

Golder Associates Ltd.

2390 Argentia Road
Mississauga, Ontario, Canada L5N 5Z7
Telephone: (905) 567-4444
Fax: (905) 567-6561



**FOUNDATION
INVESTIGATION AND DESIGN REPORT
TRICHORD OVERHEAD SIGNS
BETWEEN MOODIE DRIVE AND HIGHWAY 416
HIGHWAY 417 WIDENING
G.W.P. 458-98-00**

Submitted to:

Marshall Macklin Monaghan
80 Commerce Valley Drive East
Thornhill, Ontario
L3T 7N4

GEOCREs No. 31G5-199

DISTRIBUTION:

- 1 Copy - Marshall Macklin Monaghan, Thornhill, Ontario
- 1 Copy - Totten Sims Hubicki, Whitby, Ontario
- 3 Copies - Ministry of Transportation, Kingston, Ontario
- 1 Copy - Ministry of Transportation, Downsview, Ontario
- 2 Copies - Golder Associates Ltd., Mississauga, Ontario

December 2006

021-1155-11



TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
PART A - FOUNDATION INVESTIGATION REPORT	
1.0 INTRODUCTION	1
2.0 SITE DESCRIPTION	2
3.0 INVESTIGATION PROCEDURES	3
4.0 SITE GEOLOGY AND STRATIGRAPHY	4
4.1 Regional Geological Conditions	4
4.2 Site Stratigraphy	4
4.2.1 Embankment Fill	5
4.2.2 Topsoil	6
4.2.3 Silty Sand	6
4.2.4 Clayey Silt to Silty Clay	6
4.2.5 Sand and Silt Till	7
4.2.6 Sandstone Bedrock	7
4.3 Groundwater Conditions	8
5.0 CLOSURE	9
PART B - FOUNDATION DESIGN REPORT	
6.0 ENGINEERING RECOMMENDATIONS	10
6.1 General	10
6.2 Trichord Overhead Sign Foundations	10
6.2.1 Caisson Foundations in Soil	12
6.2.2 Caisson Foundations Socketted into Rock	14
6.2.3 Foundations Anchored to Rock	14
6.3 Construction Considerations	15
7.0 CLOSURE	16

In Order
Following
Page 16

Table 1
Lists of Abbreviations and Symbols
Lithological and Geotechnical Rock Description Terminology
Records of Boreholes / Drillholes 03-1 to 03-10
Drawing 1
Figures 1 to 3

LIST OF TABLES

Table 1 Design Parameters for Trichord Overhead Sign Foundations

LIST OF DRAWINGS

Drawing 1 Highway 417, Overhead Sign Replacement, Borehole Locations

LIST OF FIGURES

Figure 1 Grain Size Distribution Test Results – Silty Clay

Figure 2 Plasticity Chart – Silty Clay

Figure 3 Grain Size Distribution Test Results – Sand and Silt Till

PART A

**FOUNDATION INVESTIGATION REPORT
TRICHORD OVERHEAD SIGNS
BETWEEN MOODIE DRIVE AND HIGHWAY 416
HIGHWAY 417 WIDENING
G.W.P. 458-98-00**

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Marshall Macklin Monaghan (MMM) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out foundation investigations associated with the twinning of Highway 7 from two to four lanes in the former West Carleton and Goulbourn Townships which are now part of the City of Ottawa, and in Beckwith Township in Lanark County. The sections of Highway 7 included in this assignment extend from Highway 417 westerly 7 km to 3 km west of Jinkinson Road (W.P. 256-99-00), and from 3 km west of Jinkinson Road westerly to Carleton Place (W.P. 251-99-00 and 252-99-00). Foundation investigation services are also required as part of this project for the widening of Highway 417 from the Highway 417-7 interchange easterly to approximately Highway 416 (W.P. 458-98-00).

Foundation investigation services are required for the following components:

- **W.P. 256-99-00:** New structures at the Highway 417E-7W ramp and Hazeldean Road, including a high fill embankment along the Highway 417E-7W ramp, overhead and ground-mounted signs, and high mast light poles.
- **W.P. 251-99-00 and 252-99-00:** Five new structures at Appleton Sideroad, Ashton Station Road, Dwyer Hill Road, the Trans-Canada Trail, and Lavallee Creek.
- **G.W.P. 458-98-00:** Widening of two existing structures (the Carp River bridge and CN Rail overpass) into the existing Highway 417 median area, a 900 m long section of high fill embankment within the Highway 417 median in the vicinity of the CN Rail overpass, and overhead signs.

This report addresses the five trichord overhead signs associated with the widening of Highway 417 in the area immediately west of Highway 416, under G.W.P. 458-98-00.

The terms of reference for the original scope of work and Addenda 1 through 7 issued during the proposal period are outlined in the MTO's Request for Proposal (RFP) and in Golder's Proposal No. P21-1301, dated July 2002. Scope changes (Scope Change No. 1) related to additional borehole investigation work at the abutments of several structures and the high fill embankment on the Highway 417E-7W ramp are outlined in Golder's letters dated November 12, 2002 and November 18, 2002, respectively. Additional scope changes (Scope Change No. 2) related to additional borehole investigation work associated with overhead signs, high mast light pole foundations, the high fill embankments at the Hazeldean Road site, and additional investigation work for the south abutment at the Hazeldean Road site, are outlined in Golder's letter dated May 7, 2003.

2.0 SITE DESCRIPTION

A total of five trichord overhead signs along Highway 417, in the vicinity of Highway 416, will be reconstructed as part of the Highway 417 widening under W.P. 458-98-00. The proposed sign locations are summarized in the following table:

<i>Sign Number</i>	<i>Location</i>
OH-2	Highway 417 EBL, Station 14+912, Nepean Twp.
OH-3	Highway 417 EBL, Station 15+402, Nepean Twp.
OH-4	Highway 417 EBL, Station 15+852, Nepean Twp.
OH-5	Highway 417 WBL, Station 14+662, Nepean Twp.
OH-6	Highway 417 WBL, Station 15+068, Nepean Twp.

The terrain over this area is generally flat to very gently undulating. The ground surface along Highway 417 varies from about Elevation 65 m to 67.5 m, and the existing highway embankments are up to about 1.5 m high relative to the natural ground surface. Drainage ditches are present adjacent to the embankment toe, along the outside of the highway.

3.0 INVESTIGATION PROCEDURES

A subsurface investigation was carried out for the proposed trichord overhead signs along Highway 417 in December 2003, at which time a total of ten boreholes were advanced as close as practicable to the proposed foundation locations.

The boreholes were drilled with a CME-55 drill rig supplied and operated by Marathon Drilling Ltd. of Ottawa, Ontario. The boreholes were advanced through the overburden soils using 108 mm internal diameter hollow stem augers. Samples of the overburden were obtained at 0.75 m to 1.5 m intervals of depth using 50 mm outside diameter split-spoon samplers in accordance with the Standard Penetration Test (SPT) procedure. Since bedrock was encountered within 10 m depth below ground surface, 3 m of bedrock coring was carried out in one borehole at each trichord overhead sign location, using NQ-size coring equipment. On completion of drilling, the boreholes were backfilled with soil cuttings mixed with bentonite, and a surficial bentonite seal was placed.

The field work was supervised on a full-time basis by a member of Golder's staff who located the boreholes in the field, directed the drilling, sampling, and in-situ testing operations, and logged the boreholes. The soil and bedrock samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Ottawa for further examination and testing. Index and classification tests consisting of water content determinations and grain size distribution analyses were carried out on selected soil samples.

The borehole locations and ground surface elevations were determined by Golder personnel relative to existing site features and the DTM for this area. The borehole locations, including MTM NAD83 northing and easting coordinates, and ground surface elevations referenced to geodetic datum are summarized in the following table and are shown on Drawing 1.

<i>Sign Number and Location</i>	<i>Borehole Number</i>	<i>MTM NAD83 Northing (m)</i>	<i>MTM NAD83 Easting (m)</i>	<i>Ground Surface Elevation (m)</i>
OH-6 Hwy 417 WBL, Stn. 15+068	03-1	5,022,688.1	357,358.1	66.1
	03-2	5,022,659.7	357,367.1	65.8
OH-5 Hwy 417 WBL, Stn. 14+662	03-3	5,022,571.5	356,969.8	65.5
	03-4	5,022,541.6	356,978.2	65.8
OH-2 Hwy 417 EBL, Stn. 14+912	03-5	5,022,594.2	357,235.0	66.6
	03-6	5,022,565.2	357,243.6	66.2
OH-3 Hwy 417 EBL, Stn. 15+402	03-7	5,022,683.2	357,716.7	66.2
	03-8	5,022,719.1	357,710.1	67.4
OH-4 Hwy 417 EBL, Stn. 15+852	03-9	5,022,742.6	358,161.4	65.2
	03-10	5,022,725.5	358,161.5	65.4

4.0 SITE GEOLOGY AND STRATIGRAPHY

4.1 Regional Geological Conditions

The study area for this assignment lies within the minor physiographic region known as the Ottawa Valley Clay Plain, as delineated in *The Physiography of Southern Ontario*¹, which lies within the major physiographic region of the Ottawa-St. Lawrence Lowland. Most of this physiographic region is underlain by a series of sedimentary rocks, consisting of sandstones, dolostones, limestones and shales that are, in turn, underlain by igneous and metamorphic bedrock of the Precambrian Shield. The Shield rock generally outcrops to the north of the Ottawa River, and it is also present immediately below the overburden in a localized area between the Hazeldean Fault (approximately the location of the Carp River) and the Ottawa River.

