

**FOUNDATION INVESTIGATION  
AND DESIGN REPORT  
CULVERTS  
HIGHWAY 7 BETWEEN DRUMMOND LINE  
AND 150 M EAST OF HIGHWAY 28  
PETERBOROUGH, ONTARIO  
G.W.P. 583-93-00**

Submitted to:

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GEOCRES No. 31D-432

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## **PART A**

### **FOUNDATION INVESTIGATION REPORT CULVERTS**

**HIGHWAY 7 BETWEEN DRUMMOND LINE  
AND 150 M EAST OF HIGHWAY 28  
PETERBOROUGH, ONTARIO  
G.W.P. 583-93-00**

## 1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Genivar on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services in support of the detailed design for the widening of Highway 7 from Drummond Line to 150 m east of Highway 28, in Peterborough, Ontario.

This report addresses the extension or replacement of seven structural culverts located within the project limits. The locations of the culverts are summarized below:

| <i>Culvert<br/>Number</i> | <i>Approximate<br/>Station</i> |
|---------------------------|--------------------------------|
| 1                         | 12+402                         |
| 2                         | 13+255                         |
| 3                         | 13+494                         |
| 4                         | 13+884                         |
| 5                         | 14+434                         |
| 6                         | 15+792                         |
| 7                         | 16+129                         |

The terms of reference and scope of work for the foundation investigation are outlined in MTO's Request for Proposal for Agreement No. 4005-E-0017, and outlined in Golder's Proposal No. P61-1226 dated April 6, 2006, which forms Section 6.8 of Genivar's Technical Proposal for this assignment. An additional borehole investigation was carried out beyond that required for the original scope of work, associated with realignment of the replacement culvert at approximately Station 14+434 (such that the south end of this culvert will be located approximately 15 m east of the existing culvert alignment), and for the northward extension of the existing culvert located at Station 16+129; the scope of work for these additional services was outlined in Golder's letter to Genivar dated July 22, 2008.

## 2.0 SITE DESCRIPTION

The seven culvert sites addressed in this report are located along Highway 7 between Drummond Line and 150 m east of Highway 28, in Peterborough, Ontario. The location, dimensions and type, existing embankment height, and invert elevation for the existing structural culverts are summarized below:

| <i><b>Culvert Number</b></i> | <i><b>Approximate Station</b></i> | <i><b>Existing Culvert Dimensions/Type</b></i> | <i><b>Embankment Height</b></i> | <i><b>Invert Elevation</b></i>     | <i><b>Proposed Extension</b></i> |
|------------------------------|-----------------------------------|--|---------------------------------|------------------------------------|----------------------------------|
| 1                            | 12+402                            | 1.8 m x 1.2 m open footing                     | 3 m                             | 201.7 m (south)<br>201.7 m (north) | 15.0 m south                     |
| 2                            | 13+255                            | 5.5 m x 1.8 m concrete box                     | 2.5 m                           | 203.5 m (south)<br>203.3 m (north) | 15.0 m south                     |
| 3                            | 13+494                            | 1.2 m x 1.2 m open footing                     | 3.5 m                           | 204.3 m (south)<br>203.8 m (north) | 16.0 m south                     |
| 4                            | 13+884                            | 1.2 m x 1.2 m open footing                     | 5 m                             | 206.3 m (south)<br>206.5 m (north) | 17.0 m south                     |
| 5                            | 14+434                            | 3.7 m x 1.8 m concrete box                     | 2.5 m                           | 206.8 m (south)<br>206.9 m (north) | 16.0 m south                     |
| 6                            | 15+792                            | 1.2 m x 1.2 m open footing                     | 2 m                             | 226.0 m (south)<br>225.8 m (north) | 4.0 m south<br>4.0 m north       |
| 7                            | 16+129                            | 1.2 m x 1.2 m open footing                     | 2 m                             | 226.5 m (south)<br>226.6 m (north) | 10.0 m south                     |

In general, the terrain in the area of each culvert is relatively flat, poorly drained and swampy. The overall surface topography along Highway 7 slopes upwards towards the east: the ground surface in the immediate vicinity of the structures varies from about Elevation 202.6 m at the west end of the site, to about Elevation 229.0 m at the east end of the site.

The existing Highway 7 roadway embankment ranges in height from about 2 m to 5 m relative to the surrounding natural ground surface in the area of the structural culverts. The existing embankment slopes on the north and south sides of Highway 7 are oriented at approximately 2 to 2.5 horizontal to 1 vertical (2H:1V to 2.5H:1V) in the vicinity of these culvert locations. No evidence of distress or surficial erosion was observed on the embankment shoulders or side slopes at the time of the borehole investigations in the culvert areas. The existing Highway 7 pavement over the culvert areas was observed to be in relatively good condition at the time of the borehole investigations, with no or limited cracking, and no maintenance patching.

According to the Structural Design Report completed by Genivar/Harmer Podolak Engineering Consultants Inc., the culverts at Stations 13+255 and 14+434 underwent detailed condition surveys and supplementary visual inspections. Both of these culverts were observed to be in generally good condition, with a few isolated areas of moderate deterioration, at the time of the surveys.

### **3.0 INVESTIGATION PROCEDURES**

A borehole investigation was carried out in February and April 2007, at which time seventeen boreholes (Boreholes CU-1 to CU-9, CU-10A, CU-10B, CU-11A, CU-11B, and CU-12 to CU-15) were advanced to investigate the subsurface conditions at the culvert locations; two boreholes were advanced at each of five of the structural culvert sites, and three and four boreholes were advanced at Culverts 5 and 6, respectively. In August and September 2008, two additional boreholes (08-08 and 08-08A) were completed for the realignment of the replacement culvert at Station 14+434, and two additional boreholes (08-22 and 08-22A) were completed for the northward extension of the existing culvert at Station 16+129. The locations of all boreholes are shown on Drawings 1 to 4.

The boreholes were drilled using truck-mounted CME-75, track-mounted CME-55 and portable drill rigs, supplied and operated by Marathon Drilling Ltd. of Ottawa, Ontario. The boreholes were advanced through the overburden using continuous flight hollow stem augers or solid stem augers, and into the bedrock by NQ coring. The boreholes drilled using full-size truck- or track-mounted drill rigs were advanced to depths ranging from 7.6 m to 15.9 m; these boreholes generally terminated in limestone bedrock or hard (greater than 50 blows per 0.3 m of penetration) clayey silt till, although four of the deeper boreholes were terminated in a very dense sand and gravel, compact silty sand or stiff clayey silt stratum. The boreholes drilled using portable drilling equipment were advanced to depths ranging from 2.3 m to 8.2 m. Borehole CU-11A was advanced by hand to a depth of 0.6 m, to investigate for the presence, thickness and composition/consistency of surficial organic soils at this location.

Soil samples were obtained at 0.75 m and 1.5 m intervals of depth, using a 50 mm outer diameter split-spoon sampler driven by an automatic hammer in accordance with Standard Penetration Test (SPT) procedure. Samples from the bedrock were obtained using an 'NQ' size rock core barrel. Field vane shear tests, using an "N"-size vane, were carried out at two borehole locations where firm to stiff clayey silt soils were encountered.

The groundwater conditions in the open boreholes were observed during the drilling operations. A standpipe piezometer was installed in each of Boreholes CU-2, CU-4, CU-6, CU-8, CU-10A, and CU-15, to allow for monitoring of the groundwater level at each culvert site. Each standpipe piezometer consists of a 1.5 m long, 50 mm diameter slotted screen installed within a filter sand pack, then sealed to ground surface with bentonite pellets. The piezometer installation details and recorded water level readings are included in the Record of Borehole sheets. For boreholes in which a piezometer was not installed, the boreholes were backfilled to ground surface using bentonite pellets as per Ontario Regulation 128 (amendment to Ontario Regulation 903).



The field work was supervised throughout by a member of Golder's technical staff, who located the boreholes in the field, arranged for the clearance of underground services, supervised the drilling, sampling and in situ testing operations, and logged the boreholes. The samples were identified in the field, placed in appropriate containers, labelled and transported to Golder's Mississauga geotechnical laboratory where the samples underwent further visual examination and geotechnical classification testing (water content, Atterberg limits, grain size distribution, and organic content). All of the laboratory tests were carried out to MTO and/or ASTM standards as appropriate.

