

**REPORT ON**

**FOUNDATION INVESTIGATION**

**CULVERT REPLACEMENT AT STATION 16+255**

**HIGHWAY 89 PAVEMENT REHABILITATION FROM ROSEMONT**

**TO 0.9 KM EAST OF COUNTY ROAD 13**

**SIMCOE COUNTY, ONTARIO**

**G.W.P. 2479-04-00**

Submitted to:

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GEOCRES No. 31D-451

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## TABLE OF CONTENTS

| <b><u>SECTION</u></b>                                  | <b><u>PAGE</u></b> |
|--|--------------------|
| <b>PART A - FOUNDATION INVESTIGATION REPORT</b>        |                    |
| 1.0 INTRODUCTION.....                                  | 1                  |
| 2.0 SITE DESCRIPTION.....                              | 2                  |
| 3.0 INVESTIGATION PROCEDURES.....                      | 3                  |
| 3.1 Foundation Investigation .....                     | 3                  |
| 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS.....        | 4                  |
| 4.1 Regional Geology.....                              | 4                  |
| 4.2 Subsoil Conditions .....                           | 4                  |
| 4.2.1 Fill.....  | 5                  |
| 4.2.2 Clayey Silt with Sand to Silt and Sand Till..... | 6                  |
| 4.2.3 Groundwater Conditions .....                     | 6                  |
| 5.0 CLOSURE .....                                      | 7                  |

In Order  
Following  
Page 7

Lists of Abbreviations and Symbols  
Record of Borehole Sheets (BH 07-1 to BH 07-4)  
Drawing 1  
Figures 1 to 5

## LIST OF DRAWINGS

Drawing 1      Culvert Replacement at Station 16+255, Borehole Location and Soil Strata

## LIST OF FIGURES

Figure 1      Grain Size Distribution – Clayey Silt with sand (Fill)  
Figure 2      Plasticity Chart – Clayey Silt to Silty Clay (Fill)  
Figure 3      Grain Size Distribution – Clayey Silt with sand (Till)  
Figure 4      Grain Size Distribution – Silt and Sand (Till)  
Figure 5      Plasticity Chart – Clayey Silt (Till)

**PART A**

**FOUNDATION INVESTIGATION REPORT  
CULVERT REPLACEMENT AT STATION 16+255  
HIGHWAY 89 PAVEMENT REHABILIZATION FROM ROSEMONT  
TO 0.9 KM EAST OF COUNTY ROAD 13  
SIMCOE COUNTY, ONTARIO  
G.W.P. 2479-04-00**

## 1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by McCormick Rankin Corporation (MRC) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services associated with the rehabilitation of Highway 89 from Rosemont to 0.9 km east of County Road 13, in Simcoe County. Foundation engineering services are required for the widening of the Nottawasaga River Bridge (MTO Structure Site No.30-250), construction of a new retaining wall to the northwest of the widened bridge structure, and replacement of an existing concrete culvert structure at Station 16+255 between Rosemont and Alliston (Culvert 30-545C).

This report addresses the foundation investigation carried out for the proposed culvert replacement at Station 16+255 (Culvert 30-545C) as part of the Highway 89 rehabilitation project.

The terms of reference and scope of work for the foundation investigation are outlined in MTO's Request for Proposal for Agreement No. 2004-E-0032, issued in April 2005, and in Section 6.8 of MRC's *Technical Proposal* for G.W.P. 2479-04-00 as well as Golder's proposal letter dated January 22, 2007 for additional foundation engineering services relating to the proposed retaining wall and culvert replacement.

## **2.0 SITE DESCRIPTION**

The site of the proposed culvert replacement on Highway 89, is located approximately 0.8 km east of Simcoe County Road 13, Ontario. Highway 89 in this area is approximately 7.5 m wide consisting of two lanes with 3 m wide fully paved shoulders on both sides of the highway.

The site generally consists of the raised highway embankment with gently sloping, grass covered side-slopes. Based on the general arrangement drawing provided by MRC entitled "Hwy. 89 Culvert at Sta. 16+255.000-General Arrangement", dated January 2007, the existing Highway 89 grade is between Elevation 245 m and Elevation 245.3 m and the approximate streambed is between Elevation 243.6 m (at the culvert inlet) and Elevation 243.2 m (at the culvert outlet). The existing culvert is an open footing concrete structure, 3.67 m wide and 21 m long. The opening height (creek bottom to soffit) is approximately 0.8 m.

Vegetation in the vicinity of the existing culvert consists primarily of grasses with some small shrubs.

### **3.0 INVESTIGATION PROCEDURES**

#### **3.1 Foundation Investigation**

The subsurface investigation at the site of the proposed culvert replacement was completed on September 26, 2007. Two boreholes were advanced at the south shoulder and embankment toe of the highway, adjacent to the existing culvert; however due to access constraints in the immediate vicinity of the toe/culvert end at the north side of the embankment, one borehole was advanced 9 m north of the end of the culvert (i.e. culvert inlet) and one borehole was advanced through the north shoulder of the highway, about 6 m south of the culvert inlet. The borehole locations are shown on Drawing 1.

The field investigation was carried out using a track-mounted drill rig, supplied and operated by Walker Drilling Ltd. of Barrie, Ontario. The boreholes were advanced using 108 mm outside diameter (O.D.) solid stem augers to depths ranging from about 3.5 m to 7.8 m below the existing ground surface. Soil samples were obtained at intervals ranging from 0.75 m to 1.5 m intervals of depth, using a 50 mm outer diameter (O.D.) split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures. The groundwater conditions in the open boreholes were observed throughout the drilling operations, and a standpipe piezometer was installed in Boreholes 07-4 to permit monitoring of the groundwater level at this location. The piezometer consist of a 50 mm diameter PVC pipe with a 1.5 m long slotted screen installed within a 3 m long sand filter pack. Upon completion of drilling, the boreholes and annulus surrounding the piezometer pipe above the sand filter pack were backfilled to the surface with bentonite pellets in accordance with Ontario Regulation (O.Reg.) 903.

The field work was monitored on a full-time basis by a member of Golder's technical staff who located the boreholes in the field, cleared the site of buried utility services, directed the sampling, in situ testing operations, and logged the boreholes. The soil samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Mississauga for further examination and geotechnical laboratory testing. Index and classification tests (water content determinations, Atterberg limits and grain size distribution) as well as organic content tests were carried out on selected soil samples.

The borehole elevations were measured in the field by members of Golder's technical staff, relative to a geodetic bench mark, located at the northwest corner of the existing culvert structure (BM 621-W0427107B) and the borehole locations were measured by Golder relative to site features. The borehole locations (including MTM NAD83 northing and easting coordinates) and ground surface elevations (referenced to geodetic datum) are summarized below and are shown on Drawing 1.

| Borehole<br>Number | MTM NAD83    |             | Ground Surface<br>Elevation (m) |
|--------------------|--------------|-------------|---------------------------------|
|                    | Northing (m) | Easting (m) |                                 |
| 07-1               | 4888984.1    | 271368.2    | 245.1                           |
| 07-2               | 4888976.6    | 271365.2    | 243.6                           |
| 07-3               | 4889006.6    | 271355.7    | 243.7                           |
| 07-4               | 4888994.0    | 271361.1    | 244.9                           |

## 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

### 4.1 Regional Geology

The area of Highway 89 at the location of Culvert 30-545C lies within the Simcoe Lowlands physiographic region, as delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984<sup>1</sup>).