The Ottawa Valley Clay Plain region, present along Highway 417 from the Highway 417-7 interchange site eastward, is characterized by relatively thick deposits of sensitive marine clay, silty clay and silt that were deposited within the Champlain Sea basin. These deposits, known as the Champlain Sea clay or Leda clay, overlie relatively thin, commonly reworked glacial till and glaciofluvial deposits, that in turn overlie bedrock.¹ West of the Carp River valley along Highway 417, the upper bedrock consists of limestone of the Ottawa Formation, as described above. Within and immediately east of the Carp River valley, the upper bedrock consists of sandstones and dolostones that have been cut by igneous and metamorphic rocks, controlled by faulting in the vicinity of the Carp River.²

4.2 Site Stratigraphy

As part of the subsurface investigation, ten boreholes were advanced as close as practicable to the foundation elements for the proposed trichord overhead signs, at the locations shown on Drawing 1. The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are given on the Record of Borehole / Drillhole sheets and Figures 1 to 3. The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

The overburden soils encountered in this area consist of topsoil or existing Highway 417 embankment fill, overlying generally stiff to very stiff silty clay, which is in turn underlain by a

¹ Chapman, L.J. and D.F. Putnam. *The Physiography of Southern Ontario*, Ontario Geological Survey Special Volume 2, Third Edition, 1984. Accompanied by Map P.2715, Scale 1:600,000.

² Belanger, J.R. "Urban Geology of Canada's National Capital Area", in *Urban Geology of Canadian Cities*, Geological Association of Canada Special Paper 42, Ed. P.F. Karrow and O.L. White, 1998.

relatively thin sand and silt till deposit; a thin silty sand layer was encountered atop or below the silty clay deposit in two of the boreholes. Sandstone bedrock was encountered below the glacial till at a depth of between 1 m and 9 m below the ground surface at the borehole locations. The following table summarizes the subsurface conditions encountered at the borehole locations, and a more detailed description of the soils and bedrock is provided in the subsections that follow.

<i>Borehole Number And Sign Location</i>	<i>Summary of Subsurface Conditions Encountered in Boreholes</i>
03-1 and 03-2 OH-6, Hwy 417 WBL Stn. 15+068, Nepean Twp.	Topsoil or existing fill is underlain by 3.2 m and 3.8 m of generally stiff to very stiff clayey silt to silty clay, which is in turn underlain by 0.3 m to 1.2 m of sand and silt till. Sandstone bedrock was encountered below the till at approximately Elevation 60.5 m and 61.1 m on the north side and in the median area of the highway, respectively; the bedrock is at about 4.7 m to 5.6 m depth at the borehole locations.
03-3 and 03-4 OH-5, Hwy 417 WBL Stn. 14+662, Nepean Twp.	Compact embankment fill directly overlies bedrock, which was inferred at a depth of about 1.3 m (Elevation 64.2 m) on the north side of the highway. In the median area, the topsoil is underlain by about 0.5 m of clayey silt and 0.6 m of sand and silt till, in turn underlain by sandstone bedrock at approximately Elevation 64.6 m (about 1.3 m depth at the borehole location).
03-5 and 03-6 OH-2, Hwy 417 EBL Stn. 14+912, Nepean Twp.	Existing fill, topsoil and thin surficial silty sand are underlain by about 1.7 m to 3.1 m of stiff to very stiff silty clay, in turn underlain by about 0.5 m to 1.2 m of compact to dense sand and silt till. Sandstone bedrock underlies the till at approximately Elevation 62.4 m and 63.0 m at the median and south sides of the highway; the bedrock is at about 3.2 m to 4.2 m depth as encountered in the boreholes.
03-7 and 03-8 OH-3, Hwy 417 EBL Stn. 15+402, Nepean Twp.	Topsoil and/or existing fill are underlain by about 4.9 m and 7.7 m of stiff to very stiff silty clay, which is in turn underlain by a 0.2 m to 0.3 m thick layer of sand and silt till. The sandstone bedrock was encountered at 5.4 m and 9.2 m depth in the boreholes, at Elevation 58.3 m south of the highway, and at Elevation 60.8 m in the median area.
03-9 and 03-10 OH-4, Hwy 417 EBL Stn. 15+852, Nepean Twp.	Topsoil or existing fill is underlain by about 3.3 m to 3.9 m of firm to very stiff silty clay, which is in turn underlain by 1.2 m to 3.8 m of glacial till. Sandstone bedrock was encountered at Elevation 60.0 m (about 5.2 m depth) in the median area, and Elevation 58.2 m (about 7.2 m depth) on the south side of the highway.

4.2.1 Embankment Fill

Between 0.4 m and 1.5 m of fill, associated with the existing Highway 417 pavement structure and embankment, was encountered in Boreholes 03-1, 03-3, 03-5, 03-8 and 03-9. In Boreholes 03-1, 03-3 and 03-5, the fill consists of silty sand to sand and silt containing some gravel, as well

as cobbles and trace quantities of organics. In Boreholes 03-8 and 03-9, the fill consists of sand and gravel road base materials.

The Standard Penetration Test (SPT) “N” values measured within the fill range from 6 to 21 blows per 0.3 m of penetration, indicating that the fill has a loose to compact relative density.

4.2.2 Topsoil

Approximately 200 mm to 300 mm of topsoil was encountered immediately below ground surface in Boreholes 03-2, 03-4, 03-7, 03-8 (where it overlies the existing fill) and 03-10. About 400 mm of topsoil was encountered beneath the existing highway embankment fill in Borehole 03-5.

4.2.3 Silty Sand

A 0.3 m thick layer of silty sand is present immediately below ground surface, atop the silty clay, in Borehole 03-6. This silty sand layer contains trace gravel and organics, and is dark brown in colour.

4.2.4 Clayey Silt to Silty Clay

The predominant soil deposit at the site is a silty clay, which was encountered below the topsoil and fill materials in all of the boreholes (except Borehole 03-3, where the native soils are absent and fill material directly overlies the bedrock). At the borehole locations, the silty clay deposit varies from about 1.7 m to 7.4 m in thickness. In Boreholes 03-1 and 03-4, a 0.5 m to 0.6 m thick layer of clayey silt was encountered on top of or in place of the silty clay; this material contains organics (Borehole 03-1) or some sand (Borehole 03-4) and is considered to be less plastic than the underlying, thicker silty clay deposit, based on visual examination.

The silty clay deposit contains seams and layers of sand and silty sand, as noted on the borehole records, and a 0.3 m thick layer of silty sand was encountered within the silty clay near the base of the deposit in Borehole 03-1. The results of two grain size distribution tests conducted on samples of the silty clay (including its sand to silty sand seams) are shown on Figure 1.

Atterberg limit testing carried out on two samples of this material measured plastic limits of about 18 per cent, liquid limits of 41 and 50 per cent, and plasticity indices of 23 and 32 per cent. These results, which are plotted on the plasticity chart on Figure 2, confirm that the material is a silty clay of intermediate plasticity. The measured natural water contents in the deposit range from about 26 to 52 per cent.

The SPT “N” values measured within the silty clay deposit range from 1 to 21 blows per 0.3 m of penetration. In situ vane testing carried out within “softer” portions of the deposit measured undrained shear strengths that were between 50 kPa and 100 kPa, except near the base of the silty clay deposit in Borehole 03-9, where an undrained shear strength of about 37 kPa was measured. The results of the SPT and in situ vane testing indicate that the silty clay deposit generally has a stiff to very stiff consistency, except in Borehole 03-9 where the bottom portion of the deposit has a firm consistency. It is noted, based on the measured remoulded strengths of 6 kPa to 16 kPa, that the silty clay deposit is sensitive to extra-sensitive.

4.2.5 Sand and Silt Till

A deposit of glacial till is present below the silty clay in all of the boreholes (except Borehole 03-3 where the native soils are absent, and the fill directly overlies the bedrock surface). The till typically consists of sand and silt, containing some gravel and trace clay; however, in Borehole 03-10, the lower portion of the sand and silt till contains more gravel (approximately 40 per cent gravel by weight on one tested sample). The results of two grain size distribution tests are shown on Figure 3.

The till deposit encountered in the boreholes is between 0.2 m and 1.2 m in thickness, except in Borehole 03-10 where the glacial till is approximately 3.8 m thick. The glacial till has a loose to very dense relative density, based on measured SPT “N” values of 5 to greater than 100 blows per 0.3 m, but is typically compact to dense.

4.2.6 Sandstone Bedrock

The existing fill and native soils are underlain by sandstone bedrock. The following table summarizes the bedrock surface depth and elevation as encountered at the borehole locations. It is noted that bedrock was cored in five of the ten boreholes (one borehole per overhead sign location).

<i>Sign Number and Location</i>	<i>Borehole No.</i>	<i>Depth to Bedrock</i>	<i>Bedrock Surface Elevation</i>
OH-6 Hwy 417 WBL, Stn. 15+068	03-1	5.6	60.5 m
	03-2	4.7	61.1 m (Cored)
OH-5 Hwy 417 WBL, Stn. 14+662	03-3	1.3	64.2 m *
	03-4	1.3	64.6 (Cored)
OH-2 Hwy 417 EBL, Stn. 14+912	03-5	4.2	62.4 m (Cored)
	03-6	3.2	63.0 m
OH-3 Hwy 417 EBL, Stn. 15+402	03-7	5.4	60.8 m (Cored)
	03-8	9.2	58.3 m
OH-4 Hwy 417 EBL, Stn. 15+852	03-9	5.2	60.0 m
	03-10	7.2	58.2 m (Cored)

* **NOTE:** Sandstone bedrock is also exposed in stream bed / culvert area adjacent to Borehole 03-3.

