



December 14, 2009

FOUNDATION INVESTIGATION REPORT

**North Wicklow River Bridge Replacement
Highway 11, Site No. 39E-063
Township of Hanna, Ontario
Ministry of Transportation, Ontario
GWP 5055-06-00**

Submitted to:
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REPORT

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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 replacement of the structure carrying Highway 11 over North Wicklow River in the Township of Hanna, south of Cochrane, Ontario.

The purpose of this investigation is to establish the subsurface conditions at the proposed replacement structure 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 the surveying company retained by LEA. The location of the investigated area is shown in plan on the Contract Drawing.

2.0 SITE DESCRIPTION

The site is situated in the Township of Hanna on Highway 11 crossing North Wicklow River, approximately 10 km south of Highway 652 near Cochrane, Ontario. The crossing is located within the North Wicklow River valley, which is about 100 m wide at the existing/proposed crossing with the existing road grade about 6 m to 7 m above the river water level. The river valley is vegetated with grass and small shrubs and the surrounding area is generally grass and tree covered. The river is shallow and mainly used for recreation and is about 10 m wide at the existing and proposed crossing location.

The existing bridge was constructed circa 1960. The two lane structure is a steel girder bridge consisting of nine spans with an asphalt covered concrete deck. The overall structure length is approximately 87 m with a width of about 9.5 m. The piers consist of cast-in-place concrete caps supported on exposed steel tube piles that have an estimated length of approximately 27 m driven to below Elevation 228 m, as shown on the existing bridge General Arrangement drawing dated March 1959.

The existing highway grade is at about Elevation 256 m and 257 m at the existing south and north bridge abutments, respectively. The water level in the river was measured at Elevation 248.8 m in November 2007.

3.0 INVESTIGATION PROCEDURES

The fieldwork at the bridge site was carried out between July 15 and 23, 2008, between August 5 and 20, 2008 and on July 28 and 29, 2009 and consisted of drilling a total of eight (8) boreholes along the proposed realigned highway centreline. Four (4) boreholes (Boreholes NW-1 to NW-3 and NW-8) were advanced on the south side of the river and four (4) boreholes (Boreholes NW-4 to NW-7) were advanced on the north side of the river. Borehole NW-8 was advanced at the proposed south abutment, Borehole NW-4 was drilled near the proposed pier location and Borehole NW-6 was advanced near the proposed north abutment. Although Boreholes NW-4 and NW-6 are not positioned directly within the proposed final foundation footprints as is normal practice required by MTO, the actual borehole locations are considered appropriate by MTO Foundations. Boreholes NW-1 to NW-7 were drilled using a CME 850 track-mounted drill rig supplied and operated by Landcore Drilling Inc. (Landcore) of Sudbury, Ontario. Borehole NW-8 was advanced by a CME 55 track mounted drill rig supplied and operated by George Downing Estate Drilling Ltd. of Grenville-Sur-La-Rouge, Quebec.



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The boreholes were advanced using either 108 mm inside diameter (I.D.) continuous-flight hollow-stem augers or NW casing and wash boring. Soil samples were obtained, where possible, continuously or at intervals of depth of about 0.75 m to 3 m, using a 50 mm outside diameter (O.D.) split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586-08). Shelby tube samples were taken in cohesive deposits at select borehole locations. Field vane shear tests were conducted in cohesive soils for assessment of undrained shear strengths (ASTM D2573-08) using an MTO standard "N"-size vane. Rock core samples were obtained using an 'NQ' size core barrel.

Boreholes NW-1 and NW-7 were advanced to depths of about 11.3 m and 6.4 m, respectively, and Boreholes NW-2 to NW-6 and NW-8 were advanced to depths ranging between about 28.6 m and 40.7 m. A Dynamic Cone Penetration Test (DCPT) was advanced from the bottom of Borehole NW-1 to a depth of 19.8 m and from the bottom of Borehole NW-4 to refusal at a depth of 31.7 m. A DCPT (NW-DC1) was advanced adjacent to Borehole NW-7 to a depth of 17.7 m. Between 3.6 m and 5.3 m of rock core was obtained from Boreholes NW-2, NW-3, NW-5, NW-6 and NW-8.

The groundwater conditions in the open boreholes were observed during the drilling operations and piezometers were installed in Boreholes NW-1 and NW-7, at the south and north approaches, respectively, to allow monitoring of the groundwater level at these locations. The piezometers consisted of a 50 mm O.D. rigid PVC tubing with a 1.5 m long slotted screen, sealed within the silty clay stratum. Artesian conditions were noted in Boreholes NW-2 to NW-6. The boreholes were backfilled with bentonite as per Ontario Regulation (O.Reg.) 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 November 6, 2008. The installation details and water level readings are presented on the Record of Borehole sheets in Appendix A.

The fieldwork was supervised throughout by members of our engineering and technical staff, who located the boreholes, 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, grain size distribution and organic contents) 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 two boreholes. 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 LEA's subconsultant SRQ Geomatics Inc. (SRQ), based on the dimensions shown on the General Arrangement drawing supplied by LEA in June 2008. In July 2008, Golder surveyed the ground surface at the location of Boreholes NW-1 to NW-7 relative to the Benchmark northeast of the existing north abutment (Station 0011993U808, Geodetic Elevation 256.670 m). In August 2008, the ground surface elevation at Boreholes NW-3 and NW-4 were surveyed by SRQ, and the elevations were provided to Golder on site. Golder surveyed the ground surface at the location of Borehole NW-8 referencing the ground surface elevation at Station 13+225 as previously staked by SRQ. We understand that the river water level was surveyed by LEA in November 2007. The ground surface and water surface elevations are referenced to geodetic datum and the borehole locations are referenced to the MTM NAD 83 coordinate system.

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



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Borehole Number	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)
NW-1	5423373.7	304153.6	252.4
NW-2	5423387.3	304140.2	251.3
NW-3	5423393.6	304133.9	251.0
NW-4	5423416.9	304110.6	250.3
NW-5	5423429.6	304097.8	251.6
NW-6	5423443.8	304083.4	255.1
NW-7	5423457.6	304069.2	257.5
NW-8	5423378.8	304148.6	252.2
NW-DC1	5423458.7	304070.2	257.5

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Published literature indicates that the site is located in the Abiti Subprovince of the Superior Province (Geology of Ontario; OGS Special Volume 4)¹. The bedrock of the Abiti Subprovince consists of granite-greenstone-gneiss, generally with minor metasedimentary rock overlying the metavolcanic rock.

Based on terrain mapping by the Ontario Geological Survey², the subsurface soils in the vicinity of the site consist of glaciolacustrine plain deposits generally comprising clayey silts and surficial peat organic deposits.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions, as encountered in the boreholes advanced during this investigation are given on the Record of Borehole and Drillhole sheets in Appendix A. The results of the laboratory tests carried out on selected soil and rock samples are presented in Appendix B. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling and observations of drilling progress and 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 North Wicklow River bridge location is shown on the Contract Drawing.

In general, the subsoils at the structure site consist of fill materials and/or organic soils underlain by deposits of soft to stiff silty clay to clay, very loose to compact silt to sandy silt and/or silty sand to sand underlain by a layer of sand and gravel containing cobbles overlying bedrock. The total thickness of overburden at the borehole and DCPT locations ranges from at least about 17.7 m to about 35.9 m.

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 Reference Number 42A/NW.



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

4.2.1 Fill Materials

Fill material consisting of sand with organics or inclusions of clay and some gravel or peat with clay pockets was encountered at ground surface in Boreholes NW-2, NW-4 to NW-6 and NW-8 with a thickness between about 0.6 m and 2.2 m.

The water content measured on one sample of the fill is about 18 percent.

4.2.2 Peat and Silt of High Plasticity to Organic Silty Clay

Underlying the fill in Borehole NW-4, a layer of black peat with sand pockets and wood pieces was encountered.

Brown to black silt to organic silty clay was encountered from ground surface in Boreholes NW-1, NW-3 and NW-7, below the fill materials in Boreholes NW-2 and NW-5, and below the peat in Borehole NW-4. The top of the organic soils, including the localized layer of peat, was encountered between about Elevation 249.7 m and 257.5 m and the thickness of the deposit ranges between about 0.6 m and 3.2 m.

SPT 'N' values measured within the silt to organic silty clay deposits range from 1 to 5 blows per 0.3 m of penetration indicating a very soft to firm relative consistency.

Atterberg limits testing carried out on one (1) sample of the organic deposit indicate a liquid limit of about 53 percent and a plastic limit of about 31 percent, yielding a plasticity index of 22 percent. The results of the Atterberg limits testing are shown on the plasticity chart on Figure B-1 and indicate that the sample tested consisted of a silt of high plasticity. The organic content measured on two samples of the organic silt to silty clay deposit was about 5 percent and 9 percent.

The natural water content measured on samples of the peat and organic silt to clayey silt to silty clay deposit range from about 27 percent to 72 percent.

4.2.3 Silty Clay to Clay

Underlying the organic soils in Boreholes NW-1 to NW-5 and NW-7 and the fill material in Borehole NW-6 and NW-8, the boreholes encountered a deposit of brown to grey silty clay to clay, trace to some sand and trace gravel. The top of the silty clay to clay deposit was encountered between about Elevation 256.8 m and 247.5 m and the thickness ranges from at least 6.4 m to 19.2 m. Boreholes NW-1 and NW-7 were terminated within the silty clay to clay stratum at Elevation 241.1 m and 251.1 m, respectively. In Boreholes NW-2 to NW-6 and NW-8, the silty clay to clay was noted to be varved generally below about Elevation 236 m to 244 m. A clayey silt seam was encountered within the silty clay to clay deposit in Borehole NW-4 at a depth of about 5.8 m, as noted in Section 4.2.4.

SPT 'N' values measured within the silty clay to clay range from 0 (i.e. weight of rods) to 10 blows per 0.3 m of penetration suggesting a very soft to stiff consistency. In situ field vane testing carried out within this stratum measured undrained shear strengths ranging from about 15 kPa to 81 kPa, but typically range from about 19 kPa to 50 kPa indicating a predominantly soft to firm consistency.



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Atterberg limits testing carried out on twenty-two (22) samples of the silty clay to clay silt deposit indicate liquid limits ranging from about 38 percent to 63 percent and plastic limits ranging from about 18 percent to 25 percent, yielding plasticity indices ranging from about 19 percent to 39 percent. The results of the Atterberg limits testing for the silty clay to clay are shown on the plasticity charts on Figure B-2 and indicate that the stratum ranges from a silty clay of medium plasticity to a clay of high plasticity.

Grain size distribution tests were carried out on seventeen (17) samples of the silty clay to clay deposit and the results are shown on Figure B-3.

The natural water content measured on select samples of the silty clay to clay deposit range between 27 percent and 62 percent.

Two laboratory consolidation (oedometer) tests were carried out on specimens of the silty clay to clay obtained from Boreholes NW-2 and NW-5 and the test results are shown on Figures B-4 and B-5, respectively. The preconsolidation stresses 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)
NW-2/13	238.8	100	220	120	2.2	1.66	0.13	0.63	0.003
NW-5/7	246.0	50	143	93	2.9	1.38	0.10	0.51	0.005

Note: *For approximate stress range of $20 \leq \sigma_v' \leq 200$ kPa

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

σ_p' preconsolidation stress 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

4.2.4 Clayey Silt

Underlying the silty clay to clay stratum in Boreholes NW-3, NW-5 and NW-6, a deposit of grey clayey silt was encountered. The top of the deposit was encountered between about Elevation 239.7 m and 231.8 m and the thickness ranges from about 2.1 m to 3.3 m. As noted in Sections 4.2.3 and 4.2.5, clayey silt seams were penetrated within the silty clay to clay deposit in Borehole NW-4 and within the underlying silt deposit in Borehole NW-2.

SPT 'N' values measured within the clayey silt range from 0 (i.e. weight of rods) to 8 blows per 0.3 m of penetration suggesting a very soft to stiff consistency. In situ field vane testing carried out within this stratum measured undrained shear strengths ranging from about 19 kPa to 46 kPa, indicating a soft to firm consistency, although an undrained shear strength greater than 100 kPa was recorded at the top of the deposit in Borehole NW-3.

Atterberg limits testing carried out on four (4) samples of the clayey silt deposit, including the clayey silt seam within the silty clay to clay deposit, indicate liquid limits ranging from about 28 percent to 31 percent and plastic limits ranging from about 17 percent to 20 percent, yielding plasticity indices ranging from about 8 percent to 14 percent. The results of the Atterberg limits testing are shown on the plasticity chart on Figure B-6, and indicate that the stratum is a clayey silt of low plasticity.



Grain size distribution tests were carried out on two (2) samples of the clayey silt seams are shown on Figure B-7.

The natural water content measured on samples of the silt to clayey silt deposits range from about 28 percent to 31 percent.

4.2.5 Silt to Sandy Silt

The silty clay to clay or clayey silt strata in Boreholes NW-2 to NW-8 are underlain by a deposit of grey silt to sandy silt. As noted in Section 4.2.4, the silt deposit in Borehole NW-2 contained a clayey silt seam at a depth of about 22.9 m at Elevation 228.4 m. The top of the silt to sandy silt deposit ranges from between about Elevation 236.7 m and 229.7 m and the thickness of the deposit ranges from about 5.5 m to 13.7 m. In Borehole NW-5, when the casing tip was at about Elevation 231.8 m or generally below about 6 m from the top of this deposit, about 11.0 m of heaved sandy silt/silt was noted within the casing.

SPT 'N' values measured within the silt to sandy silt deposit range from 0 (i.e. weight of rods) to 27 blows per 0.3 m of penetration suggesting a very loose to compact relative density.

An Atterberg limits test carried out on one (1) sample of the silt deposit indicates a liquid limit of about 24 percent and a plastic limit of about 19 percent, yielding a plastic index of about 5 percent. The results of the Atterberg limits test are shown on the plasticity chart on Figure B-8, and indicate that the stratum is a silt of low plasticity.

Grain size distribution tests were carried out on seven (7) samples of the silt to sandy silt deposit and the results are shown on Figure B-9.

The natural water content measured on samples of the silt to sandy silt deposit range from about 24 percent to 29 percent.

4.2.6 Silty Sand to Sand

In Borehole NW-6, a deposit of grey silty sand to sand was encountered underlying the silt to sandy silt stratum. The top of this deposit was encountered at about Elevation 230.1 m and the thickness of the deposit is about 7.0 m. About 3.7 m of heaved silty sand/sand was noted in the casing within this deposit at a depth of about 30.5 m.

SPT 'N' values measured within the silty sand to sand deposit are 6 and 23 blows per 0.3 m of penetration suggesting a loose to compact relative density. The lower SPT "N" value may be due to the loosening and heave of the material during the drilling as noted above.

A grain size distribution test was carried out on one (1) sample of the silty sand to sand deposit and the results are shown on Figure B-10.

The natural water content measured on a sample of the silty sand to sand deposit is about 14 percent.

4.2.7 Sand and Gravel (containing Cobbles)

Underlying the silt to sandy silt stratum in Boreholes NW-2 to NW-5 and NW-8 and the silty sand to sand stratum in Borehole NW-6, a deposit of sand and gravel containing cobbles was encountered. A boulder (approximately 300 mm in size) was also encountered in this deposit in Borehole NW-8. The top of this deposit ranges between about Elevation 223.3 m and 219.8 m and the thickness of the deposit ranges from at least 1.2 m to about 5.5 m.



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Near the top of the sand and gravel deposit in Borehole NW-2 and within this deposit in Boreholes NW-3 and NW-4, sand and gravel heave was noted inside the casing. The measured heave ranged from approximately 0.8 m to 4.9 m above the casing tip.

A grain size distribution test was carried out on one (1) sample of the sand and gravel deposit and the results are shown on Figure B-11.

4.2.8 Bedrock

Bedrock was encountered at depths ranging between about 31.7 m and 35.9 m below ground surface, with the bedrock surface ranging between about Elevation 219.3 m and 215.6 m in Boreholes NW-2, NW-3, NW-5, NW-6 and NW-8. In these boreholes, the bedrock was cored for lengths ranging between about 3.6 m and 5.3 m. In Borehole NW-4, dynamic cone refusal was encountered within the deposit of sand and gravel containing cobbles or on bedrock at a depth of 31.7 m corresponding to Elevation 218.6 m.

The depth to bedrock and corresponding bedrock surface elevation encountered at each borehole is summarized below.

Borehole	Depth to Bedrock Surface (m)	Bedrock Surface Elevation (m)	Comments
NW-2	34.5	216.8	Bedrock Cored
NW-3	35.4	215.6	Bedrock Cored
NW-4	31.7	218.6 (Assumed)	DCPT Refusal
NW-5	32.9	218.7	Bedrock Cored
NW-6	35.8	219.3	Bedrock Cored
NW-8	35.9	215.3	Bedrock Cored

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

The Rock Quality Designation (RQD) measured on the core samples ranges from about 20 percent to 100 percent indicating rock mass of variable quality, ranging from very poor to very good. The RQD values are typically between 40 percent and 60 percent indicating that the bedrock is generally of poor to fair quality. In all boreholes, broken rock was recovered at various depths within the cored zone. The Total Core Recovery (TCR) during bedrock coring was generally 100 percent.

