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**REPORT ON**

**FOUNDATION INVESTIGATION  
HIGHWAY 400, BAXTER TOWNSHIP  
TRANSFER STATION ROAD  
G.W.P 370-00-00  
MINISTRY OF TRANSPORTATION, ONTARIO**

Submitted to:

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GEOCRES NO. 31D-406

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## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder) has been retained by URS Canada Inc. (URS) to carry out a detailed foundation investigation as part of the detailed design for the new Baxter Township Transfer Station Road being carried out for the Ministry of Transportation, Ontario (MTO). The proposed works consist of construction of a road connecting Muskoka Road 48/South Bay Road to the existing Transfer Road and includes associated embankments and four culverts.

This report addresses the foundation investigation for the four culverts, including the swamp crossing at Culvert No. 1 and high fill embankment at Culvert No. 4, which have total lengths of about 70 m and 30 m, respectively. The general location of the Transfer Station Road and culverts are shown on the Key Plan on Drawing 1. The plans and profiles detailing the proposed Station Road alignment and culvert locations were provided to Golder by URS in November, 2003. The locations of the four culvert sites within the project limits are shown in plan on Drawing 1.

## **2.0 SITE DESCRIPTION**

The site is located about 300 m west of the existing Highway 400, extending from approximately the northwest corner of Lot 26, Concession 6 to the northwest corner of Lot 25, Concession 8 ending at South Bay Road. The four proposed culverts will cross underneath the future Transfer Station Road between Stations 8+215 m and 9+840 m.

The overall site of the project has been divided into four subsites (Culverts Nos. 1 – 4) for the purposes of design and description. In general, the overall site consists of rolling terrain including open fields, bush areas, swamp areas, and numerous rock outcrops at ground surface. The ground surface within the limits of the project area varies between Elevations 185 m and 200 m.

### 3.0 INVESTIGATION PROCEDURES

#### 3.1 Foundation Investigation

Field investigation work was carried out by Golder Associates Ltd. between November 11 and 20, 2003 for Culverts No. 2 to 4 and on May 31, 2004 for Culvert No. 1. A total of eight boreholes were advanced during the November 2003 field investigation (three at Culvert No. 2, two at Culvert No. 3 and three at Culvert No. 4), with bedrock cored in six of the eight boreholes. The proposed boreholes at Culvert No. 1 were postponed given that suitable frozen conditions did not develop during the winter 2003/2004. Due to standing water throughout the area (with depths ranging from 0.3 m to 0.45 m), drilling with a draft mounted rig was not possible and four hand auger probes were completed in May 2004. The table below summarizes all four areas investigated.

The borehole investigation was carried out using a HILTI manual portable drill rig supplied and operated by Marathon Drilling Co. Ltd. of Ottawa, Ontario. Soil samples were obtained continuously using a 50 mm O.D. split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586-99). The boreholes were advanced to depths ranging from 0.8 m to 5.4 m below ground surface with depths to bedrock ranging from 0.3 m to 3.7 m below ground surface. The hand auger probes in the swamp crossing at Culvert No. 1 were advanced to refusal with depths ranging from 0.9 m to 2.4 m below ground surface.

#### BOREHOLE LOCATION SUMMARY

<i>Station</i>	<i>Culvert No.</i>	<i>Crossing</i>	<i>Swamp/High Fill Station</i>	<i>Foundation Holes</i>
8+215	3		-	BH C3-2 and BH C3-3
8+345	2		-	BH C2-1 to BH C2-3
9+600	1	Swamp	Sta 9+560 to 9+630	HP C1-1 to HP C1-4
9+840	4	High Fill	Sta 9+820 to 9+850	BH C4-1 to BH C4-3

The field work was supervised throughout by members of our engineering and technical staff, who located the boreholes and test holes, arranged for the clearance of underground service locations, supervised the drilling, sampling and in-situ testing operations, logged the boreholes, and examined and cared for the soil samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Mississauga 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 relevant. Classification testing such as water content, grain size distribution and Atterberg Limits were carried out. The results of the laboratory testing are included in Appendix A.

The boreholes were located and measured by members of our engineering staff with reference to stationing and offsets from the proposed median centre-line as staked by URS. The northing and easting coordinates depicted on the Record of Borehole and Record of Drillhole sheets were derived from these station and off-set measurements and using the DTM (digital terrain map) for the project.

## **4.0 GENERAL SITE GEOLOGY AND SUBSURFACE CONDITIONS**

### **4.1 Regional Geology**

From published geologic information, the site is located in the physiographic region known as the Georgian Bay Fringe, a broad belt bordering Georgian Bay. This area forms the southern part of the Canadian Precambrian Shield, and part of the Grenville Province (The Physiography of Southern Ontario; OGS Special Volume 2). The Georgian Bay Fringe is characterized by very shallow, narrow strips of fine sand, silt and clay loams in valleys and bare rock knobs and ridges of granite and other rocks of Precambrian age.

### **4.2 General Overview of Local Subsurface Conditions**

The detailed subsurface soil and groundwater conditions as encountered in the boreholes and probeholes advanced during this investigation, together with the results of the laboratory tests carried out on selected soil samples, are given on the attached Table 1, Record of Borehole and Record of Drillhole sheets following the text of this report. The laboratory testing details are provided in Appendix A. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from observations of drilling progress and the results of Standard Penetration Tests (SPTs) and in situ testing. 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 soil stratigraphy as encountered in the boreholes and hand probes in the culvert areas are shown on Drawings 1 and 2; stratigraphic sections for the high fill and swamp areas are shown on Drawing 3.

In general, the stratigraphy encountered at the areas investigated is similar; however, the overburden (soil materials) thickness is variable ranging from 0.3 m to about 3.7 m deep. The stratigraphy generally consists of:

- surficial layers of topsoil or fibrous peat ranging in thickness from about 0.1 m to 2.0 m, typically less than 1.0 m;
- relatively thin (up to 2.4 m thick) deposits of silt and sand in some areas, particularly at Stations 8+215 and 8+345;
- deposits of cohesive silt and clay ranging in thickness from about 0.3 m to about 1.5 m; and
- between the cohesive deposits and bedrock, silt and sand deposits were encountered with thicknesses from 0.1 m up to 1.3 m.



Detailed descriptions of the subsurface conditions at each investigated area are provided in the following sections.

### **4.3 Culvert No. 3 (Station 8+215)**

The plan and centreline profile of Culvert No. 3 showing the borehole locations and interpreted stratigraphy between Stations 8+210 to 8+240 are shown on Drawing 1. A total of 2 boreholes (Boreholes BH C3-2 and C3-3) were completed to obtain information on the subsurface conditions within this area. The topography of this site is generally rolling with a beaver dam present in the northern portion of the area and the central and southern portions being tree covered and ponded water to the east of the area.

In general, the subsurface soils along the proposed main alignment of this section consist of thin alternating surficial deposits of sand/silty sands and silty clay overlying bedrock. Bedrock outcroppings were noted in the southern portion of the area and the deepest borehole at this site extended to 3.7 m below ground surface.

#### **4.3.1 Sand / Silty Sand**

A 0.6 m thick surficial layer of grey, medium to coarse sand was encountered in Borehole BH C3-3 at Station 8+210, 15 m east of the main alignment. Underlying this sand, a 0.6 m thick silty sand deposit was encountered with top at approximate Elevation 184.5 m.

Grey, fine to medium sand was encountered from ground surface and extending to 2.4 m depth approximate Elevation 183.6 m in Borehole BH C3-2 at Station 8+215.

Standard Penetration Testing (SPT) measured 'N' values ranging from 1 blow to 18 blows per 0.3 m of penetration, indicating a very loose to compact relative density within this layer. The natural water content measured on selected samples of this deposit ranged from 15 to 29 percent.

#### **4.3.2 Silty Clay**

Underlying the silty sand in Borehole C3-3 at Station 8+210, a 1.2 m thick deposit of brown and grey to grey silty clay with trace to some sand was encountered at approximate Elevation 183.9 m.

Standard Penetration Testing (SPT) measured 'N' values ranging from 11 blows to 15 blows per 0.3 m of penetration indicating a stiff consistency.

Atterberg limits testing carried out on two (2) samples of the silty clay gave liquid limits of about 45 and 49 percent, plastic limits of 16 and 18 percent, and plasticity indices of about 29 and 32 percent. The results are shown on Figure A-1 in Appendix A and indicate that the material is a clay of intermediate plasticity.

The natural water content measured on selected samples of this deposit ranged between 35 percent and 37 percent.

#### **4.3.3 Sand**

Below the silty clay in Borehole BH C3-3, a 0.7 m thick deposit of grey coarse sand was encountered, containing trace gravel, at approximate Elevation 182.7 m.

Standard Penetration Testing (SPT) carried out within this stratum measured an 'N' value of 2 blows per 0.3 m of penetration, indicating a very loose relative density.

#### **4.3.4 Silty Sand**

A lower, grey silty sand deposit (about 0.6 m thick) was encountered below the coarse sand at approximate Elevation 182.0 m. The lower silty sand contained trace amounts of gravel.

Standard Penetration Testing (SPT) carried out within this stratum measured an 'N' value of 15 blows per 0.3 m of penetration, indicating a compact relative density.

A natural water content of about 10 percent was measured on one sample of this deposit.

#### **4.3.5 Bedrock**

Bedrock was encountered at both Culvert No. 3 borehole locations. The depth to bedrock below ground surface was 2.4 m in Borehole C3-2 and 3.7 m in Borehole C3-3. The bedrock core samples retrieved from both boreholes are described as fresh, medium to fine grained, medium strong to strong granite. The RQD values measured on the core samples typically are greater than 60 per cent in Borehole C3-2 and greater than 75 per cent in Borehole C3-3 indicating fair to excellent rock quality.

#### **4.3.6 Groundwater Conditions**

In general, the samples taken in the boreholes were noted to be wet and the groundwater level was generally found to be at or near ground surface during drilling. It should be noted that groundwater levels in the area are subject to seasonal fluctuations and the groundwater level will vary depending on precipitation and local soil permeability.

#### **4.4 Culvert No. 2 (Station 8+345)**

The plan and centreline profile of Culvert No. 2 showing the borehole locations and interpreted stratigraphy are shown on Drawing 1. A total of 3 boreholes (Boreholes BH C2-1 to C2-3) were completed to the subsurface conditions within this area. The topography of this site is generally rolling with mostly mixed forest covering the area, and rock outcroppings to the south and north of the site.

