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**FOUNDATION INVESTIGATION AND DESIGN REPORT  
VARIABLE MESSAGE SIGN #10  
HIGHWAY 11 WESTBOUND, APPROXIMATELY  
1.6 KM WEST OF HIGHWAY 655  
DRIFTWOOD, ONTARIO  
G.W.P. 5762-04-00, W.P. 5762-04-01**

Submitted to:

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GEOCRE NO.: 42A-68

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**PART A**

**FOUNDATION INVESTIGATION REPORT  
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## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder) has been retained by IBI Group (IBI) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out a foundation investigation as part of the detailed design for a variable message sign (VMS #10) on Highway 11 westbound near Driftwood, Ontario. The general location of the site is shown on the Key Plan on Drawing 1.

The terms of reference for the scope of work were outlined in Golder's Proposal P7-1191-0039, dated June 25, 2007, that formed part of the Consultant's Agreement (Number 5006-E-0083) for this project, as well as Change Request 1 – Credit, dated November 2, 2007. The work was carried out in accordance with Golder's Quality Control Plan for this project dated October 2007. The site plan showing the proposed sign location was provided to Golder by IBI in January 2008.

We understand the proposed structure will be a sign mounted on a single pole and supported by a spread footing.

## **2.0 SITE DESCRIPTION**

The site of the proposed VMS #10 is located on Highway 11 approximately 1.6 km west of the intersection with Highway 655 at Station 16+350 near Driftwood, Calder Township, Ontario. This section of Highway 11 consists of one westbound lane and one eastbound lane. The westbound gravel shoulder is approximately 3 m wide and a shallow drainage ditch parallels the gravel shoulder. The ground surface at the proposed structure location is at approximately Elevation 269.2 m.

### 3.0 INVESTIGATION PROCEDURES

#### 3.1 Foundation Investigation

The subsurface investigation work for the VMS #10 structure was carried out on November 16, 2007, at which time one sampled borehole, numbered BH07-5, was drilled on the shoulder of the westbound lane, approximately 1.0 m from the centre of the proposed sign location, as shown on Drawing 1.

The foundation investigation was carried out using a truck-mounted CME-55 drill rig supplied and operated by Landcore Drilling of Chelmsford, Ontario. The borehole was advanced using 108 mm I.D. hollow stem augers and soil samples were obtained at intervals of depth ranging from 0.75 m to 1.5 m, using a 50 mm outside diameter split-spoon sampler in accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586-99). Borehole BH07-5 was advanced to a depth of 9.8 m below the existing ground surface. Details of the subsurface conditions encountered at the borehole location are shown on the Record of Borehole following the text of this report. The borehole was backfilled with a bentonite holeplug to the ground surface in accordance with Ontario Regulation 128 (Amendment to O. Reg. 903).

The fieldwork was supervised throughout by a member of Golder's technical staff, who located the borehole, arranged for the clearance of underground services and for traffic protection, supervised the drilling, sampling and in situ testing operations, logged the borehole, and examined and cared for the soil samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to Golder's Sudbury geotechnical laboratory, where the samples underwent further visual examination and laboratory testing.

The borehole was located using a measuring tape relative to the stake positioned in the field by IBI. The as-drilled borehole location (relative to MTM NAD83 system) and the ground surface elevation (referenced to Geodetic datum) was subsequently surveyed by IBI and forwarded to Golder. The borehole location is depicted on Drawing 1 and the borehole coordinates and ground surface elevation are presented below.

| <b>Borehole Number</b> | <b>MTM NAD83<br/>Zone 17<br/>Northing (m)</b> | <b>MTM NAD83<br/>Zone 17<br/>Easting (m)</b> | <b>Ground Surface<br/>Elevation (m)</b> |
|------------------------|---|--|---|
| BH07-5                 | 5444311.9                                     | 276640.7                                     | 269.2                                   |

## **4.0 GENERAL SITE GEOLOGY AND STRATIGRAPHY**

### **4.1 Regional Geology**

Based on terrain mapping by the Ontario Geological Survey, the subsurface soils in the vicinity of the site consist of morainal deposits comprising till and clay<sup>1</sup>.

### **4.2 Site Stratigraphy**

Detailed descriptions of the subsurface soil and groundwater conditions as encountered in Borehole BH07-5, advanced during this investigation, together with the results of the laboratory tests carried out on selected samples, are given on the Record of Borehole sheet following the text of this report. The stratigraphic boundaries shown on the Record of Borehole sheet are inferred from non-continuous sampling, observations of drilling progress and the results of SPTs. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary beyond the borehole location.

In summary, the subsoil conditions at the site consist of granular fill (roadway shoulder materials) underlain by firm to very stiff clayey silt. A more detailed description of the subsurface conditions encountered in the borehole is provided in the following sections.