The Simcoe Lowlands comprise the lowlands bordering Georgian Bay to the west and Lake Simcoe to the east (Chapman and Putnam, 1984<sup>1</sup>). To the west are the plains lying between Elevation 176 m and Elevation 228 m, draining into Nottawasaga Bay by way of the Nottawasaga River and are referred to as the Nottawasaga Basin. To the east are the lowlands surrounding Lake Simcoe lying between Elevation 219 m and Elevation 259 m which are referred to as the Lake Simcoe Basin.

Within the southern portion of the Nottawasaga Basin in the Alliston area lies Adjala Township where the proposed culvert replacement site is located. The surficial soils in the Alliston area are typically comprised of sandy loam and silt loam. Most of the Nottawasaga Basin was at one time part of the floor of Lake Algonquin and its surface beds are of deltaic and lacustrine origin.

### 4.2 Subsoil Conditions

Four boreholes (Boreholes 07-1 to 07-4) were drilled at the site of the culvert replacement as shown on Drawing 1. Two boreholes were advanced through the existing Highway 89 north and south embankments and two borehole were drilled at the embankment toes, adjacent to the existing culvert structure.

The detailed subsurface soil and groundwater conditions as encountered in the boreholes, together with the results of the laboratory tests carried out on selected soil samples, are given on the attached Record of Borehole sheets following the text of this report. The laboratory test results are also presented on Figures 1 to 5.

<sup>1</sup> 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.

The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests (SPTs). These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change and the subsurface conditions will vary between and beyond the borehole locations. The inferred soil stratigraphy based on the results of the boreholes at the site of the culvert replacement is shown on Drawing 1.

In summary, the subsoil conditions encountered in the boreholes generally consist of surficial silty sand and clayey silt fill materials underlain by a very stiff to hard clayey silt with sand till deposit, which grades into a silt and sand till at the location of Borehole 07-3. A detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

#### **4.2.1 Fill**

Fill materials were encountered in all of the boreholes immediately below the ground surface. In Boreholes 07-1, 07-2, and 07-4, the fill consists of an upper layer of silty sand, between 500 mm and 800 mm thick, overlying clayey silt containing variable amounts of sand, trace gravel, and trace quantities of organic matter. In Borehole 07-3, drilled some 9 m north of the existing culvert inlet at the north embankment toe, the fill consists of silty clay with trace sand and organic matter. The thickness of the fill ranges from about 1.8 m in Borehole 07-3 to about 3.5 m in Borehole 07-1.

The measured SPT “N” values within the fill materials typically range from 3 to 11 blows per 0.3 m of penetration, indicating a very loose to compact relative density /soft to stiff consistency . One SPT “N” value of 35 blows per 0.3 m of penetration was measured in the upper silty sand fill at the location of Borehole 07-1, which was advanced through the embankment on the south shoulder of the highway.

The clayey silt and silty clay fill materials contain variable amounts of organic matter; organic content tests carried out on samples of these materials, selected on the basis of visual and olfactory indication of organics, yielded organic contents varying from 5.2 percent to 7.2 percent for the soil samples collected between about Elevation 241.5 m and Elevation 243.5 m.

The results of one grain size distribution test carried out on a sample of the clayey silt fill is shown on Figure 1 and indicates that the sample tested is a clayey silt with sand. Atterberg limits tests carried out on two samples of the clayey fill materials encountered in Boreholes 07-2 and 07-3 yielded plastic limits of 16 percent and 24 percent, liquid limits of 26 percent and 41 percent, and corresponding plasticity indices of 10 percent and 17 percent, respectively. These results indicate that the samples tested are comprised of clayey silt of low plasticity to silty clay of intermediate plasticity as illustrated on Figure 2.



The measured water contents on samples of the fill materials vary between about 6 percent and 37 per cent.

#### **4.2.2 Clayey Silt with Sand to Silt and Sand Till**

A till deposit consisting of clayey silt with sand was encountered below the fill materials between approximately Elevation 241.4 m and Elevation 242.2 m in the boreholes located on the shoulders of the roadway and the south end of the culvert. The till at the location of the Borehole 07-3 beyond the north end of the culvert is granular, comprised of silt and sand and was encountered at Elevation 241.9 m. The clayey silt with sand till extends to the termination depths of boreholes 07-1, 07-2, and 07-4 between about Elevation 237.1 m and Elevation 240.2 m.

The results of three grain size distribution tests carried out on selected samples of the clayey silt till and silt and sand till materials are shown on Figures 3 and 4, respectively. Atterberg limits tests carried out on two selected samples of the clayey silt with sand yielded plastic limits of about 9 and 10 percent, liquid limits of about 14 and 18, and corresponding plasticity indices of 5 percent and 8 percent for the clayey silt portion of this deposit, whereas a non-plastic result was obtained for the silt and sand till encountered in Borehole 07- 3. The results, plotted on Figure 5, confirm that the cohesive till deposit is a clayey silt of low plasticity. The measured water contents on samples of the clayey silt with sand till range between approximately 6 percent and 20 per cent.

The measured SPT “N” values in the clayey silt with sand till range from 26 blows per 0.3 m of penetration to 109 blows for 0.15 m of penetration, indicating a very stiff to hard consistency; while the SPT “N” values measured in the silt and sand till encountered in Borehole 07-3, range from 75 blows to 94 blows per 0.3 m of penetration, indicating a very dense relative density.

#### **4.2.3 Groundwater Conditions**

All of the open boreholes were dry upon completion of drilling. The water levels measured in the piezometer installed in Borehole 07-4 are summarized below:

| <i><b>Borehole Number</b></i> | <i><b>Ground Surface Elevation (m)</b></i> | <i><b>Measured Groundwater Elevation (m)</b></i> |                                |
|-------------------------------|--|--|--------------------------------|
|                               |  | <i><b>September 26, 2007</b></i>                 | <i><b>October 15, 2007</b></i> |
| 07-4                          | 244.9                                      | 240.1  | 242.8                          |

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

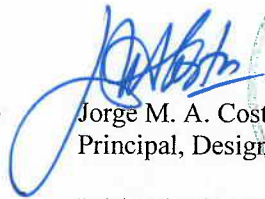
## 5.0 CLOSURE

This Foundation Investigation Report was prepared by Ms. Veronica Olatunji, and reviewed by Ms. Houda Jadi, P.Eng., a Geotechnical Engineer with Golder. Mr. Jorge M. A. Costa, P.Eng., a Designated MTO Contact and Principal with Golder conducted an independent technical review and quality control of the report.

### GOLDER ASSOCIATES LTD.

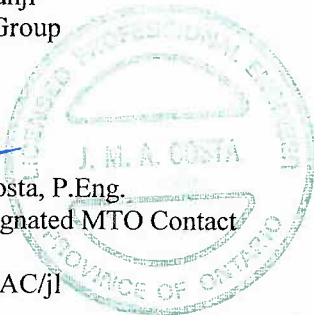


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## LIST OF ABBREVIATIONS

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<br>(Relative Density) | N<br>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 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 <sub>4</sub> | 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.

