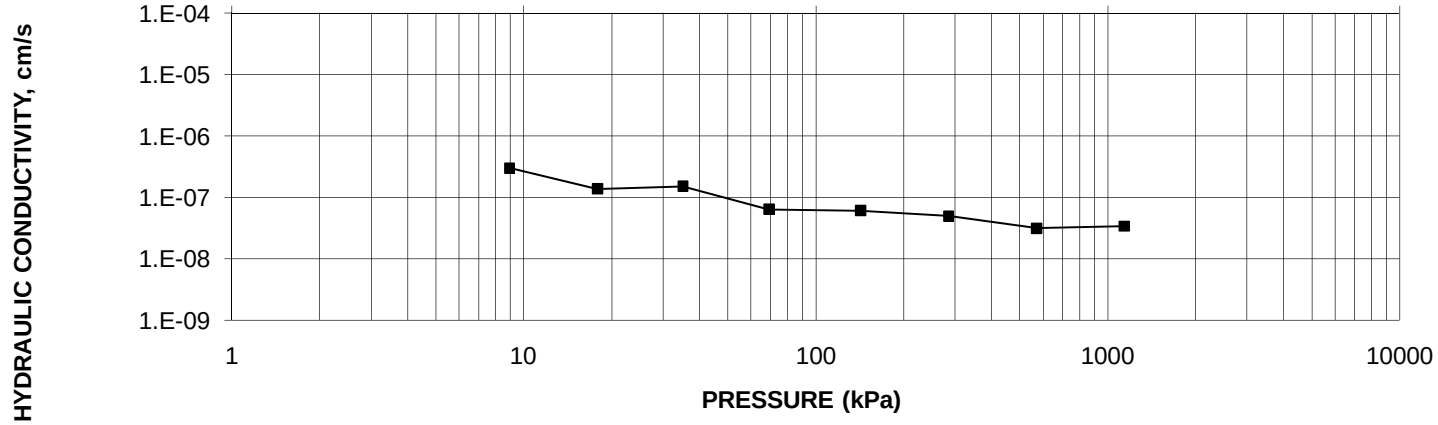
CONSOLIDATION TEST
CV cm²/s VS PRESSURE (kPa)
BH FR-5, Sa 9



CONSOLIDATION TEST
MV m²/MN vs PRESSURE (kPa)
BH FR-5, Sa 9

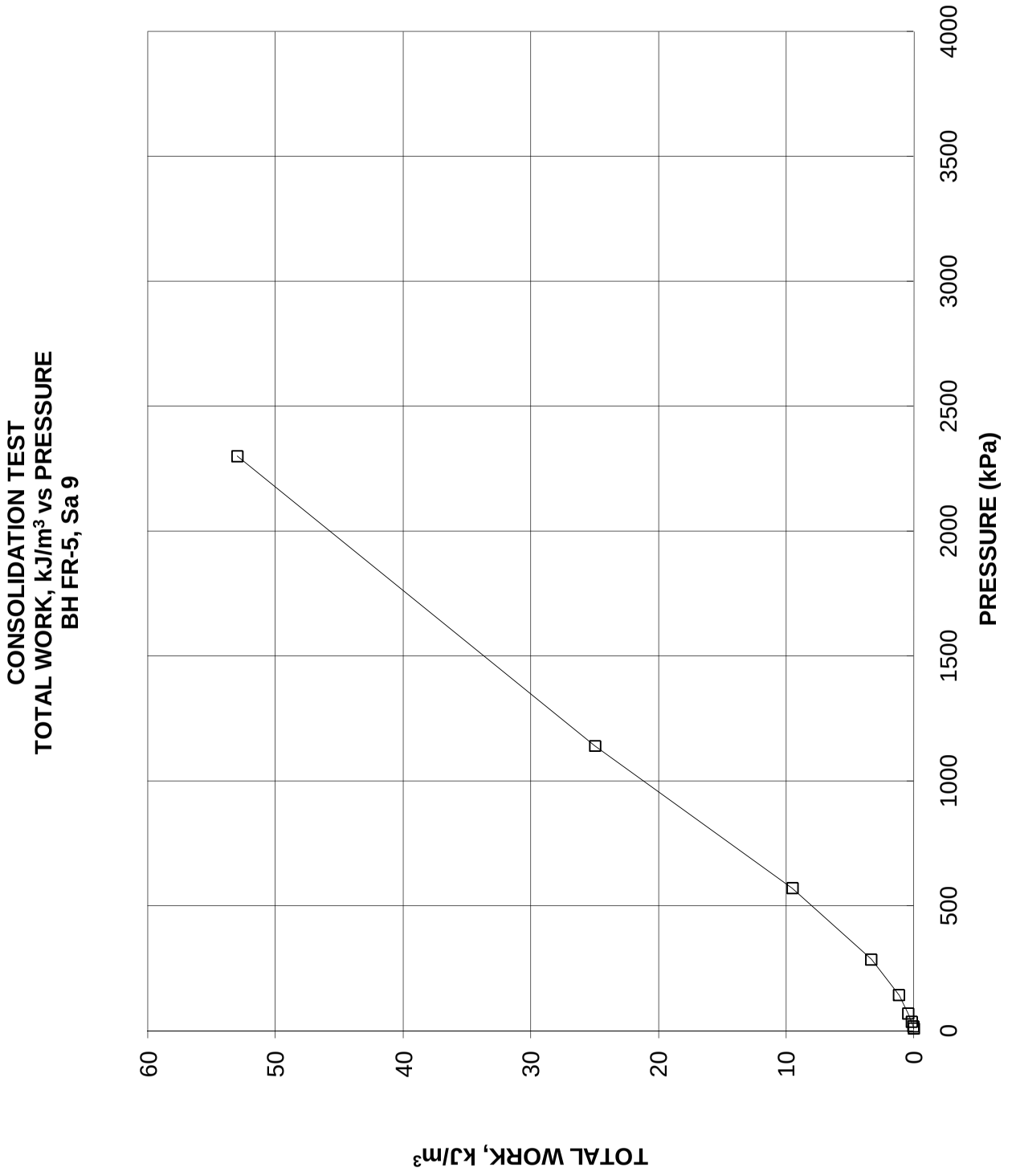


CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs PRESSURE
BH FR-5, Sa 9



PRIMARY CONSOLIDATION TEST
TOTAL WORK VS. PRESSURE

FIGURE B-5
Page 4 of 4



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Checked by: AB

Project No. 07-1191-0007-FR

OEDOMETER CONSOLIDATION SUMMARY

FIGURE B-6

SAMPLE IDENTIFICATION

Project Number	07-1191-0007-FR	Borehole, Sample	FR-6, 8
		Sample Depth, (m)	6.4

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	1		
Date Started	June 1/09		
Date Completed	June 15/09		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.538	Unit Weight, kN/m^3	17.6
Sample Diameter, cm	6.342	Dry Unit Weight, kN/m^3	12.8
Area, cm^2	31.59	Specific Gravity, assumed	2.7
Volume, cm^3	80.17	Solids Height, cm	1.226
Water Content, %	37.3	Volume of Solids, cm^3	38.72
Wet Mass, g	143.54	Volume of Voids, cm^3	41.46
Dry Mass, g	104.54	Degree of Saturation, %	94.1