Laboratory UCS testing was carried out on nine (9) core samples of the granite bedrock. The UCS results range between 6 MPa and 76 MPa, indicating weak to strong rock. The depths and corresponding elevations of the samples tested and the results of the UCS testing are presented in Table B-1.



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4.2.9 Groundwater Conditions

The water levels were noted during and after the drilling and coring operations in the boreholes. Piezometers were installed in Boreholes NW-1 and NW-7 with screened sections sealed within the silty clay to clay deposit. Details of the piezometer installations are shown on the Record of Borehole Sheets in 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 North Wicklow River was measured by LEA at Elevation 248.8 m in November 2007. The water levels in the piezometers and open holes during drilling and upon completion of drilling are summarized below. In Boreholes NW-2 to NW-6 and NW-8, artesian conditions were observed during drilling and the water levels measured under these conditions are also presented below. Upon completion of drilling, the boreholes were backfilled to ground surface with bentonite pellets in accordance with O.Reg.903. During a site visit on November 6, 2008 to abandon the piezometers, minor water seepage was observed at the ground surface at Borehole NW-3. Given this, the upper section of this borehole was re-backfilled with bentonite pellets by the drilling subcontractor under the supervision of Golder.

Borehole	Installation	Groundwater Level Referenced to Ground Surface (GS)	Groundwater Level Elevation (m)	Date
NW-1	Piezometer	0.3 m below GS	252.1	Nov. 6/08
NW-2	Auger Tip at 10.4 m depth (Elev. 240.9 m)	10.4 m below GS	240.9	Aug. 18/08
	Casing Tip at 30.5 m depth (Elev. 220.8 m)	0.6 m above GS	251.9	Aug. 19/08*
NW-3	Casing Tip at 34.1 m depth (Elev. 216.9 m)	1.1 m above GS	252.1	Aug. 13/08*
NW-4	Casing Tip at 29.0 m depth (Elev. 221.3 m)	1.2 m above GS	251.5	Aug. 10/08*
NW-5	Casing Tip at 19.8 m depth (Elev. 231.8 m)	0.6 m above GS	252.2	Aug. 6/08*
NW-6	Auger Tip at 19.8 m depth (Elev. 235.3 m)	7.0 m below GS	248.1	July 16/08*
	Casing Tip at 30.5 m depth (Elev. 224.6 m)	8.8 m below GS	246.3	July 17/08*
	Casing Tip at 33.5 m depth (Elev. 221.6 m)	1.9 m above GS	257.0	July 22/08*
NW-7	Piezometer	2.1 below GS	255.9	Aug. 20/08
	Piezometer	1.2 below GS	256.3	Nov. 6/08
NW-8	Casing Tip at 24.4 m depth (Elev. 227.8 m)	2.1 m above GS	254.3	July 28/09

Note: * Water level measured prior to resuming drilling operations.



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During the drilling program in July 2008, a natural spring (i.e. water seepage at the ground surface) was observed at about Station 13+085 and 10 m west of centreline of the new alignment.

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

5.0 CLOSURE

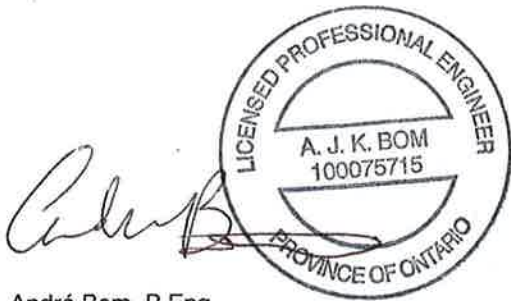
The field drilling program was supervised by Mr. Evan Childerhose, EIT. This report was prepared by Mr. Evan Childerhose, EIT, and Mr. André Bom, P.Eng., and the technical aspects were reviewed by Messrs. Jorge Costa, P.Eng., and Paul Dittrich, P.Eng., Principals with Golder. A quality control review of the report was provided by Mr. Jorge Costa, P.Eng., Golder's Designated MTO Contact for this project.



Report Signature Page

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EC/AB/JPD/JMAC/lb

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APPENDIX A

RECORD OF BOREHOLES AND DRILLHOLES

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.

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

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERING STATE

Fresh: no visible sign of weathering

Faintly weathered: weathering limited to the surface of Major discontinuities

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

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

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

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

BEDDING THICKNESS

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

JOINT OR FOLIATION SPACING

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

GRAIN SIZE

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

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

CORE CONDITION

Total Core Recovery (TCR)

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

Solid Core Recovery (SCR)

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

Rock Quality Designation (RQD)

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

DISCONTINUITY DATA

Fracture Index

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

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



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

Description and Notes

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

Abbreviations

B - Bedding	⊥ - Perpendicular To
FO - Foliation / Schistosity	- Parallel To
CL - Cleavage	P - Polished
SH - Shear Plane / Zone	K - Slickensided
VN - Vein	SM - Smooth
F - Fault	R - Rough
CO - Contact	ST - Stepped
J - Joint	PL - Planar
FR - Fracture	U - Undulating
MF - Mechanical Fracture	C - Curved

PROJECT <u>07-1191-0008</u>				RECORD OF BOREHOLE No NW-1				1 OF 2 METRIC							
W.P. <u>5055-06-00</u>				LOCATION <u>N 5423373.7 ; E 304153.6</u>				ORIGINATED BY <u>EC</u>							
DIST <u> </u> HWY <u>11</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>August 19 and 20, 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							WATER CONTENT (%)
252.4 0.0	GROUND SURFACE INORGANIC SILT of High Plasticity to ORGANIC SILTY CLAY, with sand pockets Soft to firm Black to brown Moist		1	SS	3		252								
			2	SS	5		251								
			3	SS	4										
250.1 2.3	SILTY CLAY to CLAY, trace sand Soft to stiff Brown Moist to wet Containing trace organics in samples #4 and #5. Becoming grey at 4.6 m depth.	4	SS	8	250										
		5	SS	8	249										
		6	SS	5	248										
		7	SS	2	247										
		8	SS	1	246										
		9	SS	WH	245										
		10	TO	PH	244										
241.1 11.3	Start of DCPT	11	SS	3	243										
					242										
					241										
					240										
					239										
					238										

Continued Next Page

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

MIS-MTO 001 NORTH WICKLOW BH METRIC.GPJ GAL-MISS.GDT 11/12/09 ACM

PROJECT <u>07-1191-0008</u>		RECORD OF BOREHOLE No NW-1		2 OF 2 METRIC	
W.P. <u>5055-06-00</u>	LOCATION <u>N 5423373.7 ;E 304153.6</u>	ORIGINATED BY <u>EC</u>			
DIST <u> </u> HWY <u>11</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>August 19 and 20, 2008</u>	CHECKED BY <u>AB</u>			

SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID LIMIT CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL						
ELEV DEPTH	DESCRIPTION --- CONTINUED FROM PREVIOUS PAGE ---	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa					W _p	W	W _L											
						20 40 60 80 100					20 40 60 80 100			10 20 30										
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%)													
232.6								237																
								236																
								235																
								234																
								233																
19.8	End of DCPT End of Borehole Notes: 1. Water level in open borehole at a depth of 1.8 m below ground surface (Elev. 250.6 m) upon completion of drilling. 2. Water level measured in piezometer at a depth of 0.3 m below ground surface (Elev. 252.1 m) on November 6, 2008.																							

MIS-MTO 001 NORTH WICKLOW BH METRIC.GPJ GAL-MISS.GDT 11/12/09 ACM

RECORD OF BOREHOLE No NW-2

1 OF 3 **METRIC**

PROJECT 07-1191-0008 W.P. 5055-06-00 LOCATION N 5423387.3 ; E 304140.2 ORIGINATED BY EC

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

DATUM Geodetic DATE August 13, 14, 18 and 19, 2008 CHECKED BY AB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
251.3	GROUND SURFACE							20 40 60 80 100		10 20 30				
0.0	Sand, with organics (FILL) Very loose Brown to black Moist		1	SS	3		251							
250.7														
0.6	INORGANIC SILT of High Plasticity to ORGANIC SILTY CLAY, trace to some sand Very soft to firm Black to brown Moist to wet		2	SS	3		250							
			3	SS	3		249							
			4	SS	5		248							
			5	SS	1		247							
247.5	SILTY CLAY to CLAY, trace sand Firm Grey Wet		6	SS	3		246							
3.8			7	SS	1		245							
			8	SS	WH		244							
			9	SS	WR		243							
			10	SS	WH		242							
			11	SS	WH		241							
			12	SS	WR		240							
			13	TO	WR		239							
			14	SS	WH		238							
	Varved below 13.8 m depth						237							

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

MIS-MTO 001 NORTH WICKLOW BH METRIC.GPJ GAL-MISS.GDT 11/12/09 ACM

2 OF 3 **METRIC**

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Continued Next Page

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

MIS-MTO 001 NORTH WICKLOW BH METRIC.GPJ GAL-MISS.GDT 11/12/09 ACM

PROJECT <u>07-1191-0008</u>		RECORD OF BOREHOLE No NW-2				3 OF 3 METRIC												
W.P. <u>5055-06-00</u>		LOCATION <u>N 5423387.3 ; E 304140.2</u>				ORIGINATED BY <u>EC</u>												
DIST <u> </u> HWY <u>11</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing Wash Boring</u>				COMPILED BY <u>MM</u>												
DATUM <u>Geodetic</u>		DATE <u>August 13, 14, 18 and 19, 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 LIMIT 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					WATER CONTENT (%)					
--- CONTINUED FROM PREVIOUS PAGE ---							<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED </div>					<div style="display: flex; justify-content: space-between;"> W_p W W_L </div>						
220.7 30.6	SAND and GRAVEL, containing cobbles Casing grinding was noted at 30.6 m depth.					221												
						220												
						219												
						218												
						217												
216.8 34.5	GRANITE (BEDROCK) Bedrock cored from 34.5 m to 39.0 m depth. For coring details, refer to Record of Drillhole NW-2.		1	RC	REC 100%	216										RQD = 50%		
						215										RQD = 20%		
						214												
						213											RQD = 60%	
212.3 39.0	End of Borehole Notes: 1. Switched to NW casing at 13.7 m depth (Elev. 237.6 m). 2. Water level measured in augers prior to switching to NW casing on August 18, 2008 at a depth of 10.4 m (Elev. 240.9 m). 3. Prior to the start of drilling on August 19, 2008, casing tip at 30.5 m depth (Elev. 220.8 m), water level measured in casing at 0.6 m above ground surface (Elev. 251.9 m); approximately 3.7 m of sand and gravel heave was measured in casing.																	

MIS-MTO 001 NORTH WICKLOW BH METRIC.GPJ GAL-MISS.GDT 11/12/09 ACM



SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: Landcore Drilling

MIS-RCK 004 NORTH WICKLOW BH METRIC.GPJ GAL-MISS.GDT 11/12/09 ACM

CHECKED: AB

PROJECT <u>07-1191-0008</u>		RECORD OF BOREHOLE No NW-3		1 OF 3 METRIC								
W.P. <u>5055-06-00</u>		LOCATION <u>N 5423393.6 ; E 304133.9</u>		ORIGINATED BY <u>EC</u>								
DIST <u> </u> HWY <u>11</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing Wash Boring</u>		COMPILED BY <u>MM</u>								
DATUM <u>Geodetic</u>		DATE <u>August 11 to 13, 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					
251.0 0.0	GROUND SURFACE INORGANIC SILT of High Plasticity to ORGANIC SILTY CLAY, trace to some sand Very soft to soft Black to brown Moist		1	SS	4							OC = 5.0%
			2	SS	3							
			3	SS	1							
			4	SS	3							
248.0 3.0	SILTY CLAY to CLAY, trace sand, trace gravel Firm to stiff Grey Wet		5	SS	6							1 5 32 62
			6	SS	WH							
			7	SS	WH							
			8	SS	WH							
			9	SS	WH							
			10	TO	PM							
			11	SS	WH							
			12	SS	PH							
		13	SS	PH								
	Varved below 13.5 m depth											

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

MIS-MTO 001 NORTH WICKLOW BH METRIC.GPJ GAL-MISS.GDT 11/12/09 ACM

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PROJECT <u>07-1191-0008</u>		RECORD OF BOREHOLE No NW-3				3 OF 3 METRIC										
W.P. <u>5055-06-00</u>		LOCATION <u>N 5423393.6 ; E 304133.9</u>				ORIGINATED BY <u>EC</u>										
DIST <u> </u> HWY <u>11</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing Wash Boring</u>				COMPILED BY <u>MM</u>										
DATUM <u>Geodetic</u>		DATE <u>August 11 to 13, 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								
	--- CONTINUED FROM PREVIOUS PAGE ---						<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED </div>									
29.9	SAND and GRAVEL, containing cobbles Casing grinding was noted at 29.9 m depth.															
215.6 35.4	GRANITE (BEDROCK) Bedrock cored from 35.4 m to 40.7 m depth. For coring details, refer to Record of Drillhole NW-3.		1	RC	REC 100%											RQD = 67%
			2	RC	REC 100%											RQD = 37%
			3	RC	REC 100%											RQD = 52%
			4	RC	REC 90%											RQD = 42%
210.3 40.7	End of Borehole Notes: 1. Switched to NW Casing at 9.1 m depth (Elev. 241.9 m). 2. Prior to the start of drilling on August 13, 2008, casing tip at 34.1 m depth (Elev. 216.9 m), water level measured in casing at 1.1 m above ground surface (Elev. 252.1 m); approximately 0.8 m of sand and gravel heave was measured in casing.															

MIS-MTO 001 NORTH WICKLOW BH METRIC.GPJ GAL-MISS.GDT 11/12/09 ACM

SHEET 1 OF 1

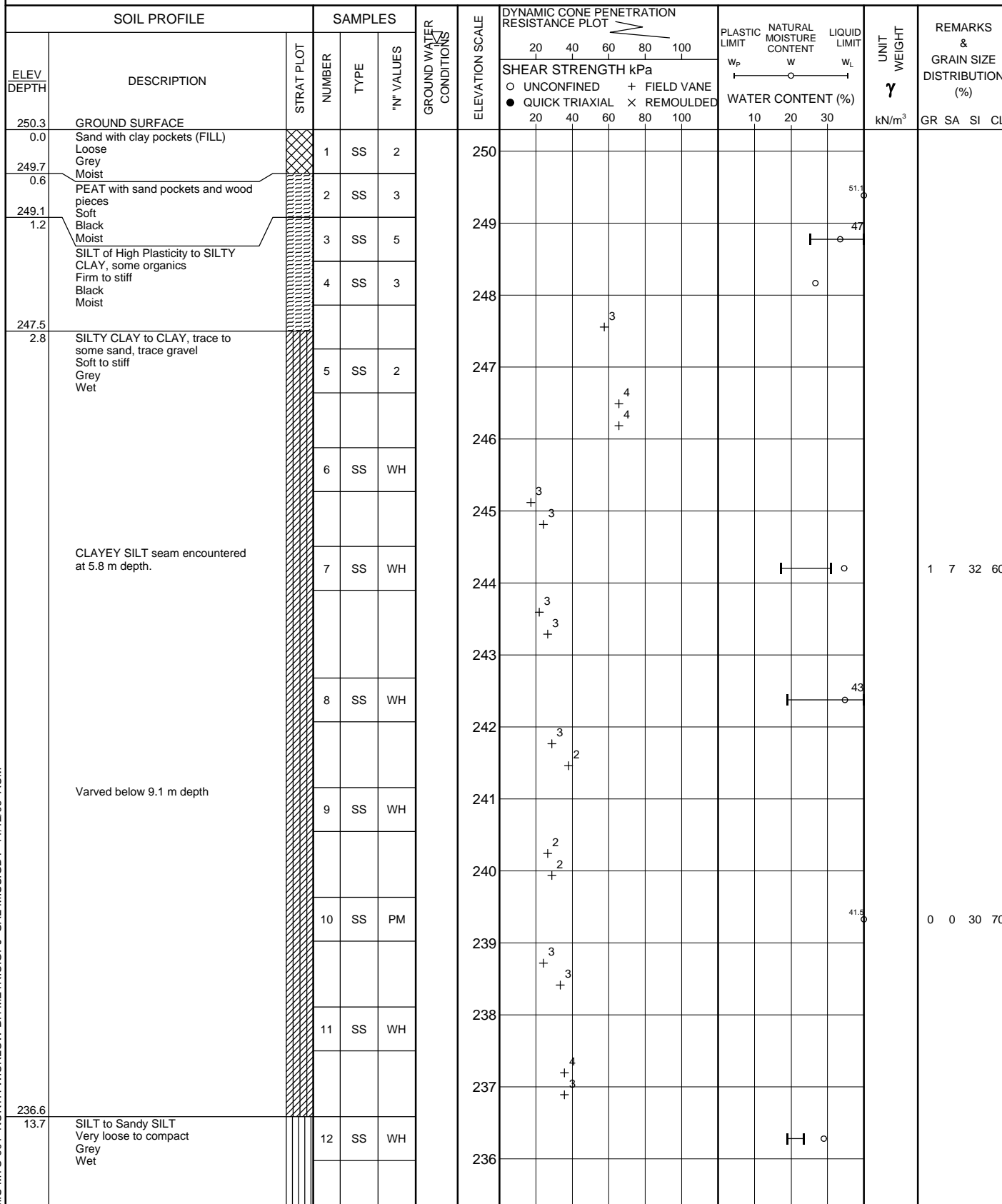
DATUM: Geodetic

DRILLING CONTRACTOR: Landcore Drilling

MIS-RCK 004 NORTH WICKLOW BH METRIC.GPJ GAL-MISS.GDT 11/12/09 ACM

CHECKED: AB

PROJECT <u>07-1191-0008</u>		RECORD OF BOREHOLE No NW-4		1 OF 3 METRIC	
W.P. <u>5055-06-00</u>		LOCATION <u>N 5423416.9 ; E 304110.6</u>		ORIGINATED BY <u>EC</u>	
DIST <u> </u> HWY <u>11</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing Wash Boring</u>		COMPILED BY <u>MM</u>	
DATUM <u>Geodetic</u>		DATE <u>August 8 to 10, 2008</u>		CHECKED BY <u>AB</u>	