In general, the subsurface soils along the proposed main alignment of this section consist of thin deposits of peat and/or topsoil underlain by surficial deposits of silty sand and silty clay. Bedrock outcrops to the north of the culvert and the deepest borehole at this site extended to 1.6 m below ground surface.

##### **4.4.1 Topsoil**

A 0.1 to 0.3 m thick surficial layer of topsoil was encountered in Borehole C2-1 at Station 8+340 (10 m west of main alignment), in Borehole C2-2 at Station 8+345 on centreline and in Borehole C2-3 at Station 8+350 (10 m east of the main alignment).

##### **4.4.2 Sand and Silt / Silty Sand**

A yellowish brown, sand and silt was encountered at approximate Elevations 192.3 m, with a thickness of 0.5 m.

A brown and grey, silty sand was encountered underlying the sand and silt in Borehole C2-1 and underlying the topsoil in Borehole C2-2 at approximate Elevations 191.8 m and 192.9 m, respectively.

Standard Penetration Testing (SPT) in Borehole C2-1 measured 'N' values ranging from 3 blows to 69 blows per 0.3 m of penetration, indicating a very loose to very dense relative density within this layer. Standard Penetration Testing (SPT) in Borehole C2-2 measured an 'N' value of 2 blows per 0.3 m of penetration, indicating a very loose relative density within this layer.

A natural water content of about 14 percent was measured on one selected sample of the sand and silt/silty sand deposits.

##### **4.4.3 Silty Clay to Clay Till**

Underlying the silty sand in Borehole C2-2, a 0.7 m thick deposit of brown and grey, silty clay to clay with trace to some sand was encountered at approximate Elevation 192.5 m.

Standard Penetration Testing (SPT) measured an 'N' value of 26 blows per 0.3 m of penetration indicating a very stiff consistency.

Atterberg limits testing was carried out on one (1) sample of the silty clay yielding a liquid limit of about 53 percent, a plastic limit of about 21 percent, and a plasticity index of about 32 percent. The results are shown on Figure A-1 in Appendix A and indicate that the material is a clay of high plasticity.

A natural water content of about 30 percent was measured on one selected sample of the silty clay deposit.

#### **4.4.4 Silty Sand Till**

In Borehole C2-2 a lower, brown and grey, silty sand deposit (about 0.4 m thick) with gravel was encountered below the silty clay at approximate Elevation 191.8 m.

Standard Penetration Testing (SPT) carried out within this stratum measured an 'N' value of 63 blows per 0.3 m of penetration, indicating a very dense relative density.

A natural water content of about 32 percent was measured on one sample of this deposit.

#### **4.4.5 Bedrock**

Refusal, typically defined by greater than 100 blows per 0.3 m penetration, was met at all three Culvert No. 2 borehole locations. The depth to bedrock below ground surface ranged from 0.3 m in Borehole C2-3 (approximate Elevation 192.7 m) to 1.6 m in Borehole C2-2 (approximate Elevation 191.4 m).

Bedrock was cored in two of the boreholes. The bedrock is described as fresh, massive, medium strong to strong granite (medium to fine grained) and/or pegmatite (large grained).

The RQD values measured on the core samples typically are greater than 60% in borehole C2-1 and range between 22% - 53% in borehole C2-3 indicating very poor to good quality.

#### **4.4.6 Groundwater Conditions**

In general, the samples taken in the boreholes were noted to be wet and the groundwater level was generally found to be at or near ground surface. It should be noted that groundwater levels in the area are subject to seasonal fluctuations. Furthermore, groundwater elevations will vary depending on precipitation and local soil permeability.

#### **4.5 Culvert No. 1 (Station 9+600)/Swamp Crossing Station 9+560 to 9+630**

The plan and centreline profile of Culvert No. 1 showing the borehole locations and interpreted stratigraphy are shown on Drawing 2. A total of 4 hand auger holes (HP C1-1 to C1-4) were completed to investigate the subsurface conditions within the area of this culvert. In addition, auger probes were also put down as part of the geotechnical investigation as shown on Drawing 3. The topography within this swamp covered area is generally flat.

In general, the subsurface soils along the proposed main alignment of this section consist of deposits of peat underlain by a deposit of silty clay, in turn overlying a thin layer of sand. Bedrock outcrops to the north and south of the swamp and the deepest hand probe at this site extended to 2.4 m depth below ground surface in the middle of the swamp.

##### **4.5.1 Peat**

A 0.8 m to 2.0 m thick surficial layer of peat was encountered in hand auger holes C1-1 to C1-4.

##### **4.5.2 Silty Clay**

A layer of soft, grey, silty clay was encountered at all hole locations ranging in thickness from 0.02 m to 0.3 m with top at approximate Elevations 186.8 m and 185.6 m, respectively.

##### **4.5.3 Sand**

Underlying the silty clay, a thin layer (less than 0.1 m thick) of compact, grey sand with trace silt was encountered.

##### **4.5.4 Bedrock / Refusal**

Refusal to further auger penetration was met at depths below ground surface ranging from 1.2 m in HPCI - 4 at Station 9+600, 11 m east (approximate Elevation 186.8 m) to 2.0 m IN HPCI - 1 at Station 9+600 m, 11 m west (approximate Elevation 185.2 m).

These refusal depths, while they do not necessarily confirm bedrock elevations, may be inferred to indicate potential proximity to the bedrock surface. Based on the results of the bedrock coring carried out in the boreholes at Culverts Nos. 2 to 4, the bedrock in the area can be described as fresh, medium strong to strong granite (medium to fine grained) and/or pegmatite (large grained).

#### **4.5.5 Groundwater Conditions**

In general, the water depth at the time of the investigation (May 2004) ranged from 0.3 m to 0.45 m at the borehole locations along Culvert No. 1 (Station 9+600). The water depth varies across the length of the swamp and is up to 1.5 m deep in areas. The groundwater level is influenced by the water level within the swamp which is subject to seasonal fluctuations and will vary depending on precipitation.

#### **4.6 Culvert No. 4 (Station 9+840)**

The plan and centreline profile of Culvert No. 4 showing the borehole locations and interpreted stratigraphy between Stations 9+820 to 9+850 are shown on Drawing 2. A total of 3 boreholes (Boreholes BH C4-1 to C4-3) were completed to investigate the subsurface conditions within this area. In addition, auger probes were put down as part of the geotechnical investigation in this area as shown on Drawing 3. The topography of this site is generally flat with bedrock outcroppings towards the southern and northern portions of the site.

In general, the subsurface soils along the proposed main alignment of this section consist of thin deposits of peat and/or topsoil underlain by surficial deposits of silty clay and fine sand/silty sand to the depth of refusal. Bedrock outcrops at the northern and southern limit of the site and the deepest borehole at this site extended to 2.1 m depth.

##### **4.6.1 Peat / Topsoil**

A 0.3 to 0.6 m thick surficial layer of peat/topsoil was encountered in Borehole C4-3 and Borehole C4-2.

Standard Penetration Testing (SPT) measured one 'N' value of 4 blows per 0.3 m of penetration, indicating a very loose state of packing.

##### **4.6.2 Silty Clay to Clay**

Underlying the peat/topsoil in Boreholes C4-2 and C4-3 and at ground surface in Borehole C4-1, a 0.3 m to 1.5 m thick deposit of brown and grey silty clay to clay with trace sand and gravel was encountered at approximate Elevations 187.4 m, 188.7 m and 188.0 m, respectively.

Standard Penetration Testing (SPT) measured 'N' values ranging from 3 blows to 14 blows per 0.3 m of penetration indicating a soft to stiff consistency.

Atterberg limits testing was carried out on two (2) selected samples of the silty clay. The liquid limit ranged from about 48 to 57 percent and the plastic limit ranged from 19 to 21 percent, and plasticity indices ranging from about 30 to 36 percent. The results are shown on Figure A-1 in Appendix A and indicate that the material is a silty clay of intermediate plasticity to clay of high plasticity.

The natural water content measured on selected samples of this deposit ranged between 35 percent and 54 percent.

#### **4.6.3 Fine Sand / Silty Sand**

A lower, brown and grey to grey fine sand/silty sand deposit with trace gravel (about 0.2 m thick) was encountered below the silty clay in Borehole C4-3 in Borehole C4-1 at approximate Elevations 188.4 m and 186.8 m, respectively.

Standard Penetration Testing (SPT) obtained for this layer were greater than 50 blows per 0.2 m due to the bedrock directly beneath this thin layer.

A natural water content of about 14 percent was measured on one sample of this deposit.

#### **4.6.4 Bedrock**

Refusal, typically defined by greater than 100 blows per 0.3 m penetration in the boreholes was met, at all three Culvert No. 4 borehole locations. The depth to bedrock below ground surface ranged from 0.8 m in Borehole C4-3 (approximate Elevation 188.2 m) to 2.1 m in Borehole C4-2 (approximate Elevation 185.9 m).

Bedrock was cored in two of the boreholes. The bedrock is described as fresh, medium to fine grained, medium strong to strong granite. The RQD values measured on the rock core samples were about 75% in Borehole C4-1 and about 55% in Borehole C4-2 indicating a fair to good rock quality.