A description of the terms used in the description of the bedrock samples from this site is provided on the *Lithological and Geotechnical Rock Description Terminology* sheet that precedes the Record of Borehole sheets included with this report.

The sandstone bedrock is grey, very thinly- to thickly-bedded, and medium strong. The bedrock is generally fresh; however, the recovered core from Borehole 03-4 (at OH-5) exhibits slight weathering, with some brown staining on the bedding planes and/or joints. Rock Quality Designation (RQD) values measured on the recovered bedrock core samples ranged from 45 to 95 per cent: the RQD values are generally above 75 per cent, indicative of good to excellent quality rock; however, the upper 0.5 m to 1.5 m of bedrock in Boreholes 03-4, 03-7 and 03-10 is of poor to fair quality, based on measured RQD values between 45 and 65 per cent. The discontinuities observed in the rock core are typically horizontal to sub-horizontal, associated with the bedding planes, although occasional vertical to sub-vertical jointing was also observed.

4.3 Groundwater Conditions

The water levels were observed in the open boreholes during the drilling operations, at which time they were measured to be between 0.3 m and 1.5 m below the ground surface at the borehole locations. The water level measurements are noted on the borehole records and are summarized in the following table:


<i>Borehole Number</i>	<i>Sign Number and Location</i>	<i>Water Depth</i>	<i>Water Elevation</i>
03-1	OH-6	1.5 m	64.6 m
03-2	Hwy 417 WBL, Stn. 15+068	1.4 m	64.4 m
03-3	OH-5	Dry at 1.3 m	Below 64.2 m
03-4	Hwy 417 WBL, Stn. 14+662	0.9 m	64.9 m
03-5	OH-2	1.5 m	65.1 m
03-6	Hwy 417 EBL, Stn. 14+912	0.8 m	65.4 m
03-7	OH-3	0.3 m	65.9 m
03-8	Hwy 417 EBL, Stn. 15+402	0.9 m	66.5 m
03-9	OH-4	1.5 m	63.7 m
03-10	Hwy 417 EBL, Stn. 15+852	0.9 m	64.5 m

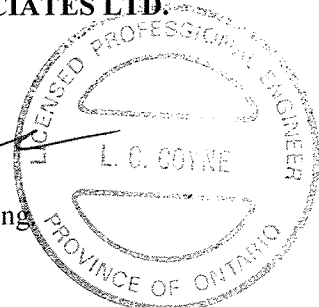
It should be noted that the groundwater levels at the site are expected to fluctuate seasonally, and are expected to rise during wet periods of the year.


5.0 CLOSURE

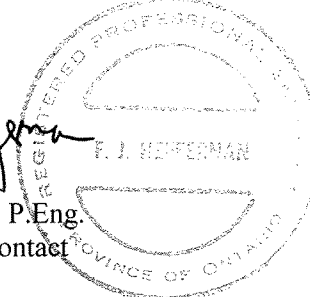
This Foundation Investigation Report was prepared by Ms. Lisa Coyne, P.Eng., an Associate and geotechnical engineer with Golder. Mr. Fintan Heffernan, P.Eng., a Designated MTO Contact for Golder, conducted an independent review of the report.

GOLDER ASSOCIATES LTD.


Lisa C. Coyne, P.Eng.
Associate




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



LCC/FJH/lcc

N:\ACTIVE\2002\1100\021-1155\REPORTS\FINAL REPORTS\021-1155 RPT11 06DEC OVERHEAD SIGNS ON WP 458-98-00.DOC

PART B

**FOUNDATION DESIGN REPORT
TRICHORD OVERHEAD SIGNS
BETWEEN MOODIE DRIVE AND HIGHWAY 416
HIGHWAY 417 WIDENING
G.W.P. 458-98-00**

6.0 ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides foundation design recommendations for the proposed trichord overhead sign foundations on Highway 417, to the west of Highway 416. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the subsurface investigation at this site. The interpretation and recommendations provided are intended to provide the designers with sufficient information to assess the feasible alternatives and to design the proposed sign foundations. Where comments are made on construction they are provided in order to highlight those aspects which could affect the design of the project, and for which special provisions may be required in the Contract Documents. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods, scheduling and the like.

6.2 Trichord Overhead Sign Foundations

The following table summarizes the depth to bedrock and the bedrock surface elevation in the boreholes at each of the proposed sign support locations, as determined by bedrock coring and inferred from auger refusal:

<i>Sign Number and Location</i>	<i>Borehole Number</i>	<i>Sign Support*</i>	<i>G.S. Elev. at Support</i>	<i>G.S. Elev. at Borehole</i>	<i>Depth to Bedrock</i>	<i>Bedrock Surface Elevation</i>
OH-2 Hwy 417 EBL Stn. 14+912	03-5	Left (N)	66.4 m	66.6 m	4.2 m	62.4 m (Cored)
	03-6	Right (S)	67.3 m	66.2 m	3.2 m	63.0 m
OH-3 Hwy 417 EBL Stn. 15+402	03-7	Right (S)	67.1 m	66.2 m	5.4 m	60.8 m (Cored)
	03-8	Left (N)	67.7 m	67.4 m	9.2 m	58.3 m
OH-4 Hwy 417 EBL Stn. 15+852	03-9	Left (N)	64.8 m	65.2 m	5.2 m	60.0 m
	03-10	Right (S)	64.8 m	65.4 m	7.2 m	58.2 m (Cored)
OH-5 Hwy 417 WBL Stn. 14+662	03-3	Right (N)	65.8 m	65.5 m	1.3 m	64.2 m
	03-4	Left (S)	66.0 m	65.8 m	1.3 m	64.6 m (Cored)
OH-6 Hwy 417 WBL Stn. 15+068	03-1	Right (N)	67.2 m	66.1 m	5.6 m	60.5 m
	03-2	Left (S)	66.9 m	65.8 m	4.7 m	61.1 m (Cored)

Caisson foundations for trichord overhead signs should be designed in accordance with the standard design methods for Tri-Chord Static Sign Supports, contained in Section 4 and Standard Drawings SS118-3, SS118-4 and SS118-5 of MTO's *Sign Support Manual*. The standard sign foundation design presented on the Standard Drawings has been developed based on the

minimum soil conditions given below; where weaker soils are encountered, a site-specific design is required.

- **Case 1 (Cohesionless Soils):** Sand with a friction angle of 28 degrees surrounding the upper two-thirds of the portion of the caisson foundation below the frost depth, and sand with a friction angle of 30 degrees surrounding the lower third of the portion of the caisson below the design frost depth.
- **Case 2 (Cohesive Soils):** Soft clay with an undrained shear strength of 25 kPa surrounding the upper two-thirds of the portion of the caisson foundation below the frost depth, and soft clay with an undrained shear strength of 50 kPa surrounding the lower third of the portion of the caisson below the design frost depth.

In the standard design, the caissons are extended 5 m below the design frost depth, unless bedrock is encountered within this depth; for sign foundation design, the frost depth in the Ottawa area may be taken as 1.8 m. The typical caisson founding level would therefore be 6.8 m below the ground surface, except where bedrock is encountered within this depth as is the case for most of the sign supports on this project.

At the left support for OH-3 (Highway 417 EBL, Station 15+402), the depth to bedrock is greater than 6.8 m and the foundation for this sign support should be designed as a caisson in soil, as discussed in Section 6.2.1. At the right support for OH-4 (Highway 417 EBL, Station 15+852), the depth to bedrock is only slightly less than the required 6.8 m, and consideration could be given to carrying out a site-specific design in accordance with the recommendations provided in Section 6.2.1 and the parameters given in Table 1, to determine whether the foundation can be constructed as a caisson in soil, or whether a shallow socket into the bedrock is required.

The depth to bedrock at all of the other proposed sign support locations is less than 5 m below the design frost depth. It is noted that the boreholes for these sign supports were drilled on the highway shoulder or at the embankment toe, as practicable, a few metres away from the actual sign support locations. The inferred depth to bedrock at the actual sign support locations is listed below, based on the ground surface elevations at the actual sign support locations (which vary by up to about 1.1 m from the ground surface elevations at the borehole locations, as noted in the table on the preceding page). Using the standard design approach, a nominal socket into the rock will be required for the following sign supports; further discussion is provided in Section 6.2.2:

- OH-2 (Highway 417 EBL, Station 14+912) – Bedrock at about 4 m and 4.3 m depth for the left and right sign supports, respectively.
- Right support for OH-3 (Highway 417 EBL, Station 15+402) – Bedrock at approximately 6.3 m depth.
- OH-4 (Highway 417 EBL, Station 15+852) – Bedrock at approximately 4.8 m and 6.6 m depth for the left and right sign supports, respectively.
- OH-6 (Highway 417 WBL, Station 15+068) – Bedrock at about 5.8 m and 6.7 m depth for the left and right sign supports, respectively.

Finally, the depth to bedrock at OH-5 (Highway 417 WBL, Station 14+662) is very shallow, at approximately 1.2 m to 1.3 m depth relative to the ground surface at the sign support locations. The foundation for this overhead sign support could consist of a caisson embedded into the bedrock, or a spread footing or caisson anchored/dowelled to the surface of the bedrock. Recommendations pertaining to these foundation alternatives are provided in Sections 6.2.2 and 6.2.3.