TEST COMPUTATIONS

Pressure	Primary Consolidation	Corr. Height	Void	Average Height	t_{50}	cv.	m_v	k
kPa	mm	cm	Ratio	cm	s	cm^2/s	m^2/MN	cm/s
0.0	0	2.538	1.071	2.538				
8.9	0.07	2.531	1.065	2.535	210	0.00600	0.300	1.764E-07
17.9	0.10	2.522	1.057	2.526	270	0.00463	0.429	1.950E-07
35.1	0.16	2.506	1.045	2.514	280	0.00442	0.360	1.560E-07
69.2	0.23	2.483	1.026	2.495	320	0.00381	0.263	9.851E-08
142.6	0.30	2.454	1.002	2.469	300	0.00398	0.163	6.379E-08
284.9	0.61	2.393	0.952	2.423	500	0.00230	0.175	3.945E-08
570.5	1.95	2.198	0.793	2.295	1400	0.00074	0.285	2.065E-08
1139.6	1.55	2.043	0.667	2.120	650	0.00136	0.124	1.648E-08
2300.0	1.16	1.927	0.572	1.985	400	0.00193	0.049	9.266E-09
570.5	-0.39	1.965	0.603	1.946				
142.6	-0.63	2.028	0.655	1.997				
35.1	-0.62	2.090	0.705	2.059				
8.9	-0.60	2.151	0.755	2.120				

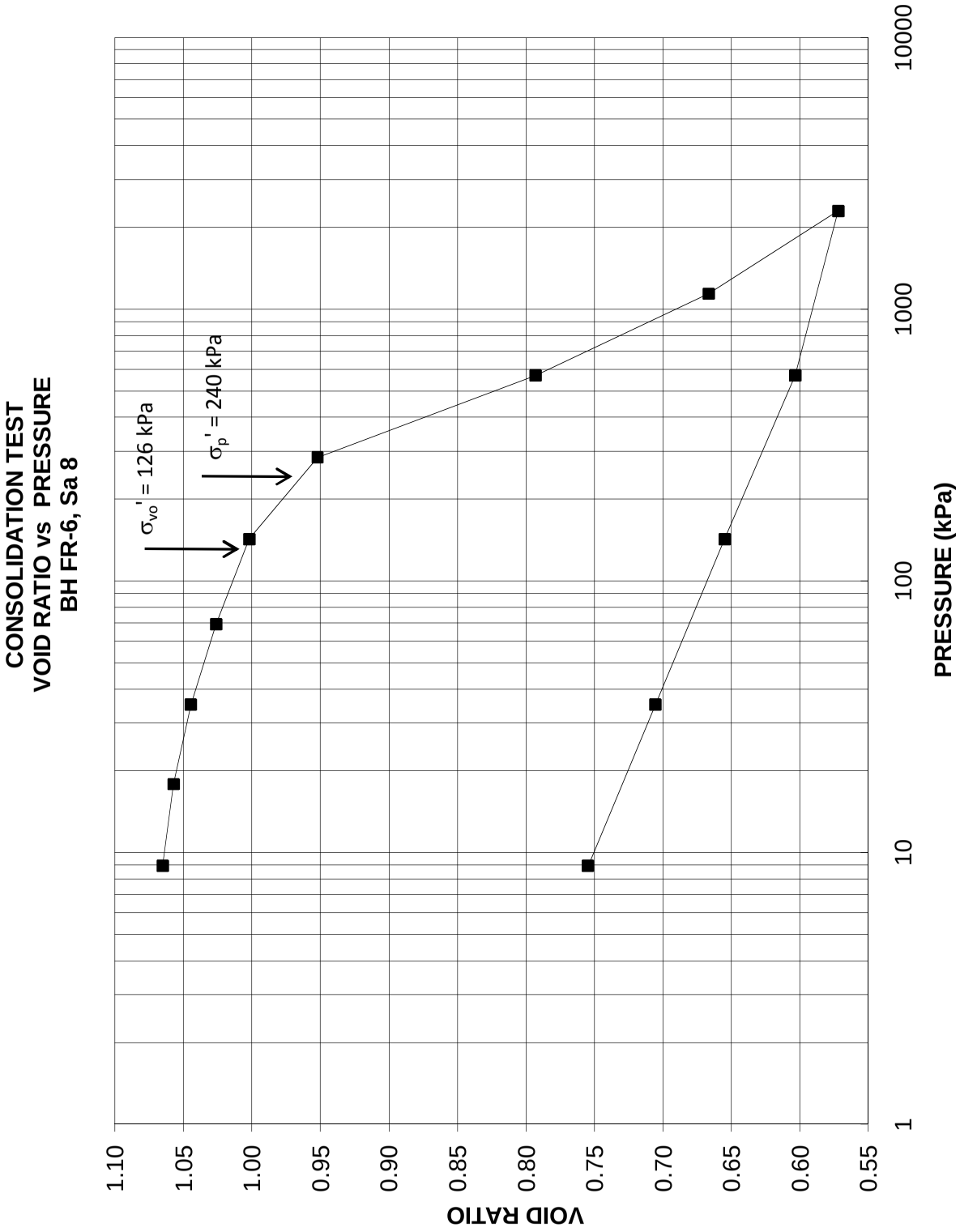
Notes:
k calculated using cv based on t_{50} values.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	2.151	Unit Weight, kN/m^3	18.6
Sample Diameter, cm	6.342	Dry Unit Weight, kN/m^3	15.1
Area, cm^2	31.59	Specific Gravity, assumed	2.7
Volume, cm^3	67.94	Solids Height, cm	1.226
Water Content, %	23.3	Volume of Solids, cm^3	38.72
Wet Mass, g	128.90	Volume of Voids, cm^3	29.22
Dry Mass, g	104.54	Degree of Saturation, %	83.4