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

MIS-MTO 001 NORTH WICKLOW BH METRIC.GPJ GAL-MISS.GDT 11/12/09 ACM




2 OF 3 **METRIC**

CHECKED BY AB

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

MIS-MTO 001 NORTH WICKLOW BH METRIC.GPJ GAL-MISS.GDT 11/12/09 ACM

PROJECT <u>07-1191-0008</u>		RECORD OF BOREHOLE No NW-4		3 OF 3 METRIC	
W.P. <u>5055-06-00</u>		LOCATION <u>N 5423416.9 ; E 304110.6</u>		ORIGINATED BY <u>EC</u>	
DIST <u> </u> HWY <u>11</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing Wash Boring</u>		COMPILED BY <u>MM</u>	
DATUM <u>Geodetic</u>		DATE <u>August 8 to 10, 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 LIMIT 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 + FIELD VANE ● QUICK TRIAXIAL × REMOULDED									
	--- CONTINUED FROM PREVIOUS PAGE ---							20 40 60 80 100									
219.2	SAND and GRAVEL, containing cobbles						220										
31.1	Start of DCPT						219										
218.6	End of DCPT																
31.7	End of Borehole																
	Notes: 1. Switched to NW Casing at 10.7 m depth (Elev. 239.6 m). 2. Grinding noted at 27.3 m depth and casing was seated at 27.4 m depth. NQ core barrel was advanced to 31.1 m depth with minimal recovery (4 gravel sizes pieces was advanced). Casing could not be advanced past 31.1 m and DCPT was advanced to 31.7 m depth. 3. Prior to the start of drilling on August 10, 2008, casing tip at 29.0 m (Elev. 221.3 m), water level measured in casing at 1.2 m above ground surface (Elev. 251.5 m); approximately 4.9 m of sand and gravel heave was measured in casing.																

MIS-MTO 001 NORTH WICKLOW BH METRIC.GPJ GAL-MISS.GDT 11/12/09 ACM

RECORD OF BOREHOLE No NW-5

1 OF 3 **METRIC**

PROJECT 07-1191-0008

W.P. 5055-06-00

LOCATION N 5423429.6 :E 304097.8

ORIGINATED BY EC

DIST HWY 11

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

COMPILED BY MM

DATUM Geodetic

DATE July 22 and 23 and August 5 and 6, 2008

CHECKED BY AB

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

MIS-MTO 001 NORTH WICKLOW BH METRIC.GPJ GAL-MISS.GDT 11/12/09 ACM

MIS-MTO 001 NORTH WICKLOW BH METRIC.GPJ GAL-MISS.GDT 11/12/09 ACM

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

PROJECT <u>07-1191-0008</u>		RECORD OF BOREHOLE No NW-5				3 OF 3 METRIC										
W.P. <u>5055-06-00</u>		LOCATION <u>N 5423429.6 ;E 304097.8</u>				ORIGINATED BY <u>EC</u>										
DIST <u> </u> HWY <u>11</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing Wash Boring</u>				COMPILED BY <u>MM</u>										
DATUM <u>Geodetic</u>		DATE <u>July 22 and 23 and August 5 and 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								
	--- CONTINUED FROM PREVIOUS PAGE ---						20	40	60	80	100					
218.7	SAND and GRAVEL, containing cobbles															
32.9	GRANITE (BEDROCK)		1	RC	REC 100%											RQD = 39%
	Bedrock cored from 32.9 m to 36.5 m depth. For coring details, refer to Record of Drillhole NW-5.		2	RC	REC 100%											RQD = 60%
			3	RC	REC 100%											RQD = 37%
215.1	End of Borehole															
36.5	Notes: 1. Switched to NW Casing at 10.7 m depth (Elev. 240.9 m). 2. Prior to the start of drilling on August 6, 2008, casing tip at 19.8 m depth (Elev. 231.8 m), water level measured in casing at 0.6 m above ground surface (Elev. 252.2 m). Approximately 11.0 m of sand and gravel was measured above casing tip in afternoon.															

MIS-MTO 001 NORTH WICKLOW BH METRIC.GPJ GAL-MISS.GDT 11/12/09 ACM

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: Landcore Drilling

CHECKED: AB

PROJECT <u>07-1191-0008</u>		RECORD OF BOREHOLE No NW-6		1 OF 3 METRIC	
W.P. <u>5055-06-00</u>	LOCATION <u>N 5423443.8 ; E 304083.4</u>	ORIGINATED BY <u>EC</u>			
DIST <u> </u> HWY <u>11</u>	BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing Wash Boring</u>	COMPILED BY <u>MM</u>			
DATUM <u>Geodetic</u>	DATE <u>July 15 to 17 and 21, 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							WATER CONTENT (%)			
								20 40 60 80 100										
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED										

255.1	GROUND SURFACE						255									
0.0	Sand, some gravel, some silt, some clay with organics (FILL)		1	AS	-											
254.5	Brown to black Moist															
0.6	SILTY CLAY to CLAY, trace gravel, trace to some sand, trace organics in upper samples		2	SS	3		254								43	
	Soft to firm															
	Brown to grey Moist		3	SS	2		253									
			4	SS	2		252									
			5	SS	4		251									1 6 37 56
	Becoming grey at 4.6 m depth.		6	SS	3		250									
			7	TO	PH		249									
			8	SS	WH		248									0 6 33 61
			9	SS	WH		247									
							246									
			10	SS	WH		245									0 1 6 93
			11	SS	WH		244									0 0 6 94
	Varved below 11.6 m depth						243									
			12	SS	WH		242									
			13	SS	WH		241									

Continued Next Page

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

MIS-MTO 001 NORTH WICKLOW BH METRIC.GPJ GAL-MISS.GDT 11/12/09 ACM



2 OF 3 METRIC

CHECKED BY AB

Continued Next Page

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

MIS-MTO 001 NORTH WICKLOW BH METRIC.GPJ GAL-MISS.GDT 11/12/09 ACM

PROJECT <u>07-1191-0008</u>		RECORD OF BOREHOLE No NW-6				3 OF 3 METRIC						
W.P. <u>5055-06-00</u>		LOCATION <u>N 5423443.8 ;E 304083.4</u>				ORIGINATED BY <u>EC</u>						
DIST <u> </u> HWY <u>11</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing Wash Boring</u>				COMPILED BY <u>MM</u>						
DATUM <u>Geodetic</u>		DATE <u>July 15 to 17 and 21, 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 (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	W _p W W _L			WATER CONTENT (%)
	--- CONTINUED FROM PREVIOUS PAGE ---											
223.1	Silty SAND to SAND, trace clay Loose to compact Grey Wet		19	SS	6		225					
							224					
32.0	SAND and GRAVEL, containing cobbles						223					
	Casing grinding was noted at 32.0 m depth.						222					
							221					
							220					
219.3	GRANITE (BEDROCK)						219					
35.8	Bedrock cored from 35.8 m to 39.5 m depth. For coring details, refer to Record of Drillhole NW-6.		1	RC	REC 100%		218					
			2	RC	REC 88%		217					
			3	RC	REC 100%		216					
215.6	End of Borehole											
39.5	Notes: 1. Switched to NW Casing at 25.9 m depth (Elev. 241.9 m). 2. Prior to the start of drilling on July 16, 2008, auger tip at 19.8 m depth (Elev. 235.3 m), water level measured at 7.0 m depth below ground surface (Elev. 248.1 m). 3. Prior to the start of drilling on July 17, 2008, casing tip at 30.5 m depth (Elev. 224.6 m), water level measured at 8.8 m depth below ground surface (Elev. 246.3 m); approximately 3.7 m of silty sand heave was measured in casing. 4. Prior to the start of drilling on July 22, 2008, casing tip at 33.5 m depth (Elev. 221.6 m), water level measured at 1.9 m depth above ground surface (Elev. 257.0 m).											

MIS-MTO 001 NORTH WICKLOW BH METRIC.GPJ GAL-MISS.GDT 11/12/09 ACM

PROJECT: 07-1191-0008

RECORD OF DRILLHOLE: NW-6

SHEET 1 OF 1

LOCATION: N 5423443.8 ;E 304083.4

DRILLING DATE: July 15 to 17 and 21, 2008

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 850

DRILLING CONTRACTOR: Landcore Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.	RUN No.	PENETRATION RATE min/m	FLUSH	COLOUR % RETURN	JN - Joint FLT - Fault SHR - Shear VN - Vein CJ - Conjugate	BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage	PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular	PO - Polished K - Slickensided SM - Smooth Ro - Rough MB - Mechanical Break	BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.	NOTES WATER LEVELS INSTRUMENTATION														
				DEPTH											RECOVERY	R.Q.D. %	FRACT INDEX PER 0.3 m	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY				Diameter Point Load Index (MPa)	RMC -Q AVG.	
				(m)														TOTAL CORE %	SOLID CORE %	B Angle	DIP w/L CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn			K, cm/sec
		Refer to Previous Page		219.29 35.81																								
36	July 21 and 22, 2008 NQ RC	GRANITE Fine to medium grained Slightly weathered Weak to medium strong Pinkish grey		1																								
37		Moderately weathered from 36.6 m depth to 36.8 m depth, from 37.2 m depth to 37.5 m depth, from 37.6 m depth to 37.8 m depth and from 38.2 m depth to 38.3 m depth.		2												UCS = 11 MPa												
38		Alteration zone from 38.4 m depth to end of drillhole.		3												UCS = 34 MPa												
39																												
40		End of Drillhole		215.63 39.47																								
41																												
42																												
43																												
44																												
45																												

DEPTH SCALE

1 : 50





LOGGED: EC

CHECKED: AB

MIS-RCK 004 NORTH WICKLOW BH METRIC.GPJ GAL-MISS.GDT 11/12/09 ACM

PROJECT <u>07-1191-0008</u>		RECORD OF BOREHOLE No NW-7				1 OF 1 METRIC					
W.P. <u>5055-06-00</u>		LOCATION <u>N 5423457.6 ; E 304069.2</u>				ORIGINATED BY <u>EC</u>					
DIST <u> </u> HWY <u>11</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>July 18, 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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa			
257.5	GROUND SURFACE							20 40 60 80 100	W _p — W — W _L		
0.0	SILT of High Plasticity to ORGANIC SILTY CLAY, trace sand Firm to stiff Brown to black Moist		1	AS	-		257				
256.8			2	SS	10		256				
0.7	SILTY CLAY Soft to stiff Brown Wet		3	SS	6		255				
	Becoming grey below 2.3 m depth		4	SS	2		254				
			5	SS	WH		253				
			6	TO	PH		252				
			7	SS	PH						
251.1	End of Borehole										
6.4	Notes: 1. Borehole dry upon completion of drilling. 2. Water level measured in piezometer at a depth of 2.1 m below ground surface (Elev. 255.9 m) on August 20, 2008 and at a depth of 1.2 m below ground surface (Elev. 256.3 m) on November 6, 2008. 3. Advanced NW-DC1 1.0 m north and 1.0 m east of Borehole NW-7. Refer to Record of Penetration Test NW-DC1.										

PROJECT <u>07-1191-0008</u>		RECORD OF BOREHOLE No NW-8		1 OF 3 METRIC	
W.P. <u>5055-06-00</u>	LOCATION <u>N 5423378.8 ; E 304148.6</u>	ORIGINATED BY <u>ID</u>			
DIST <u> </u> HWY <u>11</u>	BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing Wash Boring</u>	COMPILED BY <u>DA</u>			
DATUM <u>Geodetic</u>	DATE <u>July 28 and 29, 2009</u>	CHECKED BY <u>AB</u>			



SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	*N VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)	
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × REMOULDED							
252.2	GROUND SURFACE						20 40 60 80 100		10 20 30							
0.0	PEAT, containing clay pockets (FILL) Very loose Black to brown Moist to wet		1	SS	4											
			2	SS	4											
			3	SS	3											
250.1																
2.1	SILTY CLAY to CLAY Firm to stiff Grey Wet		4	SS	7								48			
			5	SS	7											
			6	SS	1											
			7	SS	WH											
			8	SS	WH											
			9	SS	WH											
			10	SS	WH											
			11	SS	WH											
			12	SS	WH											

Continued Next Page

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

MIS-MTO 001 NORTH WICKLOW BH METRIC.GPJ GAL-MISS.GDT 11/12/09 ACM

PROJECT <u>07-1191-0008</u>		RECORD OF BOREHOLE No NW-8		2 OF 3 METRIC	
W.P. <u>5055-06-00</u>		LOCATION <u>N 5423378.8 ; E 304148.6</u>		ORIGINATED BY <u>ID</u>	
DIST <u> </u> HWY <u>11</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing Wash Boring</u>		COMPILED BY <u>DA</u>	
DATUM <u>Geodetic</u>		DATE <u>July 28 and 29, 2009</u>		CHECKED BY <u>AB</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W _p	W	W _L			
								SHEAR STRENGTH kPa					WATER CONTENT (%)					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED										
	--- CONTINUED FROM PREVIOUS PAGE ---																	
	SILTY CLAY to CLAY Firm to stiff Grey Wet		13	SS	WH													
	Varved below 16.2 m depth																	
			14	SS	WH													
			15	SS	4													
		16	SS	4														
230.9																		
21.3	SILT to SANDY SILT Loose to compact Grey Wet		17	SS	8													
			18	SS	19													
			19	SS	26													

MIS-MTO.001 NORTH WICKLOW BH METRIC.GPJ GAL-MISS.GDT 11/12/09 ACM

Continued Next Page

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

RECORD OF BOREHOLE No NW-8

3 OF 3 **METRIC**

PROJECT 07-1191-0008 W.P. 5055-06-00 LOCATION N 5423378.8 ;E 304148.6 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 28 and 29, 2009 CHECKED BY AB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)			
								20 40 60 80 100								10 20 30			
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED											
--- CONTINUED FROM PREVIOUS PAGE ---							222												
220.8 31.4	SILT to SANDY SILT Loose to compact Grey Wet						221												
	SAND and GRAVEL, containing cobbles, and occasional boulders Compact to very dense Grey		21	SS	14		220								37 45 16 2				
							219												
			22	SS	100/0.05		218												
	Note: Spoon bouncing at 35.0 m depth.		23	SS			217												
216.3 35.9	GRANITE (BEDROCK)						216								RQD = 22%				
	Bedrock cored from 35.9 m to 40.7 m depth. For coring details, refer to Record of Drillhole NW-8.		1	RC	REC 64%		215								RQD = 47%				
			2	RC	REC 75%		214								RQD = 49%				
			3	RC	REC 98%		213								RQD = 88%				
			4	RC	REC 100%		212												
211.5 40.7	End of Borehole																		
	Notes: 1. Switched to NW casing at 8.2 m depth (Elev. 244.0 m). 2. On July 28, 2009, with casing at 24.4 m depth (Elev. 227.8 m) water level measured in casing at 2.1 m above existing ground surface (Elev. 254.3 m).																		