The locations and ground surface elevations of the as-drilled borehole locations were measured in the field by a member of Golder's technical staff, relative to the existing culverts. The borehole locations (NAD83 MTM Zone 12 coordinates) and the ground surface elevation at the borehole locations (relative to geodetic datum) are summarized in the following table.

| <i><b>Culvert Number<br/>and Location</b></i> | <i><b>Borehole<br/>Number</b></i> | <i><b>MTM NAD83<br/>Northing (m)</b></i> | <i><b>MTM NAD83<br/>Easting (m)</b></i> | <i><b>Ground Surface<br/>Elevation (m)</b></i> |
|---|-----------------------------------|--|---|--|
| 1<br>Station 12+402                           | CU-1                              | 4,907,852.2                              | 405,300.8                               | 202.6  |
|   | CU-2                              | 4,907,819.1                              | 405,308.2                               | 203.2  |
| 2<br>Station 13+255                           | CU-3                              | 4,908,253.0                              | 406,056.5                               | 206.6  |
|   | CU-4                              | 4,908,223.5                              | 406,064.8                               | 205.3  |
| 3<br>Station 13+494                           | CU-5                              | 4,908,350.3                              | 406,262.5                               | 207.4  |
|   | CU-6                              | 4,908,324.5                              | 406,265.7                               | 204.7  |
| 4<br>Station 13+884                           | CU-7                              | 4,908,513.9                              | 406,618.4                               | 210.9  |
|   | CU-8                              | 4,908,487.7                              | 406,637.3                               | 206.6  |
| 5<br>Station 14+434                           | CU-9                              | 4,908,742.9                              | 407,118.5                               | 209.9  |
|   | CU-10A                            | 4,908,733.9                              | 407,129.3                               | 209.7  |
|   | CU-10B                            | 4,908,723.8                              | 407,119.7                               | 208.1  |
|   | 08-08                             | 4,908,729.0                              | 407,140.7                               | 207.8  |
|   | 08-08A                            | 4,908,840.0                              | 407,137.3                               | 209.8  |
| 6<br>Station 15+792                           | CU-11A                            | 4,909,175.1                              | 408,392.6                               | 226.7  |
|   | CU-11B                            | 4,909,167.6                              | 408,392.6                               | 228.6  |
|   | CU-12                             | 4,909,147.3                              | 408,396.3                               | 228.3  |
|   | CU-13                             | 4,909,138.1                              | 408,394.8                               | 226.5  |
| 7<br>Station 16+129                           | CU-14                             | 4,909,113.5                              | 408,724.2                               | 229.0  |
|   | CU-15                             | 4,909,106.0                              | 405,726.4                               | 226.7  |
|   | 08-22                             | 4,909,135.0                              | 408,733.0                               | 227.0  |
|   | 08-22A                            | 4,909,124.0                              | 408,734.2                               | 229.2  |

## 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

### 4.1 Regional Geology

As delineated in *The Physiography of Southern Ontario*<sup>1</sup>, the study area for this assignment lies within the physiographic region known as the Peterborough Drumlin Field.

The surficial soils in the Peterborough Drumlin Field consist of drumlinized till. Toward the southwestern portion of this physiographic region, near the Oak Ridges Moraine, the till is typically sandy. Some of the drumlins in this area have shallow coverings of silt and fine sand, ranging in thickness from about 0.5 m to 2.5 m. “Wave-washed” drumlins, with exposed bouldery surfaces, are also present near the Simcoe Lowlands immediately south and east of Lake Simcoe. Localized deposits of silt, clay and peat are found in the low-lying areas between drumlins.

### 4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of laboratory tests are given on the Record of Borehole sheets and on Figures 1 to 6. The stratigraphic boundaries shown on the borehole records, and on the interpreted stratigraphic sections on Drawings 1 to 4, are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

A brief overview of the subsurface conditions at each of the seven culverts along Highway 7 is provided below:

| <i>Culvert Number</i> | <i>Location</i> | <i>Boreholes</i> | <i>General Subsurface Conditions</i>  |
|-----------------------|-----------------|------------------|---|
| 1                     | Station 12+402  | CU-1, CU-2       | Approximately 1.5 m to 2.3 m of embankment fill is present at this site. The fill is underlain by firm to hard clayey silt till, which is in turn underlain by limestone bedrock that was encountered at Elevations 198.5 m and 198.6 m (at a depth of about 4.1 m and 4.6 m below the ground surface at the borehole locations). |

<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.

| <b><i>Culvert Number</i></b> | <b><i>Location</i></b> | <b><i>Boreholes</i></b>            | <b><i>General Subsurface Conditions</i></b>  |
|------------------------------|------------------------|------------------------------------|--|
| 2                            | Station 13+255         | CU-3, CU-4                         | One borehole drilled through the embankment shoulder encountered 2.1 m of fill, overlying a thin organic deposit. The native soils at the site consist of loose to dense sand and silt, underlain by stiff to very stiff clayey silt till, which is underlain by or interlayered with sand and gravel. The soils are underlain by limestone bedrock that was encountered at Elevations 200.1 m and 200.2 m (at a depth of 5.2 m and 6.4 m relative to the ground surface at the borehole locations).   |
| 3                            | Station 13+494         | CU-5, CU-6                         | One borehole drilled through the embankment shoulder encountered 2.3 m of fill. The native soils at the site consist of 2.3 m of silty sand to sand, which contained a peat interlayer in one of the boreholes. The upper silty sand to sand is underlain by a 1.5 m to 2.3 m thick deposit of firm to stiff clayey silt, which is in turn underlain by a 3.0 m to 4.0 m thick lower deposit of loose to compact silty sand to sandy silt. The boreholes were terminated in a hard clayey silt till deposit, the surface of which was encountered in the boreholes between Elevations 197.1 m and 197.3 m (at a depth of about 7.6 m and 10.1 m in the boreholes). |
| 4                            | Station 13+884         | CU-7, CU-8                         | One borehole drilled through the embankment shoulder encountered 4.6 m of fill overlying 0.2 m of peat. The native soils consist of loose to compact silty sand to sand, underlain by hard clayey silt till, the surface of which was encountered at Elevations 197.5 m and 200.2 m (at depths of 9.1 m and 10.7 m); in one of the boreholes, the clayey silt till is underlain or interlayered with a very dense sand and gravel deposit that was encountered below Elevation 199.6 m.  |
| 5                            | Station 14+434         | CU-9, C-10A, CU-10B, 08-08, 08-08A | Three of the boreholes were drilled through the embankment shoulders and encountered 1.8 m to 3.8 m of fill; in two of the boreholes, a 0.8 m to 2.8 m thick layer of peat/organic silt was present below the fill. The fill and peat/organic silt (where present) were underlain by loose to dense sand to silt and firm to very stiff clayey silt deposits.  |
| 6                            | Station 15+792         | CU-11A, CU-11B, CU-12, CU-13       | Two of the boreholes were drilled through the embankment shoulders and encountered 2.3 m of fill; outside of the embankment, the boreholes/probeholes encountered 0.6 m of peat. The fill and peat are underlain by a 0.6 m to 1.5 m thick deposit of generally firm to stiff clayey silt, which is underlain by a deposit of stiff to hard clayey silt till.  |

| <i><b>Culvert Number</b></i> | <i><b>Location</b></i> | <i><b>Boreholes</b></i>     | <i><b>General Subsurface Conditions</b></i>  |
|------------------------------|------------------------|-----------------------------|--|
| 7                            | Station 16+129         | CU-14, CU-15, 08-22, 08-22A | Two boreholes were drilled through the highway embankment shoulder and encountered 2.1 m and 2.3 m of fill; to the south of the embankment, a 0.8 m thick layer of organic silty sand was encountered immediately below the ground surface. The fill and organic silty sand are underlain by a 0.6 m to 1.7 m thick layer of firm to stiff clayey silt, which is underlain by a deposit of very stiff to hard clayey silt till. Cobbles and boulders were encountered within the clayey silt till deposit at this culvert site, requiring in some boreholes the use of NQ coring after split-spoon sampler and auger refusal, to further advance the boreholes through the cobbles and boulders. |

A more detailed description of the soil deposits and bedrock encountered in the boreholes is provided in the following sections.

#### **4.2.1 Fill**

Fill was encountered at the seven culverts locations in the boreholes advanced through the highway embankment, namely in Boreholes CU-1 to CU-3, CU-5, CU-7, CU-9, CU-10A, CU-11B, CU-12, CU-14, 08-08A and 08-22A. The fill encountered in the boreholes ranged in thickness between 1.5 m and 4.6 m.

The fill varies in composition from sand and gravel to gravelly sand to silty sand containing trace to some gravel, to clayey silt containing some sand and trace gravel; trace quantities of organic material were noted in some of the recovered samples. The results of grain size distribution tests on five samples of cohesionless fill (sand and gravel to silty sand) are shown on Figure 1A; the result of a grain size distribution test on one sample of cohesive (clayey silt) fill is shown on Figure 1B.

The measured Standard Penetration Test (SPT) “N” values within the cohesionless portions of the fill range from 4 to 62 blows per 0.3 m of penetration, indicating that this portion of the fill has a loose to very dense relative density. The measured SPT “N” values within the cohesive fill range from 5 to 28 blows per 0.3 m of penetration, indicative of a firm to very stiff consistency.

#### **4.2.2 Topsoil, Peat and Organic Silt**

Approximately 100 mm of topsoil was encountered immediately below the existing ground surface in Boreholes CU-10A, 08-08 and 08-22.

A 0.2 m to 1.0 m thick peat/organic deposit was encountered at the sites for Culverts 2, 3, 4, 5, 6 and 7, in some cases below the existing embankment fill, in Boreholes CU-3, CU-5, CU-7, CU-9, CU-10B, CU-11A, CU-13, CU-15, 08-08 and 08-08A.

The deposit is generally described as peat, or peat containing organic clayey silt layers, or organic silt/clayey silt, or organic silty sand. The result from organic content tests scheduled on two samples of organic silt/silty sand deposit measured organic contents of 22 and 23 per cent. The results of grain size distribution tests completed on two samples of organic silt/clayey silt are shown on Figure 2.