PRIMARY CONSOLIDATION TEST
VOID RATIO VS. LOG PRESSURE

FIGURE B-6
Page 2 of 4



Prepared by: SL
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Project No. 07-1191-0007-FR

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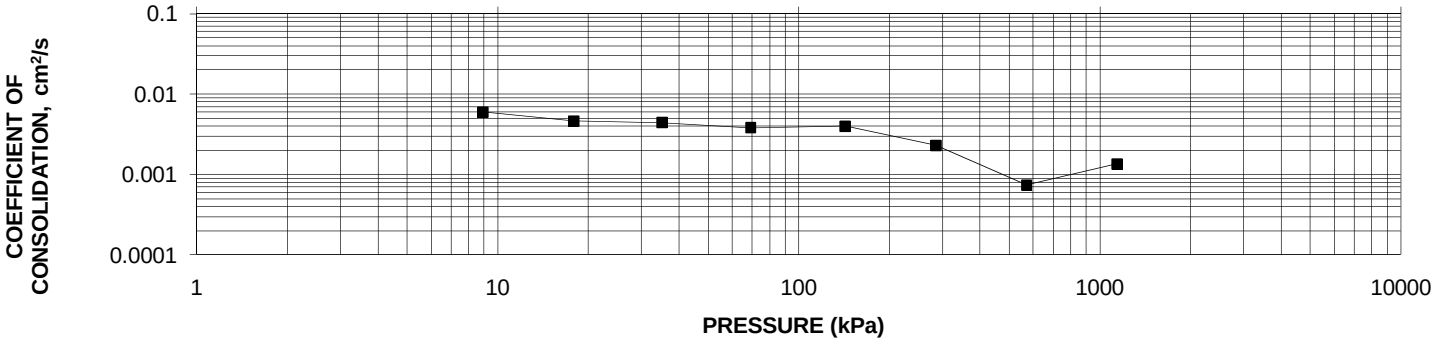
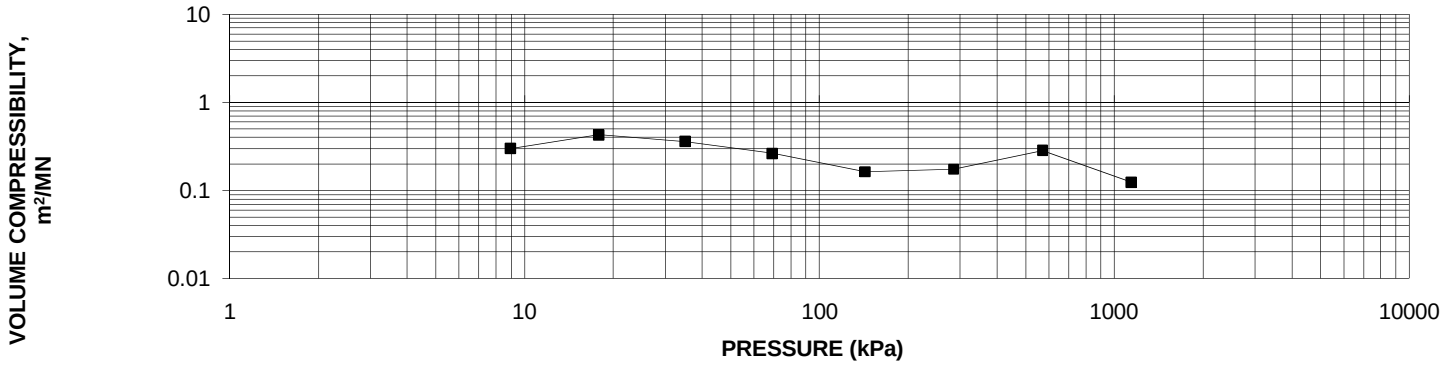
OEDOMETER CONSOLIDATION SUMMARY

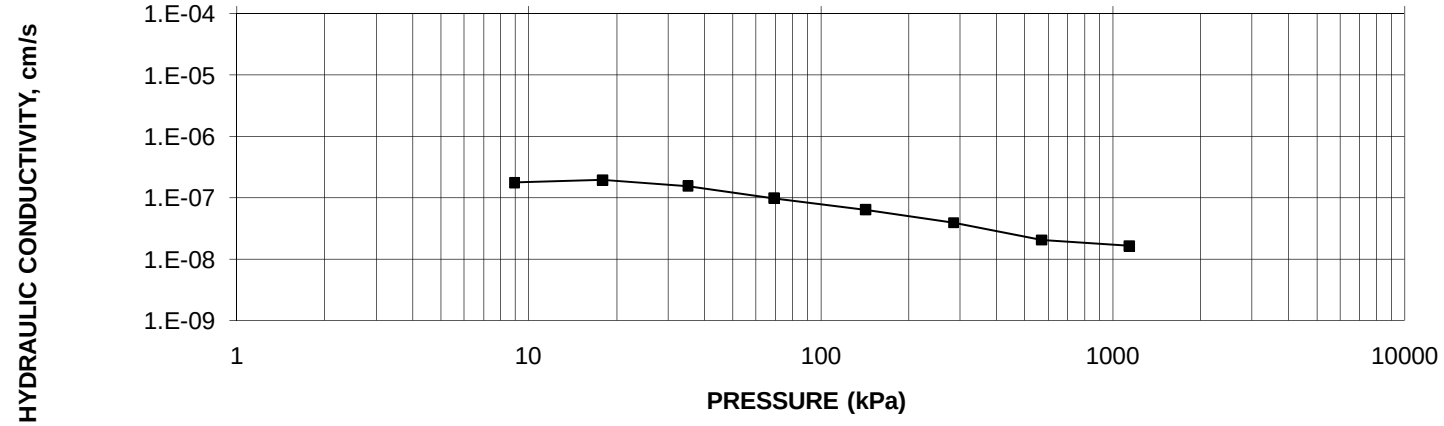
CONSOLIDATION TEST
CV cm²/s VS PRESSURE (kPa)
BH FR-6, Sa 8