## 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 stresses (major, intermediate, minor)                            |
| $\sigma_{oct}$               | mean stress or octahedral stress<br>= $(\sigma_1 + \sigma_2 + \sigma_3)/3$ |
| $\tau$                       | 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  |
| *                  | Density symbol is $\rho$ . Unit weight symbol is $\gamma$ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity) |

#### (a) Index Properties (cont'd.)

|           |  |
|-----------|--|
| $w$       | 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 = $(e_{max} - e)/(e_{max} - e_{min})$<br>(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 (overconsolidated range)       |
| $C_s$       | swelling index                                     |
| $C_\alpha$  | 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         | Overconsolidation 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

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

MIS-MTO 001 05-111-034 (W.P. 2479-04-00).GPJ GAL-MISS.GDT 1/13/09 DD

| PROJECT 05-1111-034 |   | <b>RECORD OF BOREHOLE No BH07-2</b>  |         |      |            | 1 OF 1 <b>METRIC</b>    |                 |  |    |    |    |     |                                 |                               |                                |                  |                                       |
|---------------------|---|--|---------|------|------------|-------------------------|-----------------|--|----|----|----|-----|---------------------------------|-------------------------------|--------------------------------|------------------|---------------------------------------|
| W.P. 2479-04-00     |   | LOCATION N 4888976.6 ; E 271365.2  |         |      |            | ORIGINATED BY SB        |                 |  |    |    |    |     |                                 |                               |                                |                  |                                       |
| DIST Central HWY    |   | BOREHOLE TYPE Power Auger, 108 mm O.D. Solid Stem Augers                           |         |      |            | COMPILED BY DD          |                 |  |    |    |    |     |                                 |                               |                                |                  |                                       |
| DATUM Geodetic      |   | DATE September 26, 2007  |         |      |            | CHECKED BY SMM          |                 |  |    |    |    |     |                                 |                               |                                |                  |                                       |
| SOIL PROFILE        |   |  | SAMPLES |      |            | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT |    |    |    |     | PLASTIC LIMIT<br>W <sub>p</sub> | NATURAL MOISTURE CONTENT<br>W | LIQUID LIMIT<br>W <sub>L</sub> | UNIT WEIGHT<br>γ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
| ELEV DEPTH          | DESCRIPTION   | STRAT PLOT   | NUMBER  | TYPE | "N" VALUES |                         |                 | SHEAR STRENGTH kPa                       |    |    |    |     |                                 |                               |                                |                  |                                       |
| 243.6               | GROUND SURFACE  |  |         |      |            |                         |                 | 20                                       | 40 | 60 | 80 | 100 |                                 |                               |                                |                  |                                       |
| 0.0                 | Silty sand, trace gravel (FILL)<br>Loose<br>Brown<br>Moist  |  | 1       | SS   | 5          |                         |                 |  |    |    |    |     |                                 |                               |                                |                  |                                       |
| 243.0               |   |  | 2       | SS   | 3          |                         |                 |  |    |    |    |     |                                 |                               |                                |                  |                                       |
| 0.6                 | Clayey Silt with sand, trace gravel, containing organics (FILL)<br>Soft to stiff<br>Grey<br>Moist |  | 3       | SS   | 9          |                         |                 |  |    |    |    |     |                                 |                               |                                |                  |                                       |
| 241.4               |   |  |         |      |            |                         |                 |  |    |    |    |     |                                 |                               |                                |                  |                                       |
| 2.2                 | CLAYEY SILT with sand, some gravel (TILL)<br>Hard<br>Grey<br>Dry                                  |  | 4       | SS   | 83         |                         |                 |  |    |    |    |     |                                 |                               |                                |                  |                                       |
|                     |   |  | 5       | SS   | 62/15      |                         |                 |  |    |    |    |     |                                 |                               |                                |                  |                                       |
|                     |   |  | 6       | SS   | 105        |                         |                 |  |    |    |    |     |                                 |                               |                                |                  |                                       |
|                     |   |  | 7       | SS   | 76         |                         |                 |  |    |    |    |     |                                 |                               |                                |                  |                                       |
|                     |   |  | 8       | SS   | 85/15      |                         |                 |  |    |    |    |     |                                 |                               |                                |                  |                                       |
| 237.2               | END OF BOREHOLE   |  |         |      |            |                         |                 |  |    |    |    |     |                                 |                               |                                |                  |                                       |
| 6.4                 | Note:<br>1. Borehole dry upon completion of drilling.   |  |         |      |            |                         |                 |  |    |    |    |     |                                 |                               |                                |                  |                                       |