#### **4.2.1 Fill**

Fill, consisting of sandy gravel to silty sand containing trace to some organics, was encountered from the ground surface to a depth of 2.1 m.

The measured SPT 'N' values within the fill materials were 3 and 5 blows per 0.3 m of penetration, indicating that the deposit had a very loose to loose relative density.

The natural water content of samples of the fill material were about 14 percent and 26 percent. The results of one grain size distribution test on a sample of the fill material are shown on Figure 1.

#### **4.2.2 Clayey Silt**

A clayey silt deposit was encountered below the fill at a depth of 2.1 m below existing ground surface, corresponding to Elevation 267.1 m. The clayey silt deposit extended to the bottom of the borehole at a depth of 9.8 m below existing ground surface (Elevation 259.4 m).

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<sup>1</sup> Northern Ontario Engineering Geology Terrain Study, OGS Electronic Map Reference Number 42 H/SW



The measured SPT 'N' values within the clayey silt deposit ranged from 5 to 28 blows per 0.3 m of penetration, indicating the deposit had a firm to very stiff consistency. The natural water content of the clayey silt deposit varied between about 15 percent and 21 percent.

Atterberg limits testing carried out on two samples of the deposit provided liquid limits of 24 percent and 25 percent, and plastic limits of 15 percent, corresponding to plasticity indices of 9 percent and 10 percent. As shown on Figure 2, the two tested samples are classified as clayey silt of low plasticity.

The results of grain size distribution tests on three samples of the clayey silt deposit are shown on Figure 3.

#### **4.2.3 Groundwater Conditions**

Details of the groundwater conditions and water level observed in the open borehole at the time of drilling are summarized on the Record of Borehole sheet following the text of this report. In general, the samples taken in the borehole were noted to be wet to a depth of approximately 3.7 m below ground surface and moist from 3.7 m below ground surface to the bottom of the borehole. The groundwater level observed in the open borehole was recorded at a depth of 9.1 m below the existing ground surface upon completion of drilling, corresponding to Elevation 260.1 m. Based on the results of moisture content testing on samples of the subsoils, the stabilized groundwater level may likely be at approximately 2.1 m below existing ground surface, corresponding to Elevation 267.1 m. It should be noted that this water level does not represent the stabilized water level and that the groundwater elevation will fluctuate seasonally depending on precipitation and local soil permeability and should be expected to rise during wet periods of the year.

## 5.0 CLOSURE

The fieldwork for this project was carried out by a technician from our Sudbury office under the coordination of Mr. André Bom, P.Eng. This report was prepared by Mr. André Bom, P.Eng., a Geotechnical Engineer, and the technical aspects were reviewed by Mr. André Zerwer, P.Eng., Associate and Senior Geotechnical Engineer and Mr. Jorge M.A. Costa, P.Eng. a Principal with Golder. Mr. Costa, also a Designated MTO Contact for Golder, conducted a quality control review of the report.

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**PART B**

**FOUNDATION DESIGN REPORT  
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## **6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS**

### **6.1 General**

This section of the report provides foundation design recommendations for the proposed variable message sign (VMS #10). The recommendations are based on interpretation of the factual data obtained from the borehole advanced during the subsurface investigation at this site and from site observations. The interpretation and recommendations provided are intended only to provide the designers with sufficient information to assess feasible foundation design alternatives and to design the proposed sign foundation. As such, where comments are made on construction, they are provided only in order to highlight those aspects which could affect the planning of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods, scheduling and the like.

### **6.2 Sign Foundation**

We understand the proposed sign will be located on the east side of Highway 11 with the centre of the footing located approximately 4.5 m from the edge of pavement at Station 16+350 facing the westbound traffic. Borehole BH07-5 was advanced at Station 16+350 approximately 1.0 m from the centre of the proposed sign location (i.e. approximately 3.5 m from the edge of the pavement). Borehole BH07-5 penetrated a 2.1 m thick layer of sandy gravel to silty sand fill, underlain by a deposit of firm to very stiff clayey silt from 2.1 m below ground surface to the bottom of the borehole. The unstabilized groundwater level in the open borehole upon completion of drilling was 9.1 m below the existing ground surface (Elevation 260.1 m). Based on the results of moisture content testing on samples of the subsoils, the stabilized groundwater level may likely be at approximately 2.1 m below existing ground surface, corresponding to Elevation 267.1 m.

Overhead sign supports are typically designed with a standard caisson foundation in accordance with the requirements in MTO's *Sign Support Manual*. However, for the proposed site, we understand from IBI that a site-specific design consisting of a single pole mounted sign founded on a spread footing has been selected. The following sections provides recommendations for both a caisson foundation and spread footing.