#### **4.2.3 Sand to Silt**

A deposit of cohesionless soils, ranging in composition from sand to sand and silt to silty sand to sandy silt to silt, was encountered at the sites of Culverts 2, 3, 4, 5, and 6, in Boreholes CU-3 to CU-9, CU-10A, and CU-11A. The top of the cohesionless deposit was generally encountered between Elevation 206.6 m and Elevation 203.6 m, and the deposit was found to be between 0.7 m and 9.1 m in thickness; however, the hand-excavated Borehole CU-11A terminated within this deposit at a depth of 0.6 m (deposit thickness of 0.1 m), and Borehole CU-9 terminated within the silty sand deposit at a depth of 15.8 m (deposit thickness of 11.2 m).

The cohesionless deposit contains varying amounts of silt and sand, trace gravel and clay; clay seams were noted within the deposit in some samples. The results of grain size distribution tests on thirteen samples of the cohesionless deposit are shown on Figures 3A and 3B.

The measured SPT “N” values within the cohesionless deposit ranged from 4 to 34 blows per 0.3 m of penetration, indicating a loose to compact density.

#### **4.2.4 Clayey Silt**

A clayey silt deposit was encountered at the sites of Culverts 3, 5, 6 and 7, in Boreholes CU-5, CU-6, CU-9, CU-10A, CU-10B, CU-11B, CU-12 to CU-15, 08-08, 08-08A, 08-22 and 08-22A. The top of the clayey silt deposit was encountered between Elevation 226.9 m and 206 m, with layers under or within the underlying granular deposits encountered between Elevations 199.0 m and 200.2 m. The deposit was found to be between 0.6 m and 4.7 m in thickness at the borehole locations. Boreholes CU-10A, CU-10B and 08-08 were terminated within this deposit at depths of 12.8 m (Elevation 196.9), 4.9 m (Elevation 203.2 m) and 8.2 m (Elevation 199.6 m), respectively.

The clayey silt deposit contains trace to some sand and gravel, with trace organics noted in Borehole CU-10B and rootlets noted in Borehole CU-13. The results of grain size distribution tests on three samples of the clayey silt are shown on Figure 4. Atterberg limits testing on ten

samples of the clayey silt measured plastic limits of 15 to 21 per cent and liquid limits of 23 to 31 per cent, with resultant plasticity indices of 4 to 16 per cent. These test results, which are plotted on a plasticity chart on Figure 5, confirm that this material is a clayey silt of low plasticity.

The measured SPT “N” values within the clayey silt deposit ranged between 2 and 25 blows per 0.3 m of penetration, but were generally between 2 and 15 blows per 0.3 m of penetration. Two in situ vane tests carried out on the softer portions of the clayey silt deposit recorded undrained shear strengths of 29 kPa and 58 kPa, indicative of a firm to stiff consistency. The sensitivity of the clayey silt ranges from about 1.2 to 3.3.

#### **4.2.5 Clayey Silt Till to Silt and Sand Till**

A till deposit was encountered at the sites of Culverts 1, 2, 3, 4, 6 and 7, in Boreholes CU-1 to CU-8, CU-11B, CU-12 to CU-15, 08-22 and 08-22A. The top of the till deposit was encountered between Elevation 226.3 m and Elevation 197.1 m, and the deposit was found to be between 0.3 m and 8.9 m in thickness. Boreholes CU-5, CU-6, CU-8, CU-11B, CU-12 to CU-14, 08-22 and 08-22A were terminated within this deposit at depths ranging from 2.3 m to 12.6 m below the ground surface.

The till deposit consists predominantly of clayey silt with sand to trace sand; however, the deposit grades to a non-plastic silt and sand till, containing trace to some gravel, at the site of Culvert 1 (Boreholes CU-1 and CU-2). Cobbles and boulders were observed in some of the boreholes, particularly in Boreholes CU-14 and CU-15 which required coring through the boulders to advance the boreholes. The results of grain size distribution tests on eight samples of the till are shown on Figures 6A and 6B.

Atterberg limit testing was carried out on thirteen samples of the till, and measured plastic limits of 9 to 15 per cent and liquid limits of 14 to 22 per cent, with plasticity indices of 2 to 10 per cent. These test results, which are plotted on a plasticity chart on Figure 6, confirm that this till material is typically a clayey silt of low plasticity; however, two of the tested samples from the site of Culvert 1 are only slightly plastic and, based on the grain size distribution testing, have been classified as sand and silt till to silt till of slight plasticity.

The measured SPT “N” values within the till deposit ranged from 3 to 91 blows per 0.3 m of penetration, indicating that the clayey silt till has a variable, soft to hard consistency. In general, the lower SPT “N” values were measured near the surface of the till deposit.

#### **4.2.6 Sand and Gravel**

A deposit of sand and gravel, containing trace silt and clay, was encountered as a layer within or underlying the clayey silt till at the sites of Culverts 2 and 4, in Boreholes CU-3, CU-4, and CU-

7. The top of the sand and gravel deposit was encountered between Elevation 202.6 m and Elevation 199.6 m, and the deposit was found to be between 1.2 m and more than 2.5 m in thickness (Borehole CU-7 was terminated within this deposit at a depth of 13.8 m, or Elevation 197.1).

The measured SPT “N” values within the sand and gravel deposit ranged from 22 to greater than 100 blows per 0.3 m of penetration, indicating that the sand and gravel has a compact to very dense relative density.

#### 4.2.7 Bedrock

Limestone bedrock was encountered underlying either the clayey silt till or the sand and gravel deposit. The depth to the bedrock surface and its elevation as confirmed by coring at least 3 m at the locations of Borehole CU-1 to CU-4 are summarized in the following table:

| <i>Culvert No.</i> | <i>Borehole No.</i> | <i>Ground Surface Elevation (m)</i> | <i>Depth to Bedrock (m)</i> | <i>Bedrock Surface Elevation (m)</i> |
|--------------------|---------------------|-------------------------------------|-----------------------------|--------------------------------------|
| 1                  | CU-1                | 202.6                               | 4.1                         | 198.5                                |
|                    | CU-2                | 203.2                               | 4.6                         | 198.6                                |
| 2                  | CU-3                | 206.6                               | 6.4                         | 200.2                                |
|                    | CU-4                | 205.3                               | 5.2                         | 200.1                                |

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

The limestone bedrock at this site is a member of the Gull River Formation; it is fresh, thinly laminated to laminated, light and dark grey, medium strong to strong, and contains dark grey shale interbeds. The Rock Quality Designation (RQD) values measured on the bedrock core samples recovered from the boreholes range from about 0 per cent to 77 per cent, indicating that the bedrock is of poor to good quality.

Point load strength tests were performed on selected samples of the limestone bedrock core from Boreholes CU-1 to CU-4. The results of the diametral and axial point load strength testing, and the approximate unconfined compressive strength (UCS) based on correlation with the point load strength indices, are summarized in the following table:

| <i>Borehole Number</i> | <i>Elevation (m)</i> | <i>Test Type</i> | <i>Is Axial (MPa)</i> | <i>Is Diametral (MPa)</i> | <i>Is<sub>50</sub> (MPa)</i> | <i>UCS (MPa)</i> |
|------------------------|----------------------|------------------|-----------------------|---------------------------|------------------------------|------------------|
| CU-1                   | 197.1                | Diametral        | -                     | 3.7                       | 3.6                          | 83               |
|                        | 195.9                | Axial            | 3.6                   | -                         | 3.6                          | 84               |
|                        | 195.3                | Diametral        | -                     | 1.3                       | 1.3                          | 29               |
| CU-2                   | 197.4                | Diametral        | -                     | 3.8                       | 1.2                          | 28               |
|                        | 196.6                | Axial            | 5.8                   | -                         | 5.8                          | 134              |
|                        | 194.2                | Diametral        | -                     | 0.8                       | 0.8                          | 18               |
| CU-3                   | 199.6                | Diametral        | -                     | 0.6                       | 0.6                          | 14               |
|                        | 198.2                | Diametral        | -                     | 4.6                       | 4.5                          | 103              |
| CU-4                   | 199.6                | Axial            | 5.0                   | -                         | 5.0                          | 116              |
|                        | 198.2                | Diametral        | -                     | 4.6                       | 4.5                          | 103              |

\* The UCS values have been approximated using  $Is_{50} \times 23$ , from ISRM ("Suggested Methods for Determining Point Load Strength", International Society for Rock Mechanics Commission on Testing Methods, Int. J. Rock. Mech. Min. Sci. and Geomechanical Abstr., Vol 22, No. 2 1985, pp. 51-60).

The point load test results and approximate unconfined compressive strengths summarized above indicate that the limestone is strong.