MIS-MTO 001 NORTH WICKLOW BH METRIC.GPJ GAL-MISS.GDT 11/12/09 ACM

PROJECT: 07-1191-0008

RECORD OF DRILLHOLE: NW-8

SHEET 1 OF 1

LOCATION: N 5423378.8 ;E 304148.6

DRILLING DATE: July 28 and 29, 2009

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 45

DRILLING CONTRACTOR: Downing Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE min(m)	FLUSH	COLOUR % RETURN	JN - Joint FLT - Fault SHR- Shear VN - Vein CJ - Conjugate										BD- Bedding FO- Foliation CO- Contact OR- Orthogonal CL - Cleavage										PL - Planar CU- Curved UN- Undulating ST - Stepped IR - Irregular										PO- Polished K - Slickensided SM- Smooth Ro - Rough MB- Mechanical Break										BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.	NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
									RECOVERY			R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA										HYDRAULIC CONDUCTIVITY K, cm/sec		Diameter Point Load Index (MPa)	RMC -Q AVG.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
									TOTAL CORE %	SOLID CORE %	B Angle			DIP W.R.T. CORE AXIS	TYPE AND SURFACE DESCRIPTION										Jr			Ja	Jn	10°	10°	10°																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
36	July 29, 2009 NQ RC	Refer to Previous Page		216.30 35.90																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	

DEPTH SCALE

1 : 50



LOGGED: ID

CHECKED: AB

MIS-RCK 004 NORTH WICKLOW BH METRIC.GPJ GAL-MISS.GDT 11/12/09 ACM

MIS-MTO 001 NORTH WICKLOW BH METRIC.GPJ GAL-MISS.GDT 11/12/09 ACM

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



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

MIS-MTO 001 NORTH WICKLOW BH METRIC.GPJ GAL-MISS.GDT 11/12/09 ACM



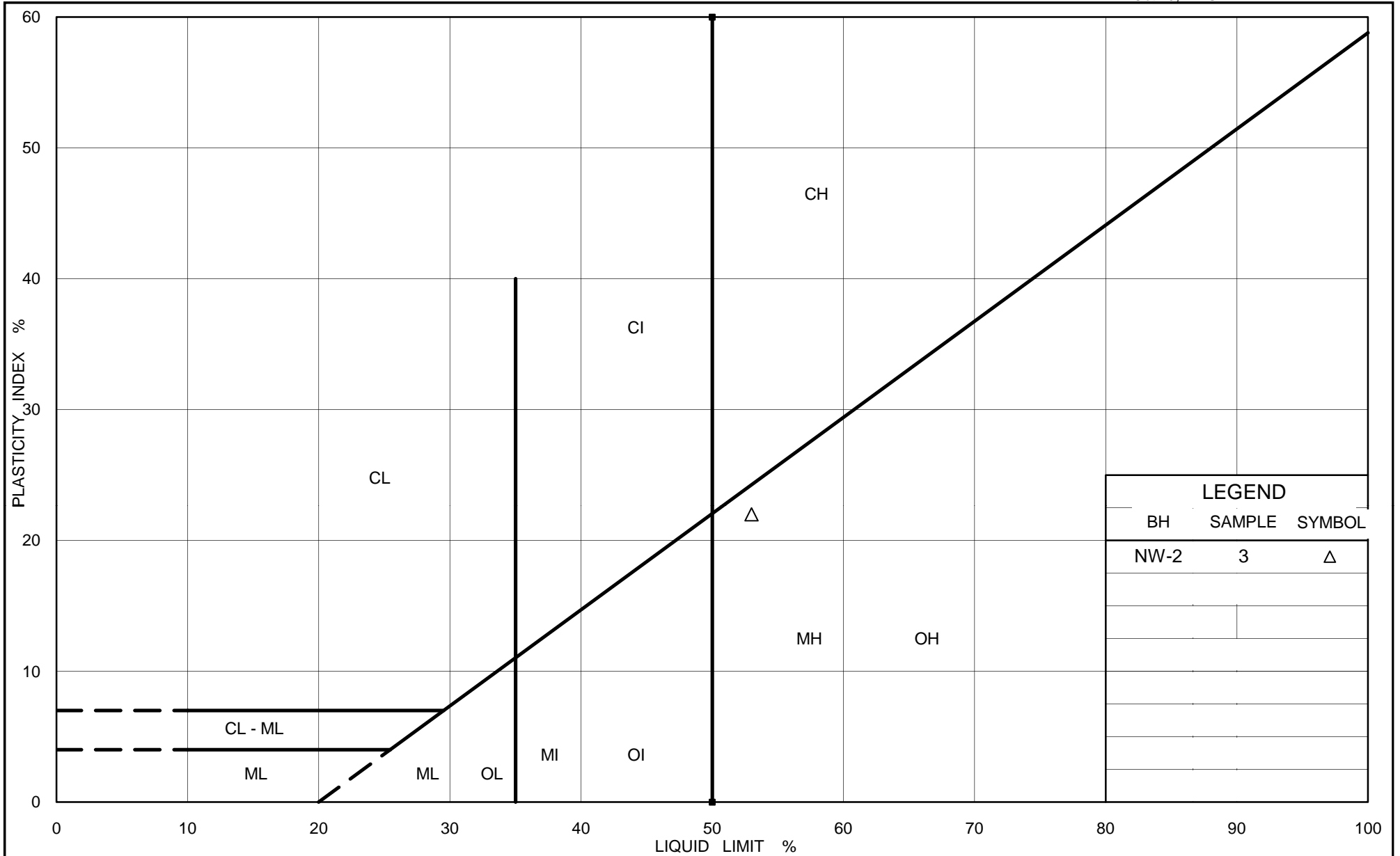
APPENDIX B

LABORATORY TEST RESULTS

TABLE B-1
UNIAXIAL COMPRESSIVE STRENGTH TEST RESULTS
REPLACEMENT OF NORTH WICKLOW RIVER STRUCTURE
GWP 5055-06-00, SITE NO. 39E-063
HIGHWAY 11, TOWNSHIP OF HANNA

Borehole Number	Sample Depth (m)	Sample Elevation (m)	Rock Type	Core Diameter (mm)	Uniaxial Compressive Strength (MPa)
NW-2	35.7	215.6	Granite	47.5	20
NW-2	38.7	212.6	Granite	47.5	40
NW-3	37.2	213.8	Granite	47.5	6
NW-3	38.7	212.3	Granite	47.5	6
NW-5	33.8	217.8	Granite	47.5	64
NW-5	35.7	215.9	Granite	47.5	76
NW-6	36.9	218.2	Granite	47.5	11
NW-6	38.6	216.5	Granite	47.5	34
NW-8	37.0	215.2	Granite	47.5	26