CONSOLIDATION TEST
MV m²/MN vs PRESSURE (kPa)
BH FR-6, Sa 8

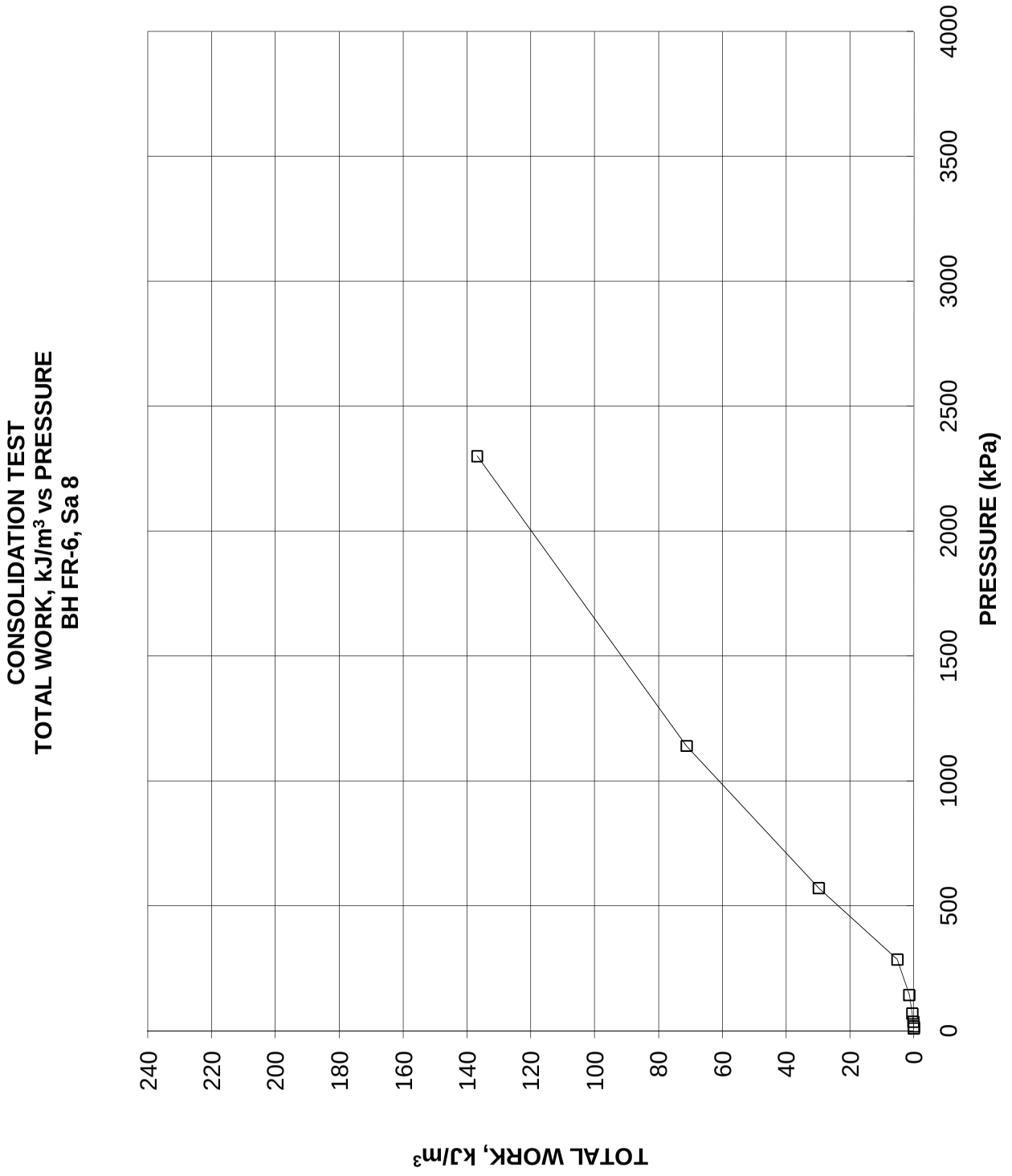


CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs PRESSURE
BH FR-6, Sa 8



PRIMARY CONSOLIDATION TEST
TOTAL WORK VS. PRESSURE

FIGURE B-6
Page 4 of 4



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Project No. 07-1191-0007-FR

OEDOMETER CONSOLIDATION SUMMARY

FIGURE B-7

SAMPLE IDENTIFICATION

Project Number	07-1191-0007-FR	Borehole, Sample	FR-7, 8
		Sample Depth, (m)	6.3

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	1		
Date Started	May 14/09		
Date Completed	May 28/09		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.538	Unit Weight, kN/m^3	17.9
Sample Diameter, cm	6.342	Dry Unit Weight, kN/m^3	12.3
Area, cm^2	31.59	Specific Gravity, assumed	2.7
Volume, cm^3	80.17	Solids Height, cm	1.181
Water Content, %	45.4	Volume of Solids, cm^3	37.29
Wet Mass, g	146.43	Volume of Voids, cm^3	42.88
Dry Mass, g	100.69	Degree of Saturation, %	106.7

TEST COMPUTATIONS

Pressure	Primary Consolidation	Corr. Height	Void	Average Height	t_{50}	cv.	m_v	k
kPa	mm	cm	Ratio	cm	s	cm^2/s	m^2/MN	cm/s
0.0	0.00	2.538	1.150	2.538				
8.9	0.06	2.532	1.145	2.535	180	0.00700	0.256	1.756E-07
17.9	0.06	2.526	1.140	2.529	220	0.00570	0.265	1.483E-07
35.1	0.11	2.516	1.131	2.521	200	0.00623	0.244	1.490E-07
69.2	0.14	2.502	1.119	2.509	220	0.00561	0.159	8.725E-08
142.6	0.20	2.482	1.103	2.492	180	0.00676	0.108	7.147E-08
284.9	0.31	2.451	1.076	2.467	190	0.00628	0.088	5.404E-08
570.5	0.77	2.374	1.011	2.413	400	0.00285	0.110	3.078E-08
1139.6	1.80	2.194	0.859	2.284	750	0.00136	0.133	1.782E-08
2300.0	1.20	2.074	0.757	2.134	320	0.00279	0.047	1.290E-08
570.5	-0.40	2.114	0.791	2.094				
142.6	-0.64	2.178	0.845	2.146				
35.1	-0.68	2.245	0.902	2.212				
8.9	-0.59	2.304	0.952	2.275				

Notes:
k calculated using cv based on t_{50} values.