The stratigraphy and design parameters for the subsurface conditions encountered in the boreholes at the sign support locations are given in Table 1.

6.2.1 Caisson Foundations in Soil

The left support for trichord overhead sign OH-3 may be designed as a caisson foundation within soil. Based on the results from Borehole 03-8, the silty clay soils at this location have an undrained shear strength of approximately 55 kPa to 75 kPa, which exceeds the minimum criteria on which the standard sign foundation is based. Therefore, the standard caisson foundation design may be applied for the left support for trichord overhead sign OH-3.

As discussed in Section 6.2, at the right support for trichord overhead sign OH-4, the depth to bedrock is expected to be slightly shallower than the standard caisson length; it is recommended that a site-specific design check be done to determine whether the foundation for this sign support can be constructed as a caisson in soil with no requirement for a shallow bedrock socket.

The standard foundation design may be checked using the following equations to calculate the unfactored passive lateral earth pressure, P_p (kPa), distributed along the depth of the caisson foundation; this earth pressure distribution is triangular with depth:

$$\begin{aligned} P_p &= K_p \gamma d_w && \text{above the groundwater table, and} \\ P_p &= K_p \gamma d_w + K_p \gamma' (d - d_w) && \text{below the groundwater table,} \end{aligned}$$

where K_p is the passive earth pressure coefficient, as given in Table 1;
 γ is the bulk unit weight (kN/m^3), as given in Table 1;
 γ' is the effective unit weight below the groundwater level (kN/m^3);
 d is the depth below the ground surface (m); and
 d_w is the depth to the groundwater level (m), as given in Table 1.

The unfactored lateral resistance should be calculated assuming an equivalent pile width equal to three times the caisson diameter. A resistance factor of 0.5 should be applied to the unfactored lateral resistance to obtain the factored lateral geotechnical resistance at Ultimate Limit States (ULS).

The undrained capacity of the caisson should also be checked to establish whether the drained or the undrained case will govern. For the undrained case, the lateral resistance for the length of the caisson within the cohesive soil should be calculated assuming an internal angle of friction, $\phi' = 0$ degrees and an unfactored passive lateral pressure distribution equivalent to nine times the undrained shear strength, acting over the actual width of the caisson. A resistance factor of 0.5 should be applied to this calculated lateral resistance in order to obtain the factored lateral geotechnical resistance at ULS.

For both the drained and undrained cases, the passive resistance in front of the caisson within the upper 1.8 m below ground surface should be neglected in the design of the foundations to account for frost action.

The foundation design for the right support at OH-4 can also be modelled by the structural designers using subgrade reaction theory, where the coefficient of horizontal subgrade reaction, k_h , is based on the equations given below.

For cohesive soils:

$$k_h = \frac{6Zs_u}{B} \quad \text{where} \quad \begin{array}{l} k_h \text{ is the coefficient of horizontal subgrade reaction (kPa/m);} \\ s_u \text{ is the undrained shear strength of the soil (kPa); and} \\ B \text{ is the pile diameter (m).} \end{array}$$

For cohesionless soils:

$$k_h = \frac{n_h z}{B} \quad \text{where} \quad \begin{array}{l} n_h \text{ is the constant of subgrade reaction} \\ z \text{ is the depth (m)} \\ B \text{ is the pile diameter (m)} \end{array}$$

The following values of s_u and n_h may be assumed in the structural analysis for the right support of OH-4, based on the subsurface conditions encountered in Borehole 03-10:

<i>Soil Unit</i>	s_u	n_h
Very stiff silty clay above Elevation 64.0 m	100 kPa	—
Stiff silty clay between Elevation 64.0 m and 62.0 m	60 kPa	—
Very loose sand and silt till between Elevation 62.1 m and 60.8 m	—	2 MPa/m
Compact sand and gravel till between Elevation 60.8 m and 58.2 m	—	4 MPa/m

6.2.2 Caisson Foundations Socketted into Rock

In accordance with Standard Drawing SS118-3 of MTO's *Sign Support Manual* (Standard Drawing SS118-3, dated March 1999), where bedrock is encountered at a depth, z (in metres), of less than 5 m below the bottom of the frost layer, the required depth of the foundation below the frost layer may be taken as:

$$z + (5 \text{ m} - z) / 2$$

For OH-5 (Highway 417 WBL, Station 14+662), the depth to the surface of the bedrock is less than the frost depth of 1.8 m. Based on the above equation, the caissons for support of this sign will be socketted 2.5 m into the sandstone bedrock.

For OH-2, OH-3 (right support), OH-4 and OH-6, the depth to bedrock is less than 5 m below the design frost depth. The depth of rock socket required can be determined based on the equation above or, alternatively, site-specific design could be carried out for these locations using the parameters given in Table 1, to determine whether the overburden soils can provide the required lateral resistance; this is particularly the case for the right support of OH-4, where the depth to bedrock is expected to be slightly less than the standard caisson length requires. Where a bedrock socket is required, the unfactored passive lateral resistance of the rock mass may be taken as 1 MPa (to take account of fracturing in the upper portion of the rock mass, based on the lower RQD values in some of the boreholes). A resistance factor of 0.5 should be applied in order to obtain the factored lateral geotechnical resistance at ULS.

It is noted that the sandstone bedrock at the site is medium strong, corresponding to uniaxial compressive strengths for intact rock samples of approximately 25 MPa to 50 MPa. Coring or churn drilling will, therefore, be necessary to advance the socket into the bedrock. In order to minimize coring within the medium strong bedrock, consideration could be given to the use of spread footing or caisson foundations anchored to the rock (particularly for OH-5, where a 2.5 m deep socket would be required). Recommendations for the rock anchors are provided in the following section.

6.2.3 Foundations Anchored to Rock

Where anchoring of caissons or spread footings is adopted, it is recommended that MTO's Special Provision SP902S01 be included in the Contract Documents, requiring inspection and approval of the foundation area by the Quality Verification Engineer prior to footing construction, to ensure that all loose and/or highly fractured rock has been removed from the foundation areas.

The horizontal resistance of the dowels is dependent on the strength of the bedrock, grout and steel. The dowels may be designed based on an unfactored passive lateral resistance for the rock

mass of 1 MPa. A resistance factor of 0.5 should be applied in order to obtain the factored lateral geotechnical resistance at ULS. The rock dowels should have a minimum embedded length within the bedrock of 1 m, and the structural strength of the dowel and the compressive strength of the grout should not be exceeded.

For uplift of the dowels, a factored value of 700 kPa may be assumed for the cement grout-to-rock bond stress for ULS design. The actual bond stress along the rock-grout interface may vary from the design value given and it should, therefore, be verified in the field by pull-out testing; in this case, a Special Provision will have to be included in the Contract Documents to cover this testing. It should be noted that it is important that the annular space be compatible with the dowel size; typically, an annular space of about 6 mm to 10 mm (1/4 in. to 3/8 in.) is appropriate for use with deformed bar and cement grout.

6.3 Construction Considerations

It is recommended that a Non-Standard Special Provision (NSSP) be included in the Contract Documents to warn the Contractor of the following items that are expected to affect the installation of the trichord overhead sign foundations:

- **Control of overburden soils and groundwater:** The overburden soils at the sign locations include water-bearing sand to silty sand interlayers within the silty clay deposit, and water-bearing sand and silt to sand and gravel till. These soils should be expected to be unstable below the groundwater level. It should be anticipated that the caisson holes will have to be advanced using a temporary liner, possibly in conjunction with fluid support, in order to minimize ground loss during drilling and concrete placement.
- **Bedrock strength:** Some of the sign foundations will require sockets to be formed within the bedrock. The bedrock at the site consists of medium strong sandstone. It should be anticipated that it will be necessary to use rock coring or churn drilling techniques to advance the caisson holes into the medium strong bedrock, that wear of the drill bits will be high, and that the rate of progress in forming the socket will be slow.

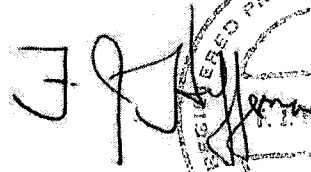
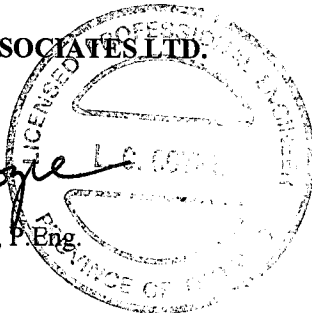
7.0 CLOSURE

This Foundation Design Report was prepared by Ms. Lisa Coyne, P.Eng., an Associate and geotechnical engineer with Golder. Mr. Fintan Heffernan, P.Eng., a Designated MTO Contact for Golder, conducted an independent review of the report.

GOLDER ASSOCIATES LTD.