#### **4.6.5 Groundwater Conditions**

In general, the samples taken in the boreholes were noted to be wet and the groundwater level was generally found to be at or near ground surface. It should be noted that groundwater levels in the area are subject to seasonal fluctuations and will vary depending on precipitation and local soil permeability

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**TABLE 1**  
**SUMMARY OF SUBSOIL CONDITIONS AT**  
**PROBE HOLE LOCATIONS – STATION 9+560 TO 9+630**  
**CULVERT 1 / SWAMP CROSSING**

Station		Borehole Number	Elevation (m)	Depth	Description
9+564	14 m Lt	A	189.0	0 – 1.2 m 1.2 – 1.6 m 1.6 m	Water Black organics, soft NFP bedrock
	C/L	B	188.0	0 – 1.2 m 1.2 – 1.4 m 1.4 m	Water Black organics, soft NFP bedrock
	14 m Rt	C	188.4	0 – 1.2 m 1.2 – 1.9 m 1.9 m	Water Black organics, soft NFP bedrock
9+600	11 m Lt	HPC1-1	188.0	0 – 0.45 m 0.45 – 2.5 m 2.5 – 2.7 m 2.7 – 2.8 m 2.8 m	Water Peat Grey silty clay, trace sand, soft Grey sand, trace silt, compact NFP bedrock
	C/L	HPC1-2	188.0	0 – 0.45 m 0.45 – 2.4 m 2.4 – 2.68 m 2.68 – 2.74 m 2.74 m	Water Peat Grey silty clay, trace sand, soft Grey sand, trace silt, compact NFP bedrock
	5.5 m Rt	HPC1-3	188.0	0 – 0.4 m 0.4 – 1.4 m 1.4 m	Water Peat NFP bedrock
	11 m Rt	HPC1-4	188.0	0 – 0.33 m 0.33 – 1.16 m 1.16 – 1.18 m 1.18 – 1.22 m 1.22 m	Water Peat Grey silty clay, soft overlying Grey sand, trace silt, compact NFP bedrock
9+620	12 m Lt	D	188.0	0 – 1.2 m 1.2 – 2.2 m 2.2 – 2.4 m 2.4 m	Water Muckamor, soft Grey sand with silt, trace gravel, compact NFP bedrock
	C/L	E	188.0	0 – 1.1 m 1.1 – 1.5 m 1.5 – 1.6 m 1.6 m	Water Black organics, soft Grey sand with silt, trace gravel, compact NFP bedrock
	12 m Rt	F	188.0	0 – 1.2 m 1.2 – 2.2 m 2.2 – 2.4 m 2.4 m	Water Muckamor, soft Grey sand with silt, trace gravel, compact NFP bedrock
9+630	C/L	G	189.1	0 – 0.25 m 0.25 – 0.5 m 0.5 – 0.6 m 0.6 m	Water Black organics, soft Grey sand with silt, trace gravel, compact NFP bedrock

Note: Refer to Figure 3 for Probe Hole Locations

**TABLE 2**  
**SUMMARY OF SUBSOIL CONDITIONS AT**  
**PROBE HOLE LOCATIONS – STATION 9+818 TO 9+850**  
**HIGH FILL**

Station		Borehole Number	Elevation (m)	Depth	Description
9+818	C/L	H	193.0	0 m	Bedrock
9+840	C/L	L	188.0	0 – 0.3 m 0.3 – 0.8 m 0.8 – 2.0 m	Black organics, soft Brown sandy silt, trace clay, trace gravel, compact Brown silty clay with sand, stiff
9+850	14 m Lt	I	188.0	0 – 0.25 m 0.25 – 0.7 m 0.7 – 2.0 m	Black organics, soft Brown sandy silt, trace clay, trace gravel, compact Brown silty clay with sand, stiff
	C/L	J	190.0	0 – 0.1 m 0.1 m	Dark brown silt NFP bedrock
	14 m Rt	K	195.1	0 m	Bedrock

Note: Refer to Figure 3 for Probe Hole Locations

## **APPENDIX A LABORATORY TEST RESULTS**

## 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

	$c_u, s_u$	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 cm<sup>2</sup> pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance ( $Q_t$ ), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

### IV. SOIL TESTS

w	water content
$w_p$	plastic limit
$w_l$	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
$D_R$	relative density (specific gravity, $G_s$ )
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
$SO_4$	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
$\gamma$	unit weight

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

S:\FINALDATA\ABBREV\2000\LOFA-D00.DOC

## LIST OF SYMBOLS

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

### I. General

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

### II. STRESS AND STRAIN

$\gamma$	shear strain
$\Delta$	change in, e.g. in stress: $\Delta \sigma$
$\epsilon$	linear strain
$\epsilon_v$	volumetric strain
$\eta$	coefficient of viscosity
$\nu$	poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )
$\sigma'_{vo}$	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
$\sigma_{oct}$	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
$\tau$	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

### III. SOIL PROPERTIES

#### (a) Index Properties

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

#### (a) Index Properties (continued)

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

#### (b) Hydraulic Properties

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

#### (c) Consolidation (one-dimensional)

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

#### (d) Shear Strength

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

- Notes:**
- 1  $\tau = c' + \sigma' \tan \phi'$
  - 2 shear strength = (compressive strength)/2
  - \* density symbol is  $\rho$ . Unit weight symbol is  $\gamma$  where  $\gamma = \rho g$  (i.e. mass density x acceleration due to gravity)

PROJECT		2021-1103		<b>RECORD OF BOREHOLE No C2-1</b>		1 OF 1		<b>METRIC</b>						
W.P.		370-00-00		LOCATION		N 4967290.8 ; E 285772.2		ORIGINATED BY						
DIST		52		HWY		BOREHOLE TYPE		HILTI Manual Portable Rig; Continuous Split Spoon Sampling						
DATUM		Geodetic		DATE		Nov. 11, 2003		CHECKED BY						
								CAB						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
192.4	GROUND SURFACE							20 40 60 80 100	20 40 60 80 100	15 30 45				
0.9	TOPSOIL													
191.8	SAND and SILT with roots, trace to some gravel		1	SS	3		192							
0.6	Very loose													
191.3	Yellowish brown		2	SS	69									
1.1	Moist													
	Silty SAND, trace gravel (TILL)						191							
	Very dense													
	Brown and grey													
	Moist													
	Granite (BEDROCK)													
	Fresh													
	Medium strong to strong													
	Grey						190							
189.7	Pegmatite (BEDROCK)													
189.4	Fresh													
3.1	Medium to strong													
	Pink													
	Bedrock cored from 1.1m to 2.7m depth.													
	For coring details see Record of Drillhole C2-1.													
	End of Borehole													
	NOTE:													
	1. Spoon refusal at 1.1m depth.													
	2. Culvert #2 (Sta. 8+340, 10 m WEST)													

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

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: Marathon Drilling

CHECKED: CAB

PROJECT		RECORD OF BOREHOLE		No C2-2		1 OF 1		METRIC							
W.P.		LOCATION		ORIGINATED BY		COMPILED BY		CHECKED BY							
DIST		BOREHOLE TYPE		DATE		DATE		DATE							
Geodetic		HILTI Manual Portable Rig; Continuous Split Spoon Sampling		Nov. 11, 2003		Nov. 11, 2003		Nov. 11, 2003							
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	
193.0	GROUND SURFACE							20 40 60 80 100		15 30 45					
0.4	TOPSOIL							○ UNCONFINED + FIELD VANE		Wp W WL					
192.5	Silty SAND with to gravel, trace clay		1	SS	2			● QUICK TRIAXIAL × REMOULDED		Wp W WL					
0.5	Very loose														
	Brown and grey														
	Wet														
191.8	Silty CLAY, trace to some sand (TILL)		2	SS	26		192								
	Very stiff														
191.4	Brown and grey		3	SS	63										
1.6	Moist														
	Silty SAND with gravel (TILL)														
	Very dense														
	Brown and grey														
	Wet														
	End of Borehole														
NOTES: 1. Water level in open borehole at ground surface. 2. Spoon refusal at 1.6m depth below ground surface. 3. Culvert #2 (Sta. 8+345)															



PROJECT		RECORD OF BOREHOLE				No C2-3		1 OF 1		METRIC								
W.P.		LOCATION		ORIGINATED BY		DIST		BOREHOLE TYPE		COMPILED BY								
DATUM		DATE		CHECKED BY		GRAIN SIZE DISTRIBUTION (%)		REMARKS										
021-1103		N 4967301.7 ; E 285791.7		SB		52 HWY		HILTI Manual Portable Rig; Continuous Split Spoon Sampling		DD								
Geodetic		Nov. 11, 2003		CAB														
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 <sub>p</sub>	W	W <sub>L</sub>	15 30 45				
193.0	0.0	GROUND SURFACE																
192.7	0.3	TOPSOIL																
		Pegmatite (BEDROCK) Fresh Medium strong to strong Pink						192										
		Bedrock cored between 0.3m and 1.83m depth. For coring details, refer to Record of Drillhole C2-3.																
191.2	1.8	End of Borehole																
		NOTES: 1. No samples taken. 2. Hand dug with shovel. 3. Culvert #2 (Sta. 8+350, 10 m EAST)																

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: Marathon Drilling

CHECKED: CAB

PROJECT		021-1103		<b>RECORD OF BOREHOLE No C3-2</b>				1 OF 1		<b>METRIC</b>						
W.P.		370-00-00		LOCATION		N 4967168.9 ; E 285760.2				ORIGINATED BY		SB				
DIST		52		HWY		BOREHOLE TYPE				HILTI Manual Portable Rig; Continuous Split Spoon Sampling						
COMPILED BY		DD		DATE		Nov. 17, 2003				CHECKED BY		CAB				
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)			
186.0	GROUND SURFACE															
0.0	Fine to medium SAND with roots and some silt and gravel Very loose to compact Grey Wet		1	SS	2											
			2	SS	18											
			3	SS	14											
			4	SS	14											
183.6	Granite (BEDROCK) Fresh Medium strong Grey															
2.4																
182.6	Bedrock cored from 2.4m to 3.45m depth. For coring details, refer to Record of Drillhole C3-2. End of Borehole															
3.5																
NOTE: 1. Spoon refusal at 2.44m depth. 2. Culvert #3 (Sta. 8+215)																

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

PROJECT: 021-1103

# RECORD OF DRILLHOLE: C3-2

SHEET 1 OF 1

LOCATION: Culvert #3 (Sta. 8+215)

DRILLING DATE: Nov. 18, 2003

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: HILTI Manual Portable Rig

DRILLING CONTRACTOR: Marathon Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm)	FLUSH	RECOVERY % CORE	R.Q.D. % CORE	FRACT. INDEX PER 1m	DISCONTINUITY DATA	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION											
																CORRECTION % 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					
																						TOTAL CORE %	SOLID CORE %	B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION
		Refer to previous page		183.56																						
		Fresh, massive structure, grey, medium grained, medium strong, slight effervescence, GRANITE		2.44	1																					
3	BQ				2																					
		End of Drillhole		182.55																						
				3.45																						
4																										
5																										
6																										
7																										
8																										
9																										
10																										
11																										
12																										