Compiled by: AB
Reviewed By: JMAC



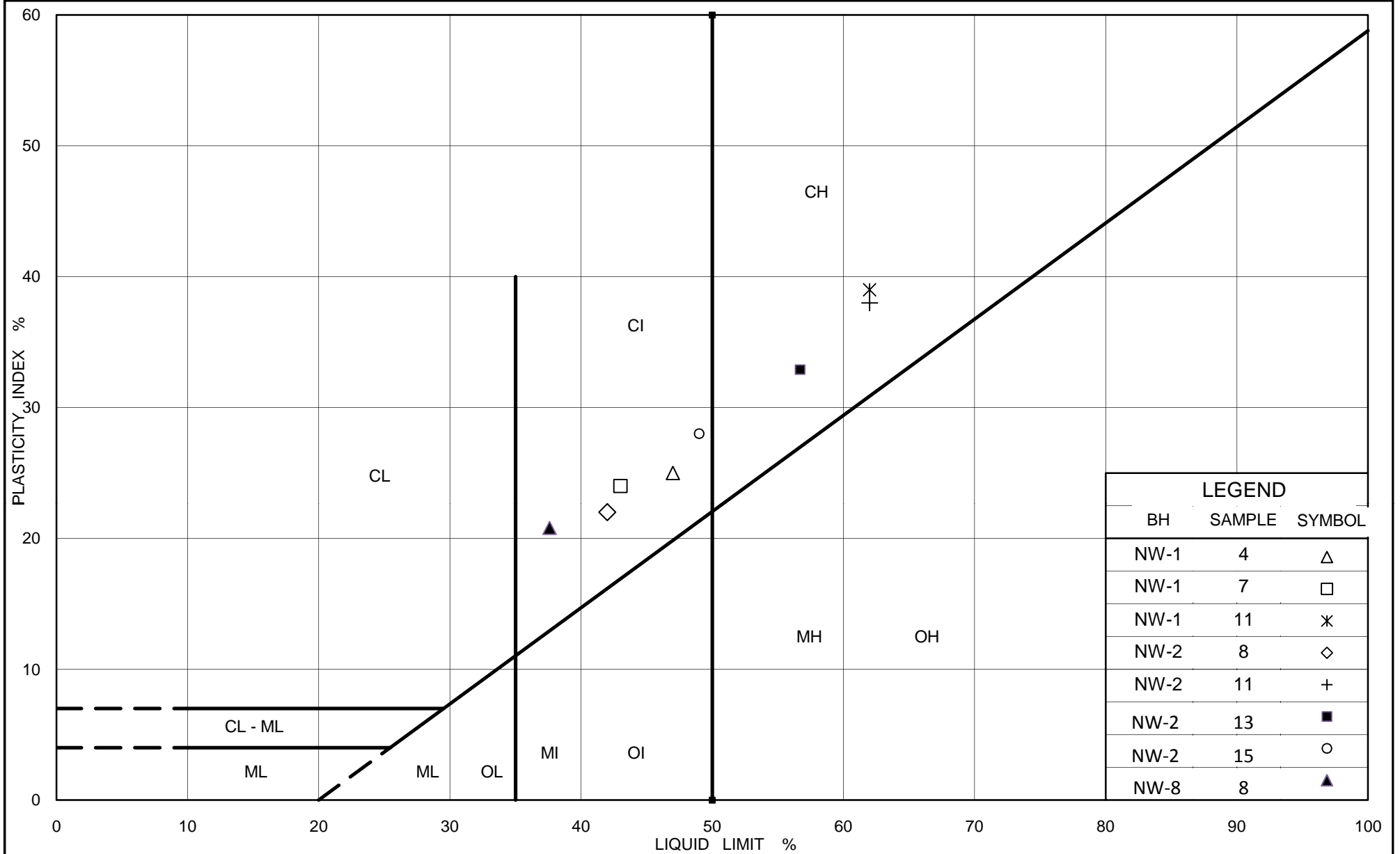
Ministry of Transportation
Ontario

PLASTICITY CHART Inorganic Silt of High Plasticity

Figure B-1

Project No. 07-1191-0008-NW

Checked By: AB



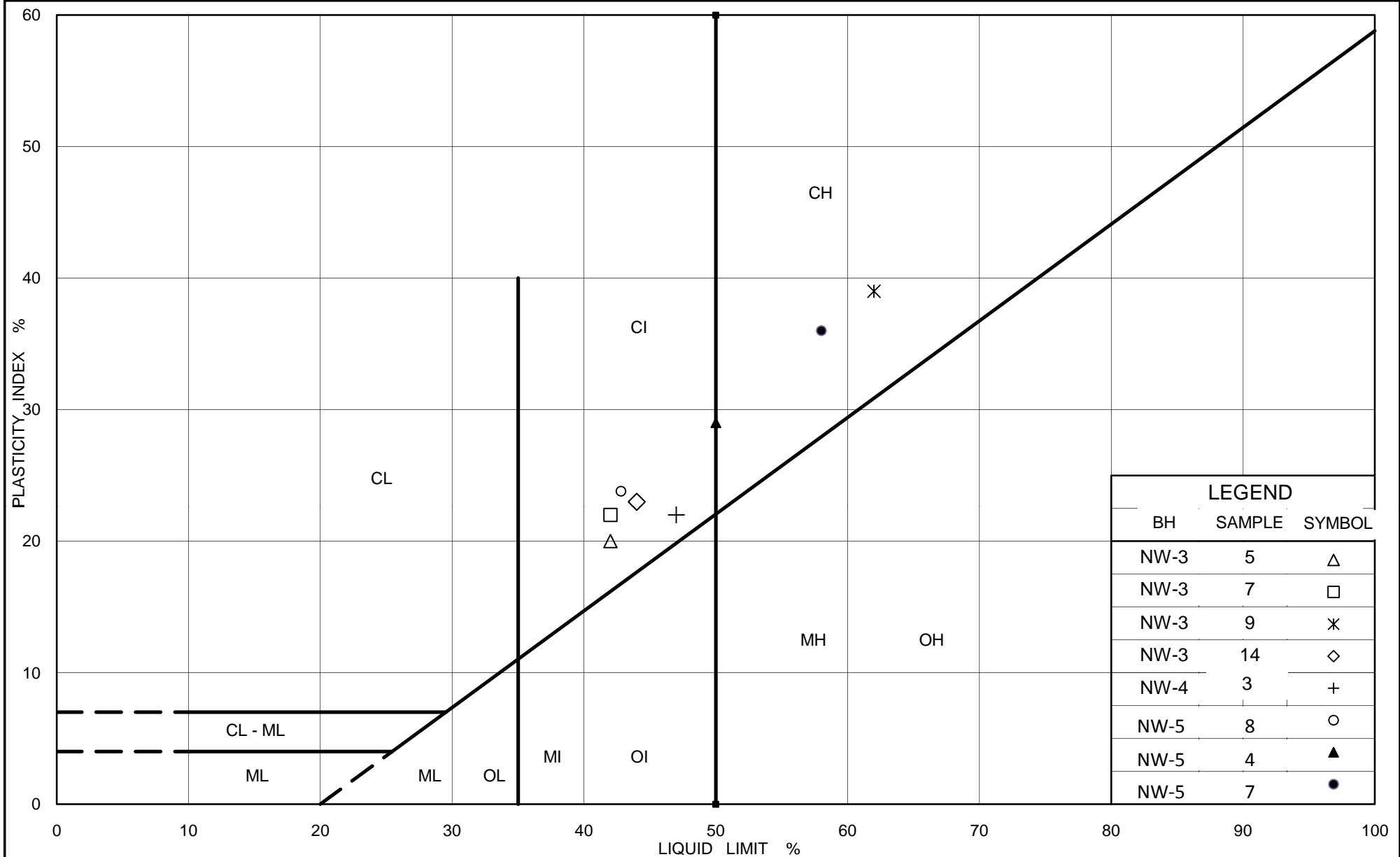
Ministry of Transportation
Ontario

PLASTICITY CHART Silty Clay to Clay

Figure B-2i

Project No. 07-1191-0008-NW

Checked By: AB



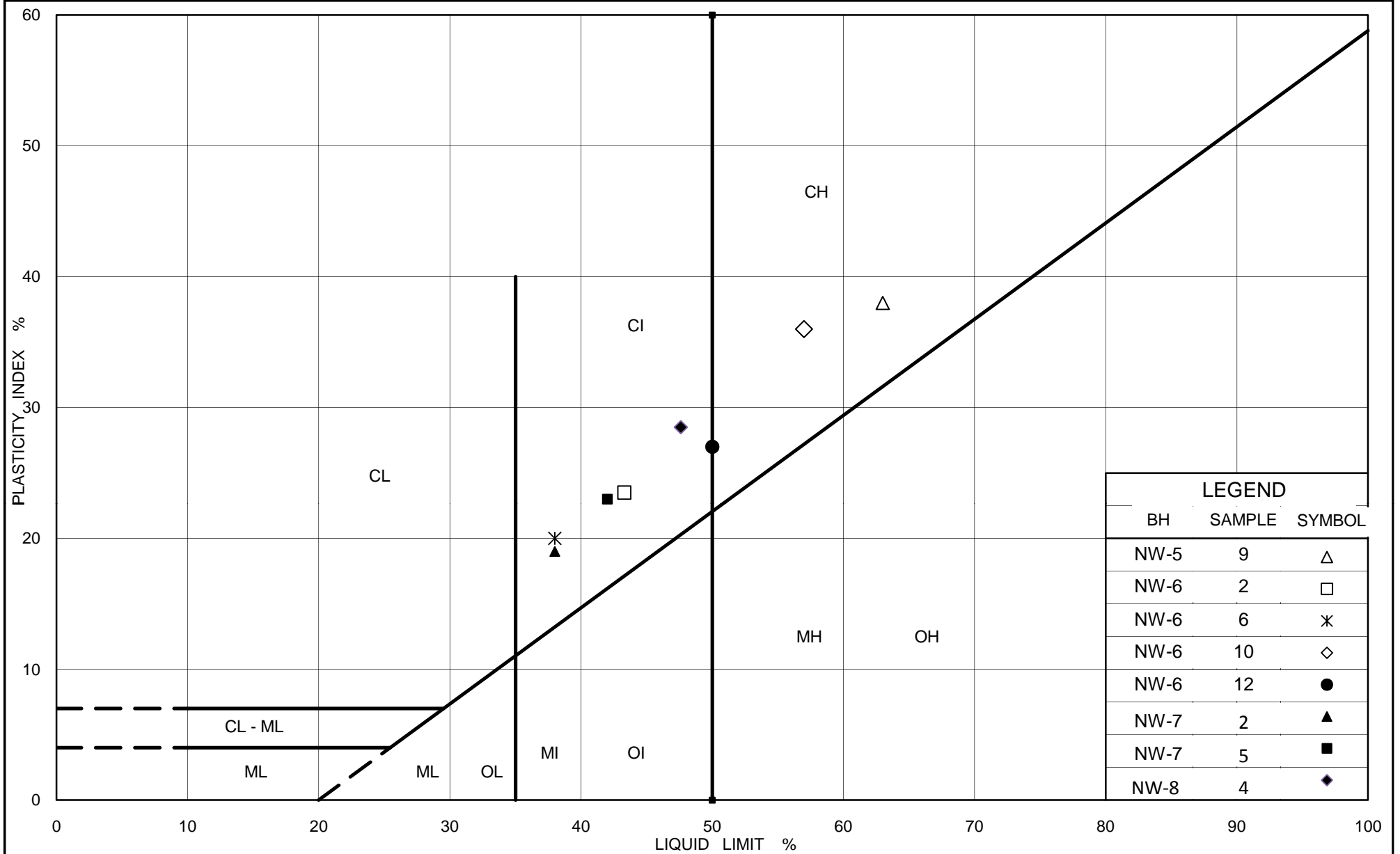
Ministry of Transportation
Ontario

PLASTICITY CHART Silty Clay to Clay

Figure B-2ii

Project No. 07-1191-0008-NW

Checked By: AB



Ministry of Transportation
Ontario

PLASTICITY CHART Silty Clay to Clay

Figure B-2iii

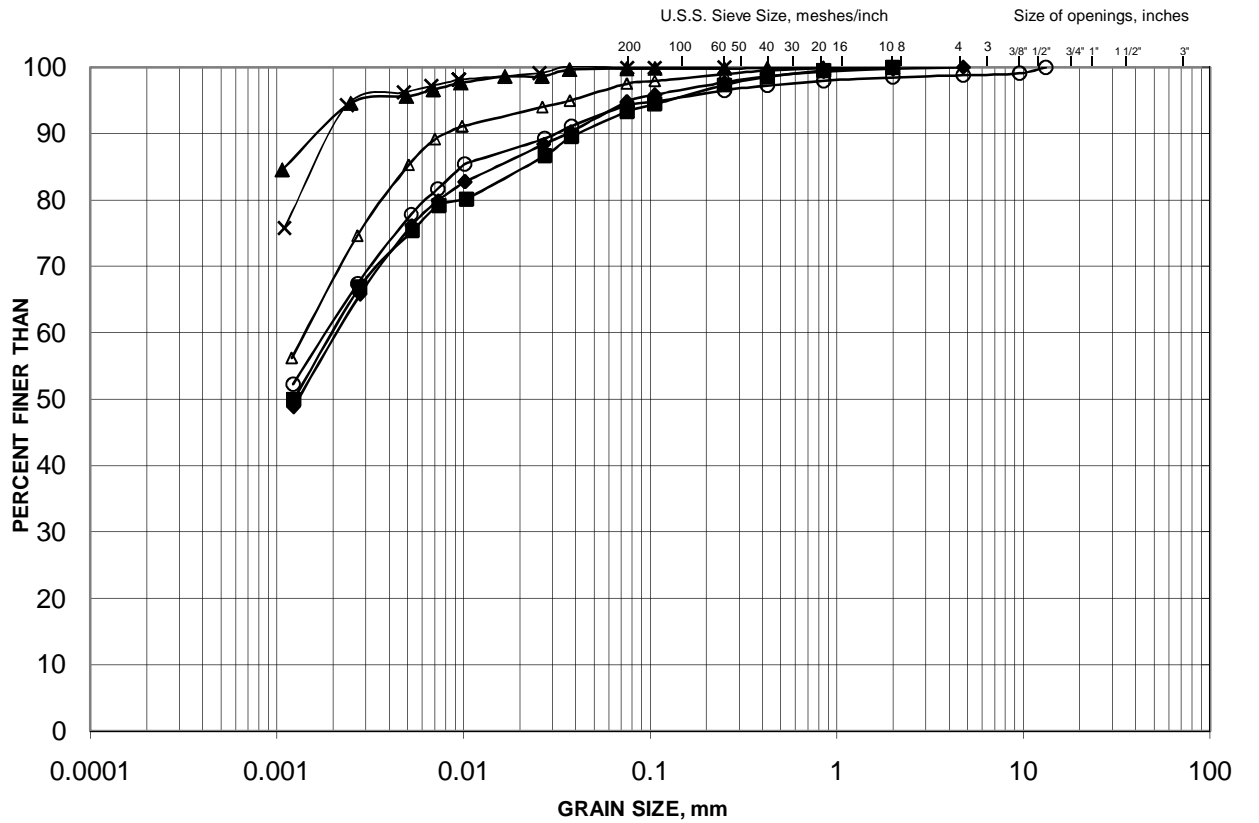
Project No. 07-1191-0008-NW

Checked By: AB

GRAIN SIZE DISTRIBUTION

Silty Clay to Clay

FIGURE
B-3i



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
△	NW-1	6	248.3
◆	NW-1	9	244.5
■	NW-2	9	244.9
▲	NW-2	14	237.3
○	NW-3	8	244.6
×	NW-3	12	238.4

Project Number: 07-1191-0008-NW

Checked By: AB

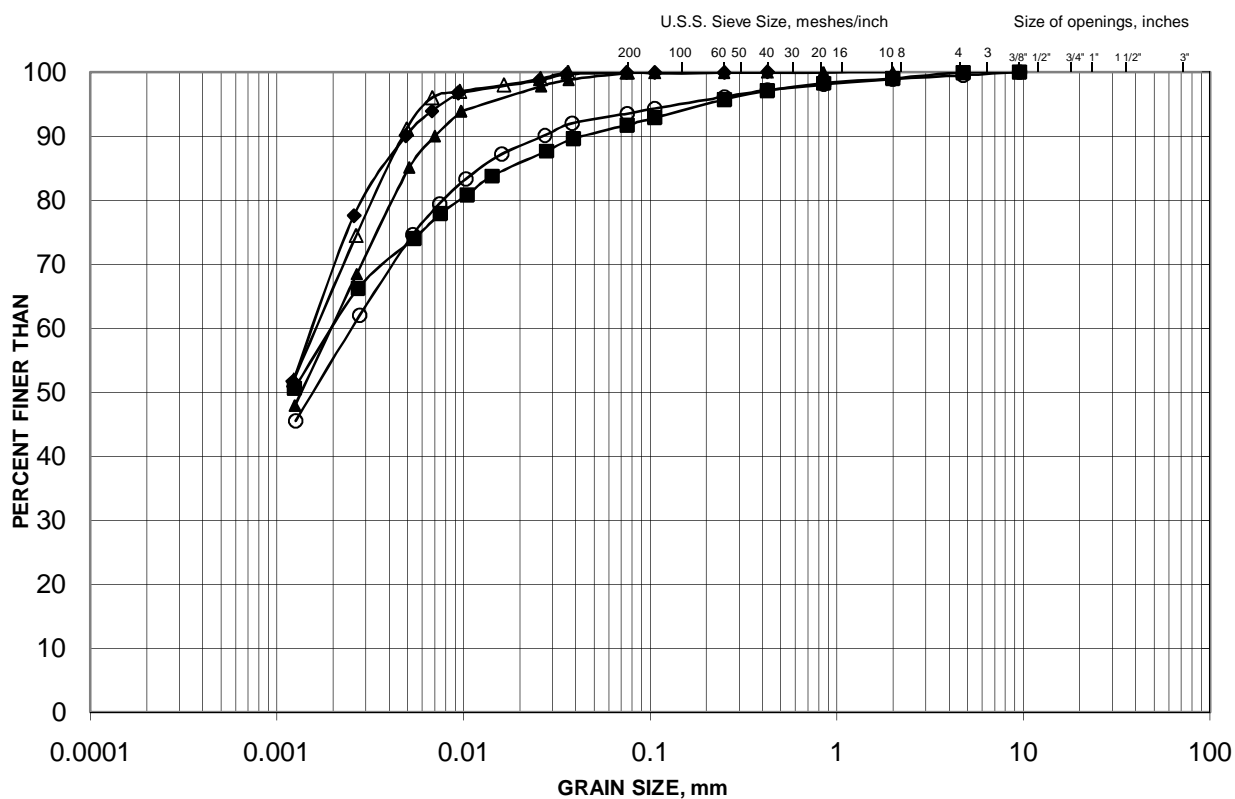
Golder Associates

Date: December 2009

GRAIN SIZE DISTRIBUTION

Silty Clay to Clay

FIGURE
B-3ii



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
▲	NW-3	16	232.3
◆	NW-4	10	239.3
■	NW-5	6	247.5
△	NW-5	11	240.6
○	NW-6	5	251.7

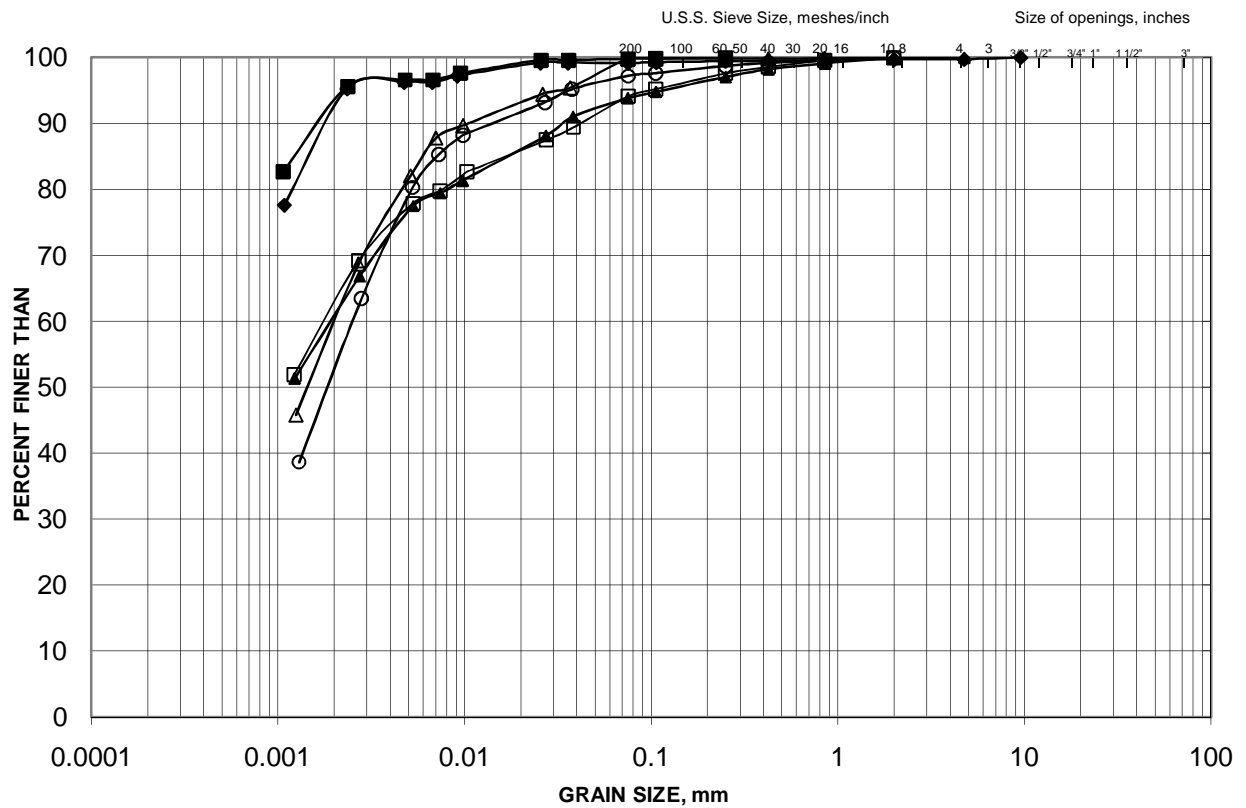
Project Number: 07-1191-0008-NW

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Date: December 2009

**FIGURE
B-3iii**



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
	NW-6	8	248.7
	NW-6	10	245.7
	NW-6	11	244.1
	NW-6	14	239.6
	NW-7	3	255.7
	NW-7	7	251.4

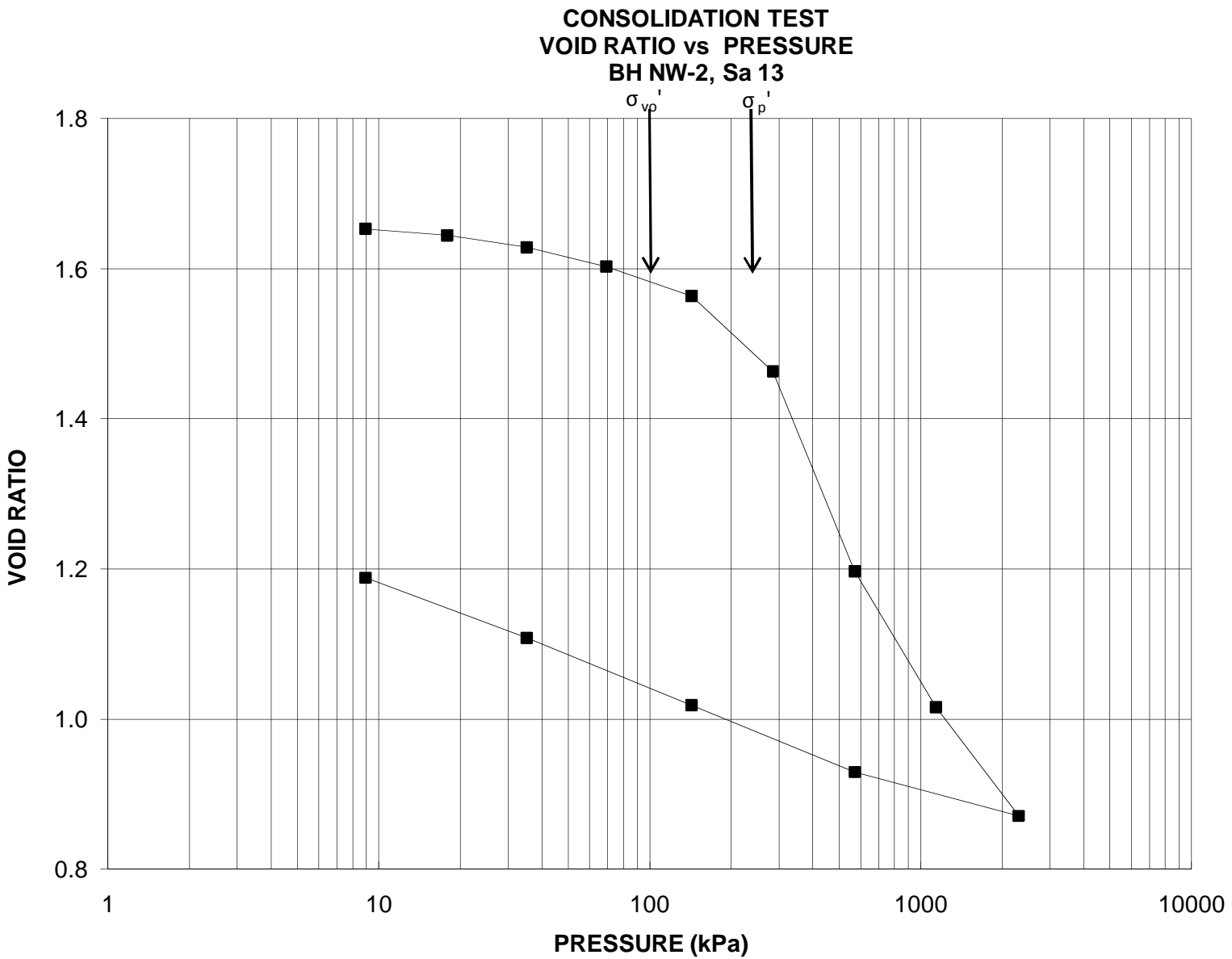
Project Number: 07-1191-0008-NW

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OEDOMETER CONSOLIDATION SUMMARY						FIGURE B-4 Page 1 of 4		
SAMPLE IDENTIFICATION								
Project Number		07-1191-0008-NW			Sample Number		13	
Borehole Number		NW-2			Sample Depth, (m)		12.5	
TEST CONDITIONS								
Test Type		Standard			Load Duration, hr		24	
Oedometer Number		1						
Date Started		11-Nov-08						
Date Completed		24-Nov-08						
SAMPLE DIMENSIONS AND PROPERTIES - INITIAL								
Sample Height, cm		2.538			Unit Weight, kN/m ³		16.5	
Sample Diameter, cm		6.342			Dry Unit Weight, kN/m ³		10.0	
Area, cm ²		31.59			Specific Gravity, assumed		2.7	
Volume, cm ³		80.17			Solids Height, cm		0.954	
Water Content, %		65.9			Volume of Solids, cm ³		30.15	
Wet Mass, g		135.07			Volume of Voids, cm ³		50.02	
Dry Mass, g		81.41			Degree of Saturation, %		107.3	
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	1.659	2.538				
8.9	0.06	2.532	1.653	2.535	190	0.00663	0.254	1.649E-07
17.9	0.08	2.524	1.644	2.528	300	0.00418	0.367	1.503E-07
35.1	0.15	2.509	1.628	2.516	410	0.00303	0.348	1.032E-07
69.2	0.24	2.484	1.603	2.497	400	0.00305	0.285	8.550E-08
142.6	0.38	2.447	1.564	2.466	440	0.00271	0.205	5.459E-08
284.9	0.96	2.351	1.463	2.399	1000	0.00113	0.276	3.051E-08
570.5	2.54	2.097	1.197	2.224	1500	0.00065	0.378	2.399E-08
1139.6	1.73	1.924	1.016	2.010	910	0.00087	0.145	1.238E-08
2300.0	1.38	1.786	0.871	1.855	600	0.00112	0.062	6.816E-09
570.5	-0.56	1.842	0.930	1.814				
142.6	-0.85	1.927	1.019	1.884				
35.1	-0.86	2.012	1.108	1.970				
8.9	-0.76	2.089	1.188	2.051				
Notes: k calculated using cv based on t ₅₀ values.								
SAMPLE DIMENSIONS AND PROPERTIES - FINAL								
Sample Height, cm		2.089			Unit Weight, kN/m ³		17.8	
Sample Diameter, cm		6.342			Dry Unit Weight, kN/m ³		12.1	
Area, cm ²		31.59			Specific Gravity, assumed		2.7	
Volume, cm ³		65.98			Solids Height, cm		0.954	
Water Content, %		46.9			Volume of Solids, cm ³		30.15	
Wet Mass, g		119.58			Volume of Voids, cm ³		35.83	
Dry Mass, g		81.41			Degree of Saturation, %		106.5	
Prepared By: SL			Golder Associates			Checked By: AB		