Lisa C. Coyne, P.Eng.
Associate



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



LCC/FJH/lcc

N:\ACTIVE\2002\1100\021-1155\REPORTS\FINAL REPORTS\021-1155 RPT11 06DEC OVERHEAD SIGNS ON WP 458-98-00.DOC

TABLE 1

**DESIGN PARAMETERS FOR TRICHORD OVERHEAD SIGN FOUNDATIONS
HIGHWAY 417 WIDENING BETWEEN MOODIE DRIVE AND HIGHWAY 416
G.W.P. 458-98-00**

Sign Support	Borehole No.	Stratum	Depth ¹ (m)	Elevation (m)	Groundwater Elevation (m)	Design Parameters ^{2,3}				
						c_u	ϕ'	γ	γ'	K_p
OH-6 Right (North) WBL Stn. 15+068	03-1	Fill	0.0 – 1.5	66.1 – 64.6	65.0	–	30	20	10	3.0
		Clayey silt to silty clay	1.5 – 5.3	64.6 – 60.8		50	32	19	9	3.3
		Sand and silt till	5.3 – 5.6	60.8 – 60.5		–	30	20	10	3.0
		Sandstone (Bedrock)	Below 5.6	Below 60.5						
OH-6 Left (South) WBL Stn. 15+068	03-2	Silty clay	0.0 – 3.5	65.8 – 62.3	65.0	50	32	19	9	3.3
		Sand and silt till	3.5 – 4.7	62.3 – 61.1		–	30	20	10	3.0
		Sandstone (Bedrock)	Below 4.7	Below 61.1						
OH-5 Right (North) WBL Stn. 14+662	03-3	Fill	0.0 – 1.3	65.5 – 64.2	65.0	–	30	20	10	3.0
		Sandstone (Bedrock)	Below 1.3	Below 64.2						
OH-5 Left (South) WBL Stn. 14+662	03-4	Clayey silt	0.0 – 0.7	65.8 – 65.1	65.0	50	32	19	9	3.3
		Sand and silt till	0.7 – 1.3	65.1 – 64.6		–	32	20	10	3.3
		Sandstone (Bedrock)	Below 1.3	Below 64.6						
OH-2 Left (North) EBL Stn. 14+912	03-5	Fill	0.0 – 0.6	66.6 – 66.0	65.5	–	30	20	10	3.0
		Silty clay	0.6 – 3.7	66.0 – 62.9		50	32	19	9	3.3
		Sand and silt till	3.7 – 4.2	62.9 – 62.4		–	32	21	11	3.3
		Sandstone (Bedrock)	Below 4.2	Below 62.4						
OH-2 Right (South) EBL Stn. 14+912	03-6	Silty sand	0.0 – 0.3	66.2 – 65.9	65.5	–	30	20	10	3.0
		Silty clay	0.3 – 2.0	65.9 – 64.2		50	32	19	9	3.3
		Sand and silt till	2.0 – 3.2	64.2 – 63.0		–	32	21	11	3.3
		Sandstone (Bedrock)	Below 3.2	Below 63.0						
OH-3 Right (South) EBL Stn. 15+402	03-7	Silty clay	0.0 – 5.4	66.2 – 60.8	66.5	50	32	19	9	3.3
		Sandstone (Bedrock)	Below 5.4	Below 60.8						
OH-3 Left (North) EBL Stn. 15+402	03-8	Fill	0.0 – 1.5	67.4 – 65.9	66.5	–	30	20	10	3.0
		Silty clay	1.5 – 9.2	65.9 – 58.3		50	32	19	9	3.3
		Sandstone (Bedrock)	Below 9.2	Below 58.3						

Sign Support	Borehole No.	Stratum	Depth ¹ (m)	Elevation (m)	Groundwater Elevation (m)	Design Parameters ^{2,3}				
						c_u	ϕ'	γ	γ'	K_p
OH-4 Left (North) EBL Stn. 15+852	03-9	Fill	0.0 – 1.1	65.2 – 63.7	64.5	–	30	20	10	3.0
		Silty clay – generally stiff	1.1 – 3.1	63.7 – 62.2		50	32	19	9	3.3
		Silty clay – firm	3.1 – 4.0	62.2 – 61.2		35	32	19	9	3.3
		Sand and silt till	4.0 – 5.2	61.2 – 60.0		–	32	21	11	3.3
		Sandstone (Bedrock)	Below 5.2	Below 60.0						
OH-4 Right (South) EBL Stn. 15+852	03-10	Silty clay	0.0 – 3.4	65.4 – 62.1	64.5	50	32	19	9	3.3
		Sand and silt / Sand and gravel till	3.4 – 7.2	62.1 – 58.2		–	32	21	11	3.3
		Sandstone (Bedrock)	Below 7.2	Below 58.2						

NOTES:

1. Depths are given for the borehole location; the ground surface elevation at the borehole location should be compared to the ground surface elevation at the actual sign support location, and the depths of the soil strata and depth to bedrock adjusted accordingly.
2. Design parameters: c_u = undrained shear strength (kPa);
 ϕ' = effective friction angle (degrees);
 γ = bulk unit weight (kN/m³);
 γ' = effective unit weight below the groundwater level (kN/m³); and
 K_p = passive earth pressure coefficient.
3. Although the passive resistance in the upper 1.8 m is neglected to account for frost action, c_u , ϕ' and K_p parameters are given in the event that the ground surface elevation varies significantly between the borehole and sign support locations.

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

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

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.)

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

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

Piezo-Cone Penetration Test (CPT)

A 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.

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. in 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

(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 $= (\text{compressive strength})/2$
 - * density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)

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 2m
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

Term	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

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 separations) 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 separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

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

PROJECT 021-1155-11			RECORD OF BOREHOLE No 03-1			1 OF 1 METRIC												
W.P. 458-98-00			LOCATION N 5022688.1 ; E 357358.1			ORIGINATED BY P.A.H.												
DIST _____ HWY 417			BOREHOLE TYPE CME 55 Bombardier			COMPILED BY T.M.S.												
DATUM Geodetic			DATE Dec. 9-10, 2003			CHECKED BY L.C.C.												
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV	DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ	GR SA SI CL
								20 40 60 80 100	○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × REMOULDED	W _p	W	W _L	25 50 75				
66.1		Ground Surface																
0.0		Sand, trace gravel (FILL)																
65.9		Brown																
0.3		Silty sand and clayey silt, some gravel, containing organics (FILL)																
		Loose/Stiff																
		Grey																
		Moist																
64.6				1	SS	9												
1.5		Clayey Silt, containing organics																
		Very stiff																
		Grey-brown to dark brown																
		Moist		2	SS	17												
64.0																		
2.1		Silty Clay																
		Very stiff to stiff																
		Grey-brown																
		Moist to wet																
				3	SS	21												
				4	SS	7												
				5	SS	3												
61.5																		
4.6		Silty Sand																
		Loose																
61.2		Grey																
4.9		Wet																
				6	SS	1												
60.8		Silty Clay																
		Soft to firm																
		Grey																
5.3		Wet																
60.5		Sand and Silt, some gravel, trace clay (TILL)																
		Grey																
5.6		End of Borehole																
		Auger Refusal on Probable Bedrock																
		Note:																
		Water level in open borehole at 1.5 m depth (Elev. 64.6 m) on completion of drilling.																

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

PROJECT: 021-1155-11

RECORD OF DRILLHOLE: 03-2

SHEET 2 OF 2

LOCATION: N 5022659.7 ;E 357367.1

DRILLING DATE: Dec. 12, 2003

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55

DRILLING CONTRACTOR: Marathon Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	PENETRATION RATE (mm/min)	FLUSH	COLLOUR % RETURN	FR/FX-FRACTURE F-FAULT				SM-SMOOTH				FL-FLEXURED				BC-BROKEN CORE				DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION				
								CL-CLEAVAGE				J-JOINT				R-ROUGH				UE-UNEVEN						MB-MECH. BREAK			
								SH-SHEAR				P-POLISHED				ST-STEPPED				W-WAVY						B-BEDDING			
								VN-VEIN				S-SLICKENSIDED				PL-PLANAR				C-CURVED									
RECOVERY		R.Q.D. %		FRACT. INDEX PER 0.3		DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY																					
TOTAL CORE %	SOLID CORE %	TOTAL CORE %	SOLID CORE %	TOTAL CORE %	SOLID CORE %	TOTAL CORE %	SOLID CORE %	TOTAL CORE %	SOLID CORE %	TOTAL CORE %	SOLID CORE %	TOTAL CORE %	SOLID CORE %	TOTAL CORE %	SOLID CORE %	TOTAL CORE %	SOLID CORE %	TOTAL CORE %	SOLID CORE %	TOTAL CORE %	SOLID CORE %								
Refer to previous page				61.10																									
5	Rotary Drill NQ Core	Sandstone (BEDROCK) Fresh Medium strong Very thinly to thickly bedded Grey		4.70																									
6				1																									
7				2																									
8		End of Borehole		58.23 7.57																									
9																													
10																													
11																													
12																													
13																													
14																													

DEPTH SCALE

1 : 50



LOGGED: P.A.H.

CHECKED: T.M.S.

MIS-RCK 001 021-1155-11-RCK.GPJ GAL-MISS.GDT 7/12/06

PROJECT <u>021-1155-11</u>		RECORD OF BOREHOLE No 03-3				1 OF 1 METRIC											
W.P. <u>458-98-00</u>		LOCATION <u>N 5022571.5 ; E 356969.8</u>				ORIGINATED BY <u>P.A.H.</u>											
DIST <u> </u> HWY <u>417</u>		BOREHOLE TYPE <u>CME 55 Bombardier</u>				COMPILED BY <u>T.M.S.</u>											
DATUM <u>Geodetic</u>		DATE <u>Dec. 10, 2003</u>				CHECKED BY <u>L.C.C.</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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
65.5	Ground Surface																
0.0	Silty sand, some gravel (FILL) Brown Moist		1	AS	-												
65.2																	
0.3	Sand and Silt, some gravel, containing cobbles and organics (FILL) Compact Dark grey Moist		2	SS	21												
64.2																	
1.3	End of Borehole Auger Refusal on Probable Bedrock Note: Borehole dry on completion of drilling.																