DEPTH SCALE

1 : 50



LOGGED: SB

CHECKED: CAB

PROJECT		2021-1103		RECORD OF BOREHOLE No C3-3		1 OF 1		METRIC					
W.P.		370-00-00		LOCATION		N 4967159.5 ; E 285769.3		ORIGINATED BY					
DIST		52		HWY		BOREHOLE TYPE		HILTI Manual Portable Rig; Continuous Split Spoon Sampling					
DATUM		Geodetic		DATE		Nov. 17, 2003		CHECKED BY					
								CAB					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT		UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	15 30 45		
185.1	GROUND SURFACE												
0.0	Medium to coarse SAND, trace gravel		1	SS	1								
184.5	Very loose Grey												
0.6	Wet Silty SAND with gravel, trace roots		2	SS	6								
183.9	Loose Grey												
1.2	Wet Silty CLAY, trace to some sand		3	SS	11								
	Stiff Brown and grey to grey												
	Moist		4	SS	15								
182.7	Coarse SAND, trace gravel												
2.4	Very loose Grey		5	SS	2								
182.1	Wet Silty SAND, trace gravel												
3.1	Compact Grey		6	SS	15								
181.4	Wet Granite (BEDROCK)												
3.7	Fresh Medium strong to strong Salt and pepper												
	Bedrock cored from 3.7m to 5.4m depth.												
	For coring details, refer to Record of Drillhole C3-3.												
179.7	End of Borehole												
5.4	NOTE: 1. Spoon refusal at 3.7m depth. 2. Culvert #3 (Sta. 8+210, 12 m EAST)												

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

PROJECT: 021-1103

**RECORD OF DRILLHOLE: C3-3**

SHEET 1 OF 1

LOCATION: Culvert #3 (Sta. 8+210, 12 m EAST)

DRILLING DATE: Nov. 18, 2003

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: HILTI Manual Portable Rig

DRILLING CONTRACTOR: Marathon Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.		RUN No.	PENETRATION RATE (m/min)	COLOUR % RETURN	FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX PER 1m	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY				Diametral Load Index (MPa)	RMC -Q' AVG	NOTES WATER LEVELS INSTRUMENTATION
				DEPTH (m)	FLUSH					TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t CORE AXIS	TYPE AND SURFACE DESCRIPTION	K, cm/sec	10	10	10	10			
		Refer to previous page		181.44 3.66																				
4	BQ	Fresh, banded, salt and pepper, medium to fine grained, medium strong to strong, GRANITE		1																				
2																								
5				3																				
		End of Drillhole		179.73 5.37																				
6																								
7																								
8																								
9																								
10																								
11																								
12																								
13																								

DEPTH SCALE

1 : 50



LOGGED: SB

CHECKED: CAB

PROJECT <u>021-1103</u>	<b>RECORD OF BOREHOLE No C4-1</b>	1 OF 1	<b>METRIC</b>
W.P. <u>370-00-00</u>	LOCATION <u>N 4968749.2 ; E 285434.6</u>	ORIGINATED BY <u>SB</u>	
DIST <u>52</u> HWY <u></u>	BOREHOLE TYPE <u>HILTI Manual Portable Rig; Continuous Split Spoon Sampling</u>	COMPILED BY <u>DD</u>	
DATUM <u>Geodetic</u>	DATE <u>Nov. 19, 2003</u>	CHECKED BY <u>CAB</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
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188.0	GROUND SURFACE																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		

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

SHEET 1 OF 1


DATUM: Geodetic

DRILLING CONTRACTOR: Marathon Drilling

CHECKED: CAB



PROJECT <u>021-1103</u>		<b>RECORD OF BOREHOLE No C4-2</b>		1 OF 1		<b>METRIC</b>	
W.P. <u>370-00-00</u>		LOCATION <u>N 4968744.1 ; E 285454.3</u>		ORIGINATED BY <u>SB</u>			
DIST <u>52</u> HWY <u></u>		BOREHOLE TYPE <u>HILTI Manual Portable Rig; Continuous Split Spoon Sampling</u>		COMPILED BY <u>DD</u>			
DATUM <u>Geodetic</u>		DATE <u>Nov. 19, 2003</u>		CHECKED BY <u>CAB</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W <sub>p</sub>	W	W <sub>L</sub>		
							20	40	60	80	100						
188.0	GROUND SURFACE																
0.0	PEAT with roots		1	SS	4												
187.4	Loose Black Wet																
0.6	Silty CLAY, trace sand		2	SS	13												
	Stiff Brown and grey Moist		3	SS	14												
185.9	Granite (BEDROCK)		4	SS	50/0.23												
2.1	Fresh Medium strong to strong Grey																
184.7	Bedrock cored from 2.1m to 3.35m depth.																
3.4	For coring details, refer to Record of Drillhole C4-2. End of Borehole																
	NOTE: 1. Spoon refusal at 2.1m depth. 2. Culvert #4 (Sta. 9+840)																

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

PROJECT: 021-1103

**RECORD OF DRILLHOLE: C4-2**

SHEET 1 OF 1

LOCATION: Culvert #4 (Sta. 9+840)

DRILLING DATE: Nov. 20, 2003

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: HILTI Manual Portable Rig

DRILLING CONTRACTOR: Marathon Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	PENETRATION RATE RUN No. (m/min)	FLUSH	COLOUR % RETURN	JN - Joint		BD - Bedding		PL - Planar		PO - Polished		BR - Broken Rock	NOTES: For additional abbreviations refer to list of abbreviations & symbols.	WATER LEVELS INSTRUMENTATION		
								FLT - Fault	FO - Foliation	CU - Curved	K - Slickensided	SHR - Shear	CO - Contact	UN - Undulating	SM - Smooth				Ro - Rough	MB - Mechanical Break
								VN - Vein	OR - Orthogonal	ST - Stepped	IR - Irregular	CL - Cleavage	IR - Irregular	IR - Irregular	IR - Irregular				IR - Irregular	IR - Irregular
		Refer to previous page		185.94																
	BQ	Fresh, massive, grey with salt and pepper, medium to fine grained, medium strong to strong, GRANITE		2.06	1															
3																				
		End of Drillhole		184.65																
				3.35																
4																				
5																				
6																				
7																				
8																				
9																				
10																				
11																				
12																				

DEPTH SCALE

1 : 50



LOGGED: SB

CHECKED: CAB

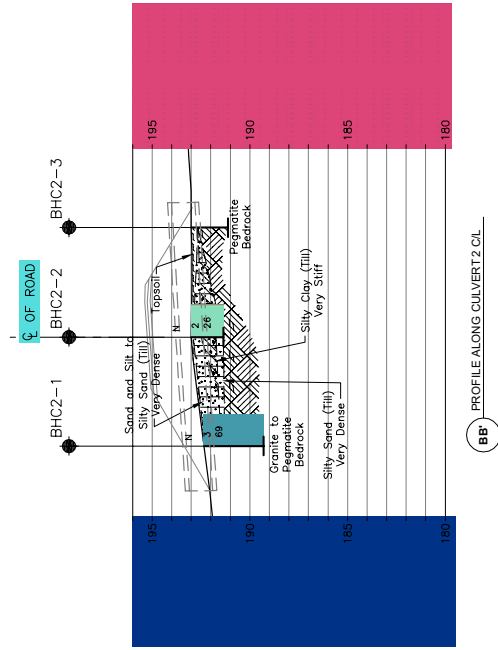
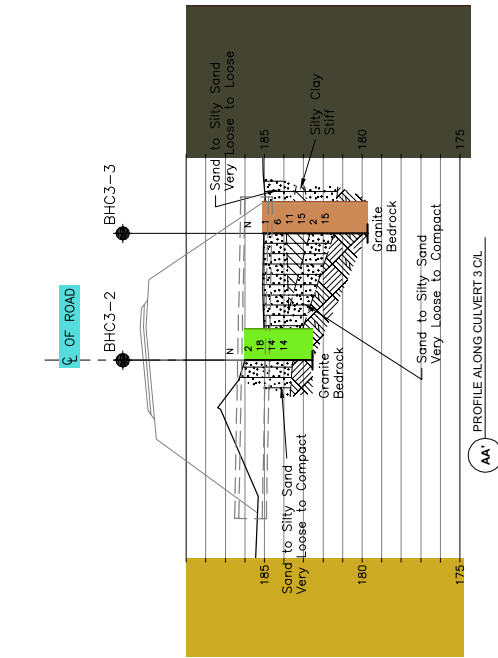
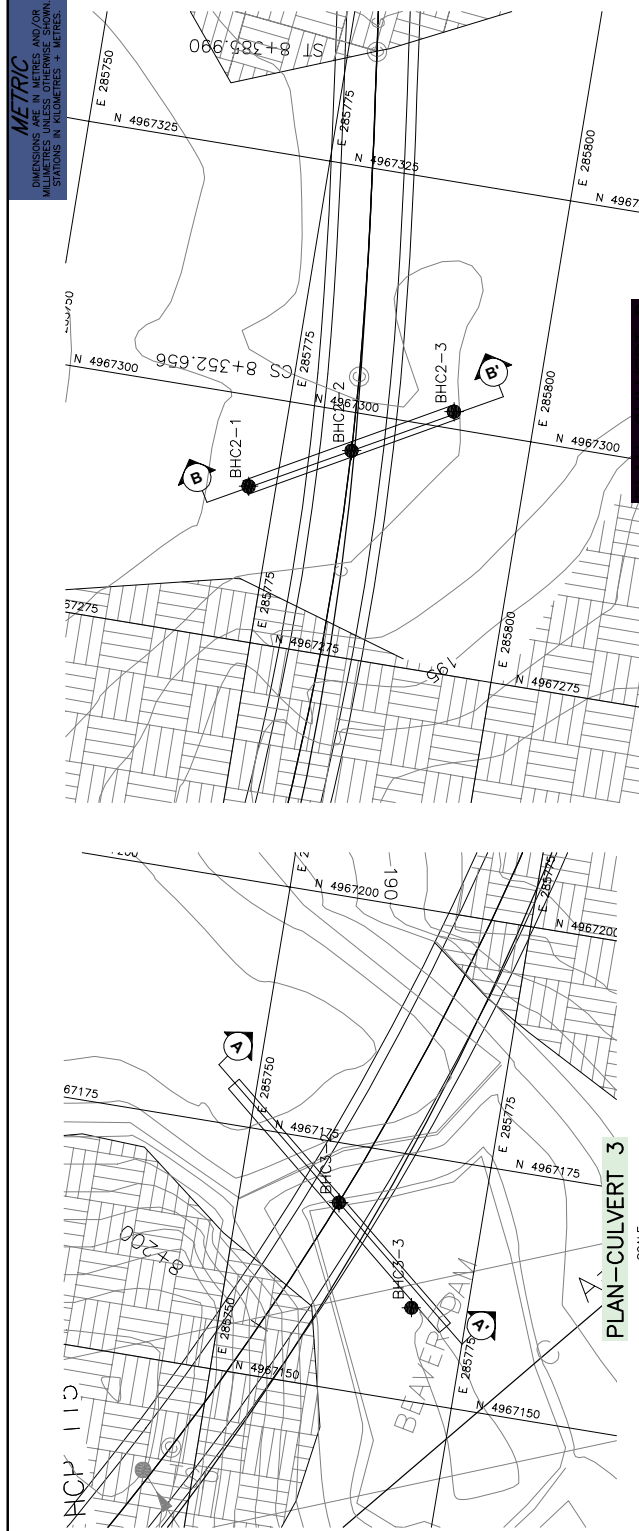
PROJECT 021-1103		<b>RECORD OF BOREHOLE No C4-3</b>				1 OF 1		<b>METRIC</b>								
W.P. 370-00-00		LOCATION Culvert #4 (Sta. 9+830, 15 m EAST)				ORIGINATED BY SB										
DIST 52 HWY		BOREHOLE TYPE HILTI Manual Portable Rig; Continuous Split Spoon Sampling				COMPILED BY DD										
DATUM Geodetic		DATE Nov. 19, 2003				CHECKED BY CAB										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
189.0	GROUND SURFACE															
0.0	TOPSOIL		1	SS	3											
188.7	Silty CLAY, trace sand and gravel Soft Brown and grey		2	SS	50/0.20											
188.4	Moist Silty SAND, trace gravel Very dense Brown and grey to grey Moist to wet End of Borehole															
0.8																