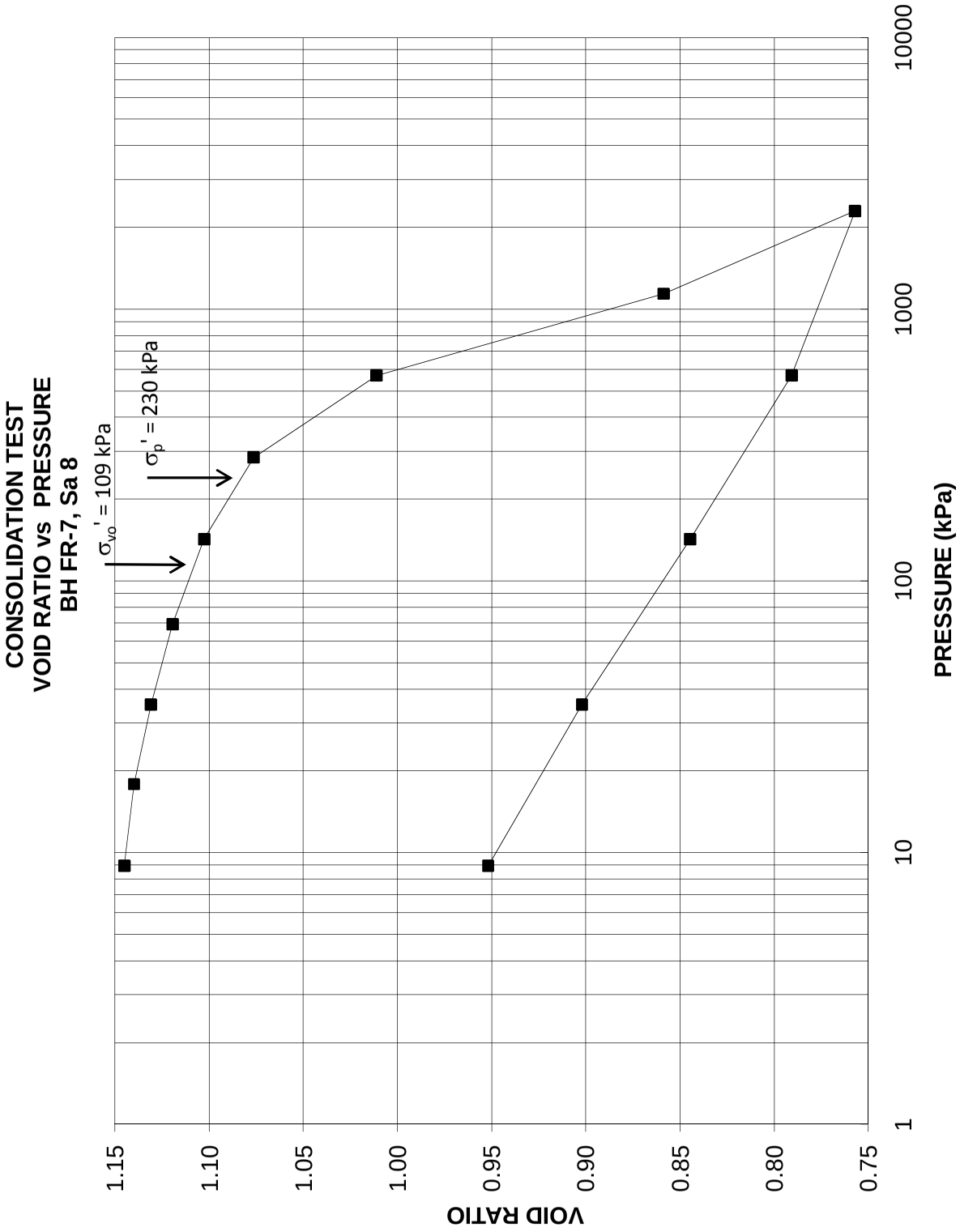
SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	2.304	Unit Weight, kN/m^3	18.7
Sample Diameter, cm	6.342	Dry Unit Weight, kN/m^3	13.6
Area, cm^2	31.59	Specific Gravity, assumed	2.7
Volume, cm^3	72.79	Solids Height, cm	1.181
Water Content, %	37.5	Volume of Solids, cm^3	37.29
Wet Mass, g	138.41	Volume of Voids, cm^3	35.50
Dry Mass, g	100.69	Degree of Saturation, %	106.3

Prepared By: SL **Golder Associates** **Checked By: AB**

PRIMARY CONSOLIDATION TEST
VOID RATIO VS. LOG PRESSURE

FIGURE B-7
Page 2 of 4



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Project No. 07-1191-0007-FR

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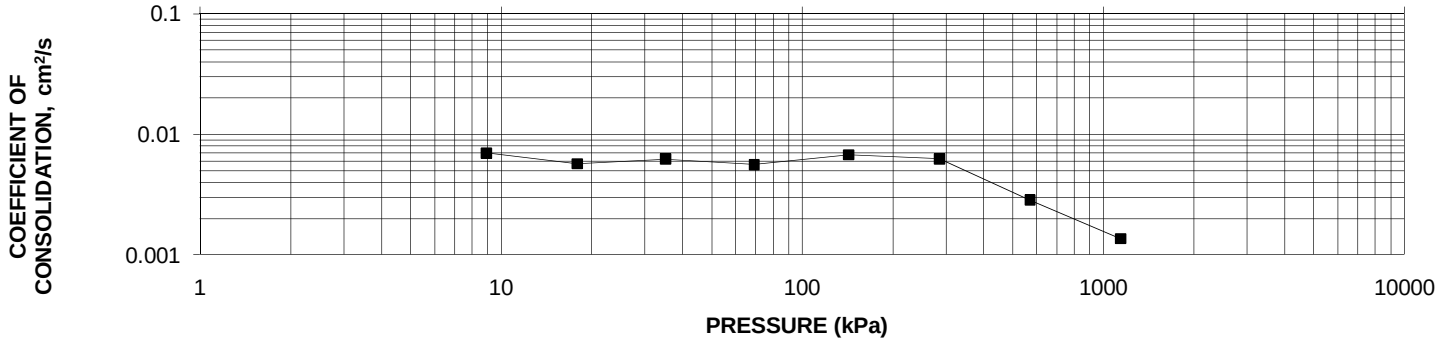
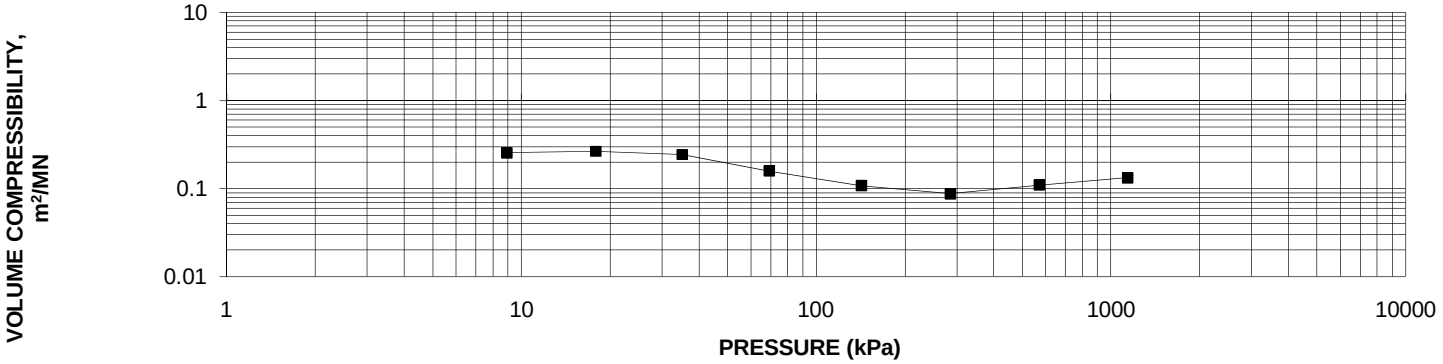
OEDOMETER CONSOLIDATION SUMMARY