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

MIS-MTO 001 021-1155-11-MTO.GPJ GAL-MISS.GDT 7/12/06

PROJECT 021-1155-11			RECORD OF BOREHOLE No 03-5			1 OF 1 METRIC											
W.P. 458-98-00			LOCATION N 5022594.2 ; E 357235.0			ORIGINATED BY P.A.H.											
DIST _____ HWY 417			BOREHOLE TYPE CME 55 Bombardier			COMPILED BY T.M.S.											
DATUM Geodetic			DATE Dec. 10, 2003			CHECKED BY L.C.C.											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ kN/m ³	GR SA SI CL
							20 40 60 80 100	20 40 60 80 100	W _p	W	W _L	25 50 75					
66.6	Ground Surface																
0.0	Sand and silt, containing organics (FILL)																
66.2	Dark brown to brown																
66.0	Topsoil		1	AS	-		66										
0.6	Silty Clay, containing silty sand layers Very stiff to stiff Grey-brown Wet		2	SS	19												
							65										
			3	SS	11												
			4	SS	8		64										
			5	SS	2												
62.9							63										
3.7	Sand and Silt, some gravel, trace clay (TILL)																
62.4	Compact Grey Wet		6	SS	*18/2												
4.2	Sandstone (BEDROCK) Fresh Medium strong Very thinly to thickly bedded Grey						62										
	Bedrock cored between 4.2 m and 7.5 m depth. For bedrock coring details refer to Record of Drillhole 03-5.						61										
							60										
59.1																	
7.5	End of Borehole																
	Notes: * Split-spoon sampler bouncing after 18 blows. Water level in open borehole at 1.5 m depth (Elev. 65.1 m) during overburden drilling.																

PROJECT: 021-1155-11

RECORD OF DRILLHOLE: 03-5

SHEET 2 OF 2

LOCATION: N 5022594.2 ;E 357235.0

DRILLING DATE: Dec. 10, 2003

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55

DRILLING CONTRACTOR: Marathon Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm/min)	FLUSH	COLLOUR % RETURN	FR/FX-FRACTURE F-FAULT				SM-SMOOTH				FL-FLEXURED				BC-BROKEN CORE				DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION				
									CL-CLEAVAGE				J-JOINT				R-ROUGH				UE-UNEVEN						MB-MECH. BREAK			
									SH-SHEAR				P-POLISHED				ST-STEPPED				W-WAVY						B-BEDDING			
									VN-VEIN				S-SLICKENSIDED				PL-PLANAR				C-CURVED									
		Refer to previous page		62.41 4.19																										
5	Rotary Drill NQ Core	Sandstone (BEDROCK) Fresh Medium strong Very thinly to thickly bedded Grey			1																									
6					2																									
7					3																									
8		End of Borehole		59.11 7.49																										
9																														
10																														
11																														
12																														
13																														
14																														

DEPTH SCALE

1 : 50



LOGGED: P.A.H.

CHECKED: T.M.S.

MIS-RCK 001 021-1155-11-RCK.GPJ GAL-MISS.GDT 7/12/06

PROJECT <u>021-1155-11</u>		RECORD OF BOREHOLE No 03-6				1 OF 1 METRIC												
W.P. <u>458-98-00</u>		LOCATION <u>N 5022565.2 ; E 357243.6</u>				ORIGINATED BY <u>P.A.H.</u>												
DIST <u> </u> HWY <u>417</u>		BOREHOLE TYPE <u>CME 55 Bombardier</u>				COMPILED BY <u>T.M.S.</u>												
DATUM <u>Geodetic</u>		DATE <u>Dec. 22, 2003</u>				CHECKED BY <u>L.C.C.</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										
66.2	Ground Surface							20	40	60	80	100						
0.0	Silty Sand, trace gravel, containing organics					▼												
65.9	Dark brown																	
0.3	Silty Clay, containing sand seams and layers																	
	Very stiff																	
	Grey-brown																	
	Wet		1	SS	11													
64.2																		
			2	SS	4													
2.0	Sand and Silt, some gravel, trace clay (TILL)																	
	Compact to dense																	
	Grey-brown to grey with depth																	
	Wet		3	SS	42													
63.0																		
			4	SS	*20/15													
3.2	End of Borehole Sampler Refusal and Auger Refusal on Probable Bedrock																	
Notes: * Split-spoon sampler bouncing after 20 blows. Water level in open borehole at 0.8 m depth (Elev. 65.4 m) during drilling.																		



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

MIS-MTO 001 021-1155-11-MTO.GPJ GAL-MISS.GDT 7/12/06

PROJECT 021-1155-11			RECORD OF BOREHOLE No 03-7			1 OF 1 METRIC									
W.P. 458-98-00			LOCATION N 5022683.2; E 357716.7			ORIGINATED BY P.A.H.									
DIST _____ HWY 417			BOREHOLE TYPE CME 55 Bombardier			COMPILED BY T.M.S.									
DATUM Geodetic			DATE Dec. 22, 2003			CHECKED BY L.C.C.									
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							
66.2	Ground Surface														
0.0	Topsoil														
65.9	Silty Clay Very stiff to stiff Grey-brown Wet		1	SS	3										
0.3															
64.4			2	SS	1										
1.8	Silty Clay, containing silty sand layers Stiff Grey Wet														
64															
63			3	SS	4										
62															
61															
60.8	Sand and Silt, some gravel, trace clay (TILL) Grey														
5.4	Sandstone (BEDROCK) Fresh Medium strong Very thinly to thickly bedded Grey														
60															
59															
58															
57.7	End of Borehole														
8.5	Note: Water level in open borehole at 0.3 m depth (Elev. 65.9 m) during overburden drilling.														

MIS-MTO 001 021-1155-11-MTO.GPJ GAL-MISS.GDT 7/12/06

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

MIS-MTO 001 021-1155-11-MTO.GPJ GAL-MISS.GDT 7/12/06

PROJECT <u>021-1155-11</u>	RECORD OF BOREHOLE No 03-8	2 OF 2 METRIC
W.P. <u>458-98-00</u>	LOCATION <u>N 5022719.1 ; E 357710.1</u>	ORIGINATED BY <u>P.A.H.</u>
DIST <u> </u> HWY <u>417</u>	BOREHOLE TYPE <u>CME 55 Bombardier</u>	COMPILED BY <u>T.M.S.</u>
DATUM <u>Geodetic</u>	DATE <u>Dec. 12, 2003</u>	CHECKED BY <u>L.C.C.</u>

SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT			UNIT WEIGHT γ	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					WATER CONTENT (%)								
	--- CONTINUED FROM PREVIOUS PAGE ---								20	40	60	80	100		25	50	75		
	End of Borehole Auger Refusal on Probable Bedrock Note: Water level in open borehole at 0.9 m depth (Elev 66.5 m) during drilling.																		

MIS-MTO 001 021-1155-11-MTO.GPJ GAL-MISS.GDT 7/12/06

PROJECT 021-1155-11			RECORD OF BOREHOLE No 03-9			1 OF 1 METRIC										
W.P. 458-98-00			LOCATION N 5022742.6 ; E 358161.4			ORIGINATED BY P.A.H.										
DIST _____ HWY 417			BOREHOLE TYPE CME 55 Bombardier			COMPILED BY T.M.S.										
DATUM Geodetic			DATE Dec. 16, 2003			CHECKED BY L.C.C.										
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								
65.2	Ground Surface															
0.0	Asphalt															
0.2	Sand and gravel, trace silt (FILL) Compact Grey Moist to wet															
64.1	Silty Clay Very stiff to stiff Grey-brown Moist to wet		1	SS	6											
63.7	Silty Clay, containing silty sand layers Stiff Grey Wet		2	SS	4											
62.2	Interlayered Silty Clay and Sand Firm Grey Wet		3	SS	2											
61.2	Sand and Silt, some gravel, trace clay (TILL) Compact Grey Wet		4	SS	11											
60.0	End of Borehole Auger Refusal on Probable Bedrock Note: Water encountered at about 1.5 m depth (Elev. 63.7 m) during drilling.		5	SS	18											


PROJECT <u>021-1155-11</u>		RECORD OF BOREHOLE No 03-10		1 OF 2 METRIC	
W.P. <u>458-98-00</u>		LOCATION <u>N 5022725.5 ; E 358161.5</u>		ORIGINATED BY <u>P.A.H.</u>	
DIST <u> </u> HWY <u>417</u>		BOREHOLE TYPE <u>CME 55 Bombardier</u>		COMPILED BY <u>T.M.S.</u>	
DATUM <u>Geodetic</u>		DATE <u>Dec. 16, 2003</u>		CHECKED BY <u>L.C.C.</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 + FIELD VANE											
								● QUICK TRIAXIAL × REMOULDED											
65.4	Ground Surface						20	40	60	80	100	25	50	75					
0.0	Topsoil																		
65.1																			
0.3	Silty Clay, containing sand seams and layers Very stiff Grey-brown Very moist		1	SS	3														
64.0																			
1.4	Silty Clay, containing silty sand layers Stiff Grey Wet		2	SS	1														
62.1																			
3.4	Sand and Silt, some gravel, trace to some clay (TILL) Very loose Grey Wet		3	SS	3														
60.8																			
4.6	Sand and Gravel, some silt, trace clay (TILL) Compact Grey Wet		5	SS	11														
60																			
59																			
58.2																			
7.2	Sandstone (BEDROCK) Fresh Medium strong Very thinly to thickly bedded Grey																		
	Bedrock cored between 7.2 m and 10.6 m depth. For bedrock coring details, refer to Record of Drillhole 03-10.																		
58																			
57																			
56																			
55.4																			