#### **6.2.1 Caisson Foundation**

As indicated above, caisson foundations for overhead sign supports should be designed in accordance with the requirements in MTO's *Sign Support Manual*. The *Sign Support Manual* includes a standard caisson foundation design (Section 4 and Standard Drawings SS118-3,

SS118-4 and SS118-5), in which the caisson is extended 5 m below the design frost depth except where bedrock is encountered within this depth. As shown on the depth of frost penetration isopleths for Northern Ontario<sup>2</sup>, the depth of frost penetration for the Driftwood area is approximately 2.6 m. The typical caisson founding level would therefore be 7.6 m below the ground surface. Bedrock was not encountered to the depth drilled at this site; therefore, the foundation for this sign support could be designed as a caisson in soil. The standard design is based on the following minimum soil conditions:

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

Cohesive soil, consisting of a firm to very stiff clayey silt was encountered below the fill materials at a depth of 2.1 m below ground surface at the borehole location. The undrained shear strength is greater than the minimum specified strength in Case 2. Therefore, the standard foundation design provided in MTO’s *Sign Support Manual* applies to this location and the soil parameter values given for Case 2 should be used in the design.

### 6.2.2 Spread Footing

We understand from IBI that the preferred alternative foundation design for the support of VMS #10 is a spread footing, 5 m long and 2.5 m wide with the centre of the footing located 4.5 m from the edge of pavement. The founding depth of the spread footing should be below the depth of frost penetration (i.e. 2.6 m below final ground surface) within the stiff clayey silt deposit.

Based on the subsurface conditions encountered at the borehole location, open cut excavations of short duration appear possible for the proposed footing construction. Excavations for footing construction will extend through the fill material into the firm to very stiff clayey silt deposit. Excavations for the proposed footing should be carried out in accordance with the latest Occupational Health and Safety Act for Construction Projects (OHSA). When referencing OHSA, the fill materials and the clayey silt deposit are classified as “Type 3 Soil”. An excavation above the groundwater level should be sloped at a gradient of 1 horizontal (H) to

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<sup>2</sup> Ontario Provincial Standard Drawing (OPSD) 3090.100

1 vertical (V) or flatter. An excavation below the groundwater level should be sloped at 2H to 1V or flatter.

Assuming excavation side slopes of 1H to 1V and a depth of excavation of 2.6 m, the crest of the excavation on the roadway side of the proposed footing will be located approximately 0.6 m from the existing edge of pavement. If side slopes flatter than 1H to 1V are required during construction, provision for protection of the existing pavement structure will be required in accordance with MTO's Protection Systems Special Provision No. 105S19, designed to meet Performance Level 2.

Relevant design parameters for the shoring are provided below.

| Design Parameter   | Fill |
|--|------|
| Unit Weight above Groundwater Level $\gamma$ (kN/m <sup>3</sup> )  | 18   |
| Unit Weight below Groundwater Level $\gamma'$ (kN/m <sup>3</sup> ) | 8    |
| Friction Angle $\phi$ (°)  | 27   |
| $K_a$ *  | 0.37 |
| $K_p$ *  | 2.66 |
| $K_o$ *  | 0.45 |

\* Earth pressure coefficients for horizontal backfill.

For the cohesive soil, the passive pressure,  $P_p$ , and active pressure,  $P_a$ , acting on the shoring may be calculated using the following equations:

$$P_p = \sigma_z + 2 c_u$$

$$P_a = \sigma_z - 2 c_u$$

The  $c_u$  value for the clayey silt should be taken as 75 kPa.

As noted in Section 6.2, the unstabilized groundwater level in Borehole BH07-5 was encountered at a depth of 9.1 m below the existing ground surface. Depending on the seasonal time of footing construction, the groundwater level or perched groundwater may be encountered during construction. The hydraulic conductivity of the clayey silt is considered low, such that perched groundwater may be removed from the excavation by pumping from properly filtered sumps.

During construction, stockpiles should be placed well away from the edge of the excavation, and their height should be controlled so they do not surcharge the sides of the excavation and/or overall slope. Generally speaking, for this site, the distance between the crest of the excavation and the toe of the stockpile should generally be greater than the diameter of the base of the stockpile.

Disturbance of the underlying materials during construction of the spread footing could influence the settlement of the structure. MTO's Special Provision No. 902S01 should be included in the Contract Documents, requiring inspection and approval of the foundation area by the Quality Verification Engineer (QVE) prior to footing construction, to ensure that adequate preparation of the foundation areas.