NOTE:





1. Water level in open borehole at ground surface.

2. Spoon refusal at 0.8 m depth.

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



	<p>CONT No. _____ WP No. 370-00-00</p>	<p>SHEET _____</p>	
<p>BAXTER TOWNSHIP TRANSFER STATION ROAD CULVERT SECTIONS BOREHOLE LOCATIONS AND SOIL STRATA</p>	<p> <b>Golden Associates Ltd.</b> MISSISSAUGA, ONTARIO, CANADA</p>	<p><b>Golden Associates Ltd.</b> MISSISSAUGA, ONTARIO, CANADA</p>	<p><b>Golden Associates Ltd.</b> MISSISSAUGA, ONTARIO, CANADA</p>

	Borehole – Current Investigation
	Borehole – Older Geotechnical/Pavement investigation
	Probehole
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 75% i/bow)
100%	Rock Quality Designation (RQD)
	WL upon completion of drilling

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
BHC2-1	192.4	4967290.8	285772.2
BHC2-2	193.0	4967301.7	285775.7
BHC2-3	193.0	4967301.7	285791.7
BHC3-2	186.0	4967168.9	285766.2
BHC3-3	185.1	4967159.5	285769.3

**NOTES**

The boundaries between soil strata have been established only at the boundaries between horizons. The boundaries are assumed from geological evidence.

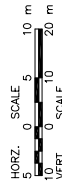
The complete foundation investigation and design report for this project is available from the Department of Civil Engineering and Surveying, Engineering and Research Office, Downsview, information contained in this report and related documents is specifically information in accordance with Section OC 2.01 of OPS General Conditions.

For subsurface information only.

## REFERENCE

Base plans provided in digital format by URS Corporation, drawing file 'Boxter.dwg', received Nov. 04, 2003.

[illegible]



**Goldner  
Associates**



**Borehole -**

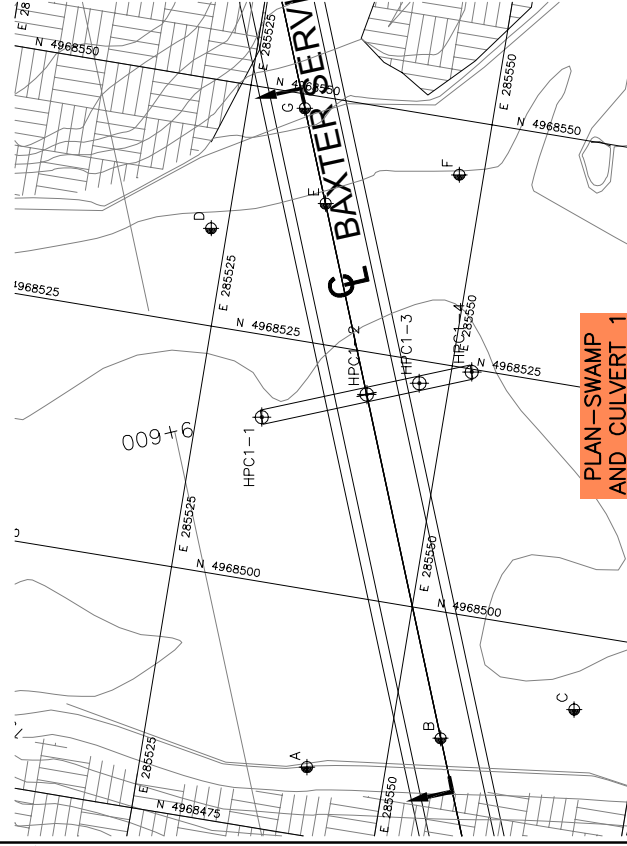
No.	ELEVATION
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## NOTES

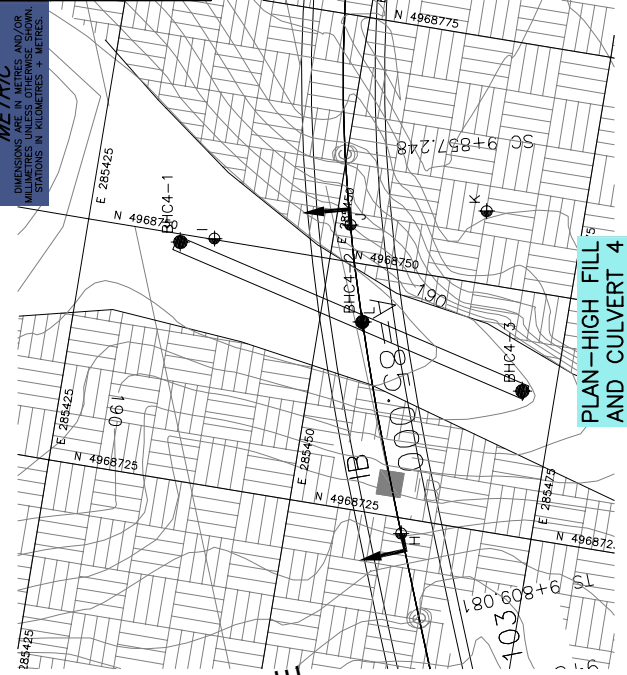
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NO.	DATE
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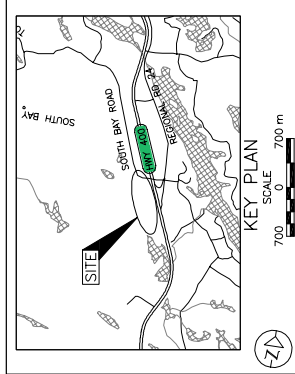
METRIC  
DIMENSIONS ARE IN METRES AND/OR  
MAKING UNLESS OTHERWISE SPECIFIED.  
STATIONS IN PARALLELS - 1000000



PLAN-SWAMP  
AND CULVERT 1



PLAN-HIGH FILL  
AND CULVERT 4



KEY PLAN

LEGEND

- Borehole - Current Investigation
- Borehole - Goldier Geotechnical/Pavement Investigation
- Probable
- N Standard Penetration Test Value
- 16 Blow/0.3m unless otherwise stated  
(Std. Pen. Test. 475 J/Blow)
- 100% Rock Quality Designation (RQD)
- Wt. upon completion of drilling