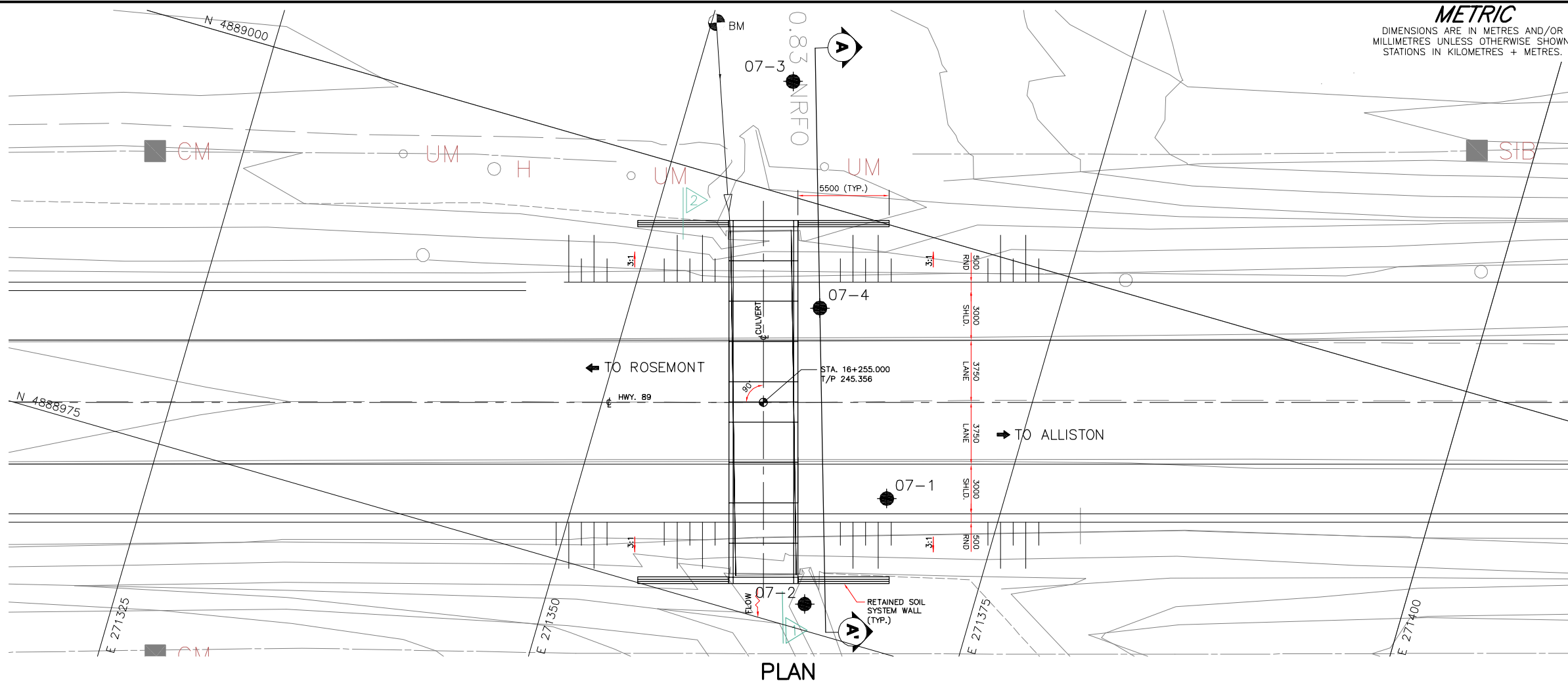
| PROJECT      |   | 05-1111-034 |         | RECORD OF BOREHOLE No BH07-3 |            |  |                 | 1 OF 1                                   |  | METRIC |  |  |                                 |                               |                                |                  |                                       |
|--------------|---|-------------|---------|------------------------------|------------|--|-----------------|--|--|--------|--|--|---------------------------------|-------------------------------|--------------------------------|------------------|---------------------------------------|
| W.P.         |   | 2479-04-00  |         | LOCATION                     |            | N 4889006.7 ; E 271355.7                   |                 | ORIGINATED BY                            |  | SB     |  |  |                                 |                               |                                |                  |                                       |
| DIST         |   | Central HWY |         | BOREHOLE TYPE                |            | Power Auger, 108 mm O.D. Solid Stem Augers |                 | COMPILED BY                              |  | DD     |  |  |                                 |                               |                                |                  |                                       |
| DATUM        |   | Geodetic    |         | DATE                         |            | September 26, 2007                         |                 | CHECKED BY                               |  | SMM    |  |  |                                 |                               |                                |                  |                                       |
| SOIL PROFILE |   |             | SAMPLES |                              |            | GROUND WATER CONDITIONS                    | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT |  |        |  |  | PLASTIC LIMIT<br>W <sub>p</sub> | NATURAL MOISTURE CONTENT<br>W | LIQUID LIMIT<br>W <sub>L</sub> | UNIT WEIGHT<br>γ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
| ELEV DEPTH   | DESCRIPTION   | STRAT PLOT  | NUMBER  | TYPE                         | "N" VALUES |  |                 | SHEAR STRENGTH kPa                       |  |        |  |  |                                 |                               |                                |                  |                                       |
| 243.7        | GROUND SURFACE  |             |         |                              |            |  |                 |  |  |        |  |  |                                 |                               |                                |                  |                                       |
| 0.0          | Silty clay, trace sand, containing organics and rootlets (FILL)<br>Soft to firm<br>Dark brown<br>Moist                                  |             | 1       | SS                           | 6          |  |                 |  |  |        |  |  |                                 |                               |                                |                  |                                       |
|              |   |             | 2       | SS                           | 3          |  |                 |  |  |        |  |  |                                 |                               |                                |                  |                                       |
| 241.9        |   |             |         |                              |            |  |                 |  |  |        |  |  |                                 |                               |                                |                  |                                       |
| 1.8          | SILT and SAND, some gravel, trace clay, containing cobbles below 2.2 m depth (TILL)<br>Compact to very dense<br>Brown and grey<br>Moist |             | 3       | SS                           | 11         |  |                 |  |  |        |  |  |                                 |                               |                                |                  |                                       |
|              |   |             | 4       | SS                           | 75         |  |                 |  |  |        |  |  |                                 |                               |                                |                  |                                       |
| 240.2        |   |             |         |                              |            |  |                 |  |  |        |  |  |                                 |                               |                                |                  |                                       |
| 3.5          | END OF BOREHOLE   |             | 5       | SS                           | 94         |  |                 |  |  |        |  |  |                                 |                               |                                |                  |                                       |
|              | Note:<br>1. Borehole dry upon completion of drilling.   |             |         |                              |            |  |                 |  |  |        |  |  |                                 |                               |                                |                  |                                       |