The base of the excavation should be free of water and loose soil prior to placing concrete. Should the materials at bearing level become saturated or disturbed, we recommend that the affected material be removed immediately prior to placing concrete. We recommend that the prepared subgrade be protected using a 150 mm thick mud mat comprised of a minimum 5 MPa concrete or a minimum 300 mm thick working mat of compacted Granular 'B' Type II or Granular 'A' meeting MTO's Special Provision SP110S13. The mat would be placed across the bottom of the excavation immediately upon completion of the excavation and review by the QVE. The purpose of the mat is to limit disturbance of the clayey silt and to provide a platform for construction of the spread footing.

### **6.2.3 Geotechnical Resistance**

Spread footings constructed on the properly prepared subgrade at or below the depth given in Section 6.2.2 may be designed based on a factored geotechnical axial resistance of 200 kPa at Ultimate Limit States (ULS) for a footing rectangular in shape up to 5.0 m long by 2.5 m wide. For the same spread footing dimension indicated above, a geotechnical axial resistance value of 100 kPa for Serviceability Limit States (SLS; for 25 mm settlement) design may be assumed. Design of the proposed sign foundation should also be checked for and provisions made to resist buoyant forces.

The ULS resistance and settlement are dependent on the footing size, configuration and applied loads; the geotechnical resistances should, therefore, be reviewed if the selected footing dimensions or founding depth differs from those given above.

The geotechnical resistances provided above are given under the assumption that the loads will be applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the surface of the footing, inclination of the load should be taken into account in accordance with Clauses 6.7.4 and C6.7.4 of the *Canadian Highway Bridge Design Code (CHBDC, 2006)* and the related commentary.

#### **6.2.4 Resistance to Lateral Loads**

Resistance to lateral forces / sliding resistance between the concrete footings and the prepared subgrade should be calculated in accordance with Section 6.7.5 of the *CHBDC*. For cast-in-place concrete footings constructed on a compacted granular pad, the coefficient of friction,  $\tan \phi'$ , can be taken as 0.45. For cast-in-place concrete footings constructed on a concrete mud mat, the coefficient of friction,  $\tan \phi'$ , can be taken as 0.55. The above noted values are unfactored; in accordance with the *CHBDC*, a factor of 0.8 is to be applied in calculating the horizontal resistance.

#### **6.3 Construction Considerations**


The excavation around and above the spread footing may be backfilled using an approved granular material meeting MTO's Special Provision SP110S13 such as Granular 'A' or 'B' Type II placed in 300 mm loose lifts and uniformly compacted to 95 percent standard Proctor maximum dry density. The use of native excavated materials as backfill is not recommended. The final grade surrounding the sign should be sloped to promote surface water drainage and pavement structure drainage away from the pavement and sign, to the adjacent ditch.



## 7.0 CLOSURE

This report was prepared by Mr. André Bom, P.Eng., a Geotechnical Engineer, and the technical aspects were reviewed by Mr. André Zerwer, P.Eng., Associate and Senior Geotechnical Engineer and Mr. Jorge M.A. Costa, P.Eng. a Principal with Golder. Mr. Costa, also a Designated MTO Contact for Golder, conducted a quality control review of the report.

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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         |

### II. PENETRATION RESISTANCE

#### Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.).

#### Dynamic Cone Penetration Resistance, $N_d$ :

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

**PH:** Sampler advanced by hydraulic pressure

**PM:** Sampler advanced by manual pressure

**WH:** Sampler advanced by static weight of hammer

**WR:** Sampler advanced by weight of sampler and rod

#### Piezcone Penetration Test (CPT)

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

### 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                        |

#### (b) Cohesive Soils

#### Consistency

|            | $C_u, S_u$ |                |
|------------|------------|----------------|
|            | kPa        | psf            |
| Very soft  | 0 to 12    | 0 to 250       |
| Soft       | 12 to 25   | 250 to 500     |
| Firm       | 25 to 50   | 500 to 1,000   |
| Stiff      | 50 to 100  | 1,000 to 2,000 |
| Very stiff | 100 to 200 | 2,000 to 4,000 |
| Hard       | over 200   | over 4,000     |

### IV. SOIL TESTS

|                 |   |
|-----------------|---|
| w               | water content   |
| $w_p$           | plastic limit   |
| $w_l$           | liquid limit  |
| C               | consolidation (oedometer) test  |
| CHEM            | chemical analysis (refer to text)   |
| CID             | consolidated isotropically drained triaxial test <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. 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<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 (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 $= (e_{max} - e) / (e_{max} - e_{min})$<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 (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