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
A	189.0	4968482.0	285542.0
B	189.0	4968487.2	285555.1
C	189.0	4968492.4	285568.2
D	189.0	4968497.6	285581.3
E	189.0	4968502.8	285594.4
F	189.0	4968508.0	285607.5
G	189.0	4968513.2	285620.6
H	189.0	4968518.4	285633.7
I	189.0	4968523.6	285646.8
J	189.0	4968528.8	285659.9
K	189.0	4968534.0	285673.0
L	189.0	4968539.2	285686.1
M	189.0	4968544.4	285699.2
N	189.0	4968549.6	285712.3
O	189.0	4968554.8	285725.4
P	189.0	4968560.0	285738.5
Q	189.0	4968565.2	285751.6
R	189.0	4968570.4	285764.7
S	189.0	4968575.6	285777.8
T	189.0	4968580.8	285790.9
U	189.0	4968586.0	285804.0
V	189.0	4968591.2	285817.1
W	189.0	4968596.4	285830.2
X	189.0	4968601.6	285843.3
Y	189.0	4968606.8	285856.4
Z	189.0	4968612.0	285869.5
AA	189.0	4968617.2	285882.6
AB	189.0	4968622.4	285895.7
AC	189.0	4968627.6	285908.8
AD	189.0	4968632.8	285921.9
AE	189.0	4968638.0	285935.0
AF	189.0	4968643.2	285948.1
AG	189.0	4968648.4	285961.2
AH	189.0	4968653.6	285974.3
AI	189.0	4968658.8	285987.4
AJ	189.0	4968664.0	285999.5
AK	189.0	4968669.2	286012.6
AL	189.0	4968674.4	286025.7
AM	189.0	4968679.6	286038.8
AN	189.0	4968684.8	286051.9
AO	189.0	4968690.0	286065.0
AP	189.0	4968695.2	286078.1
AQ	189.0	4968700.4	286091.2
AR	189.0	4968705.6	286104.3
AS	189.0	4968710.8	286117.4
AT	189.0	4968716.0	286130.5
AU	189.0	4968721.2	286143.6
AV	189.0	4968726.4	286156.7
AW	189.0	4968731.6	286169.8
AX	189.0	4968736.8	286182.9
AY	189.0	4968742.0	286196.0
AZ	189.0	4968747.2	286209.1
BA	189.0	4968752.4	286222.2
BB	189.0	4968757.6	286235.3
BC	189.0	4968762.8	286248.4
BD	189.0	4968768.0	286261.5
BE	189.0	4968773.2	286274.6
BF	189.0	4968778.4	286287.7
BG	189.0	4968783.6	286300.8
BH	189.0	4968788.8	286313.9
BI	189.0	4968794.0	286327.0
BJ	189.0	4968799.2	286340.1
BK	189.0	4968804.4	286353.2
BL	189.0	4968809.6	286366.3
BM	189.0	4968814.8	286379.4
BN	189.0	4968820.0	286392.5
BO	189.0	4968825.2	286405.6
BP	189.0	4968830.4	286418.7
BQ	189.0	4968835.6	286431.8
BR	189.0	4968840.8	286444.9
BS	189.0	4968846.0	286458.0
BT	189.0	4968851.2	286471.1
BU	189.0	4968856.4	286484.2
BV	189.0	4968861.6	286497.3
BW	189.0	4968866.8	286510.4
BX	189.0	4968872.0	286523.5
BY	189.0	4968877.2	286536.6
BZ	189.0	4968882.4	286549.7
CA	189.0	4968887.6	286562.8
CB	189.0	4968892.8	286575.9
CC	189.0	4968898.0	286589.0
CD	189.0	4968903.2	286602.1
CE	189.0	4968908.4	286615.2
CF	189.0	4968913.6	286628.3
CG	189.0	4968918.8	286641.4
CH	189.0	4968924.0	286654.5
CI	189.0	4968929.2	286667.6
CJ	189.0	4968934.4	286680.7
CK	189.0	4968939.6	286693.8
CL	189.0	4968944.8	286706.9
CM	189.0	4968950.0	286720.0
CN	189.0	4968955.2	286733.1
CO	189.0	4968960.4	286746.2
CP	189.0	4968965.6	286759.3
CQ	189.0	4968970.8	286772.4
CR	189.0	4968976.0	286785.5
CS	189.0	4968981.2	286798.6
CT	189.0	4968986.4	286811.7
CU	189.0	4968991.6	286824.8
CV	189.0	4968996.8	286837.9
CW	189.0	4969002.0	286851.0
CX	189.0	4969007.2	286864.1
CY	189.0	4969012.4	286877.2
CZ	189.0	4969017.6	286890.3
DA	189.0	4969022.8	286903.4
DB	189.0	4969028.0	286916.5
DC	189.0	4969033.2	286929.6
DD	189.0	4969038.4	286942.7
DE	189.0	4969043.6	286955.8
DF	189.0	4969048.8	286968.9
DG	189.0	4969054.0	286982.0
DH	189.0	4969059.2	286995.1
DI	189.0	4969064.4	287008.2
DJ	189.0	4969069.6	287021.3
DK	189.0	4969074.8	287034.4
DL	189.0	4969080.0	287047.5
DM	189.0	4969085.2	287060.6
DN	189.0	4969090.4	287073.7
DO	189.0	4969095.6	287086.8
DP	189.0	4969100.8	287099.9
DQ	189.0	4969106.0	287113.0
DR	189.0	4969111.2	287126.1
DS	189.0	4969116.4	287139.2
DT	189.0	4969121.6	287152.3
DU	189.0	4969126.8	287165.4
DV	189.0	4969132.0	287178.5
DW	189.0	4969137.2	287191.6
DX	189.0	4969142.4	287204.7
DY	189.0	4969147.6	287217.8
DZ	189.0	4969152.8	287230.9
EA	189.0	4969158.0	287244.0
EB	189.0	4969163.2	287257.1
EC	189.0	4969168.4	287270.2
ED	189.0	4969173.6	287283.3
EE	189.0	4969178.8	287296.4
EF	189.0	4969184.0	287309.5
EG	189.0	4969189.2	287322.6
EH	189.0	4969194.4	287335.7
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EK	189.0	4969210.0	287375.0
EL	189.0	4969215.2	287388.1
EM	189.0	4969220.4	287401.2
EN	189.0	4969225.6	287414.3
EO	189.0	4969230.8	287427.4
EP	189.0	4969236.0	287440.5
EQ	189.0	4969241.2	287453.6
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EV	189.0	4969267.2	287519.1
EW	189.0	4969272.4	287532.2
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FF	189.0	4969319.2	287650.1
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FH	189.0	4969329.6	287676.3
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FW	189.0	4969407.6	287872.8
FX	189.0	4969412.8	287885.9
FY	189.0	4969418.0	287899.0
FZ	189.0	4969423.2	287912.1
GA	189.0	4969428.4	287925.2
GB	189.0	4969433.6	287938.3
GC	189.0	4969438.8	287951.4
GD	189.0	4969444.0	287964.5
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GI	189.0	4969470.0	288030.0
GH	189.0	4969475.2	288043.1
GI	189.0	4969480.4	288056.2
HJ	189.0	4969485.6	288069.3
HK	189.0	4969490.8	288082.4
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HM	189.0	4969501.2	288108.6
HN	189.0	4969506.4	288121.7
HO	189.0	4969511.6	288134.8
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HI	189.0	4969522.0	288161.0
HP	189.0	4969527.2	288174.1
HI	189.0	4969532.4	288187.2
IJ	189.0	4969537.6	288200.3
IK	189.0	4969542.8	288213.4
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IO	189.0	4969563.6	288265.8
IP	189.0	4969568.8	288278.9
IQ	189.0	4969574.0	288292.0
IR	189.0	4969579.2	288305.1
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IV	189.0	4969605.2	288370.6
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IV	189.0	4969802.8	288868.4
IV	189.0	4969808.0	288881.5
IV	189.0	4969813.2	288894.6
IV	189.0	4969818.4	288907.7
IV	189.0	4969823.6	288920.8
IV	189.0	4969828.8	288933.9
IV	189.0	4969834.0	288947.0
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IV	189.0	4969844.4	2