FIGURE B-7

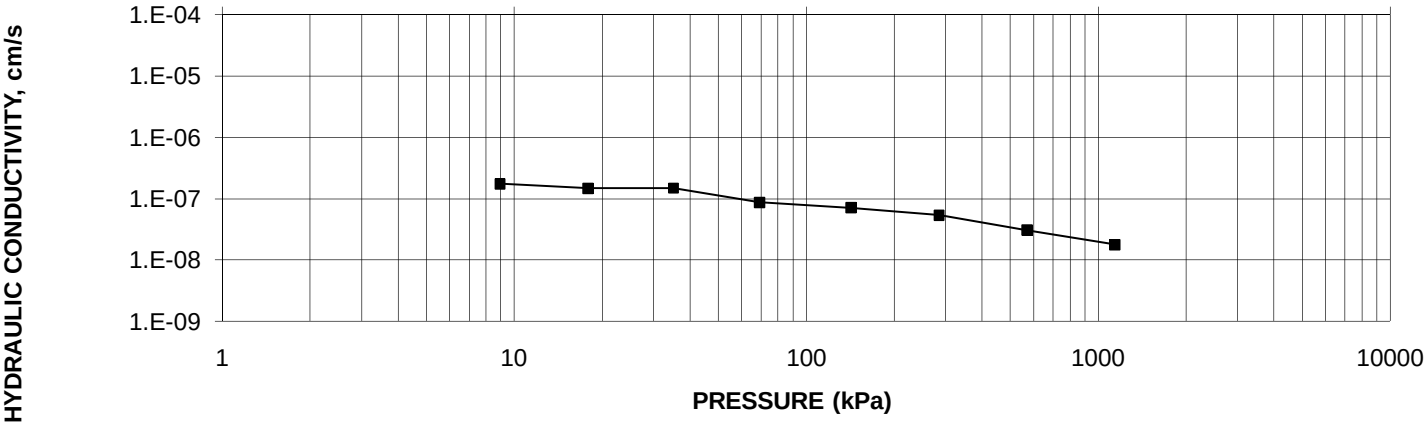
CONSOLIDATION TEST
CV cm²/s VS PRESSURE (kPa)
BH FR-7, Sa 8



CONSOLIDATION TEST
MV m²/MN vs PRESSURE (kPa)
BH FR-7, Sa 8



CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs PRESSURE
BH FR-7, Sa 8



Project No. 07-1191-0007-FR

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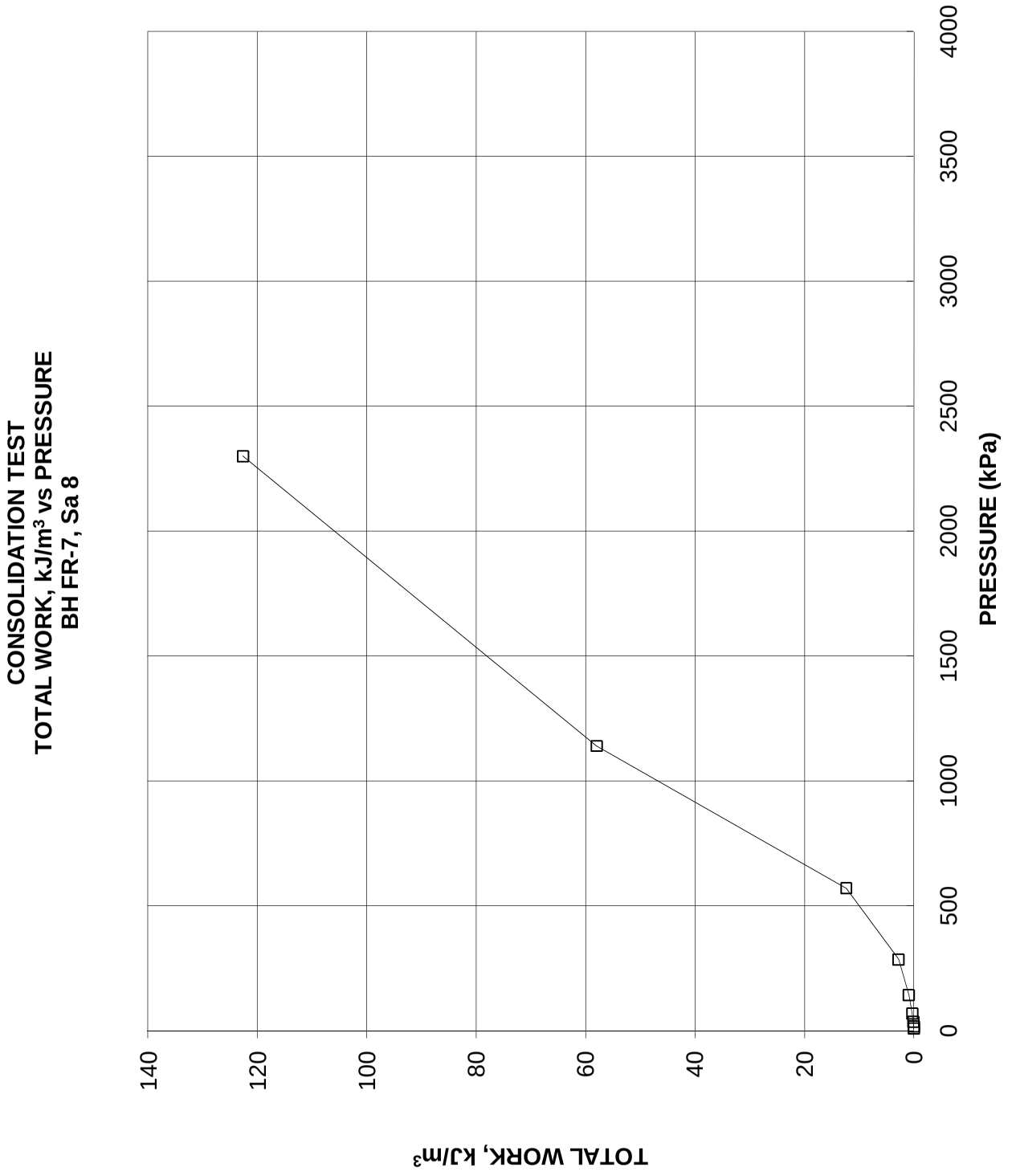
PRIMARY CONSOLIDATION TEST
TOTAL WORK VS. PRESSURE