MIS-MTO 001 DRIFTWOOD.GPJ GAL-MISS.GDT 4/16/08 ACM

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

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

CONT No.  
WP No. 5762-04-01

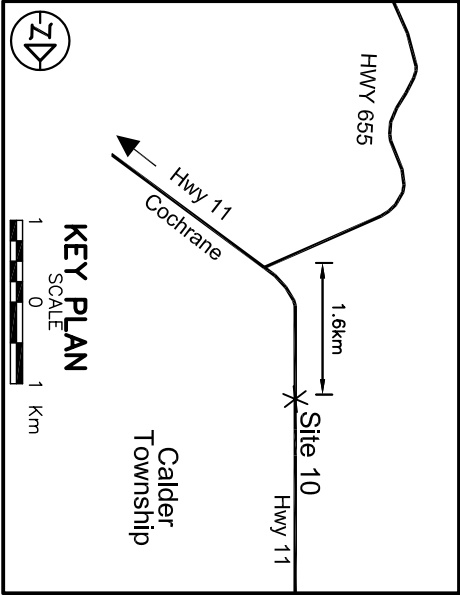


VARIABLE MESSAGE SIGN #10  
HIGHWAY 11 WESTBOUND, DRIFTWOOD  
BOREHOLE LOCATION


SHEET



Golder Associates Ltd.  
SUDBURY, ONTARIO, CANADA



LEGEND

 Borehole Location

| No.    | ELEVATION(m) | CO-ORDINATES |          |
|--------|--------------|--------------|----------|
|        |              | NORTHING     | EASTING  |
| BH07-5 | 269.2        | 5444311.9    | 276640.7 |
|        |              |              |          |

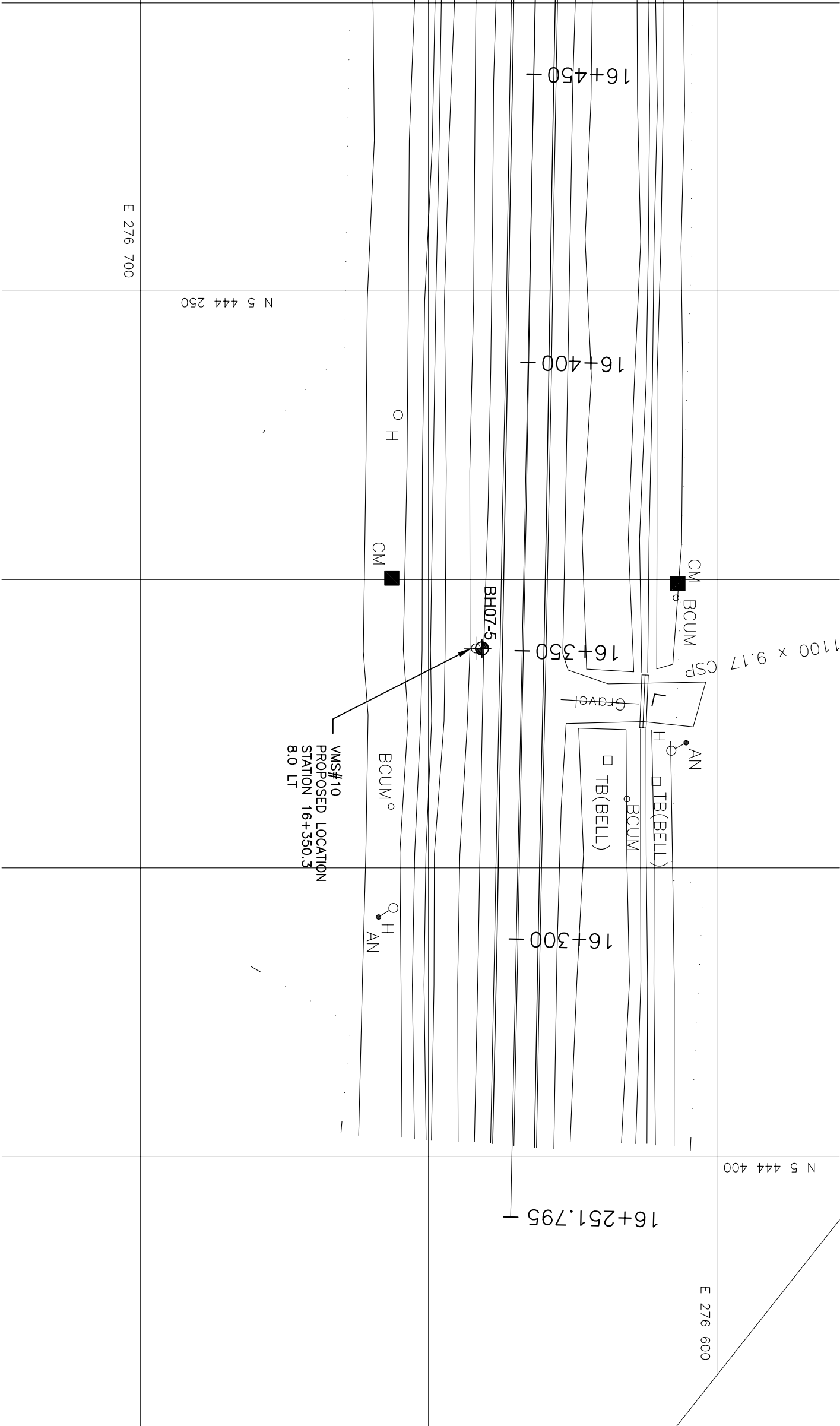
NOTES

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 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 OF-S General Conditions.