## **APPENDIX A LABORATORY TEST RESULTS**

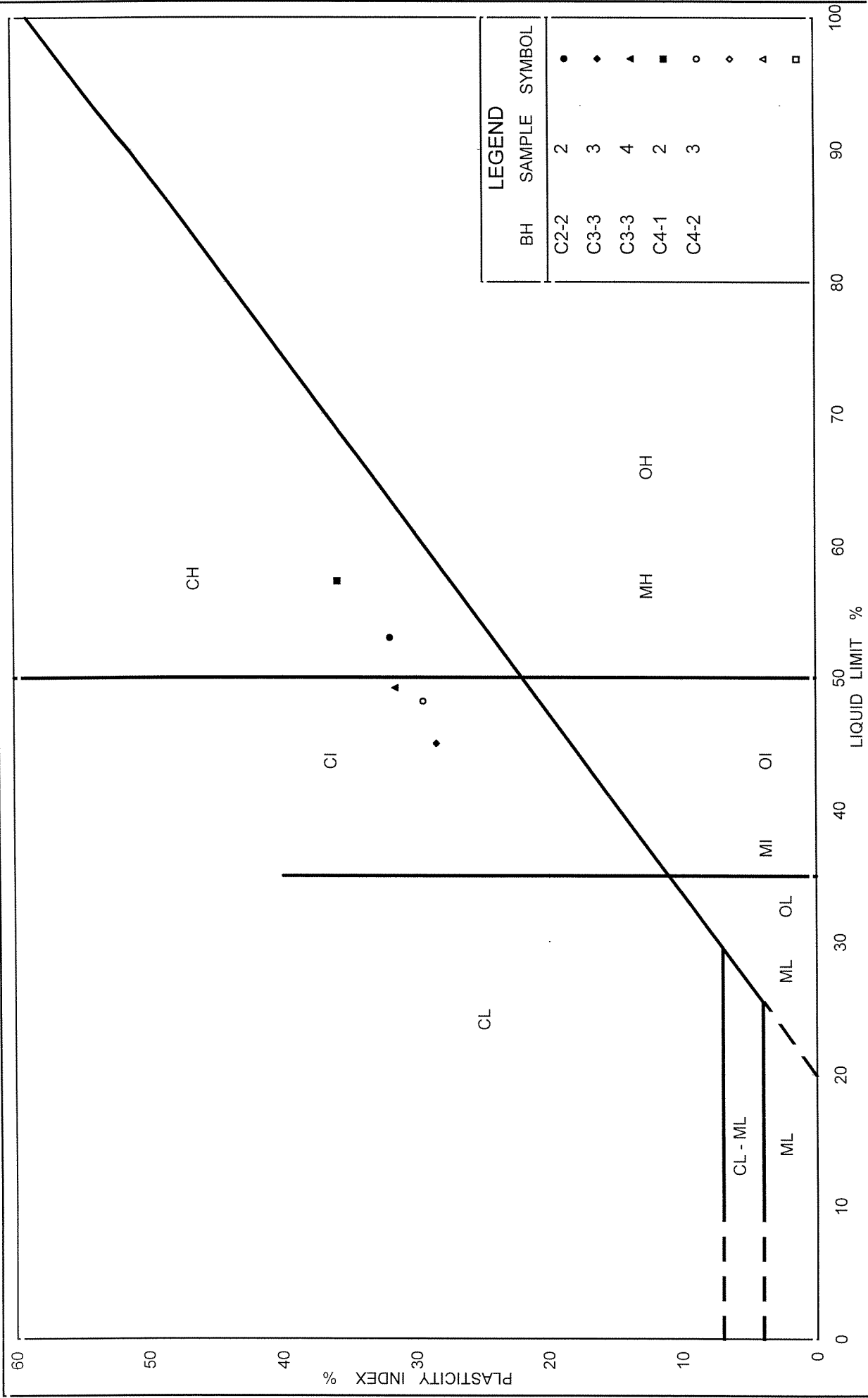


FIG No. A-1

PLASTICITY CHART  
Silty Clay to Clay

Ministry of Transportation

Project No. 021-1103



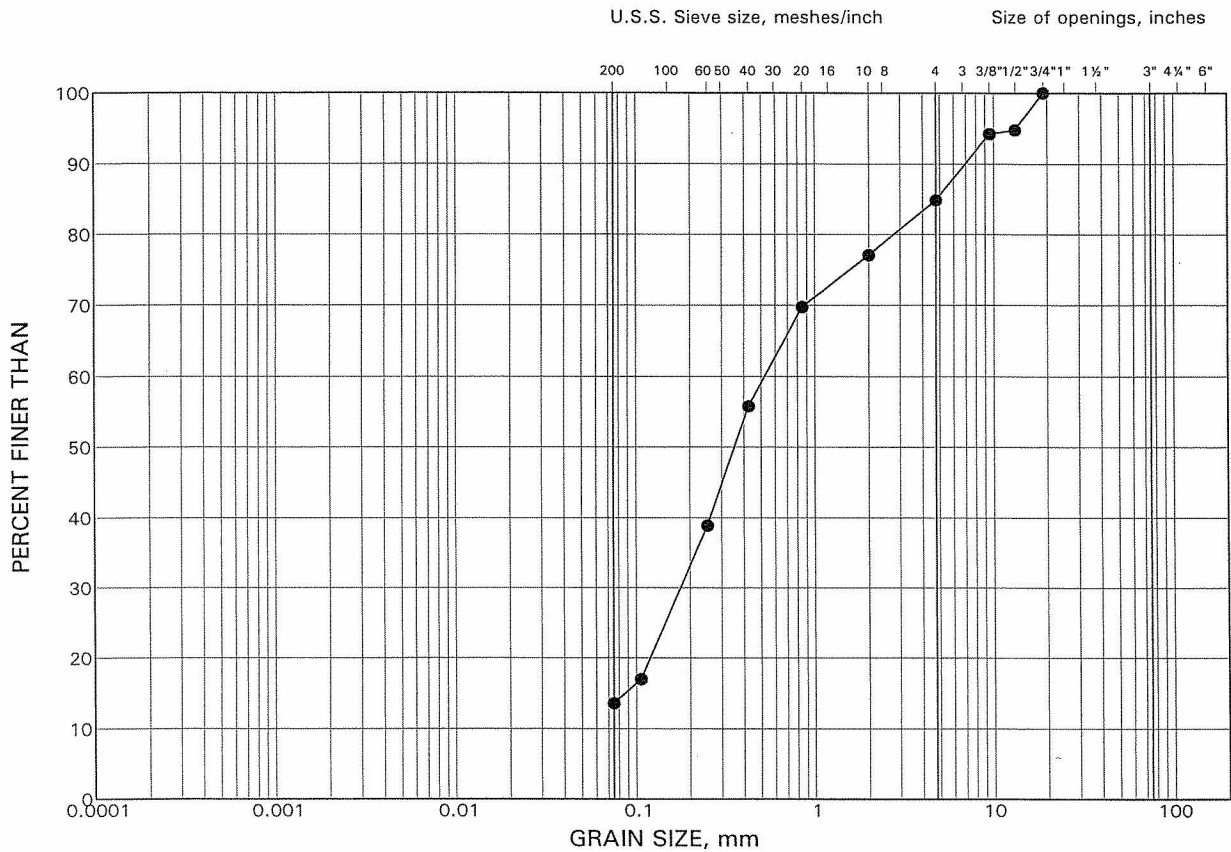
Ontario



# GRAIN SIZE DISTRIBUTION

Sand

FIGURE A-2



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

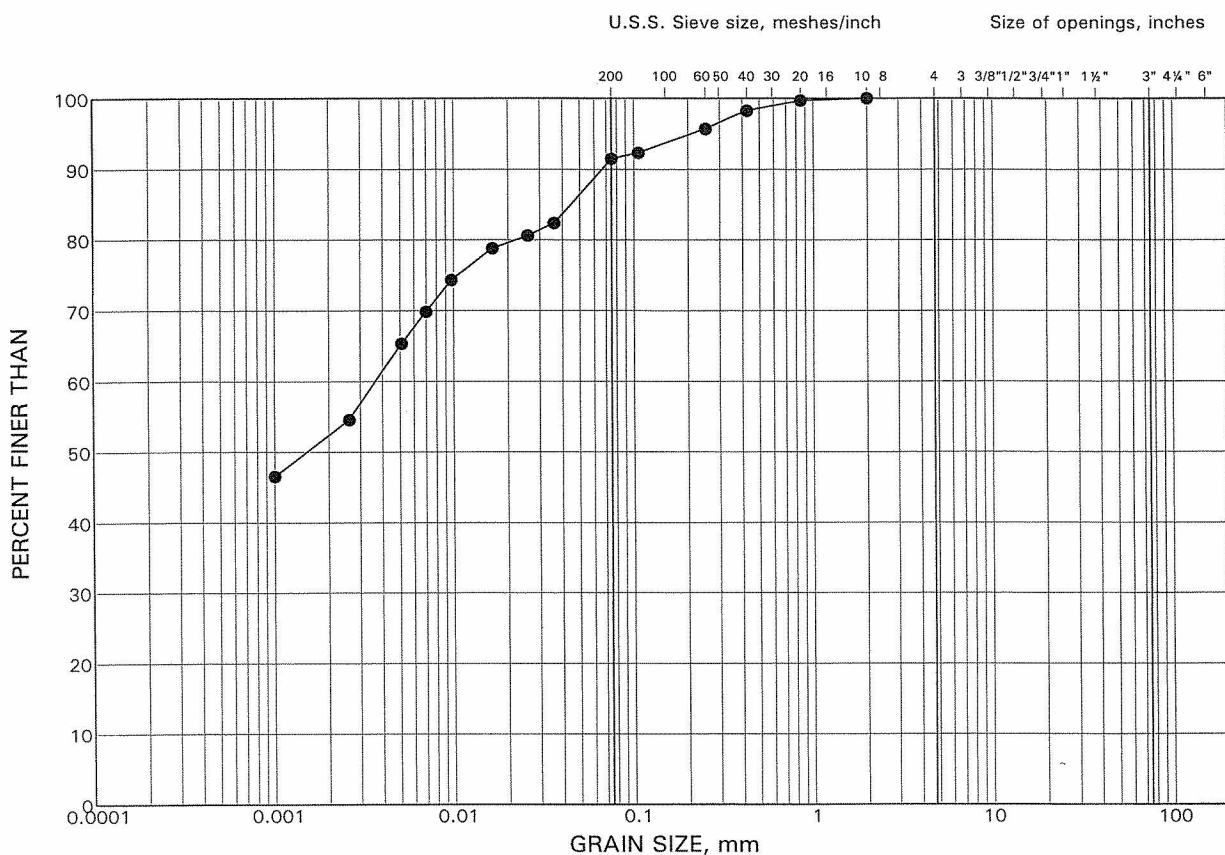
## LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
●	C3-2	3	1.2-1.8