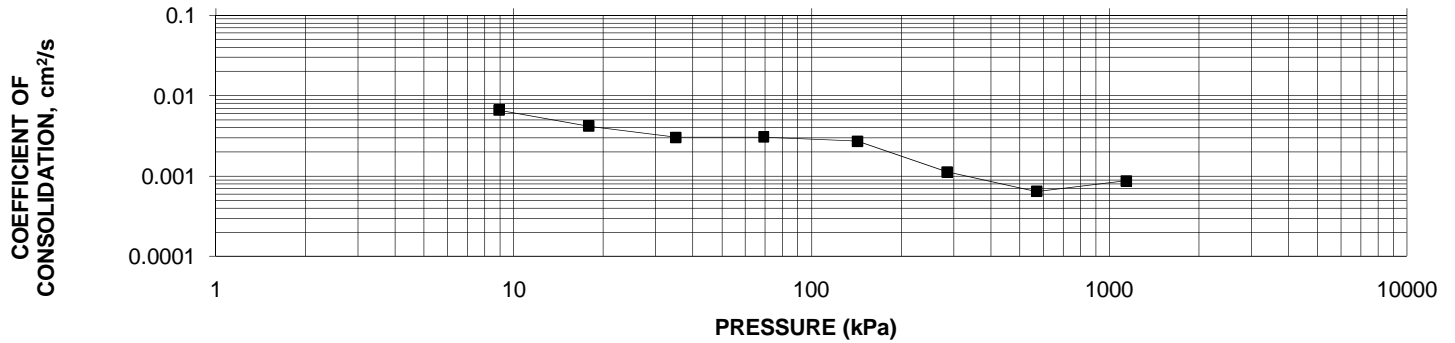


OEDOMETER CONSOLIDATION SUMMARY

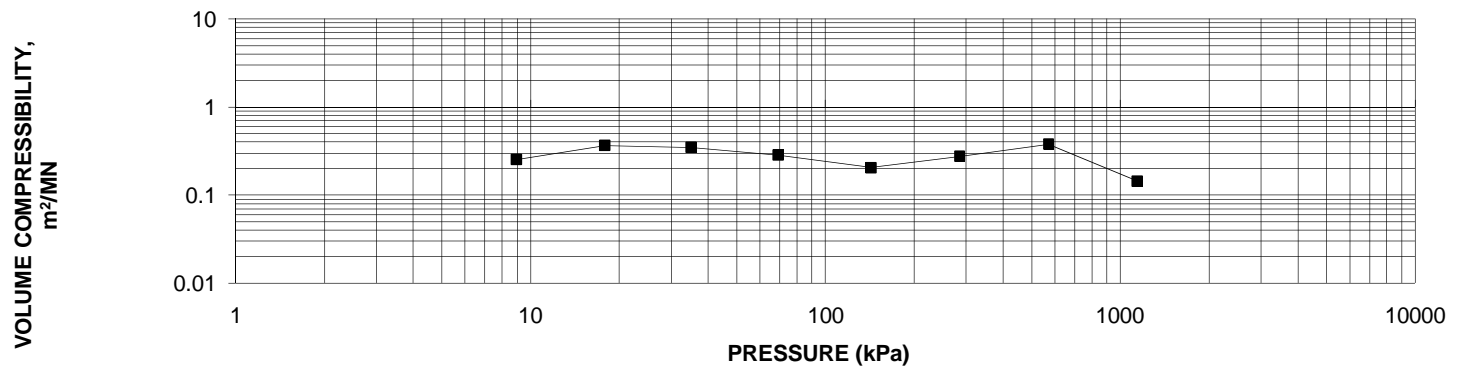
FIGURE B-4

Page 3 of 4

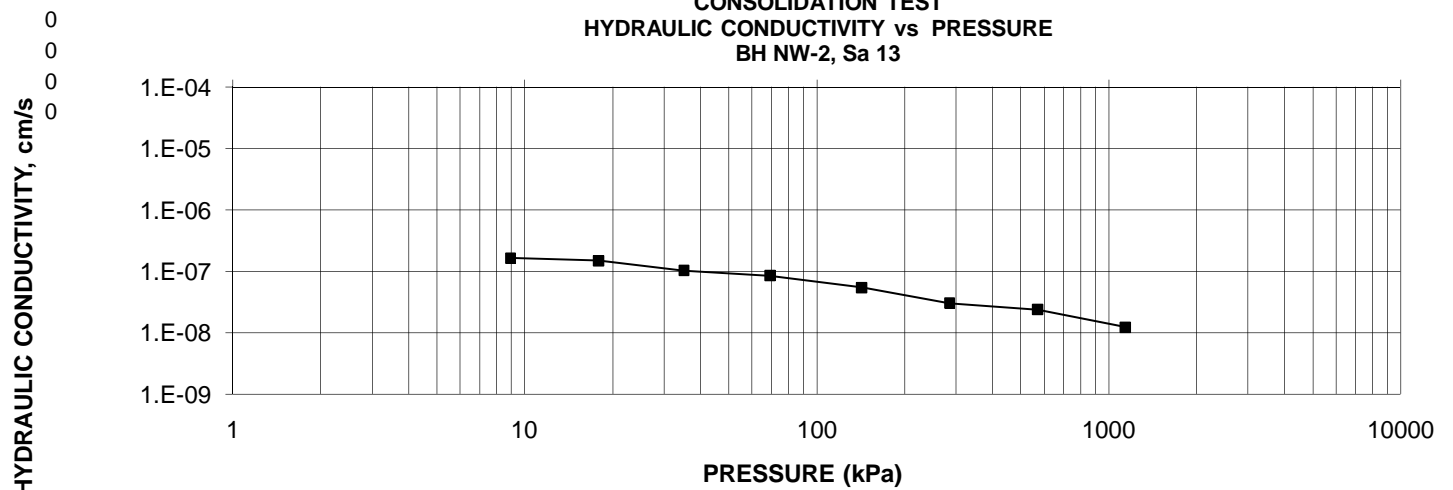
CONSOLIDATION TEST
CV cm²/s VS PRESSURE (kPa)
BH NW-2, Sa 13

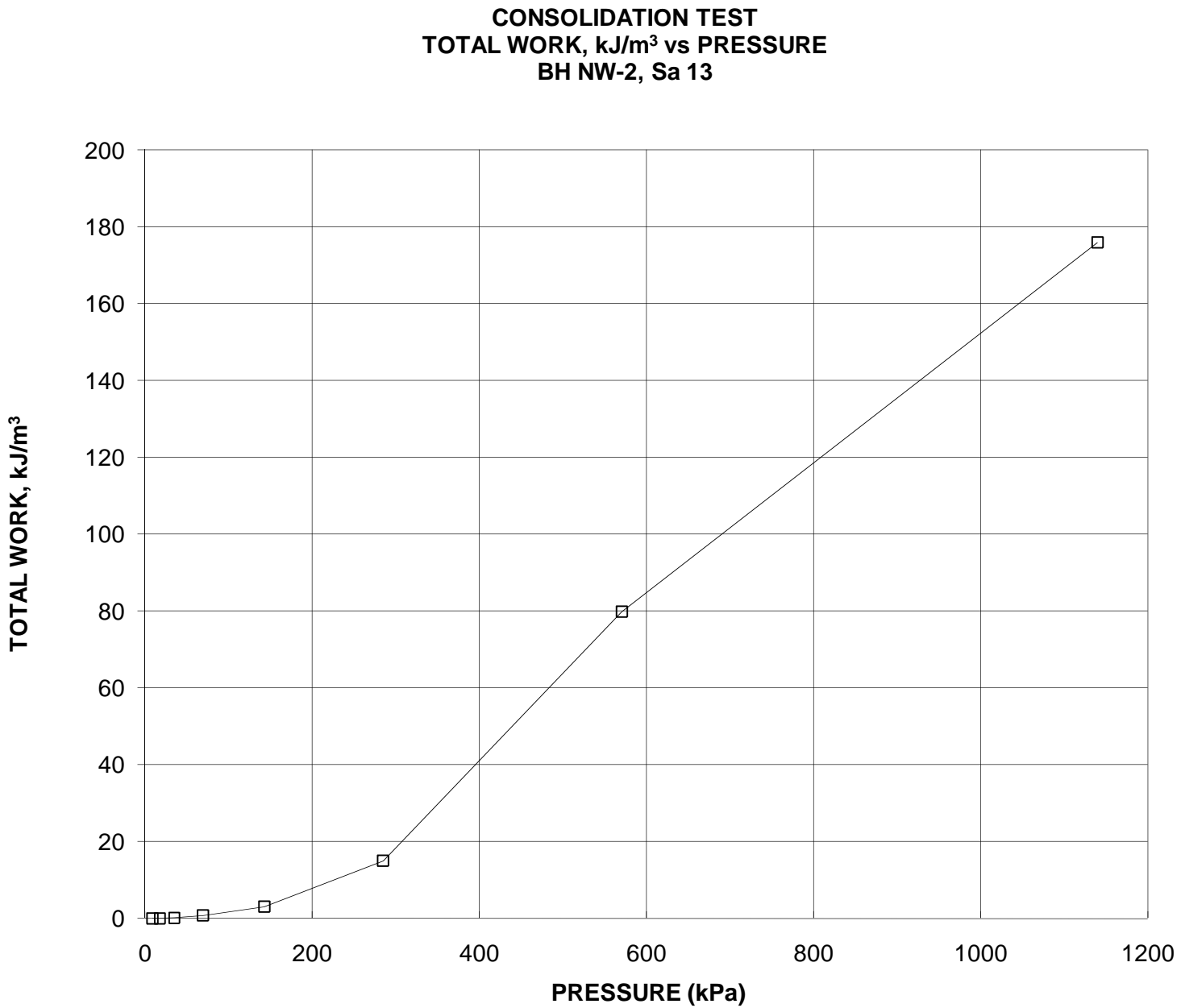


CONSOLIDATION TEST
MV m²/MN vs PRESSURE (kPa)
BH NW-2, Sa 13

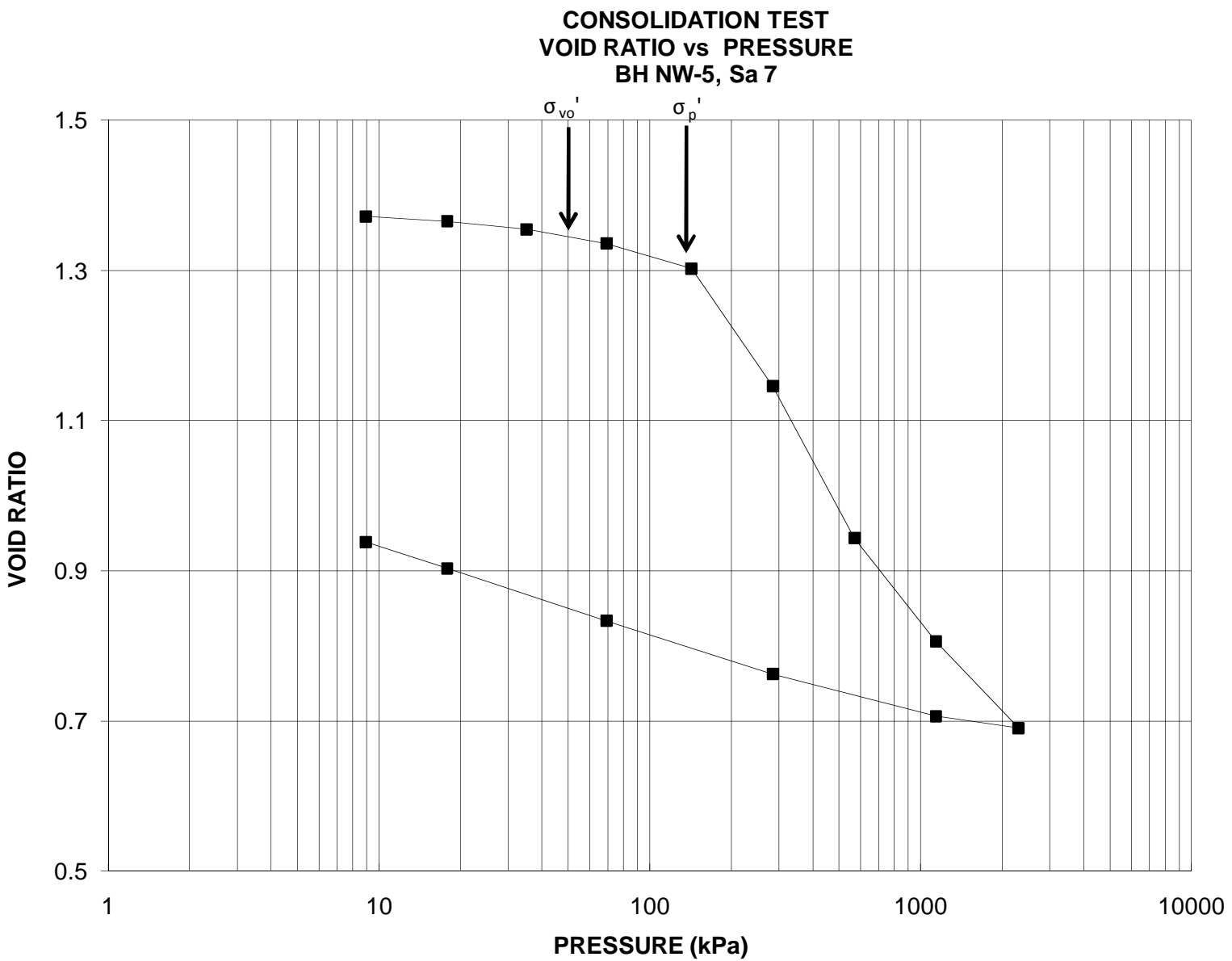


CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs PRESSURE
BH NW-2, Sa 13





OEDOMETER CONSOLIDATION SUMMARY						FIGURE B-5 Page 1 of 4		
SAMPLE IDENTIFICATION								
Project Number		07-1191-0008-NW			Sample Number		7	
Borehole Number		NW-5			Sample Depth, (m)		5.6	
TEST CONDITIONS								
Test Type		Standard			Load Duration, hr		24	
Oedometer Number		1						
Date Started		October 7, 2008						
Date Completed		October 20, 2008						
SAMPLE DIMENSIONS AND PROPERTIES - INITIAL								
Sample Height, cm		2.538			Unit Weight, kN/m ³		17.3	
Sample Diameter, cm		6.342			Dry Unit Weight, kN/m ³		11.1	
Area, cm ²		31.59			Specific Gravity, assumed		2.7	
Volume, cm ³		80.17			Solids Height, cm		1.067	
Water Content, %		55.1			Volume of Solids, cm ³		33.71	
Wet Mass, g		141.22			Volume of Voids, cm ³		46.46	
Dry Mass, g		91.03			Degree of Saturation, %		108.0	
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	1.378	2.538				
14.6	0.07	2.531	1.372	2.535	310	0.00406	0.178	7.093E-08
29.2	0.07	2.525	1.365	2.528	190	0.00659	0.186	1.206E-07
57.4	0.12	2.513	1.355	2.519	260	0.00478	0.162	7.592E-08
113.1	0.20	2.493	1.336	2.503	200	0.00614	0.143	8.641E-08
233.3	0.36	2.457	1.302	2.475	400	0.00300	0.119	3.500E-08
466.1	1.67	2.290	1.146	2.374	2200	0.00050	0.292	1.438E-08
933.2	2.16	2.074	0.944	2.182	1100	0.00085	0.202	1.681E-08
1864.2	1.47	1.927	0.806	2.001	700	0.00112	0.076	8.370E-09
3728.4	1.23	1.804	0.691	1.866	430	0.00159	0.034	5.329E-09
1864.2	-0.17	1.821	0.706	1.813				
466.5	-0.60	1.881	0.763	1.851				
113.7	-0.76	1.957	0.834	1.919				
29.2	-0.74	2.031	0.903	1.994				
14.7	-0.38	2.069	0.938	2.050				
Notes: k calculated using cv based on t ₅₀ values.								
SAMPLE DIMENSIONS AND PROPERTIES - FINAL								
Sample Height, cm		2.069			Unit Weight, kN/m ³		19.0	
Sample Diameter, cm		6.342			Dry Unit Weight, kN/m ³		13.7	
Area, cm ²		31.59			Specific Gravity, assumed		2.7	
Volume, cm ³		65.36			Solids Height, cm		1.067	
Water Content, %		39.1			Volume of Solids, cm ³		33.71	
Wet Mass, g		126.63			Volume of Voids, cm ³		31.64	
Dry Mass, g		91.03			Degree of Saturation, %		112.5	
Prepared By: SL			Golder Associates			Checked By: AB		