MIS-MTO 001 05-111-034 (W.P. 2479-04-00) GPJ GAL-MISS.GDT 1/13/09 DD

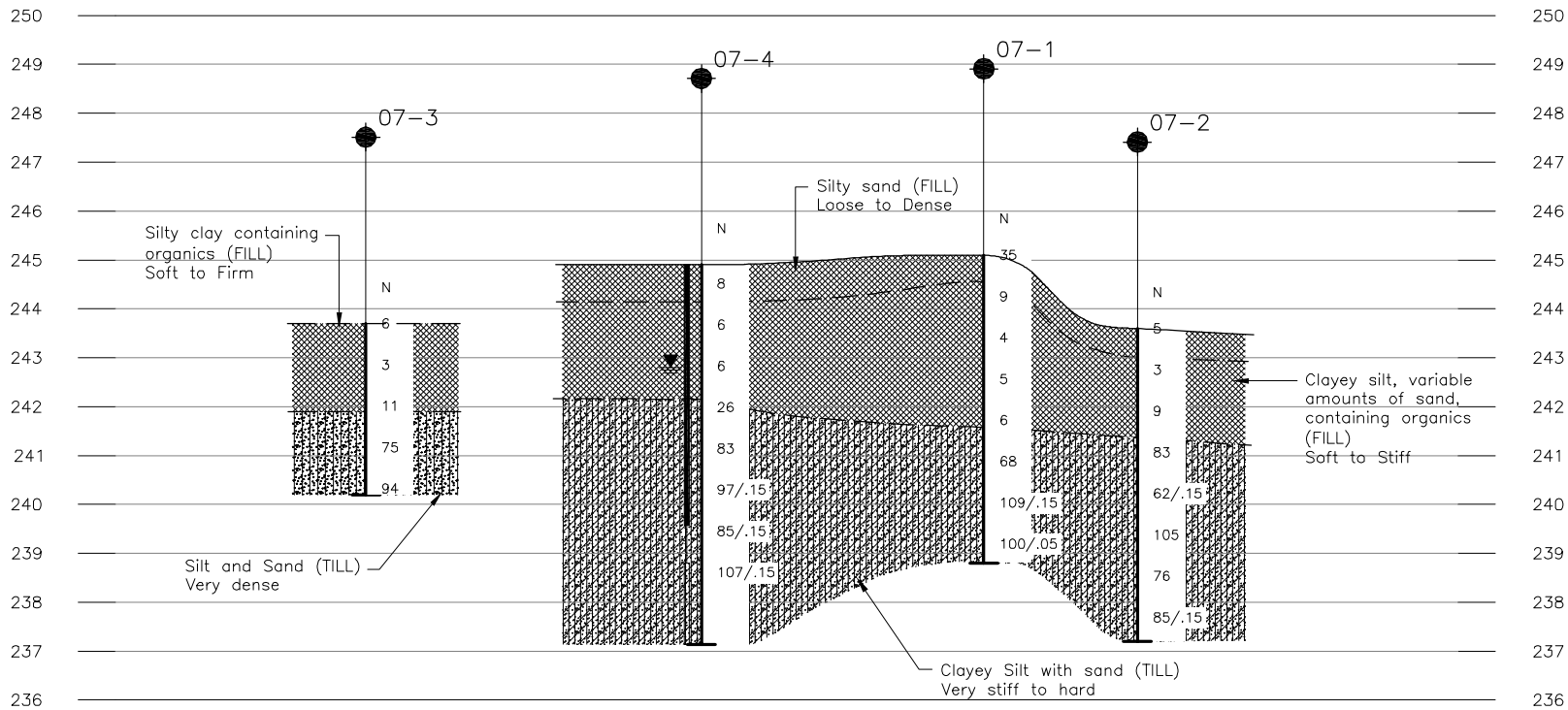
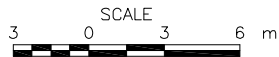
| PROJECT       |   | 05-1111-034 |         | <b>RECORD OF BOREHOLE No BH07-4</b> |            | 1 OF 1 <b>METRIC</b>                       |                 |                 |   |                |   |                |   |             |                                       |  |  |
|---------------|---|-------------|---------|-------------------------------------|------------|--|-----------------|-----------------|---|----------------|---|----------------|---|-------------|---------------------------------------|--|--|
| W.P.          |   | 2479-04-00  |         | LOCATION                            |            | N 4888994.0 ; E 271361.1                   |                 |                 |   |                |   |                |   |             |                                       |  |  |
| DIST          |   | Central HWY |         | BOREHOLE TYPE                       |            | Power Auger, 108 mm O.D. Solid Stem Augers |                 |                 |   |                |   |                |   |             |                                       |  |  |
| DATUM         |   | Geodetic    |         | DATE                                |            | September 26, 2007                         |                 |                 |   |                |   |                |   |             |                                       |  |  |
|               |   |             |         |                                     |            | ORIGINATED BY <u>SB</u>                    |                 |                 |   |                |   |                |   |             |                                       |  |  |
|               |   |             |         |                                     |            | COMPILED BY <u>DD</u>                      |                 |                 |   |                |   |                |   |             |                                       |  |  |
|               |   |             |         |                                     |            | CHECKED BY <u>SMM</u>                      |                 |                 |   |                |   |                |   |             |                                       |  |  |
| SOIL PROFILE  |   |             | SAMPLES |                                     |            | DYNAMIC CONE PENETRATION RESISTANCE PLOT   |                 |                 | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT |                |   | UNIT WEIGHT    |   |             | REMARKS & GRAIN SIZE DISTRIBUTION (%) |  |  |
| ELEV<br>DEPTH | DESCRIPTION   | STRAT PLOT  | NUMBER  | TYPE                                | "N" VALUES | GROUND WATER<br>CONDITIONS                 | ELEVATION SCALE | 20 40 60 80 100 | 20 40 60 80 100                                     | W <sub>p</sub> | W | W <sub>L</sub> | γ | GR SA SI CL |                                       |  |  |
| 244.9         | GROUND SURFACE  |             |         |                                     |            |  |                 |                 |   |                |   |                |   |             |                                       |  |  |
| 0.0           | Silty sand, trace gravel (FILL)<br>Brown<br>Moist   |             |         |                                     |            |  |                 |                 |   |                |   |                |   |             |                                       |  |  |
| 244.1         |   |             |         |                                     |            |  |                 |                 |   |                |   |                |   |             |                                       |  |  |
| 0.8           | Clayey silt, trace to some sand,<br>trace gravel, containing rootlets<br>(FILL)<br>Firm<br>Brown<br>Moist   |             | 1       | SS                                  | 8          |  | 244             |                 |   |                |   |                |   |             |                                       |  |  |
|               |   |             | 2       | SS                                  | 6          |  | 243             |                 |   |                |   |                |   |             |                                       |  |  |
|               |   |             |         |                                     |            |  |                 |                 |   |                |   |                |   |             |                                       |  |  |
| 242.2         | Becoming dark grey to black,<br>containing organics and decayed<br>wood fibres at 2.2 m depth   |             | 3       | SS                                  | 6          |  | 242             |                 |   |                |   |                |   |             |                                       |  |  |
| 2.7           | CLAYEY SILT with sand, trace<br>gravel (TILL)<br>Very stiff to hard<br>Grey<br>Dry  |             | 4       | SS                                  | 26         |  | 241             |                 |   |                |   |                |   |             |                                       |  |  |
|               |   |             | 5       | SS                                  | 83         |  | 240             |                 |   |                |   |                |   |             |                                       |  |  |
|               |   |             | 6       | SS                                  | 97/15      |  | 239             |                 |   |                |   |                |   |             |                                       |  |  |
|               |   |             | 7       | SS                                  | 85/15      |  | 238             |                 |   |                |   |                |   |             |                                       |  |  |
|               |   |             |         |                                     |            |  |                 |                 |   |                |   |                |   |             |                                       |  |  |
| 237.1         | END OF BOREHOLE   |             | 8       | SS                                  | 107/15     |  |                 |                 |   |                |   |                |   |             |                                       |  |  |
| 7.8           | Notes:<br><br>1. Borehole dry upon completion of<br>drilling.<br><br>2. Water level in piezometer at a<br>depth of 4.8 m (Elev. 240.1 m) upon<br>completion of piezometer<br>installation on September 26, 2007.<br><br>3. Water level in piezometer at a<br>depth of 2.1 m (Elev. 242.8 m)<br>below ground surface on October<br>15, 2007. |             |         |                                     |            |  |                 |                 |   |                |   |                |   |             |                                       |  |  |

MIS-MTO 001 05-111-034 (W.P. 2479-04-00) GPJ GAL-MISS GDT 1/13/09 DD

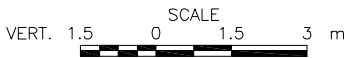
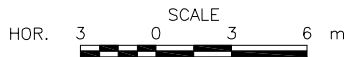




PLAN



PROFILE A-A'



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

CONT No.  
WP No. 2479-04-00

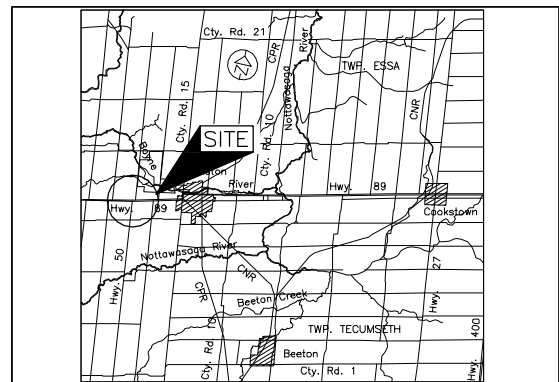


HWY 89  
CULVERT REPLACEMENT AT STATION 16+255  
BOREHOLE LOCATION AND SOIL  
STRATA

SHEET



**Golder Associates Ltd.**  
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN  
NOT TO SCALE

### LEGEND

- Borehole - Current Investigation
- Seal
- Piezometer
- Standard Penetration Test Value
- WL in piezometer, measured on October 15, 2007

| No.  | ELEVATION | CO-ORDINATES |          |
|------|-----------|--------------|----------|
|      |           | NORTHING     | EASTING  |
| 07-1 | 245.1     | 4888984.1    | 271368.2 |
| 07-2 | 243.6     | 4888976.6    | 271365.2 |
| 07-3 | 243.7     | 4889006.6    | 271355.7 |
| 07-4 | 244.9     | 4888994.0    | 271361.1 |

### NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

The complete foundation investigation and design report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

### REFERENCE

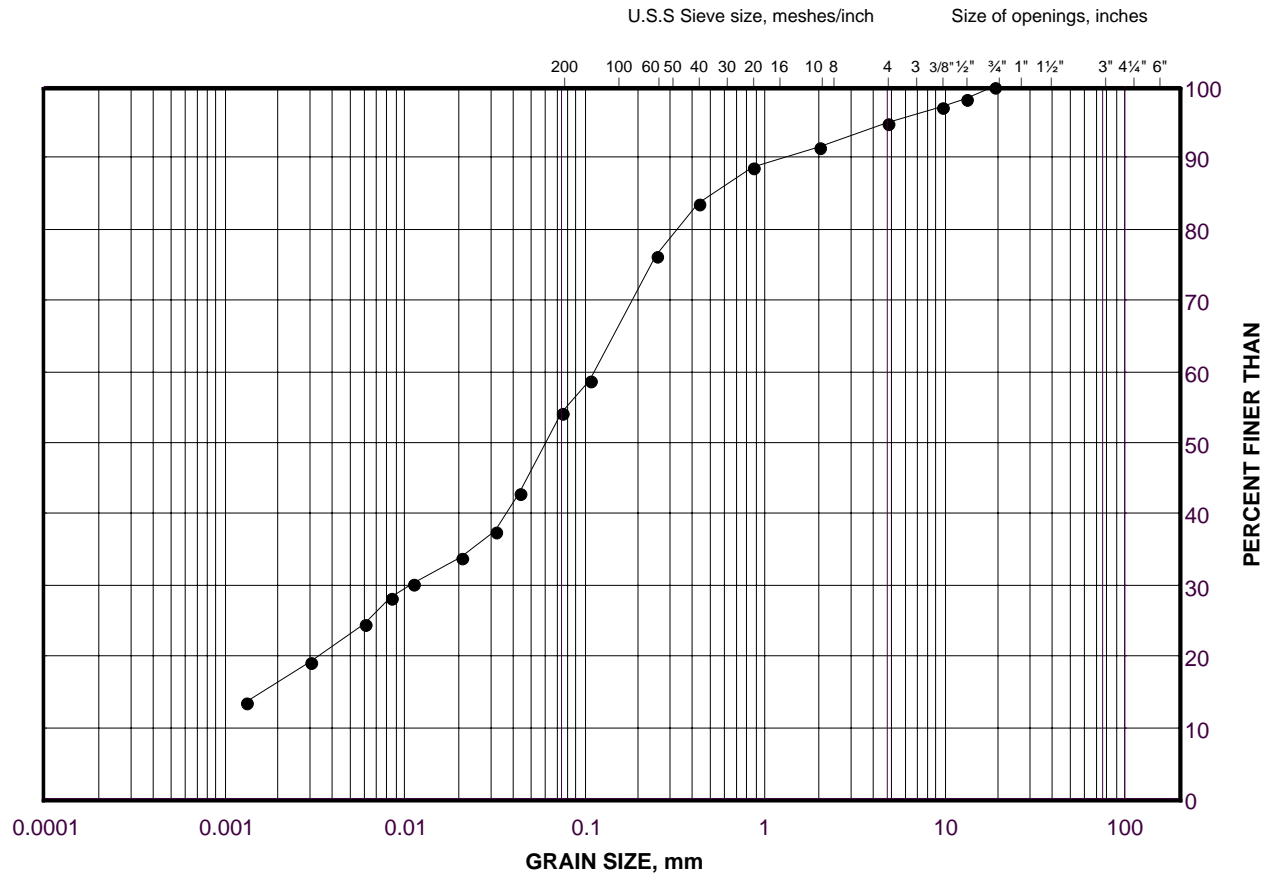
Base plans provided in digital format by MRC, drawing file no. 1 entitled "HWY 89 Culvert at sta. 16+255 general arrangement", dated Jan. 2007, received Nov. 23, 2007.

| NO.                 | DATE                    | BY                | REVISION      |
|---------------------|-------------------------|-------------------|---------------|
| Geocres No. 31D-451 |                         |                   |               |
| HWY.                | PROJECT NO. 05-1111-034 |                   | DIST.         |
| SUBM'D.             | CHKD.                   | DATE: 20-Jan-2009 | SITE: 30-545C |
| DRAWN: DD           | CHKD. HJ                | APPD. JMAC        | DWG. 1        |

# GRAIN SIZE DISTRIBUTION

Clayey Silt with Sand (Fill)

FIGURE 1



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

## LEGEND

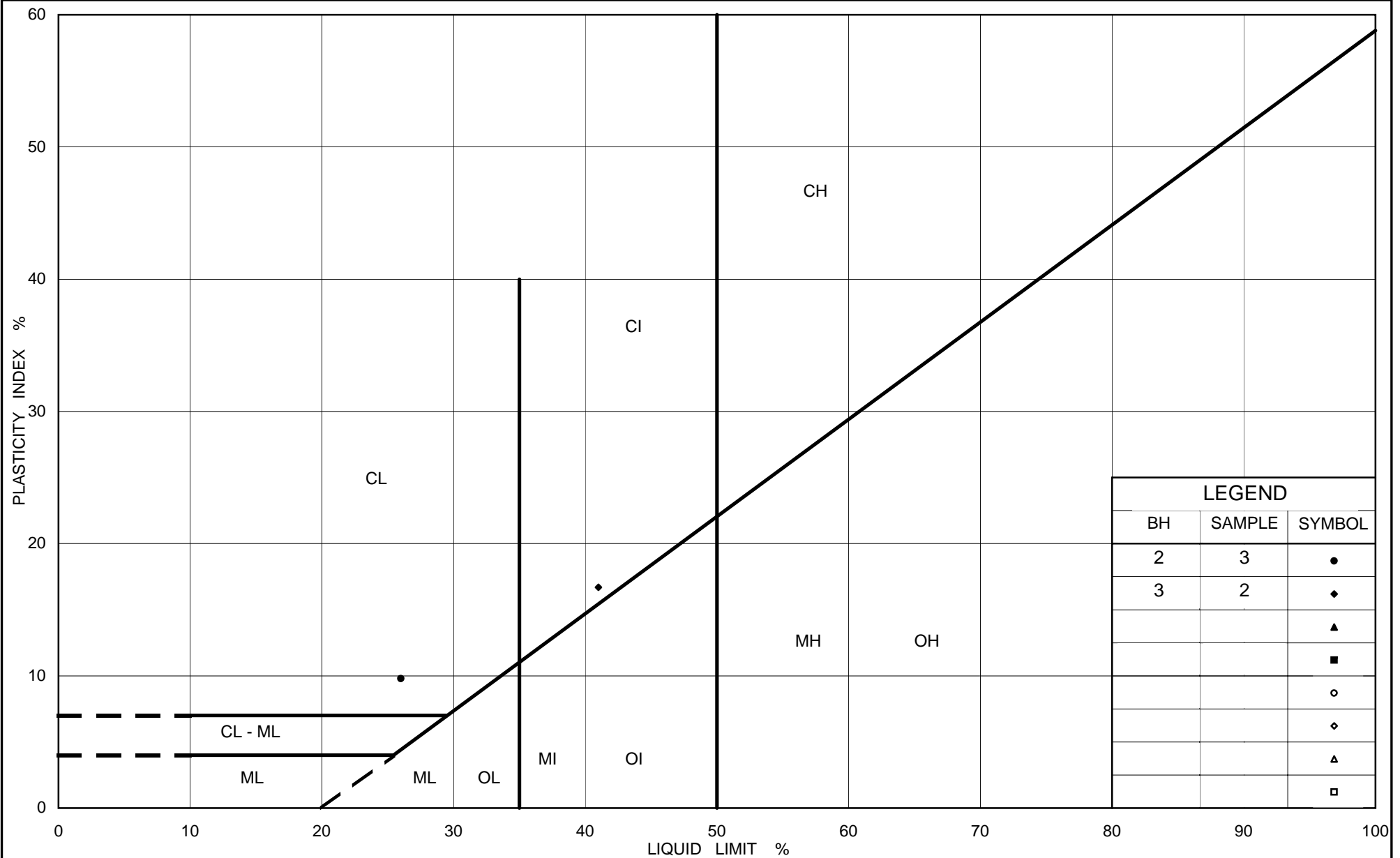
| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|--------|----------|--------|--------------|
| •      | 07-2     | 3      | 241.8        |