REFERENCE

Base plans provided in digital format by IBI, drawing file no. kplans.dwg and SBO7029.dwg, received January, 2008.



PLAN

SCALE

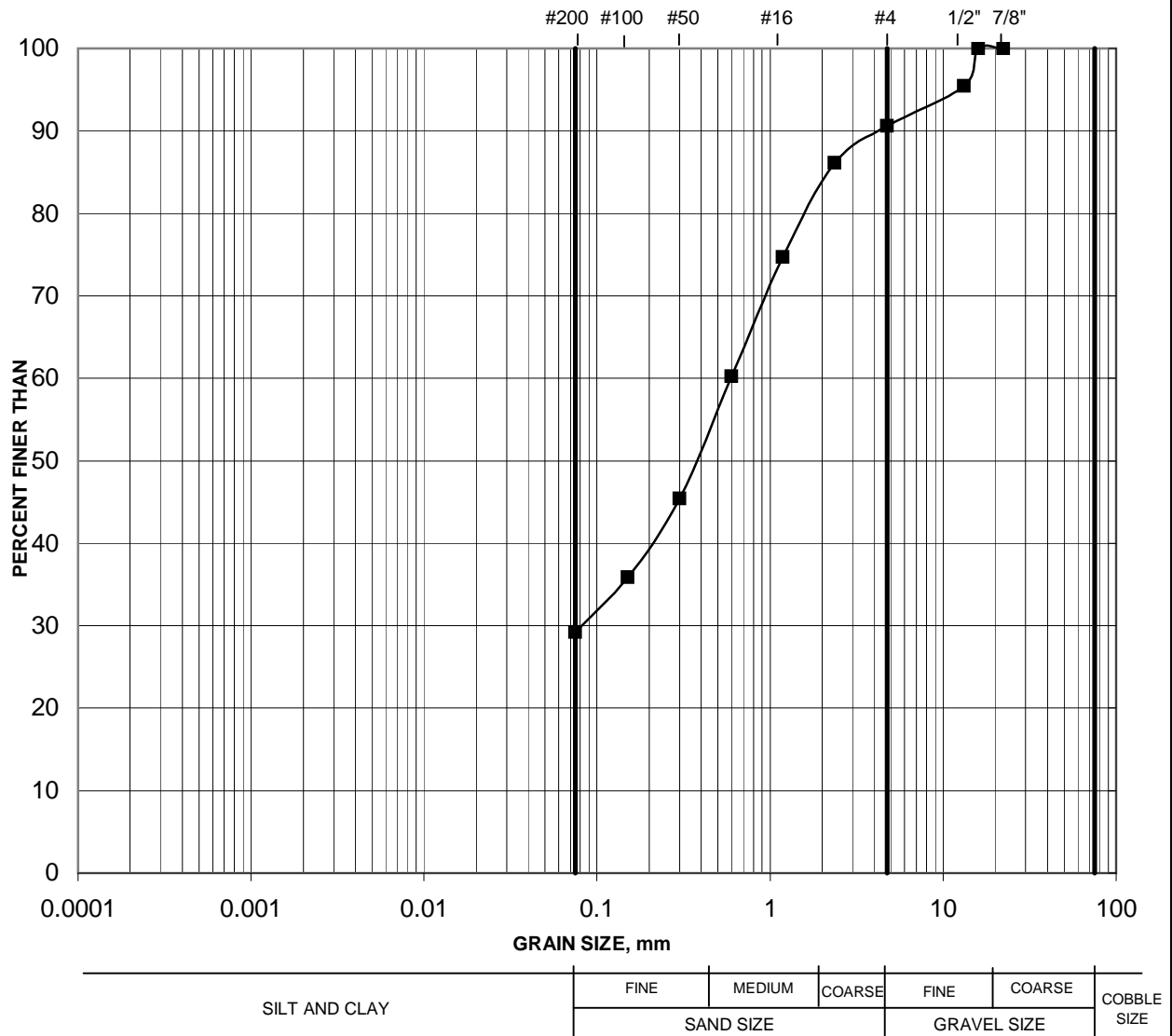


|                    |      |    |                             |                 |        |
|--------------------|------|----|-----------------------------|-----------------|--------|
|                    |      |    |                             |                 |        |
|                    |      |    |                             |                 |        |