#### 4.2.8 Groundwater Conditions

Standpipe piezometers were installed in each of Boreholes CU-2, CU-4, CU-6, CU-8, CU-10A, and C-15, sealed within the silty sand, clayey silt till or sand and gravel deposits; details of the piezometer installations are shown on the borehole records. The water levels measured in the piezometers are summarized in the following table.

| <i>Borehole No.</i> | <i>April 11, 2007</i>       |                              | <i>June 5, 2007</i>         |                              |
|---------------------|-----------------------------|------------------------------|-----------------------------|------------------------------|
|                     | <i>Depth to Groundwater</i> | <i>Groundwater Elevation</i> | <i>Depth to Groundwater</i> | <i>Groundwater Elevation</i> |
| CU-2                | 0.5 m                       | 202.7 m                      | 0.7 m                       | 202.5 m                      |
| CU-4                | 0.5 m                       | 204.8 m                      | 0.7 m                       | 204.6 m                      |
| CU-6                | 0.0 m (Frozen)              | 204.7 m                      | 0.2 m                       | 204.5 m                      |
| CU-8                | 0.2 m                       | 206.4 m                      | 0.2 m                       | 206.4 m                      |
| CU-10A              | 1.5 m                       | 208.2 m                      | 1.5 m                       | 208.2 m                      |
| CU-15               | 0.3 m                       | 226.4 m                      | 0.2 m                       | 226.5 m                      |


Based on the measurements summarized above, the groundwater level in the area is typically between 0.2 m and 1.5 m below the ground surface, and follows the general topography of the ground surface, rising from east to west from approximately Elevation 202.7 m in the vicinity of Culvert 1 to about Elevation 226.5 m in the vicinity of Culvert 7. It should be expected that the groundwater level in the area will be subject to seasonal fluctuations, and will be higher during wet periods of the year (i.e. during spring conditions).

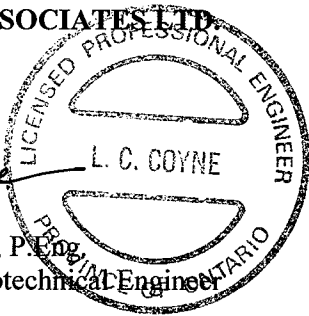


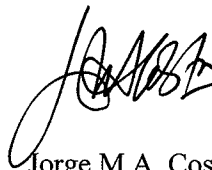
## 5.0 CLOSURE

This Foundation Investigation Report was prepared by Ms. Karyn Gallant, and reviewed by Ms. Lisa Coyne, P.Eng., an Associate and geotechnical engineer with Golder. Mr. Jorge Costa, a Designated MTO Contact for Golder, conducted an independent quality control review of the report.

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**PART B**

**FOUNDATION DESIGN REPORT  
CULVERTS**

**HIGHWAY 7 BETWEEN DRUMMOND LINE  
AND 150 M EAST OF HIGHWAY 28  
PETERBOROUGH, ONTARIO  
G.W.P. 583-93-00**

## 6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

### 6.1 General

This section of the report provides foundation design recommendations for the proposed culvert extensions or replacements associated with the widening of Highway 7 between Drummond Line and 150 m east of Highway 28. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during a subsurface investigation at this site. The interpretation and recommendations are intended to provide the designers with sufficient information to assess the feasible foundation alternatives and to design the foundations for the proposed culvert extensions or replacements. Where comments are made on construction, they are provided in order to highlight those aspects that could affect the design of the project, and for which special provisions or operational constraints may be required in the Contract Documents. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods, scheduling and the like.

Extension or replacement of seven existing structural culverts is proposed; details regarding each of these existing culverts and the proposed extensions are provided in the following table:

| <i>Culvert Number</i> | <i>Approximate Station</i> | <i>Existing Culvert Dimensions/Type</i> | <i>Embankment Height</i> | <i>Invert Elevation</i>            | <i>Proposed Extension</i>  |
|-----------------------|----------------------------|---|--------------------------|------------------------------------|----------------------------|
| 1                     | 12+402                     | 1.8 m x 1.2 m open footing              | 3 m                      | 201.7 m (south)<br>201.7 m (north) | 15.0 m south               |
| 2                     | 13+255                     | 5.5 m x 1.8 m concrete box              | 2.5 m                    | 203.5 m (south)<br>203.3 m (north) | 15.0 m south               |
| 3                     | 13+494                     | 1.2 m x 1.2 m open footing              | 3.5 m                    | 204.3 m (south)<br>203.8 m (north) | 16.0 m south               |
| 4                     | 13+884                     | 1.2 m x 1.2 m open footing              | 5 m                      | 206.3 m (south)<br>206.5 m (north) | 17.0 m south               |
| 5                     | 14+434                     | 3.7 m x 1.8 m concrete box              | 2.5 m                    | 206.8 m (south)<br>206.9 m (north) | 16.0 m south               |
| 6                     | 15+792                     | 1.2 m x 1.2 m open footing              | 2 m                      | 226.0 m (south)<br>225.8 m (north) | 4.0 m south<br>4.0 m north |
| 7                     | 16+129                     | 1.2 m x 1.2 m open footing              | 2 m                      | 226.5 m (south)<br>226.6 m (north) | 10.0 m south               |

#### 6.1.1 Foundation Options

Sections 6.2.1 to 6.8.1 discuss the foundation options for each of the proposed culvert extensions or replacements. Either open footing or box culvert extensions/replacements are feasible from a foundations perspective for all of the culvert sites. Deep foundations are not required for any of the culvert sites since shallow foundations will provide sufficient bearing resistance and satisfactory settlement performance under the widened embankment loading.

The advantages and disadvantages associated with both open footing and box culvert extensions/replacements are summarized in Table 1 following the text of this report. From a foundations perspective, box culvert extensions/replacements are generally preferred as this option generally minimizes the depth of excavation and the groundwater control requirements compared with open footings. In addition, precast box culvert segments can often be installed more expeditiously than cast-in-place open footing culverts, resulting in shorter durations for dewatering and surface water pumping. However, box culvert extensions/replacements may not satisfy fisheries requirements or, in the case of extensions, may result in compatibility problems with existing open footing culverts and, in these cases (since both foundation options are geotechnically feasible), an open footing option is considered an acceptable alternative to a box culvert.

### **6.1.2 Founding Elevations and Subexcavation Requirements**

Sections 6.2.2 to 6.8.2 provide recommendations regarding founding elevations and subexcavation requirements for the proposed culvert extensions or replacement culverts.

Strip footings for all open footing culvert extensions or for replacements, and for any associated wing walls/retaining walls, should be founded at a minimum depth of 1.5 m below the lowest surrounding grade, to provide adequate protection against frost penetration. If water will flow through the culvert year-round, frost protection for the culvert footings is not necessary; adequate frost protection for the wing wall/retaining wall footings would still be required.

Based on the subsoil conditions encountered in the boreholes, subexcavation is recommended for some of the culvert extension/replacement locations, in order to found the footings or base on suitable material. The width of the required subexcavation should be defined by lines extending from 0.3 m beyond the outside edges of the culvert outward and downward at 1 horizontal to 1 vertical (1H:1V), as shown on Figure 8. Depending on the depth of subexcavation required relative to the base of the existing box culvert or footings, some temporary excavation support may be required to prevent loss of bedding material and/or native soils from below the existing culvert during subexcavation. The subgrade should be inspected following subexcavation to ensure that all existing fill, peat and surficial organic soils or other unsuitable material have been removed, then the subexcavated area should be backfilled with granular material meeting Ontario Provincial Standard Specification (OPSS) 1010 Granular "A" or Granular "B" Type II, placed and compacted in accordance with the requirements of MTO's Special Provision SP105S10.

At all of the culvert extension and replacement sites, excavation and/or subexcavation works will extend below the groundwater level, and groundwater control will be required. This is discussed further in Sections 6.2.2 through 6.8.2, and in Section 6.12 (Construction Considerations). As noted in Section 6.12, a sample Non-Standard Special Provision (NSSP) is included in

Appendix A to this report, for inclusion in the Contract Documents, to address groundwater control for the culvert sites.

The native soil subgrade for the footings or box culverts will be susceptible to softening/loosening and degradation on exposure to water and construction traffic. It is recommended that a 100 mm thick layer of lean mix concrete or mass concrete be placed on the native soil subgrade within the footing or box culvert footprint to form a working mat for construction of the culvert extension or culvert replacement, to protect the subgrade from degradation. If a box culvert extension or replacement is adopted, a 75 mm thick levelling pad of Granular "A" or fine aggregate (meeting the gradation requirements set out in OPSS 1002) should be provided on top of the concrete mat. Alternatively, for a box culvert extension or replacement, the subgrade can be protected with a Granular "A" pad in lieu of the lean mix concrete/mass concrete working mat.

### **6.1.3 Geotechnical Resistance**

Sections 6.2.3 to 6.8.3 provide recommendations regarding the factored geotechnical resistances at Ultimate Limit State (ULS) and the geotechnical resistances at Serviceability Limit State (SLS) for each of the culvert sites.

### **6.1.4 Resistance to Lateral Loads / Sliding Resistance**

Sections 6.2.4 to 6.8.4 provide recommendations regarding the resistance to lateral loads / sliding resistance between cast-in-place concrete footings or pre-cast concrete box culvert sections and the subgrade soils or, where applicable, granular backfill placed following applicable subexcavation.

### **6.1.5 Settlement**

Sections 6.2.5 to 6.8.5 provide discussion regarding the predicted settlement under the additional loading due to embankment widening at each of the culvert sites. In order to estimate the magnitude of settlement, analyses were carried out for each site using the commercially-available program Unisettle (V3.0).

For culvert extensions, the structural design of the connection between the existing culvert and the extension (whether a rigid or an articulated connection) must take into consideration the predicted magnitude of settlement as discussed in Sections 6.2.5 to 6.8.5.