Project Number: 05-1111-034

Checked By: HJ

**Golder Associates**

Date: 17-Dec-07



Ministry of Transportation

Ontario

# PLASTICITY CHART Clayey Silt to Silty Clay Fill

Figure No. 2

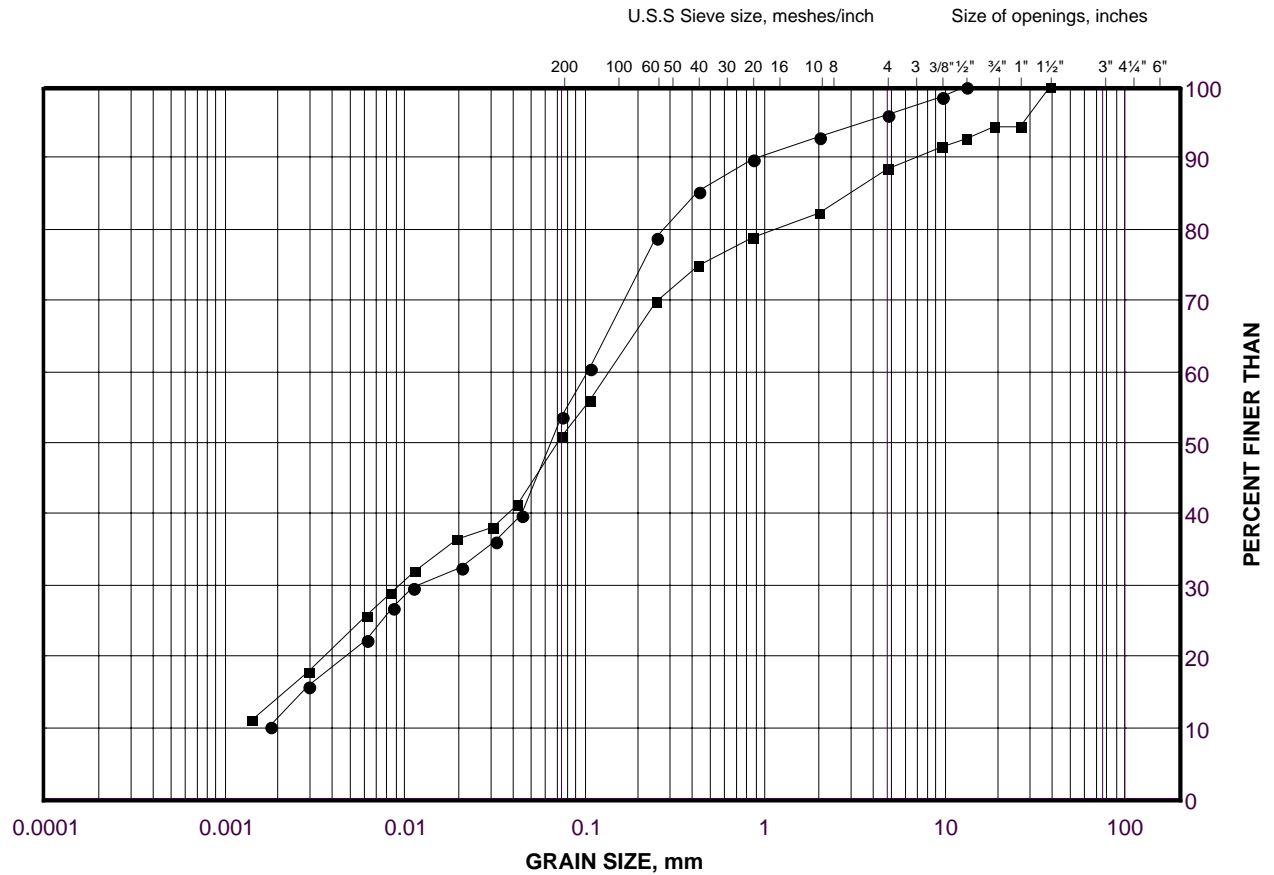
Project No. 05-1111-034

Checked By: HJ

# GRAIN SIZE DISTRIBUTION

Clayey Silt with Sand (Till)

FIGURE 3



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

## LEGEND

| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|--------|----------|--------|--------------|
| ●      | 07-4     | 7      | 238.8        |
| ■      | 07-1     | 7      | 240.5        |