| NO.                | DATE | BY | REVISION                    |                 |        |
| Geocres No. 42A-68 |      |    |                             |                 |        |
| HWY. 11            |      |    | PROJECT NO. 07-1191-0039-10 |                 | DIST.  |
| SUBWD. AB          |      |    | CHKD. JMAC                  | DATE: APR. 2008 | SITE:  |
| DRAWN: BB          |      |    | CHKD. AB                    | APPD. JMAC      | DWG. 1 |

# GRAIN SIZE DISTRIBUTION

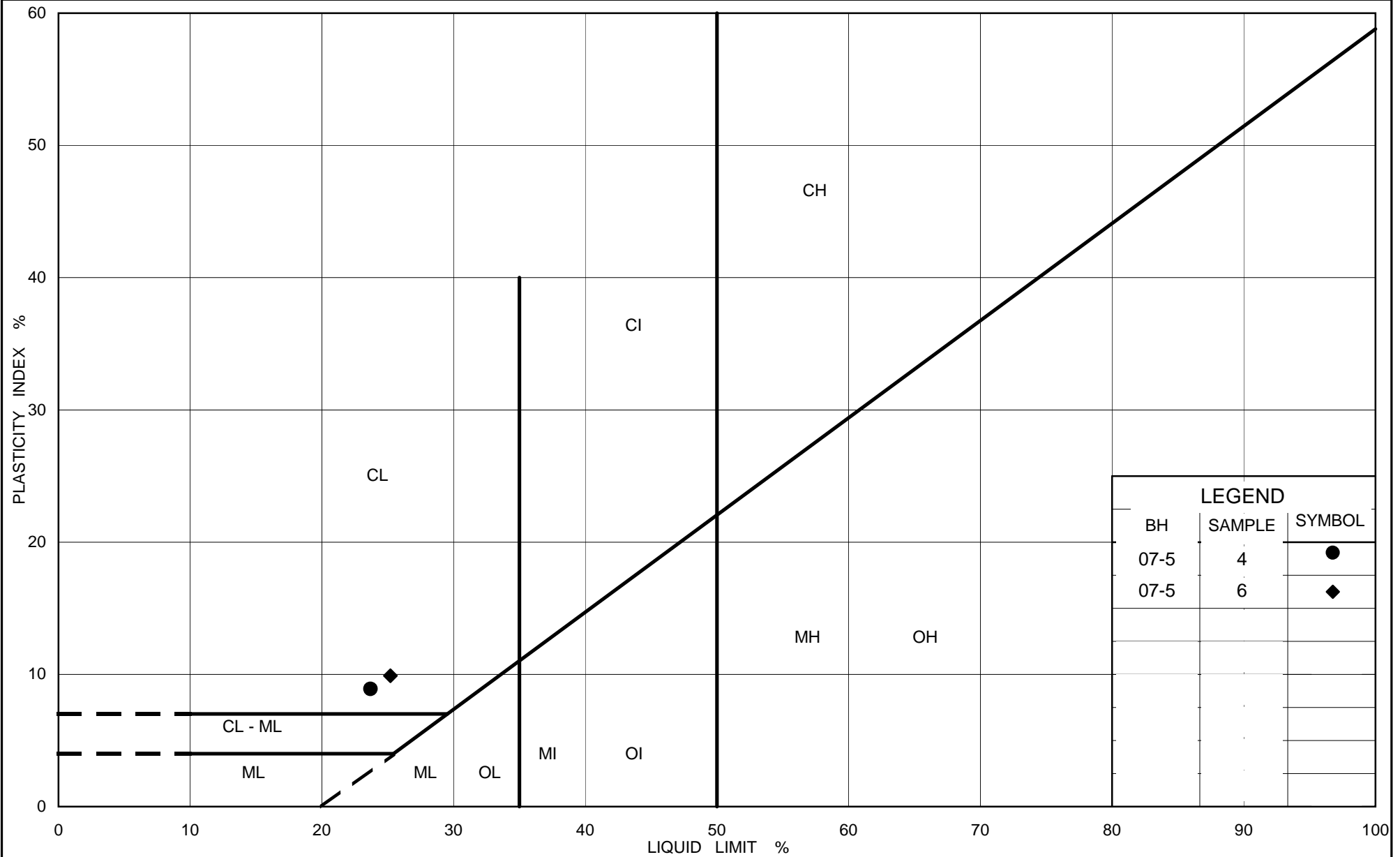
## Silty Sand (FILL)