FIGURE B-7
Page 4 of 4



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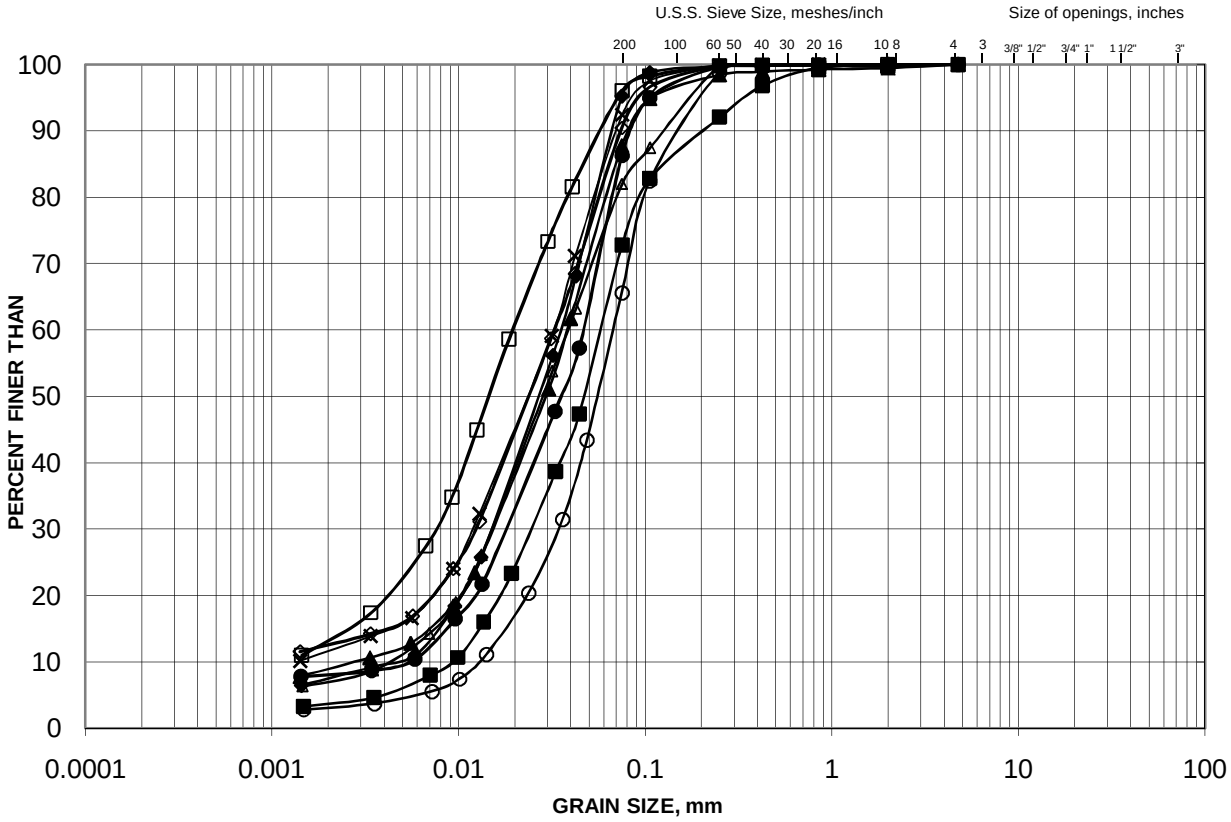
GRAIN SIZE DISTRIBUTION

Silt to 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)
	FR-1	9	241.9
	FR-2	7	242.9
	FR-2	11	236.8
	FR-3	6	240.4
	FR-3	10	235.1
	FR-5	10	245.6
	FR-6	12	245.0
	FR-7	10	242.6
	FR-8	15	241.4