# GRAIN SIZE DISTRIBUTION

## Silty Clay

FIGURE A-3



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

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
●	C3-3	4	1.8-2.4

Date 7/30/2004  
Project 021-1103

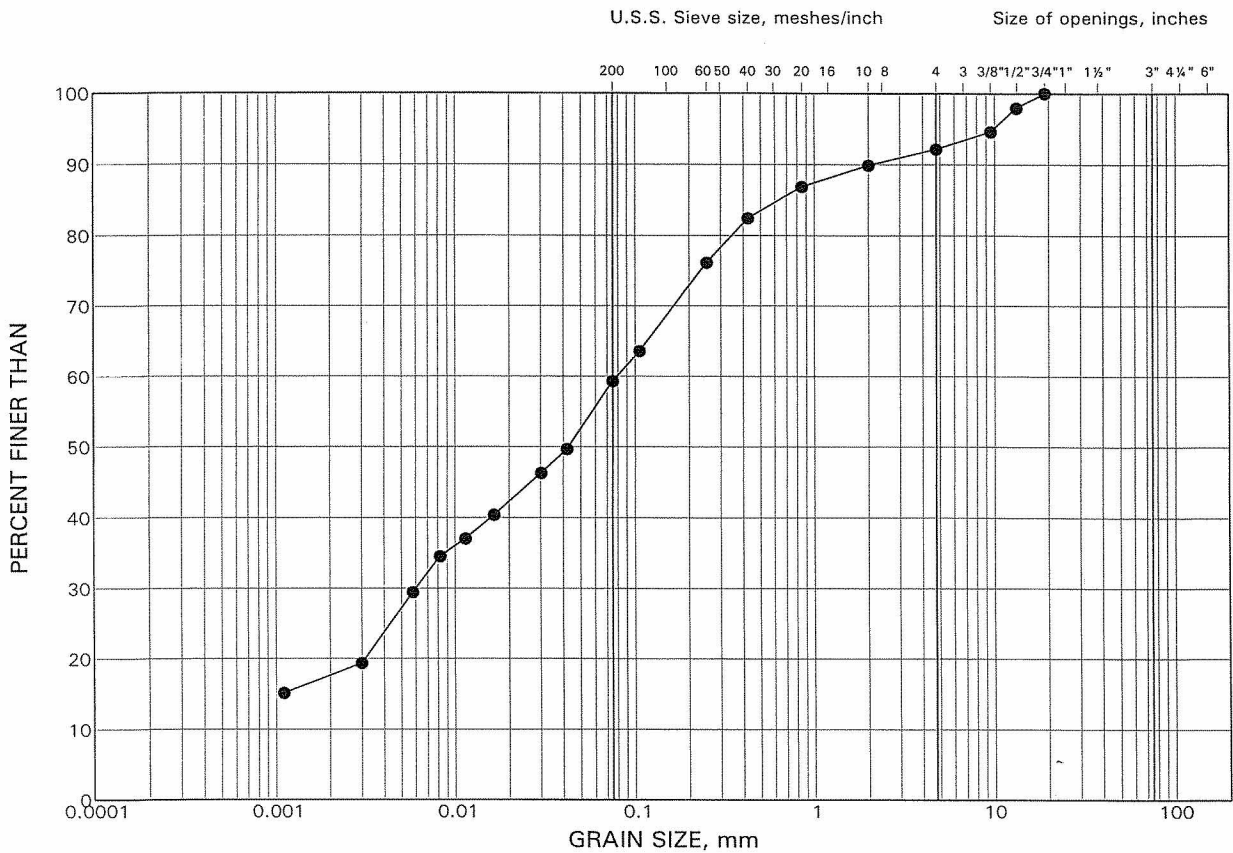
**Golder Associates**

Prepared by LG  
Checked by ASP

# GRAIN SIZE DISTRIBUTION

Silty Sand

FIGURE A-4



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

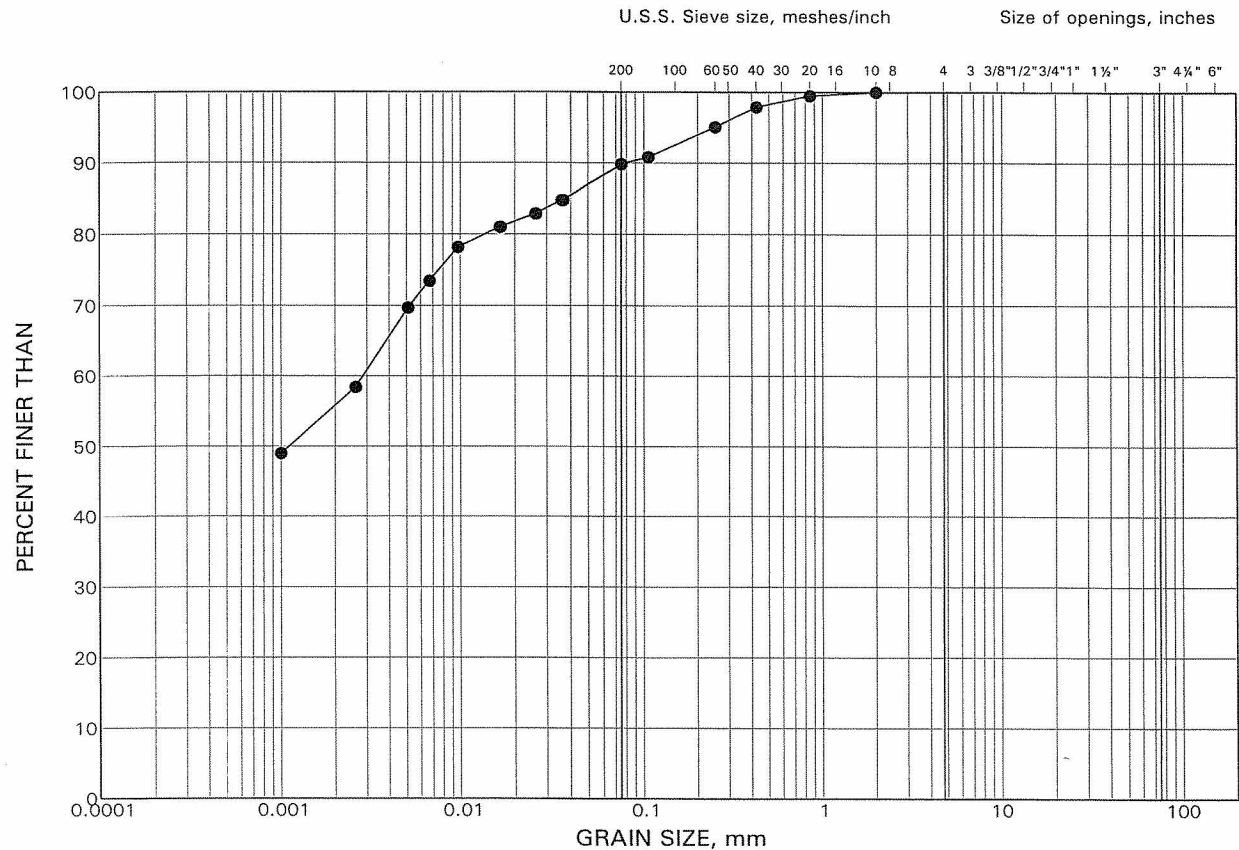
## LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
•	C2-1	2	0.6-1.1

# GRAIN SIZE DISTRIBUTION

Clay

FIGURE A-5



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

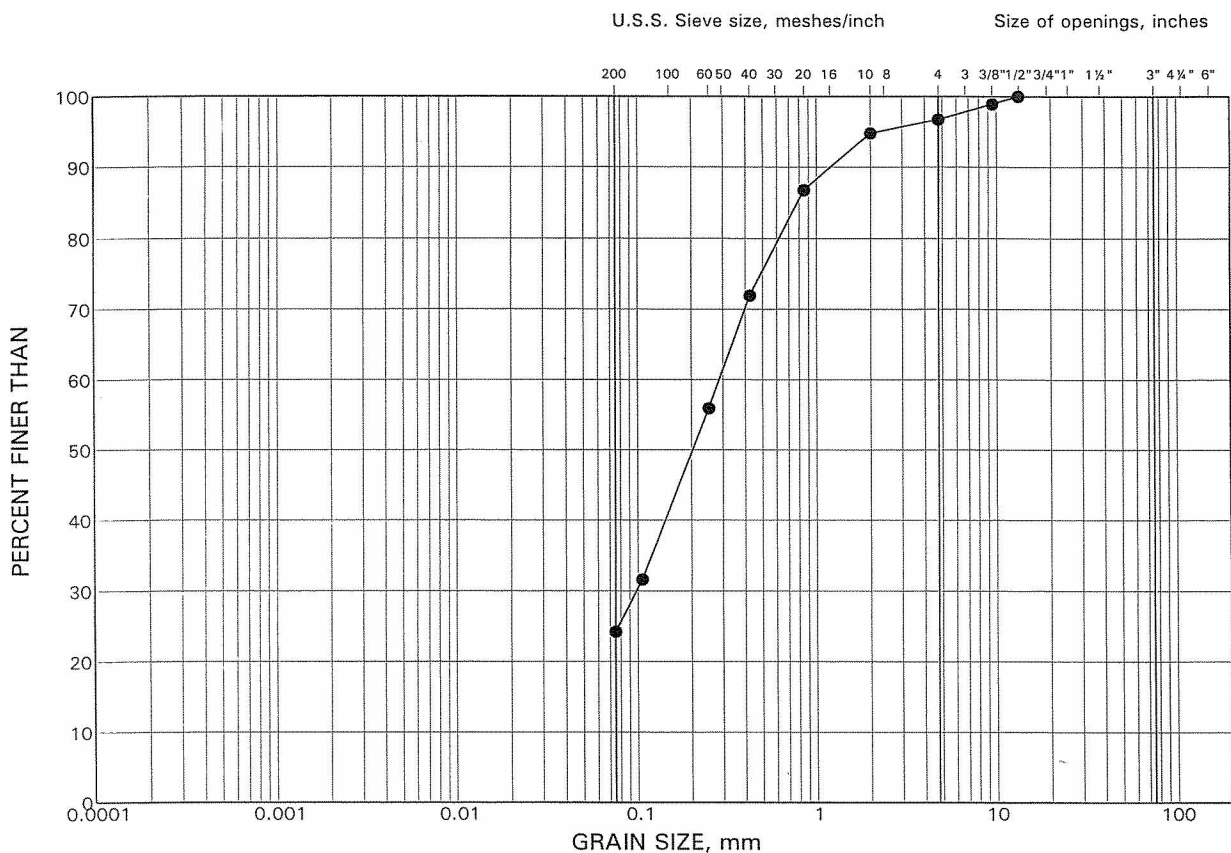
## LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
•	C2-2	2	0.6-1.2

# GRAIN SIZE DISTRIBUTION

Sand

FIGURE A-6



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

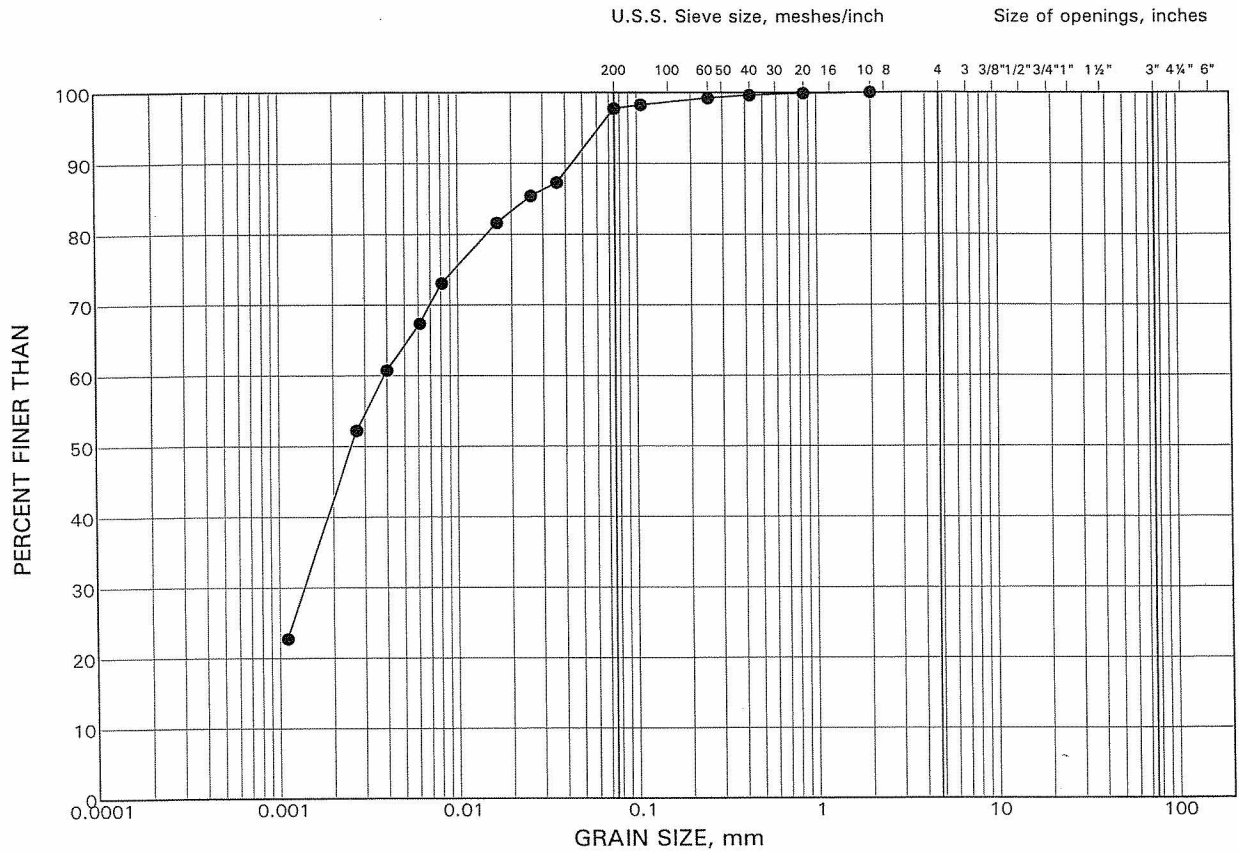
## LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
•	C4-1	3	1.2-1.4

# GRAIN SIZE DISTRIBUTION

Silty Clay

FIGURE A-7



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
•	C4-2	3	1.2-1.8

Date 7/30/2004  
Project 021-1103

**Golder Associates**

Prepared by LG  
Checked by AS