## **6.2 Culvert 1 – Station 12+402**

### **6.2.1 Foundation Options**

The existing 1.8 m wide x 1.2 m high concrete open footing culvert at Station 12+402 is to be extended approximately 15.0 m southward. As summarized in Table 1, a box culvert extension or replacement is preferred from a foundations perspective as this option minimizes the depth of excavation and groundwater control requirements; however, it is understood that an open footing extension (to match the existing open footing culvert and to satisfy fisheries requirements) is preferred. Recommendations for both foundation options are provided in the following sections.

Deep foundations are not required for the culvert extension or replacement, as shallow foundations will provide sufficient bearing resistance and satisfactory settlement performance under the approximately 3.0 m high embankment loading.

### **6.2.2 Founding Elevations and Subexcavation Requirements**

#### **Open Footing Culvert and Wing Walls/Retaining Walls**

An open footing culvert extension or replacement, and any associated wing walls/retaining walls, can be supported on strip footings founded below the surficial fill deposit, on the firm to hard/loose to dense clayey silt to silt and sand till deposit. The invert/creek bed of the existing culvert, and that for the proposed southward extension, is at approximately Elevation 201.7 m. To provide for a thickness of 1.5 m of soil cover for frost protection, the strip footings should be founded at or below Elevation 200.2 m, which is about 2.3 m below the groundwater level at this site. If frost protection is not required for the culvert footings based on year-round water flow, then the culvert footings should still be founded at or below Elevation 200.2 m on the clayey silt to sand and silt till deposit, in order to be founded below the existing fill. Groundwater control would be required for construction of strip footings founded within the clayey silt till deposit for either option.

#### **Box Culvert**

A box culvert extension or replacement can be founded below the existing fill, supported on the clayey silt till to silt till deposit. The invert/creek bed of the existing culvert, and that for the proposed southward extension, is at approximately Elevation 201.7 m. Assuming that the surface of the concrete base slab for a box culvert extension would be constructed to match the existing creek bed, and assuming that the base slab for the box culvert extension has a thickness of 400 mm, the base slab for the south extension would be founded at Elevation 201.3 m on the firm to hard clayey silt till to silt till, below the creek level and approximately 1.2 m below the groundwater level in this area.

### 6.2.3 Geotechnical Resistance

The ULS resistance and settlement for open footing and box culvert extensions/replacements are dependent on the footing size, configuration and applied loads; the geotechnical resistances should, therefore, be reviewed if the selected footing width or founding elevation differs significantly from those given in the following sections.

#### Open Footing Culvert and Wing Walls/Retaining Walls

Strip footings placed on the properly prepared subgrade, at or below Elevation 200.2 m, should be designed based on the following factored geotechnical resistances at ULS and geotechnical resistances at SLS:

| <i>Footing Width</i> | <i>Factored Geotechnical Resistance at ULS</i> | <i>Geotechnical Resistance at SLS*</i> |
|----------------------|--|--|
| 0.6 m                | 300 kPa  | 250 kPa                                |
| 0.9 m                | 325 kPa  | 250 kPa                                |

\* For 25 mm of settlement.

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 the *Canadian Highway Bridge Design Code (CHBDC)*.

#### Box Culvert

Assuming a maximum founding level of Elevation 201.3 m, a factored geotechnical resistance at ULS of 250 kPa can be used for design of the 1.8 m wide box culvert extension or replacement. The geotechnical resistance at SLS, for 25 mm of settlement, can also be taken as 250 kPa.

### 6.2.4 Resistance to Lateral Loads / Sliding Resistance

Resistance to lateral forces / sliding resistance between the concrete footings or base slab for the culvert extension or culvert replacement and the subgrade should be calculated in accordance with Section 6.7.5 of the *CHBDC*. For cast-in-place concrete footings founded on the firm to very stiff clayey silt to sand and silt till, the coefficient of friction,  $\tan \phi'$ , can be taken as 0.58. For pre-cast concrete box culvert sections placed on Granular "A" bedding, the coefficient of friction,  $\tan \delta$ , can be taken as 0.5. These values are unfactored; in accordance with the *CHBDC*, a factor of 0.8 is to be applied in calculating the horizontal resistance.

### 6.2.5 Settlement

The settlement of the founding soils has been estimated using the elastic deformation moduli given below, based on correlations with the Atterberg limits and SPT “N” values.

| <i>Soil Deposit</i>                                  | <i>Bulk Unit Weight</i> | <i>Elastic Modulus</i> |
|--|-------------------------|------------------------|
| Embankment fill                                      | 21 kN/m <sup>3</sup>    | -                      |
| Firm to hard/loose to dense clayey silt to silt till | 21 kN/m <sup>3</sup>    | 15 MPa                 |

The settlement of the foundation soils under the approximately 3 m high embankment widening is estimated to be less than 10 mm under the main widening area, decreasing to less than 5 mm under the shoulder of the existing embankment and at the toe of the widened embankment. The majority of the estimated settlement will be completed relatively quickly, during and within approximately three months following completion of the embankment widening.

If a culvert extension is adopted for this site, the connection between the existing open footing culvert and its extension should be designed to accommodate this magnitude of settlement.

## 6.3 Culvert 2 – Station 13+255

### 6.3.1 Foundation Options

The existing 5.5 m wide x 1.8 m high concrete box culvert at Station 13+255 is to be extended approximately 15.0 m southward. Although an open footing extension or replacement is feasible, a box culvert extension is preferred from a foundations perspective to minimize the depth of excavation and the dewatering requirements during construction of the culvert extension or replacement. Geotechnical recommendations for both options are provided in the following sections.

Deep foundations are not required for the culvert extension or replacement, as shallow foundations will provide sufficient bearing resistance for the extension and satisfactory settlement performance under the approximately 2.5 m high embankment loading.

### 6.3.2 Founding Elevations and Subexcavation Requirements

#### Open Footing Culvert and Wing Walls/Retaining Walls

An open footing culvert extension, and any associated wing walls/retaining walls, can be founded on strip footings extended below the existing embankment fill and any surficial organic materials. The invert of the existing box culvert at the proposed southward extension is at approximately Elevation 203.5 m. The footings should, therefore, be founded at or below Elevation 202.0 m on



the stiff clayey silt till or compact to very dense sand and gravel deposit, to provide adequate protection against frost penetration; excavations to reach this founding elevation will extend approximately 2.5 m below the groundwater level at this site. If water will flow through the culvert year-round, the footings can be founded higher, at or below Elevation 203.0 m, with the actual founding depth determined on the basis of creek flow and scour conditions. Dewatering would be required for construction of strip footings under either condition.

### Box Culvert

A box culvert extension can be founded below the existing fill and any surficial organic deposits to be supported on the compact sand to sand and silt deposit. The surface of the concrete base slab at the south end of the existing box culvert is at Elevation 203.5 m. Assuming that the surface of the concrete base slab for the extension will be constructed to match the existing box culvert slab, and assuming that the base slab has a thickness of 400 mm, the base slab for a box culvert extension would be founded at approximately Elevation 203.1 m, about 1.4 m below the groundwater level in this area.

### 6.3.3 Geotechnical Resistance

The ULS resistance and settlement for open footing and box culvert extensions/replacements are dependent on the footing size, configuration and applied loads; the geotechnical resistances should, therefore, be reviewed if the selected footing width or founding elevation differs significantly from those given in the following sections.

### Open Footing Culvert and Wing Walls/Retaining Walls

Strip footings placed on the properly prepared subgrade, at or below Elevation 202.0 m, should be designed based on the following factored geotechnical resistances at ULS and geotechnical resistances at SLS:

| <i>Footing Width</i> | <i>Factored Geotechnical Resistance at ULS</i> | <i>Geotechnical Resistance at SLS*</i> |
|----------------------|--|--|
| 0.6 m                | 200 kPa  | 200 kPa                                |
| 0.9 m                | 225 kPa  | 200 kPa                                |

\* For 25 mm of settlement.

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 the *CHBDC*.

## Box Culvert

Assuming a maximum founding level of Elevation 203.1 m, a factored geotechnical resistance at ULS of 350 kPa can be used for design of a 5.5 m wide box culvert extension or replacement. The geotechnical resistance at SLS, for 25 mm of settlement, can be taken as 250 kPa.

### 6.3.4 Resistance to Lateral Loads / Sliding Resistance

Resistance to lateral forces / sliding resistance between the concrete footings or base slab for the culvert extension or culvert replacement and the subgrade should be calculated in accordance with Section 6.7.5 of the *CHBDC*. For cast-in-place concrete footings founded on the stiff clayey silt till, the coefficient of friction,  $\tan \phi'$ , can be taken as 0.58. For pre-cast concrete box culvert sections placed on Granular “A” bedding, the coefficient of friction,  $\tan \delta$ , can be taken as 0.5. These values are unfactored; in accordance with the *CHBDC*, a factor of 0.8 is to be applied in calculating the horizontal resistance.