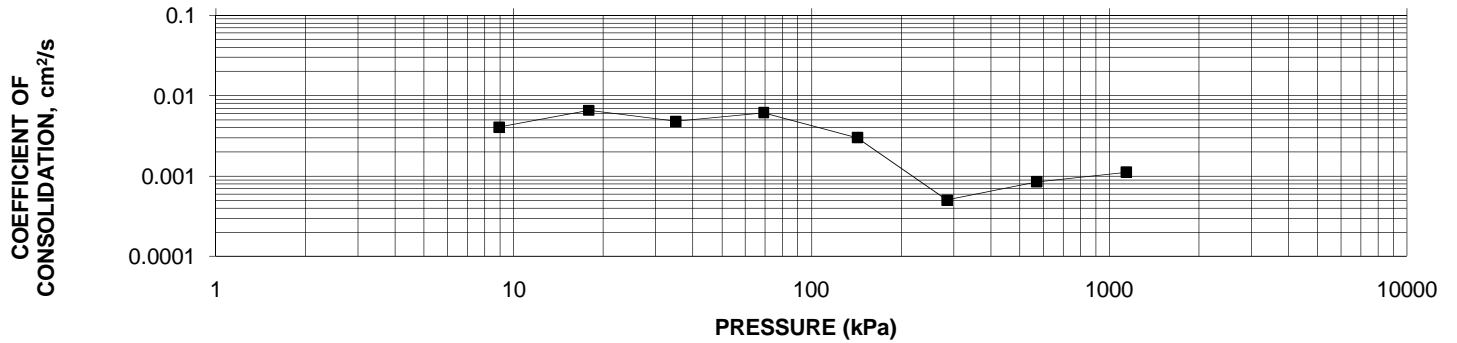


OEDOMETER CONSOLIDATION SUMMARY

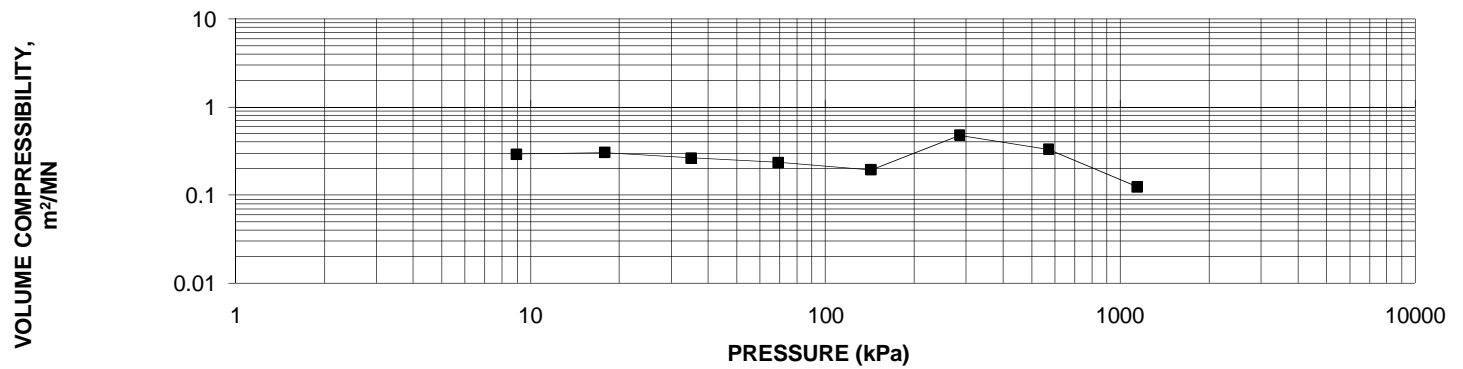
FIGURE B-5

Page 3 of 4

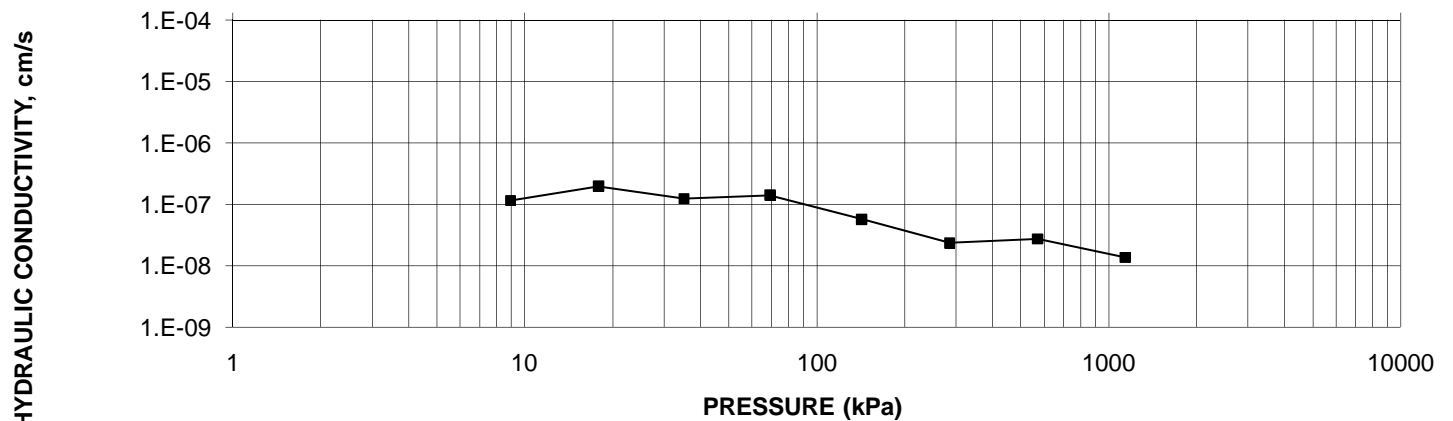
CONSOLIDATION TEST
CV cm²/s VS PRESSURE (kPa)
BH NW-5, Sa 7

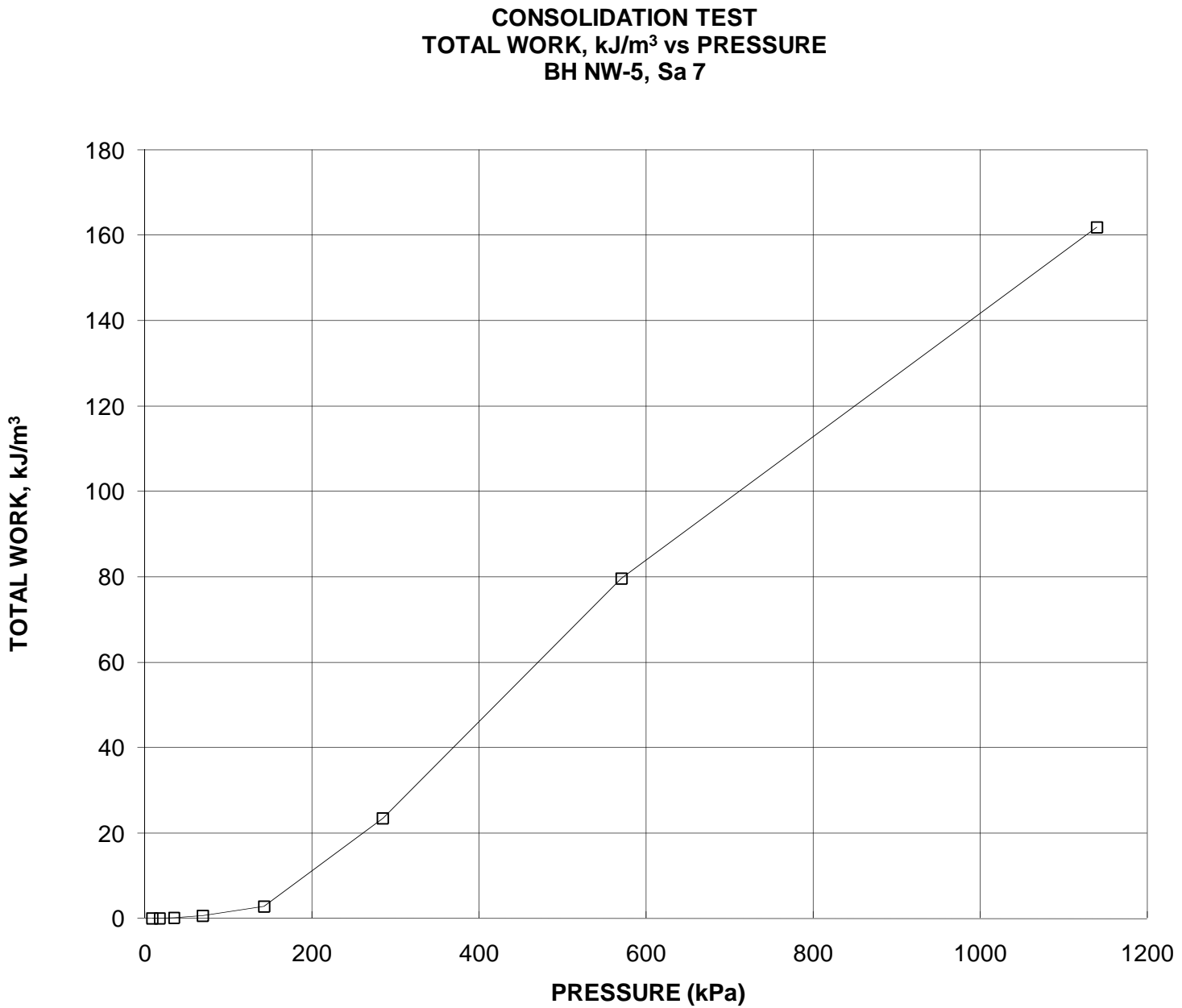


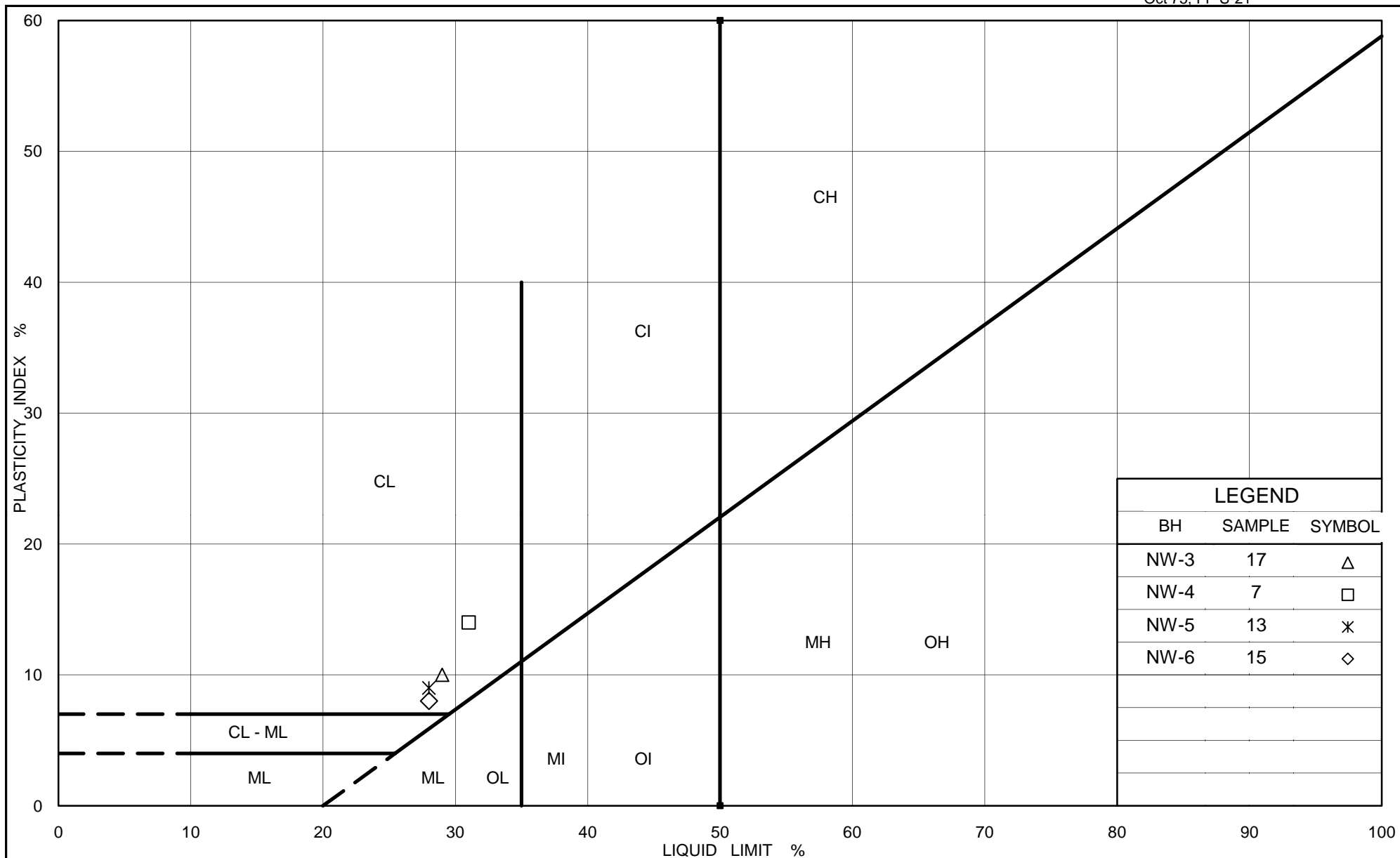
CONSOLIDATION TEST
MV m²/MN vs PRESSURE (kPa)
BH NW-5, Sa 7



CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs PRESSURE
BH NW-5, Sa 7







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PLASTICITY CHART Clayey Silt

Figure B-6

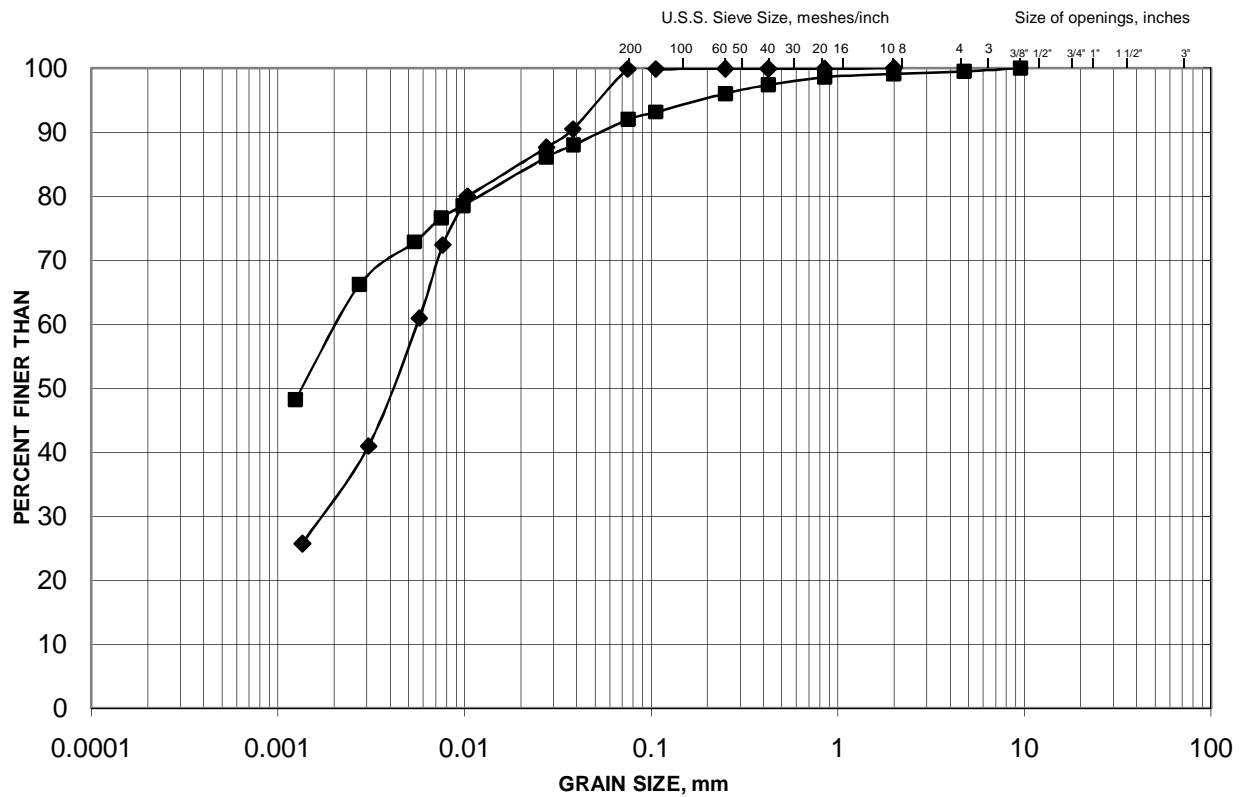
Project No. 07-1191-0008-NW

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GRAIN SIZE DISTRIBUTION

Clayey Silt (seams)