Continued Next Page

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

MIS-MTO 001 021-1155-11-MTO.GPJ GAL-MISS.GDT 7/12/06

PROJECT <u>021-1155-11</u>		RECORD OF BOREHOLE No 03-10				2 OF 2 METRIC											
W.P. <u>458-98-00</u>		LOCATION <u>N 5022725.5 ; E 358161.5</u>				ORIGINATED BY <u>P.A.H.</u>											
DIST <u> </u> HWY <u>417</u>		BOREHOLE TYPE <u>CME 55 Bombardier</u>				COMPILED BY <u>T.M.S.</u>											
DATUM <u>Geodetic</u>		DATE <u>Dec. 16, 2003</u>				CHECKED BY <u>L.C.C.</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; font-size: small;"> 20 40 60 80 100 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between; font-size: x-small;"> ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED </div>										
10.0	Sandstone (BEDROCK)					55											
54.8																	
10.6	End of Borehole																
	Notes: * Split-spoon sampler bouncing after 24 blows. Water level in open borehole at 0.9 m depth (Elev. 64.5 m) on Dec. 19, 2003.																

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

CONT No.
WP No. 458-98-00

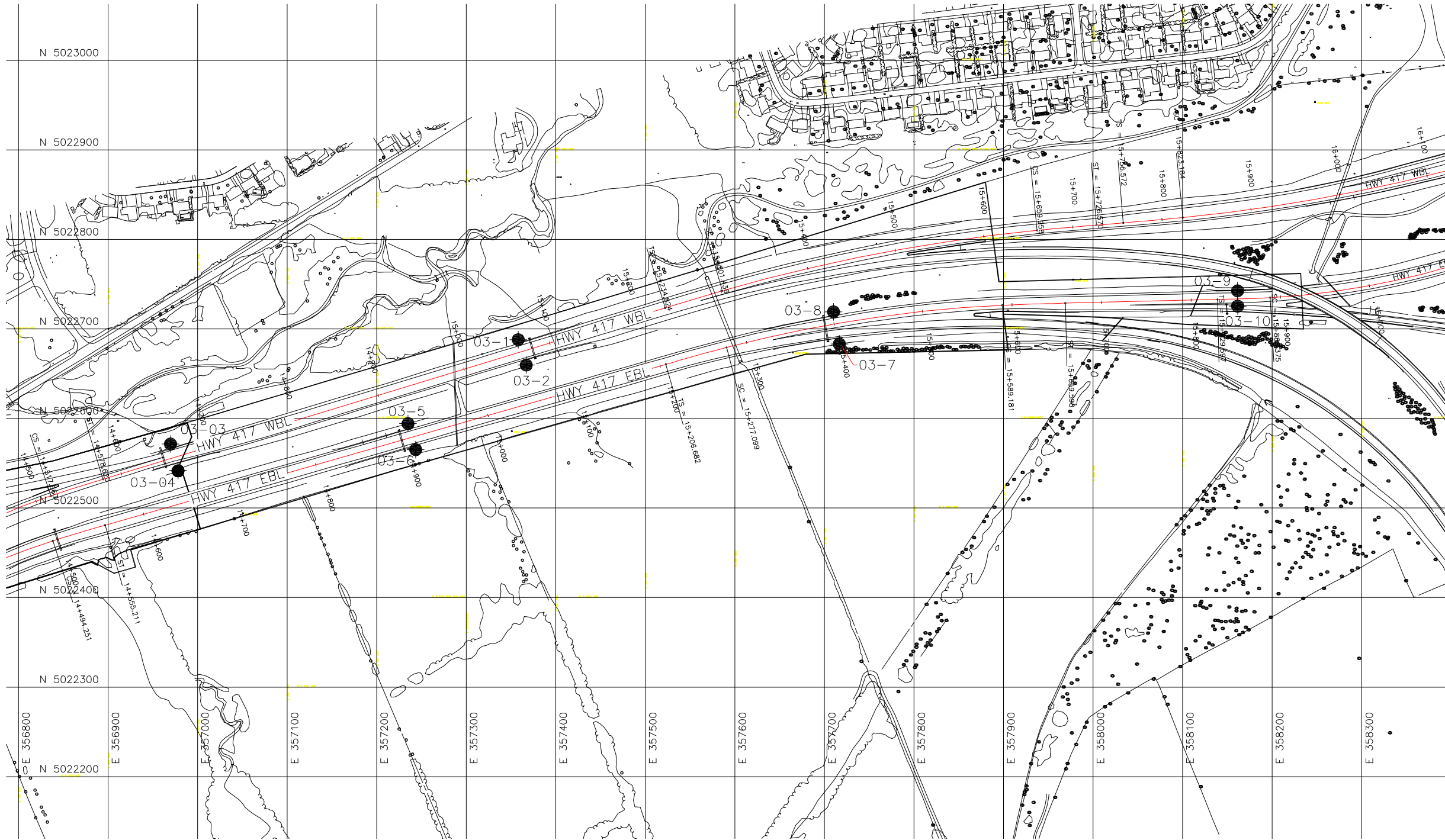
HIGHWAY 417
OVERHEAD SIGN REPLACEMENT
BOREHOLE LOCATIONS



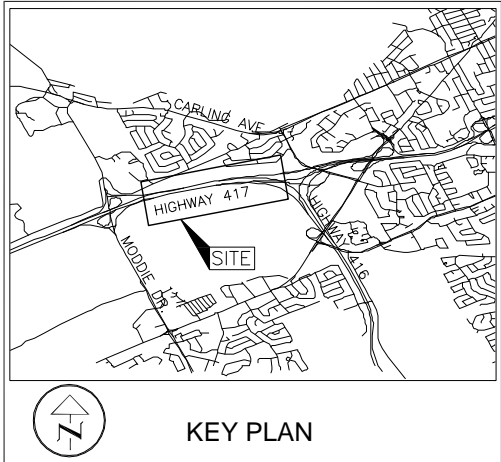
SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



PLAN



KEY PLAN

LEGEND

● Borehole - Current Investigation

No.	ELEVATION	LOCATION	
		NORTHING	EASTING
03-1	66.1	5022688.1	357358.1
03-2	65.8	5022659.7	357367.1
03-3	65.5	5022571.5	356969.8
03-4	65.8	5022541.6	356978.2
03-5	66.6	5022594.2	357235.0
03-6	66.2	5022565.2	357243.6
03-7	66.2	5022683.2	357716.7
03-8	67.4	5022719.1	357710.1
03-9	65.2	5022742.6	358161.4
03-10	65.4	5022725.5	358161.5

REFERENCE

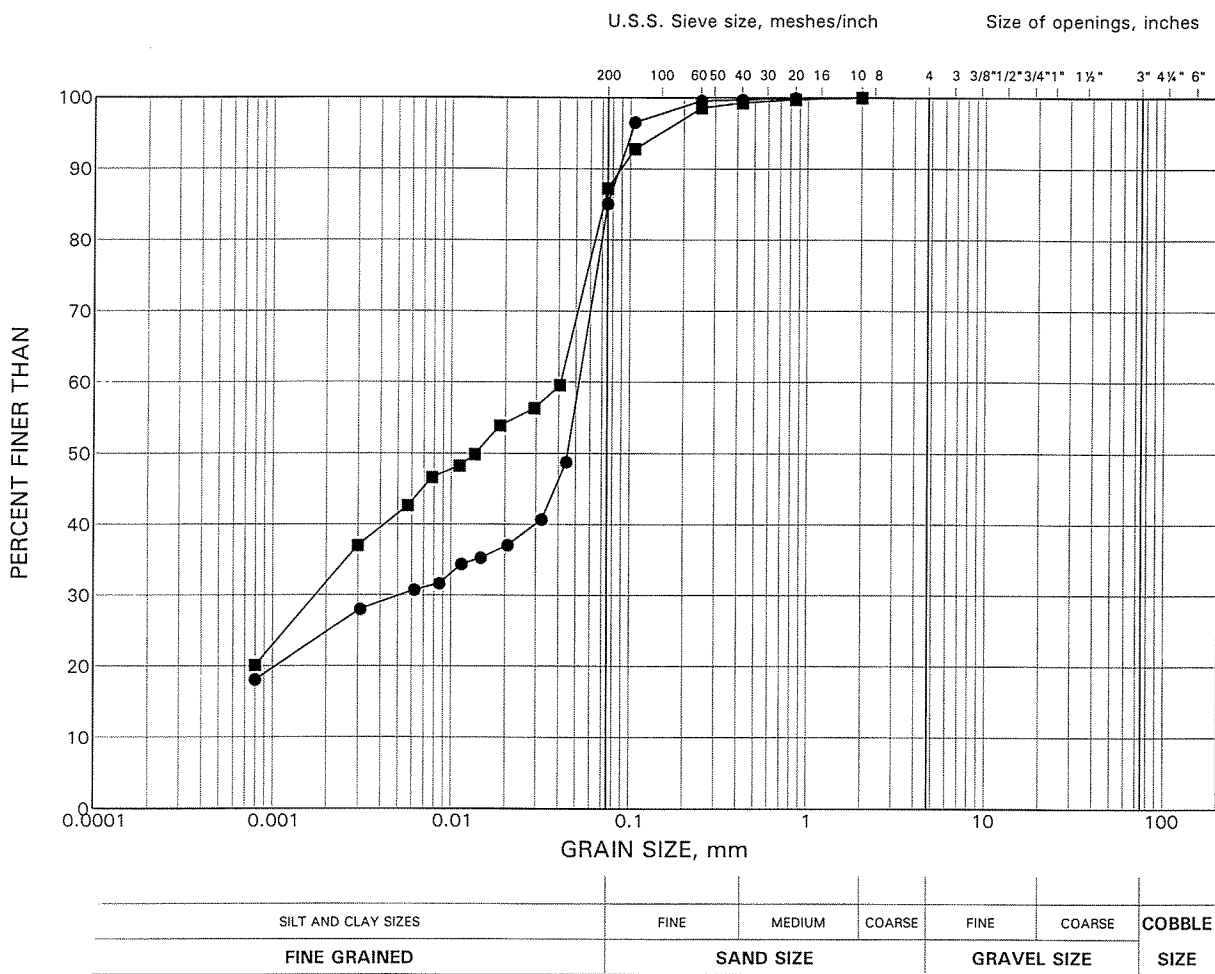
Base plan provided in digital format by Marshall Macklin Monaghan
(file name Nepean-base.dwg), received March 2004.