### 6.3.5 Settlement

Some settlement will occur below the culvert extension area as a result of placement of up to about 2.5 m of fill for the Highway 7 embankment widening. The settlement of the founding soils under this additional loading has been estimated using the elastic deformation moduli given below, based on correlations with the SPT “N” values.

| <i>Soil Deposit</i>                   | <i>Bulk Unit Weight</i> | <i>Elastic Modulus</i> |
|---------------------------------------|-------------------------|------------------------|
| Embankment fill                       | 21 kN/m <sup>3</sup>    | —                      |
| Compact sand to sand and silt         | 19 kN/m <sup>3</sup>    | 20 MPa                 |
| Stiff clayey silt till                | 21 kN/m <sup>3</sup>    | 15 MPa                 |
| Compact to very dense sand and gravel | 21 kN/m <sup>3</sup>    | 50 MPa                 |

The settlement of the foundation soils under the embankment widening is estimated to be less than 15 mm under the main widening area, decreasing to less than 5 mm at the shoulder of the existing embankment and at the toe of the widened embankment. This settlement will be completed during and immediately following construction of the embankment widening.

If a culvert extension is adopted for this site, the connection between the existing open footing culvert and its extension should be designed to accommodate this magnitude of settlement.

## **6.4 Culvert 3 – Station 13+494**

### **6.4.1 Foundation Options**

The existing 1.2 m wide x 1.2 m high concrete open footing culvert at Station 13+494 is to be extended approximately 16.0 m southward. As summarized in Table 1, a box culvert extension or replacement is preferred from a foundations perspective as this option minimizes the depth of excavation and groundwater control requirements; however, it is understood that an open footing extension (to match the existing open footing culvert and to satisfy fisheries requirements) is preferred. Recommendations for both foundation options are provided in the following sections.

Deep foundations are not required for the culvert extension or replacement, as shallow foundations will provide sufficient bearing resistance for the extension and satisfactory settlement performance under the approximately 3.5 m high embankment loading.

### **6.4.2 Founding Elevations and Subexcavation Requirements**

#### **Open Footing Culvert and Wing Walls/Retaining Walls**

An open footing culvert extension, and any associated wing walls/retaining walls, can be founded on strip footings extended below the existing fill and organic (peat) soils. The invert/creek bed of the existing culvert, and that for the proposed southward extension, is at approximately Elevation 204.3 m. The footings should, therefore, be founded at or below Elevation 202.8 m on compact sand or stiff clayey silt, to provide adequate protection against frost penetration; excavations to reach this founding elevation will extend approximately 1.7 m below the groundwater level at this site. If water will flow through the culvert year-round, the footings can be founded higher, at or below Elevation 203.8 m (to extend below the organic-containing soils and peat interlayers), with the actual founding depth determined on the basis of creek flow and scour conditions. Dewatering would be required for construction of strip footings for either condition.

#### **Box Culvert**

A box culvert extension, if adopted, should be founded below the existing fill and peat. The invert/creek bed of the existing culvert, and that for the proposed southward extension, is at approximately Elevation 204.3 m. Assuming that the surface of the concrete base slab for a box culvert extension would be constructed to match the existing creek bed, and assuming that the base slab for the extension has a thickness of 400 mm, the underside of the base slab for a box culvert extension would be founded at approximately Elevation 203.9 m. However, since peat/organic soils were encountered in one of the boreholes at the site extending down to Elevation 203.5 m, subexcavation is recommended to Elevation 203.5 m; excavations to reach this level would extend approximately 1.0 m below the groundwater level at this site, and

dewatering would be required during construction. The subexcavation and placement of engineered fill up to the box culvert subgrade level should be in accordance with the recommendations provided in Section 6.1.2.

### 6.4.3 Geotechnical Resistance

The ULS resistance and settlement for open footing and box culvert extensions/replacements are dependent on the footing size, configuration and applied loads; the geotechnical resistances should, therefore, be reviewed if the selected footing width or founding elevation differs significantly from those given in the following sections.

#### Open Footing Culvert and Wing Walls/Retaining Walls

Strip footings placed on the properly prepared subgrade, at or below Elevation 202.8 m, should be designed based on the following factored geotechnical resistances at ULS and geotechnical resistances at SLS:

| <i>Footing Width</i> | <i>Factored Geotechnical Resistance at ULS</i> | <i>Geotechnical Resistance at SLS*</i> |
|----------------------|--|--|
| 0.6 m                | 175 kPa  | 150 kPa                                |
| 0.9 m                | 200 kPa  | 150 kPa                                |

\* For 25 mm of settlement.

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 the *CHBDC*.

#### Box Culvert

Assuming that the existing soils within the loading footprint for the box culvert extension/replacement are subexcavated to Elevation 203.5 m and replaced with compacted granular fill, a factored geotechnical resistance at Ultimate Limit States (ULS) of 150 kPa can be used for design of a 1.2 m wide box culvert extension or replacement. The geotechnical resistance at Serviceability Limit States (SLS), for 25 mm of settlement, can also be taken as 150 kPa.

### 6.4.4 Resistance to Lateral Loads / Sliding Resistance

Resistance to lateral forces / sliding resistance between the concrete footings or base slab for the culvert extension or culvert replacement and the subgrade should be calculated in accordance

with Section 6.7.5 of the *CHBDC*. For cast-in-place concrete footings founded on the compact sand or stiff clayey silt, the coefficient of friction,  $\tan \phi'$ , can be taken as 0.53. For pre-cast concrete box culvert sections placed on Granular “A” bedding and/or the compacted granular pad following subexcavation as identified in Section 6.4.2, the coefficient of friction,  $\tan \delta$ , can be taken as 0.5. These values are unfactored; in accordance with the *CHBDC*, a factor of 0.8 is to be applied in calculating the horizontal resistance.

#### 6.4.5 Settlement

Some settlement will occur below the culvert extension area as a result of placement of up to approximately 3.5 m of fill for the Highway 7 embankment widening. The settlement of the founding soils has been estimated using the elastic deformation moduli given below, based on correlations with the SPT “N” values.

| <i>Soil Deposit</i>                    | <i>Bulk Unit Weight</i> | <i>Elastic Modulus</i> |
|--|-------------------------|------------------------|
| Embankment fill                        | 21 kN/m <sup>3</sup>    | -                      |
| Compact upper sand                     | 19 kN/m <sup>3</sup>    | 15 MPa                 |
| Firm to stiff clayey silt              | 20 kN/m <sup>3</sup>    | 15 MPa                 |
| Compact lower silty sand to sandy silt | 20 kN/m <sup>3</sup>    | 10 MPa                 |
| Hard clayey silt till                  | 21 kN/m <sup>3</sup>    | 75 MPa                 |

The settlement of the foundation soils under the embankment widening is estimated to be approximately 25 mm under the main widening area, decreasing to less than 10 mm at the toe of the widened embankment. The majority of this settlement will be completed during and within three months following completion of the embankment widening.

If a culvert extension is adopted for this site, the connection between the existing open footing culvert and its extension should be designed to accommodate this magnitude of settlement. If a culvert replacement is adopted, the structural designer should assess whether an articulated joint is necessary below the new embankment crest to accommodate the predicted settlement profile under the widened portion of the embankment.

### 6.5 Culvert 4 – Station 13+884

#### 6.5.1 Foundation Options

The existing 1.2 m wide x 1.2 m high concrete open footing culvert at Station 13+884 is to be extended approximately 17.0 m southward. As summarized in Table 1, a box culvert extension or replacement is preferred from a foundations perspective as this option minimizes the depth of excavation and groundwater control requirements; however, it is understood that an open footing

extension (to match the existing open footing culvert and to satisfy fisheries requirements) is preferred. Recommendations for both foundation options are provided in the following sections.

Deep foundations are not required for the culvert extension or replacement, as shallow foundations will provide sufficient bearing resistance for the extension and satisfactory settlement performance under the approximately 5.0 m high embankment loading.

## **6.5.2 Founding Elevations and Subexcavation Requirements**

### **Open Footing Culvert and Wing Walls/Retaining Walls**

An open footing culvert extension, and any associated wing walls/retaining walls, can be founded on strip footings extended below the existing fill and peat or surficial silty sand. The invert/creek bed of the existing culvert, and that for the proposed southward extension, is at approximately Elevation 206.3 m. The footings should, therefore, be founded at or below Elevation 204.8 m on the compact sand to silty sand, to provide adequate protection against frost penetration; excavations to reach this founding elevation will extend approximately 1.6 m below the groundwater level at this site. If water will flow through the culvert year-round, the footings can be founded higher, at or below Elevation 205.5 m (to extend below the existing fill and any peat/surficial organic-containing soils); the actual founding depth should be determined on the basis of creek flow and scour conditions. Dewatering would be required for construction of strip footings under either condition.

### **Box Culvert**

A box culvert extension should be founded below the existing fill and peat or surficial silty sand. The invert/creek bed of the existing culvert, and that for the proposed southward extension, is at approximately Elevation 206.3 m. Assuming that the surface of the concrete base slab for a box culvert extension will be constructed to match the existing creek bed, and that the concrete base slab for the extension has a thickness of 400 mm, the underside of the base slab for a box culvert extension would be founded at approximately Elevation 205.9 m. However, since surficial organic-containing silty sand is present at this elevation, subexcavation is recommended down to Elevation 205.6 m to found the box culvert directly on compact sand to silty sand; such subexcavation would extend approximately 0.8 m below the groundwater level at this site, and dewatering would be required. The subexcavation and placement of engineered fill up to the box culvert subgrade level should be in accordance with the recommendations provided in Section 6.1.2.