Project Number: 05-1111-034

Checked By: HJ

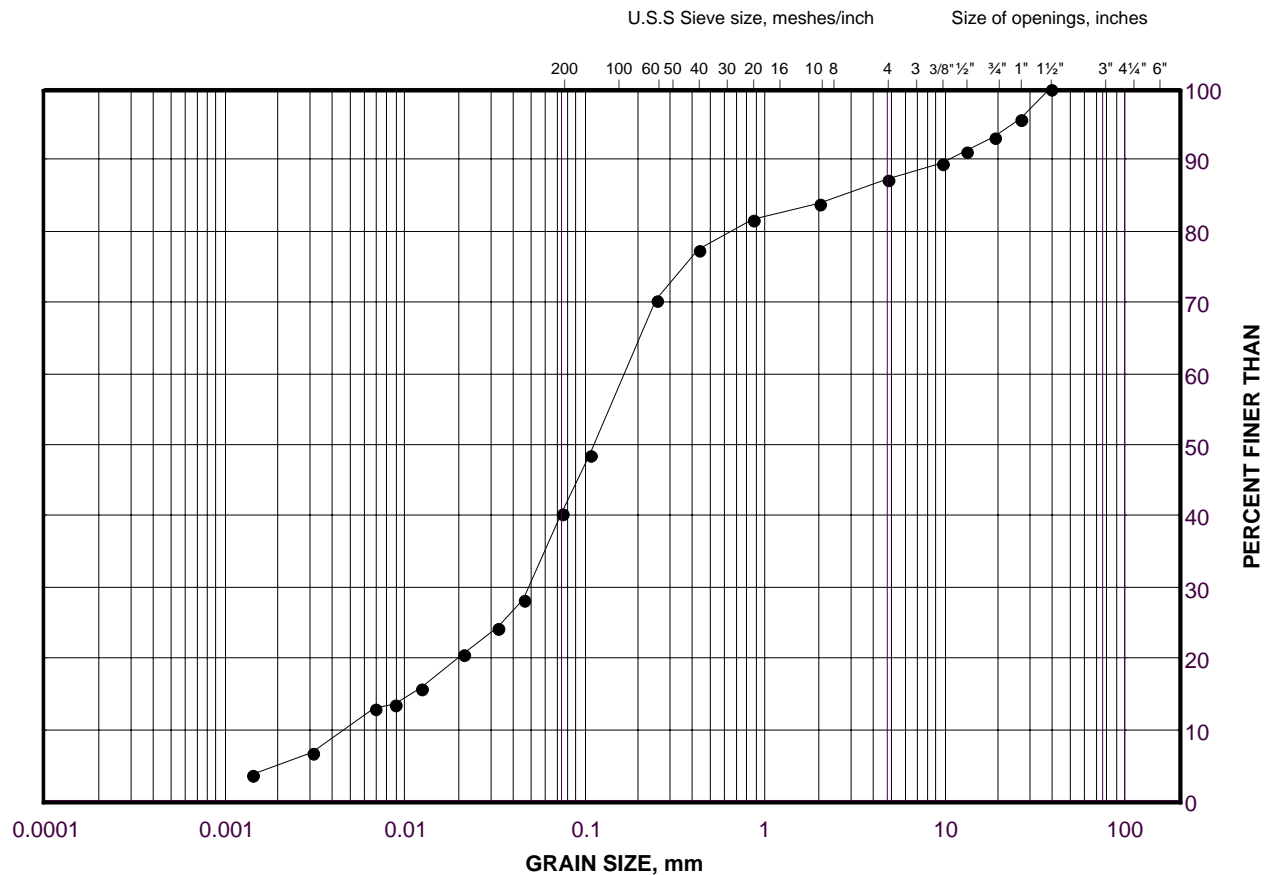
**Golder Associates**

Date: 17-Dec-07

# GRAIN SIZE DISTRIBUTION

Silt and Sand (Till)

FIGURE 4



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

## LEGEND

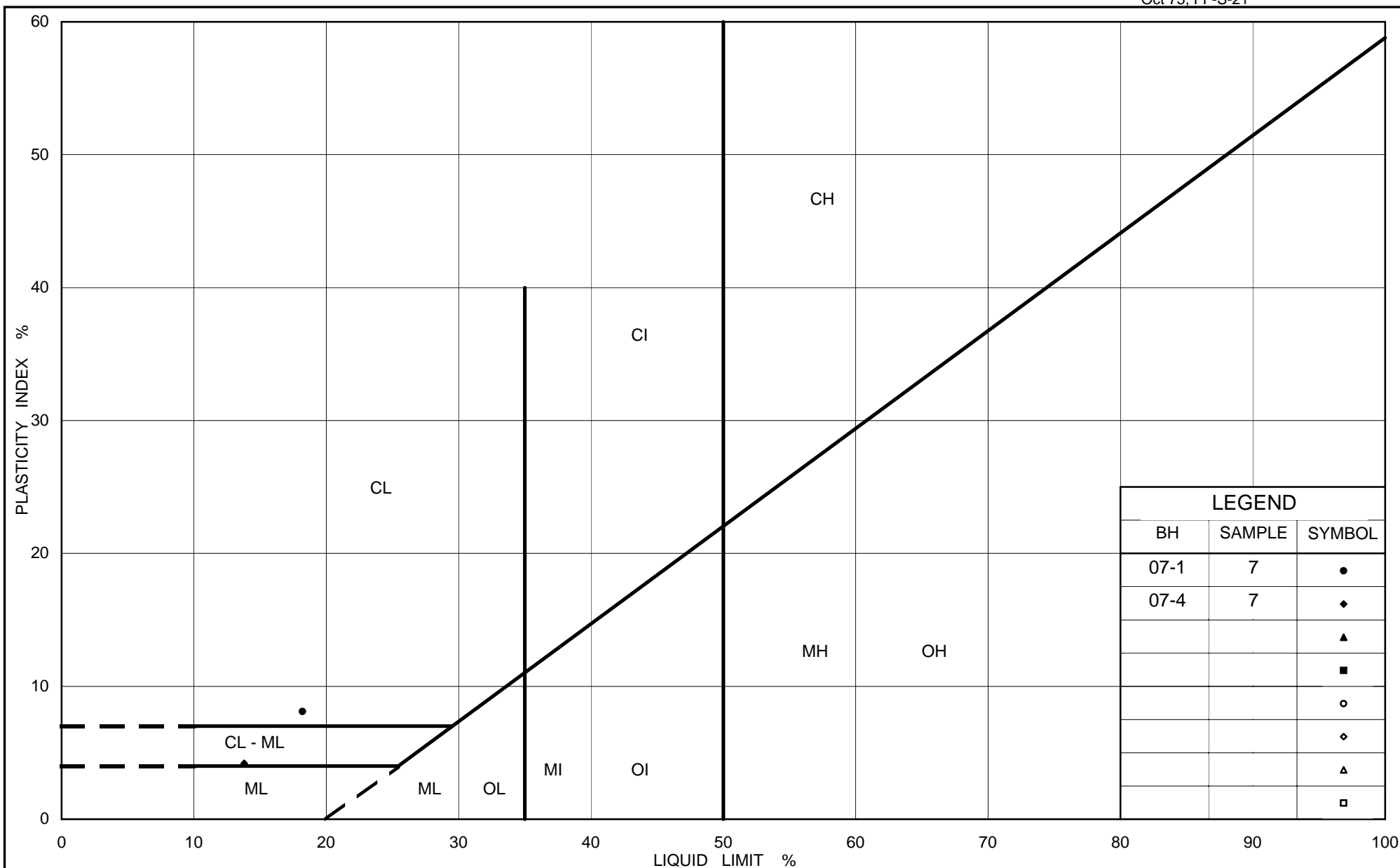
| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|--------|----------|--------|--------------|
| •      | 07-3     | 4      | 241.2        |

Project Number: 05-1111-034

Checked By: HJ

**Golder Associates**

Date: 17-Dec-07



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## PLASTICITY CHART

### Clayey Silt Till

Figure No. 5

Project No. 05-1111-034

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