FIGURE
B-7



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

LEGEND

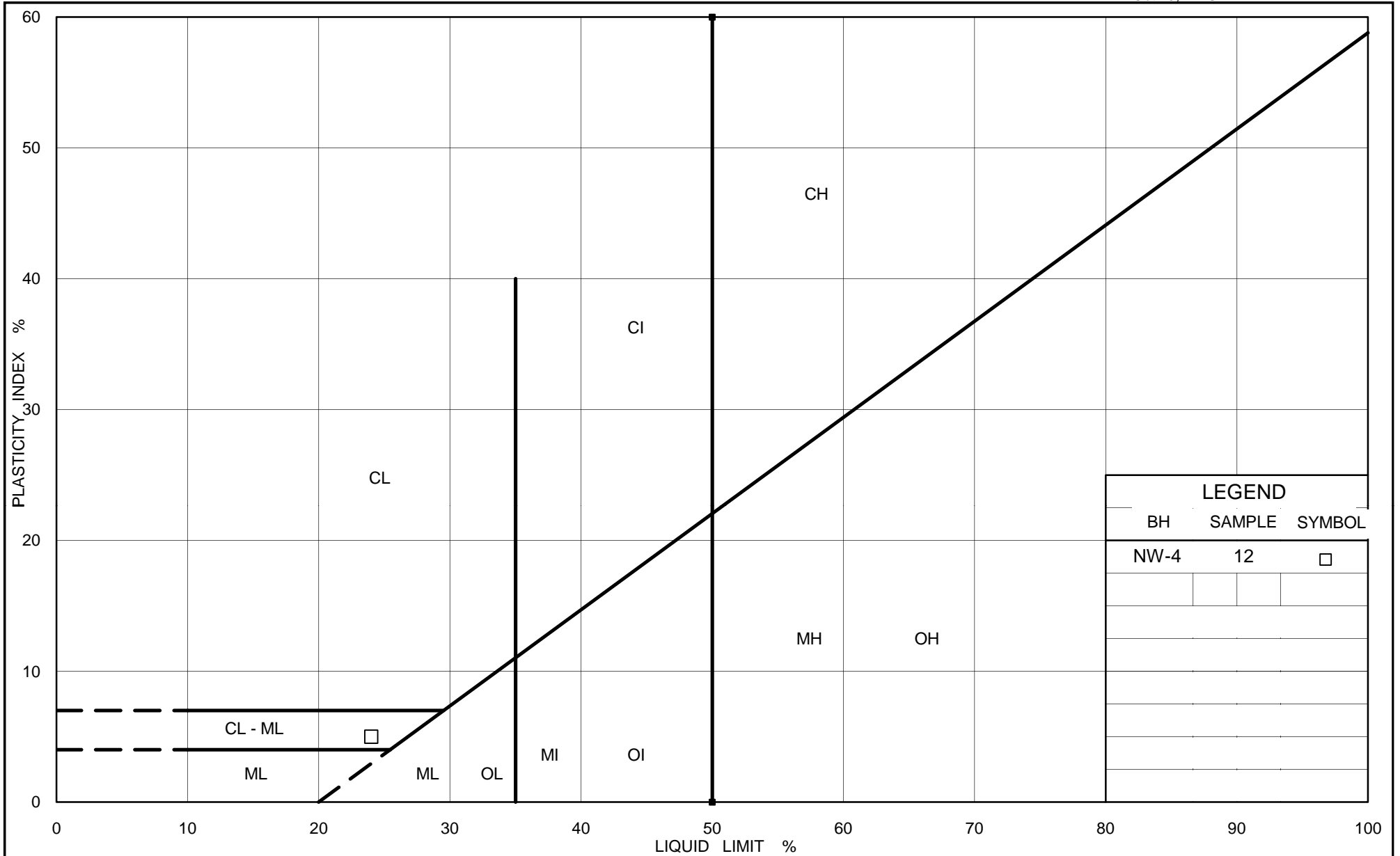
SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
◆	NW-2	18	228.1
■	NW-4	7	244.2

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Ministry of Transportation
Ontario

PLASTICITY CHART Silt

Figure B-8

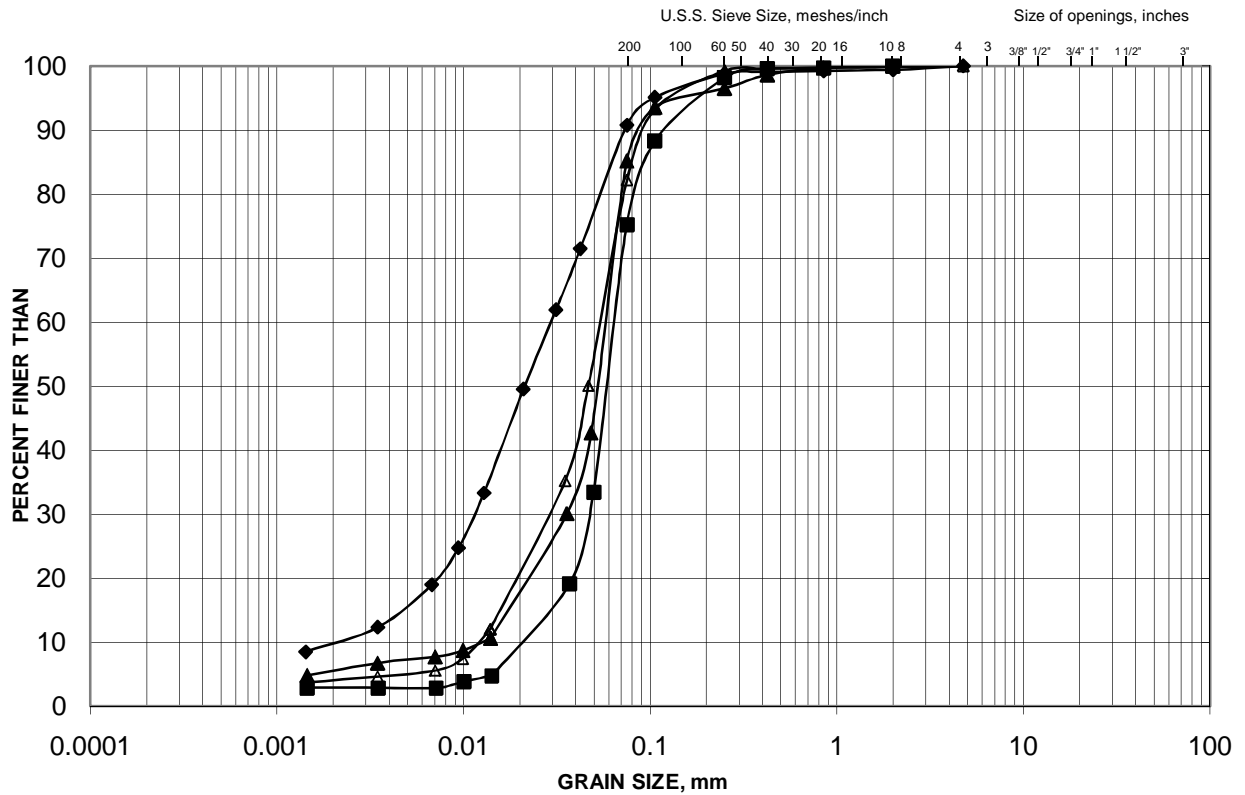
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GRAIN SIZE DISTRIBUTION

Silt to Sandy Silt

FIGURE
B-9i



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
—△—	NW-2	20	222.0
—◆—	NW-3	19	224.8
—■—	NW-4	13	234.8
—▲—	NW-4	17	227.1

Project Number: 07-1191-0008-NW

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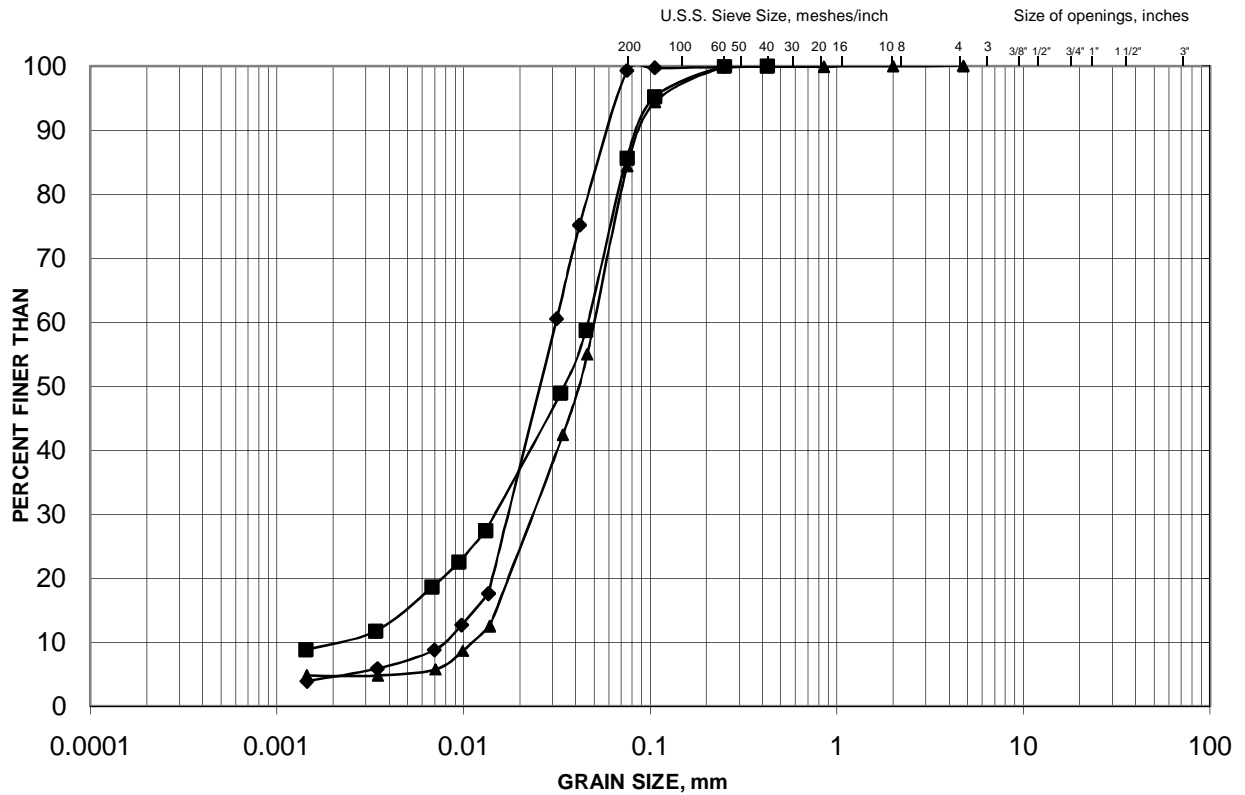
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GRAIN SIZE DISTRIBUTION

Silt to Sandy Silt

FIGURE
B-9ii



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
▲	NW-5	16	233.0
◆	NW-5	18	228.4
■	NW-6	16	235.0

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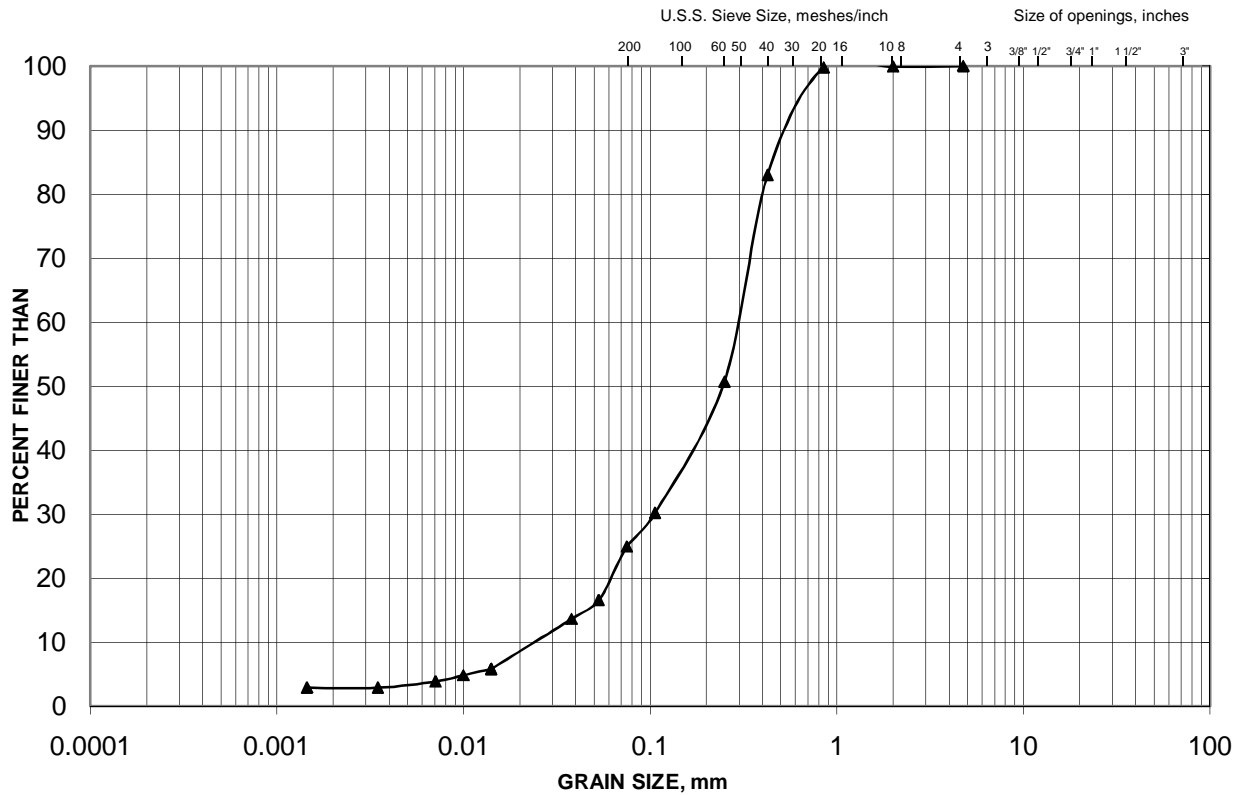
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GRAIN SIZE DISTRIBUTION

Silty Sand

FIGURE

B-10



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
▲	NW-6	18	228.9

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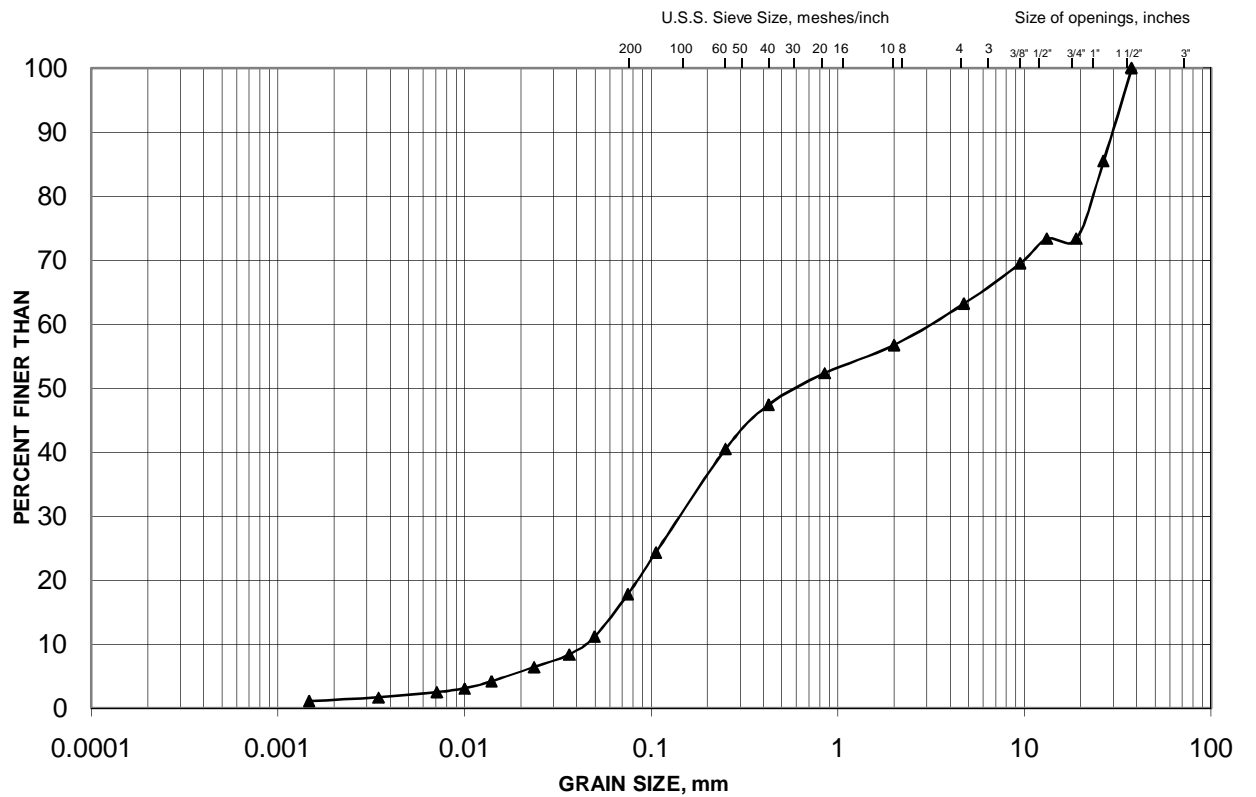
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GRAIN SIZE DISTRIBUTION

Sand and Gravel

**FIGURE
B-11**



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
—▲—	NW-8	21	219.9

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