### 6.5.3 Geotechnical Resistance

The ULS resistance and settlement for open footing and box culvert extensions/replacements are dependent on the footing size, configuration and applied loads; the geotechnical resistances should, therefore, be reviewed if the selected footing width or founding elevation differs significantly from those given in the following sections.

#### Open Footing Culvert and Wing Walls/Retaining Walls

Strip footings placed on the properly prepared subgrade, at or below Elevation 204.8 m, should be designed based on the following factored geotechnical resistances at Ultimate Limit States (ULS) and geotechnical resistances at Serviceability Limit States (SLS):

| <i>Footing Width</i> | <i>Factored Geotechnical Resistance at ULS</i> | <i>Geotechnical Resistance at SLS*</i> |
|----------------------|--|--|
| 0.6 m                | 175 kPa  | 150 kPa                                |
| 0.9 m                | 200 kPa  | 150 kPa                                |

\* For 25 mm of settlement.

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 the *CHBDC*.

#### Box Culvert

Assuming subexcavation to Elevation 205.6 m and replacement with compacted granular fill, a factored geotechnical resistance at ULS of 175 kPa can be used for design of a 1.2 m wide box culvert extension or replacement. The geotechnical resistance at SLS, for 25 mm of settlement, can be taken as 150 kPa.

### 6.5.4 Resistance to Lateral Loads / Sliding Resistance

Resistance to lateral forces / sliding resistance between the concrete footings or base slab for the culvert extension or culvert replacement and the subgrade should be calculated in accordance with Section 6.7.5 of the *CHBDC*. For cast-in-place concrete footings founded on the compact sand to silty sand, the coefficient of friction,  $\tan \phi'$ , can be taken as 0.58. For pre-cast concrete box culvert sections placed on Granular "A" bedding and/or the compacted granular pad following subexcavation as identified in Section 6.5.2, the coefficient of friction,  $\tan \delta$ , can be taken as 0.5. These values are unfactored; in accordance with the *CHBDC*, a factor of 0.8 is to be applied in calculating the horizontal resistance.

### 6.5.5 Settlement

Some settlement will occur below the culvert extension as a result of placement of up to approximately 5.0 m of fill for the Highway 7 embankment widening at this culvert site. The settlement of the founding soils has been estimated using the elastic deformation moduli given below, based on correlations with the SPT “N” values.

| <i>Soil Deposit</i>                 | <i>Bulk Unit Weight</i> | <i>Elastic Modulus</i> |
|-------------------------------------|-------------------------|------------------------|
| Embankment fill                     | 21 kN/m <sup>3</sup>    | -                      |
| Loose to compact silty sand to sand | 20 kN/m <sup>3</sup>    | 15 MPa                 |
| Hard clayey silt till               | 21 kN/m <sup>3</sup>    | 65 MPa                 |
| Very dense sand and gravel          | 21 kN/m <sup>3</sup>    | 100 MPa                |

The settlement of the foundation soils under the embankment widening is estimated to be approximately 30 mm under the main widening area, decreasing to less than 10 mm at the toe of the widened embankment. The majority of this settlement will take place during and immediately following the construction of the embankment widening.

If a culvert extension is adopted for this site, the connection between the existing open footing culvert and its extension should be designed to accommodate this magnitude of settlement. If a culvert replacement is adopted, the structural designer should assess whether an articulated joint is necessary below the new embankment crest to accommodate the predicted settlement profile under the widened portion of the embankment.

## 6.6 Culvert 5 – Station 14+434

### 6.6.1 Foundation Options

The existing 3.7 m wide x 1.8 m high concrete box culvert at Station 14+434 is to be replaced on a new alignment, with the north end of the culvert located approximately 8 m east of the existing, and the south end of the culvert located approximately 18 m east of the existing. Both open footing and box culvert options are geotechnically feasible for this site, and will require similar depths of excavation and groundwater control due to the presence of peat/organic soils and associated requirement for subexcavation. Recommendations for both foundation options are provided in the following sections.

Deep foundations are not required for the culvert replacement, as shallow foundations will provide sufficient bearing resistance for the extension and satisfactory settlement performance under the approximately 2.5 m high embankment loading.



## **6.6.2 Founding Elevations and Subexcavation Requirements**

### **Open Footing Culvert and Wing Walls/Retaining Walls**

An open footing culvert, and any associated wing walls/retaining walls, can be supported on strip footings founded below the existing fill and peat/organic soils, on the loose to dense sand to silt deposit. The invert for the replacement culvert varies from Elevation 207.4 m at the south end to Elevation 207.3 m at the north end of the culvert. The base of the peat/organic soil was encountered between about Elevation 205.3 m and 205.5 m, approximately 1.9 m to 2.1 m below the proposed culvert invert level. The footings should, therefore, be founded at or below Elevation 205.2 m.

Alternatively, the peat/organic soils can be subexcavated down to approximately Elevation 205.2 m, then backfilled with compacted granular fill to allow strip footings to be founded higher, between Elevation 205.8 m and 205.9 m (to provide 1.5 m of soil cover for frost protection purposes).

The excavations for the footings or subexcavation works would extend to a depth of about 2.9 m below the groundwater level at the site, and dewatering would be required to facilitate the excavation and footing construction.

### **Box Culvert**

A box culvert replacement, if adopted, would also require subexcavation of the peat/organic soils to approximately Elevation 205.2 m and replacement with compacted granular fill. As for the open footing option, the excavation for the box culvert would extend to a depth of about 2.9 m below the groundwater level at the site, and dewatering would be required to facilitate the excavation and box culvert construction.

## **6.6.3 Geotechnical Resistance**

The ULS resistance and settlement for an open footing and box culvert replacement are dependent on the footing size, configuration and applied loads; the geotechnical resistances should, therefore, be reviewed if the selected footing width or founding elevation differs significantly from those given in the following sections.

### **Open Footing Culvert and Wing Walls/Retaining Walls**

Strip footings placed on the properly prepared subgrade, at or below Elevation 205.2 m or below frost depth on a granular pad following subexcavation to Elevation 205.2 m, should be designed

based on the following factored geotechnical resistances at ULS and geotechnical resistances at Serviceability Limit States SLS:

| <b><i>Culvert Type</i></b>   | <b><i>Footing Width</i></b> | <b><i>Factored Geotechnical Resistance at ULS</i></b> | <b><i>Geotechnical Resistance at SLS*</i></b> |
|------------------------------|-----------------------------|---|---|
| Open Footing on Native Soil  | 0.6 m                       | 175 kPa   | 150 kPa                                       |
|                              | 0.9 m                       | 200 kPa   | 150 kPa                                       |
| Open Footing on Granular Pad | 0.6 m                       | 225 kPa   | 150 kPa                                       |
|                              | 0.9 m                       | 250 kPa   | 150 kPa                                       |

\* For 25 mm of settlement.

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 the *CHBDC*.

### **Box Culvert**

Assuming subexcavation of the fill and peat/organic soils down to Elevation 205.2 m, and replacement with compacted granular fill (as per the recommendations in Section 6.1.2), a factored geotechnical resistance at ULS of 250 kPa can be used for design of a 4.1 m wide box culvert replacement. The geotechnical resistance at SLS, for 25 mm of settlement, can be taken as 150 kPa.

#### **6.6.4 Resistance to Lateral Loads / Sliding Resistance**

Resistance to lateral forces / sliding resistance between the concrete footings or base slab for the replacement culvert and the subgrade should be calculated in accordance with Section 6.7.5 of the *CHBDC*. For cast-in-place concrete footings constructed on the compact to dense sand to silt at Elevation 205.2 m, the coefficient of friction,  $\tan \phi'$ , can be taken as 0.53, and for cast-in-place concrete footings constructed on a compacted Granular "A" pad, the coefficient of friction,  $\tan \phi'$ , can be taken as 0.6. For pre-cast concrete box culvert sections placed on Granular "A" bedding and the compacted granular pad following subexcavation as identified in Section 6.6.2, the coefficient of friction,  $\tan \delta$ , can be taken as 0.5. These values are unfactored; in accordance with the *CHBDC*, a factor of 0.8 is to be applied in calculating the horizontal resistance.

#### **6.6.5 Settlement**

Some settlement will occur below the culvert extension as a result of placement of up to approximately 2.5 m of fill for the Highway 7 embankment widening. The settlement of the founding soils has been estimated using the elastic deformation moduli given below, based on correlations with the SPT "N" values.

| <i>Soil Deposit</i>                         | <i>Bulk Unit Weight</i> | <i>Elastic Modulus</i> |
|---|-------------------------|------------------------|
| Embankment fill and compacted granular fill | 21 kN/m <sup>3</sup>    | —                      |
| Compact to dense sand to silt               | 20 kN/m <sup>3</sup>    | 10 MPa                 |
| Stiff to very stiff clayey silt             | 21 kN/m <sup>3</sup>    | 25 MPa                 |

The settlement of the foundation soils under the 2.5 m high embankment widening is estimated to be less than 25 mm under the main widening area, decreasing to less than 10 mm at the toe of the widened embankment; these estimated magnitudes of settlement assume that subexcavation of the peat/organic soils has been carried out, as discussed above. The majority of this settlement will be completed during and immediately following construction of the embankment widening.

For the culvert replacement at this site, the structural designer should assess whether an articulated joint is necessary below the new embankment crest to accommodate the predicted settlement profile under the widened portion of the embankment.