Project Number: 07-1191-0007-FR

Checked By: SEMC

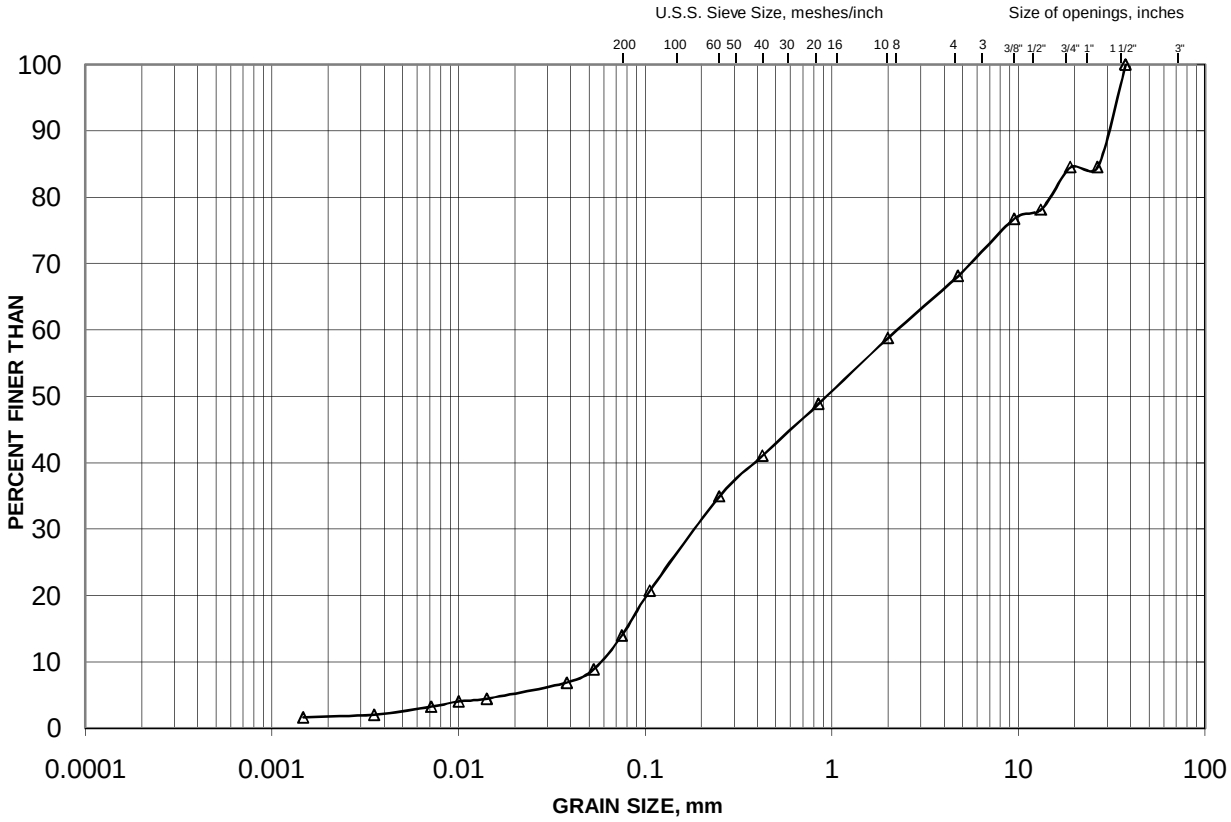
Golder Associates

Date: January 2010

GRAIN SIZE DISTRIBUTION

Sand and Gravel Interlayers

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)
—△—	FR-3	7	239.6

Project Number: 07-1191-0007-FR

Checked By: SEMC

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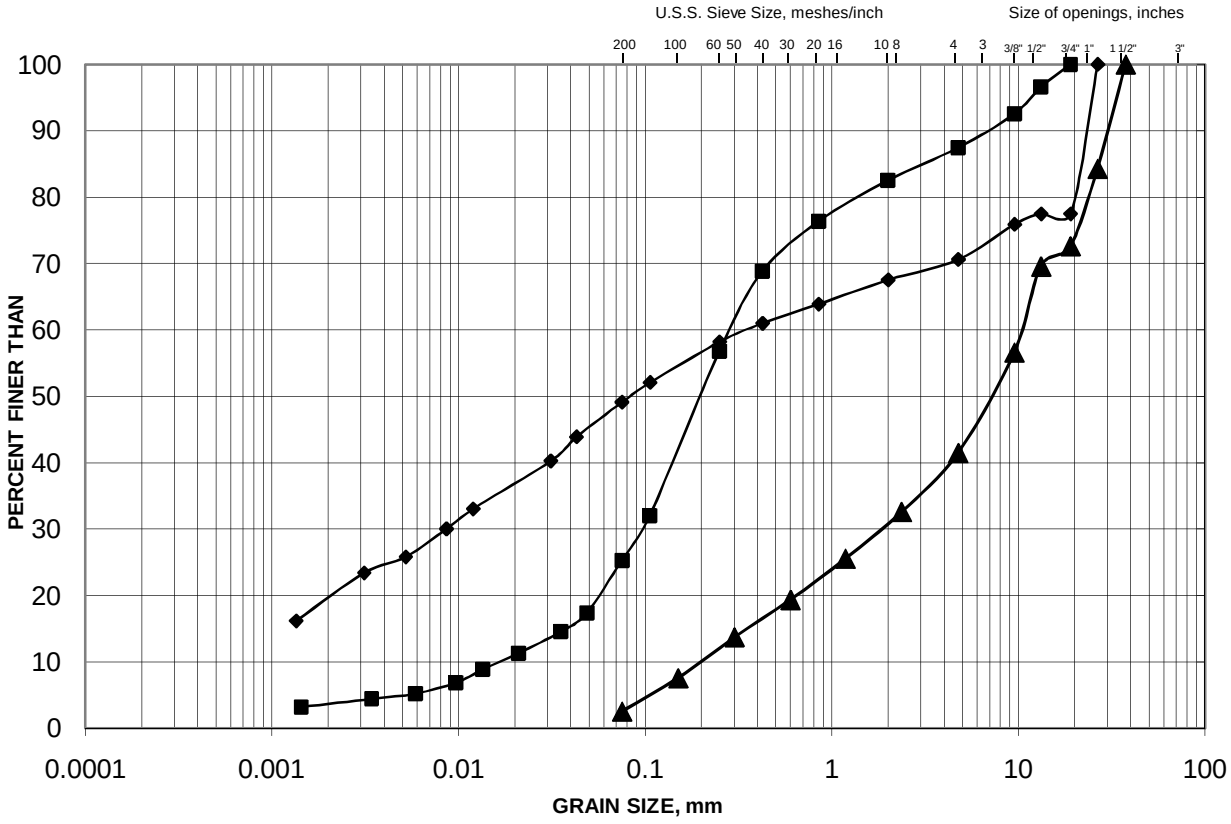
Date: January 2010

GRAIN SIZE DISTRIBUTION
Sand to Sand and Gravel

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)
◆	FR-4	5	240.0
■	FR-4A	10	236.5
▲	FR-5	13	241.3

Project Number: 07-1191-0007-FR

Checked By: SEMC

Golder Associates

Date: January 2010

TABLE B-1
UNIAXIAL COMPRESSIVE STRENGTH TEST RESULTS
HIGHWAY 11, FREDERICK HOUSE RIVER BRIDGE
GWP 5541-05-00, SITE 39E-045

Borehole Number	Sample Depth (m)	Sample Elevation (m)	Rock Type	Core Diameter (mm)	Uniaxial Compressive Strength (MPa)
FR-2	19.1	228.7	Metasediment	47.4	142
FR-3	14.4	230.5	Metasediment	47.7	175
FR-4A	19.5	229.5	Metasediment	47.4	99
FR-5	26.3	228.7	Metasediment	47.6	89

Compiled by: EC
Reviewed By: SEMC

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Europe	+ 356 21 42 30 20
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solutions@golder.com
www.golder.com

Golder Associates Ltd.
1010 Lorne Street
Sudbury, Ontario, P3C 4R9
Canada
T: +1 (705) 524 6861

Golder Associates