FIGURE 1



| Borehole | Sample | Elevation (m) |
|----------|--------|---------------|
| 07-5     | 1      | 268.1         |

Project: 07-1191-0039-10



Ministry of Transportation

Ontario

## PLASTICITY CHART

### Clayey Silt

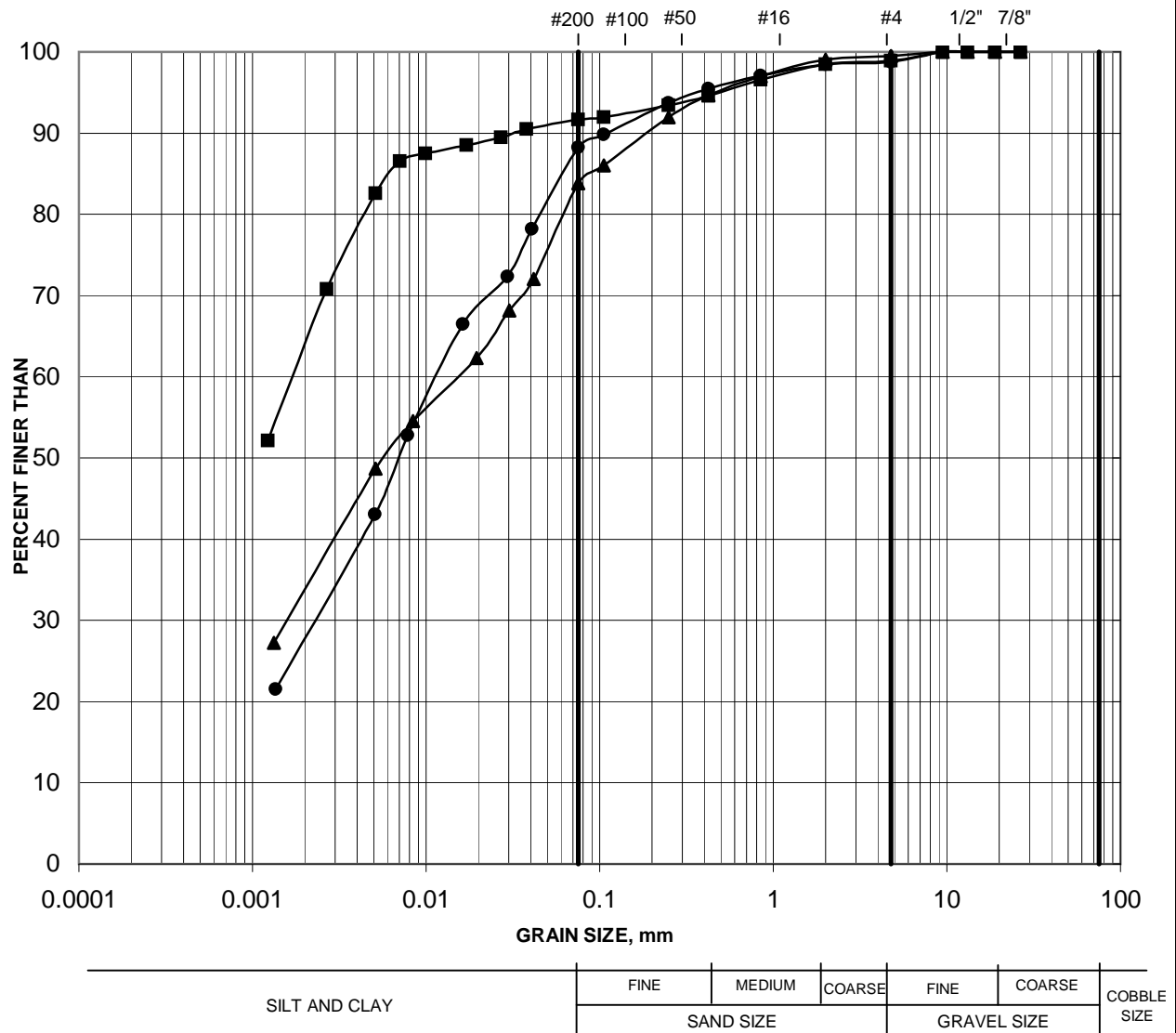
FIGURE No. 2

Project No. 07-1191-0039 VMS #10

Checked By: JMAC

# GRAIN SIZE DISTRIBUTION CLAYEY SILT

FIGURE 3



|   | Borehole | Sample | Elevation (m) |
|---|----------|--------|---------------|
| ● | 07-5     | 3      | 266.6         |
| ■ | 07-5     | 5      | 264.3         |
| ▲ | 07-5     | 7      | 261.3         |