NO.	DATE	BY	REVISION
Geocres No.			
HWY. HWY 417		PROJECT NO. 021-1155-11	DIST.
SUBM'D. T.M.S.	CHKD. L.C.C.	DATE: 2005 01 11	SITE:
DRAWN: J.M./JFC	CHKD. T.M.S	APPD. L.C.C.	DWG. 1

GRAIN SIZE DISTRIBUTION TEST RESULTS

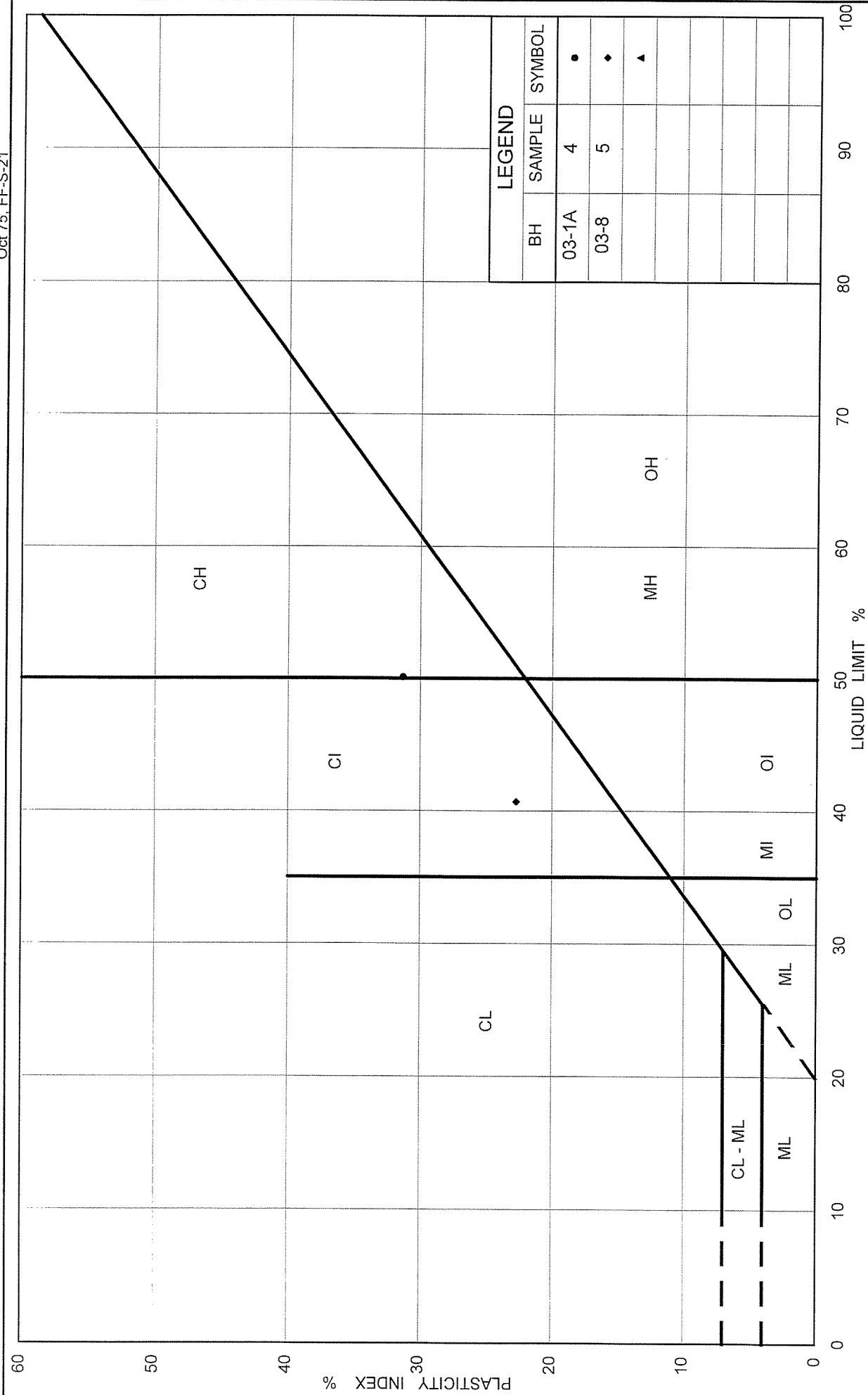
Silty Clay

FIGURE 1



LEGEND

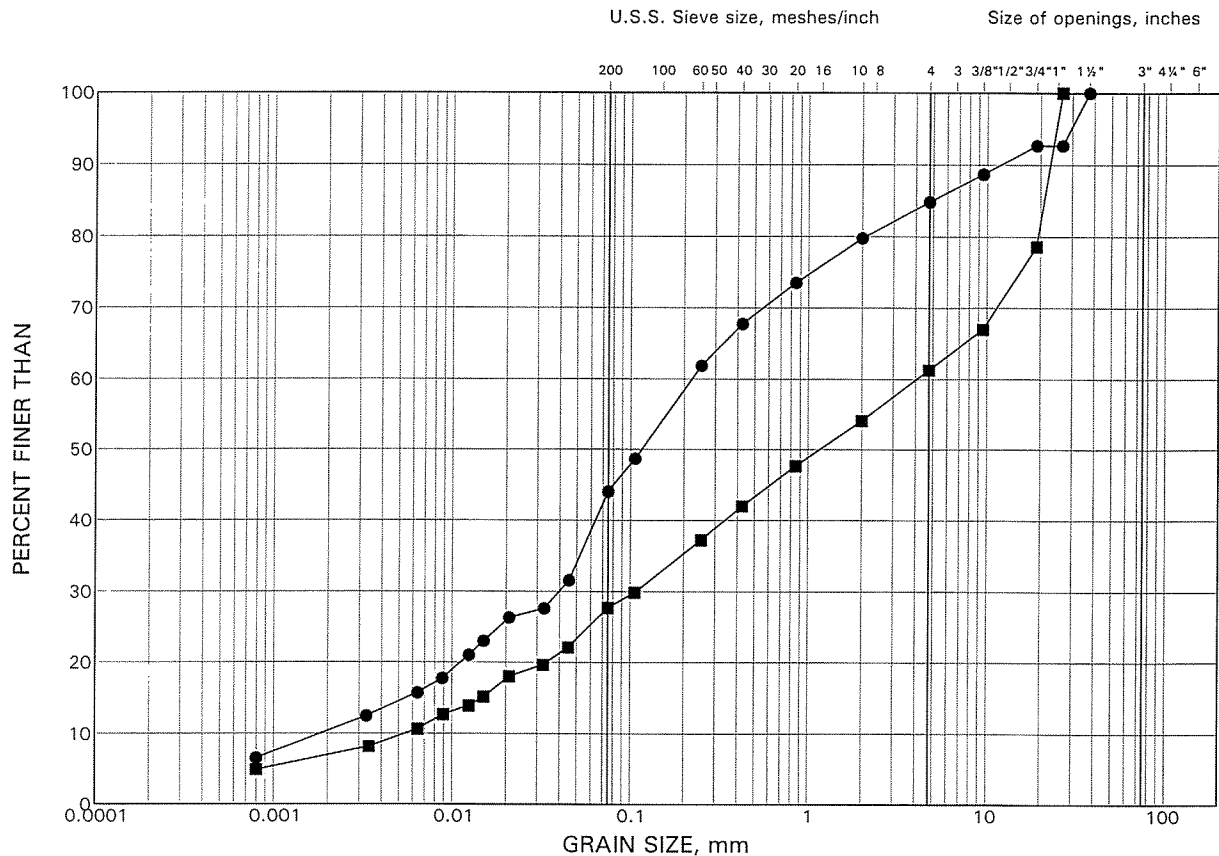
SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
●	03-5	3	3.4
■	03-9	2	1.8



GRAIN SIZE DISTRIBUTION TEST RESULTS

Sand and Silt Till

FIGURE 3



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
●	03-4	2	1.0
■	03-10	6	5.6