## **6.7 Culvert 6 – Station 15+792**

### **6.7.1 Foundation Options**

The existing 1.2 m wide x 1.2 m high concrete open footing culvert at Station 15+792 is to be extended approximately 4.0 m northward and 4.0 m southward. As summarized in Table 1, a box culvert extension or replacement is preferred from a foundations perspective as this option minimizes the depth of excavation and groundwater control requirements; however, it is understood that an open footing extension (to match the existing open footing culvert and to satisfy fisheries requirements) is preferred. Recommendations for both foundation options are provided in the following sections.

Deep foundations are not required for the culvert extensions or culvert replacement, as shallow foundations will provide sufficient bearing resistance for the extensions and satisfactory settlement performance under the approximately 2.0 m high embankment loading.

### **6.7.2 Founding Elevations and Subexcavation Requirements**

#### **Open Footing Culvert and Wing Walls/Retaining Walls**

For the northward and southward extensions, an open footing culvert and any associated wing walls/retaining walls should be founded below the embankment fill, peat or organic silty sand and the soft to firm portion of the clayey silt deposit. The invert/creek bed at the south end of the existing culvert, and that for the proposed southward extension, is at approximately Elevation 226.0 m; the invert/creek bed at the north end of the existing culvert, and that for the proposed northward extension, is at approximately Elevation 225.8 m. The strip footings should be

founded at or below Elevation 224.5 m for the south extension, and at or below Elevation 224.3 m for the north extension, to provide adequate protection against frost penetration. At these founding elevations, the subgrade will consist of the stiff to hard clayey silt till deposit. Excavations to these founding elevations would extend to a depth of as much as 1.7 m below the groundwater level at this site, and groundwater control will be required to facilitate excavation and footing construction.

If frost protection is not required for these culvert footings based on year-round water flow, then the footings can be constructed at a higher elevation. For the south and north extensions, the footings should be constructed at or below Elevation 224.9 m, to be founded below the soft to firm clayey silt soils; the actual founding depth should be determined on the basis of creek flow and scour conditions. Excavations to these founding elevations would extend to a depth of as much as 1.0 m below the groundwater level at the site, and groundwater control would be required to facilitate excavation and footing construction.

### **Box Culvert**

Box culvert extensions, if adopted, should be founded below the existing fill, peat or organic silty sand, and soft to firm clayey silt soils. The invert/creek bed of the existing culvert, and that for the proposed southward and northward extensions, are at approximately Elevation 226.0 m and Elevation 225.8 m, respectively. Assuming that the surface of the concrete base slab for the extensions will be constructed to match, and that the base slab has a thickness of 400 mm, the south extension would be founded at approximately Elevation 225.6 m and the north extension would be founded at approximately Elevation 225.4 m. Suitable subgrade soils (stiff to very stiff clayey silt and very stiff clayey silt till) are present at these elevations under the south and north culvert extensions, and no further subexcavation is required except that necessary for the placement of subgrade protection and the levelling pad. Excavations for box culvert extensions would extend to a depth of approximately 0.4 m to 0.6 m below the groundwater level at this site, and groundwater control will be required to facilitate excavation and footing construction.

### **6.7.3 Geotechnical Resistance**

The ULS resistance and settlement for open footing and box culvert extensions/replacements are dependent on the footing size, configuration and applied loads; the geotechnical resistances should, therefore, be reviewed if the selected footing width or founding elevation differs significantly from those given in the following sections.

### **Open Footing Culvert and Wing Walls/Retaining Walls**

Strip footings placed on the properly prepared subgrade, at or below Elevation 224.5 m for the south end of the culvert and at or below Elevation 224.3 m for the north end of the culvert, should

be designed based on the following factored geotechnical resistances at ULS and geotechnical resistances at SLS:

| <b><i>Footing Width</i></b> | <b><i>Factored Geotechnical Resistance at ULS</i></b> | <b><i>Geotechnical Resistance at SLS*</i></b> |
|-----------------------------|---|---|
| 0.6 m                       | 200 kPa   | 175 kPa                                       |
| 0.9 m                       | 225 kPa   | 175 kPa                                       |

\* For 25 mm of settlement.

The geotechnical resistances provided in this section 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 the *CHBDC*.

### **Box Culvert**

Assuming founding levels of Elevation 225.6 m and 225.4 m for the south and north extensions, respectively, a factored geotechnical resistance at Ultimate Limit States (ULS) of 150 kPa can be used for design. The geotechnical resistance at Serviceability Limit States (SLS), for 25 mm of settlement, can also be taken as 150 kPa.

#### **6.7.4 Resistance to Lateral Loads / Sliding Resistance**

Resistance to lateral forces / sliding resistance between the concrete footings or base slab for the culvert extension or culvert replacement and the subgrade should be calculated in accordance with Section 6.7.5 of the *CHBDC*. For cast-in-place concrete footings constructed directly on the stiff to hard clayey silt till, the coefficient of friction,  $\tan \phi'$ , can be taken as 0.58. For pre-cast concrete box culvert sections placed on Granular "A" bedding, the coefficient of friction,  $\tan \delta$ , can be taken as 0.5. These values are unfactored; in accordance with the *CHBDC*, a factor of 0.8 is to be applied in calculating the horizontal resistance.

#### **6.7.5 Settlement**

Some settlement will occur below the culvert extensions as a result of placement of up to approximately 2.0 m of fill for the Highway 7 embankment widening. The settlement of the founding soils has been estimated using the elastic deformation moduli given below, based on correlations with the SPT "N" values.

| <i>Soil Deposit</i>             | <i>Bulk Unit Weight</i> | <i>Elastic Modulus</i> |
|---------------------------------|-------------------------|------------------------|
| Embankment fill                 | 21 kN/m <sup>3</sup>    | -                      |
| Stiff to very stiff clayey silt | 20 kN/m <sup>3</sup>    | 20 MPa                 |
| Stiff to hard clayey silt till  | 21 kN/m <sup>3</sup>    | 35 MPa                 |

The settlement of the foundation soils under the embankment widening is estimated to be less than 15 mm under the main widening area, decreasing to less than 5 mm at the toe of the widened embankment.

If a culvert extension is adopted for this site, the connection between the existing open footing culvert and its extension should be designed to accommodate this magnitude of settlement.

## **6.8 Culvert 7 – Station 16+129**

### **6.8.1 Foundation Options**

The existing 1.2 m wide x 1.2 m high concrete open footing culvert at Station 16+129 is to be extended approximately 10.0 m southward; a northward extension is also required. As summarized in Table 1, a box culvert extension or replacement is preferred from a foundations perspective as this option minimizes the depth of excavation and groundwater control requirements; however, it is understood that an open footing extension may be preferred to satisfy fisheries requirements. Recommendations for both foundation options are provided in the following sections.

Deep foundations are not required for the culvert extension or replacement, as shallow foundations will provide sufficient bearing resistance for the extension and satisfactory settlement performance under the approximately 2.0 m high embankment loading.

### **6.8.2 Founding Elevations and Subexcavation Requirements**

#### **Open Footing Culvert and Wing Walls/Retaining Walls**

Open footing culvert extensions, and any associated wing walls/retaining walls, should be founded on strip footings extended below the existing fill and surficial organic silty sand, where present, or firm surficial clayey silt. The invert/creek bed of the existing culvert, and that for the proposed extensions, is at approximately Elevation 226.8 m at the north end and 226.5 m at the south end. The footings should be founded on the stiff to hard clayey silt till at or below Elevation 225.3 m at the north end and Elevation 225.0 m at the south end, to provide adequate protection against frost penetration. Excavations would extend to a depth of up to 1.5 m below

the groundwater level at the site, and groundwater control would be required to facilitate excavation and footing construction.

If frost protection is not required for the culvert extension footings based on year-round water flow, then the footings can be constructed higher, at Elevation 225.5 m, to be founded near the base of the stiff clayey silt, above the clayey silt till deposit; the actual founding depth for this option should be determined on the basis of creek flow and scour conditions. Excavations to the above-noted founding elevation would extend to a depth of approximately 1.0 m below the groundwater level at the site, and groundwater control would be required to facilitate excavation and footing construction.

The clayey silt or clayey silt till soils will be susceptible to softening and degradation on exposure to water and construction traffic. It is recommended that a 100 mm thick layer of lean mix concrete or mass concrete be placed on the footing subgrade to form a working mat for construction and protect the subgrade from such degradation.

### **Box Culvert**

The invert/creek bed of the existing culvert, and that for the proposed extensions, is at approximately Elevation 226.8 m at the north end and Elevation 226.5 m at the south end. Assuming that the surface of the concrete base slab for the extension will be constructed to match the existing, and that the base slab has a thickness of 400 mm, the base slab for the extensions would be founded at Elevation 226.4 m at the north end and Elevation 226.1 m at the south end. However, based on the presence of organic silty sand at this elevation in Borehole CU-15 in the south extension area, it is recommended that subexcavation be extended to Elevation 225.7 m in the south extension area, followed by backfilling with granular fill in accordance with the recommendations provided in Section 6.1.2. This excavation will extend approximately 0.8 m below the groundwater level at the site, and groundwater control will be required during subexcavation and culvert construction.

### **6.8.3 Geotechnical Resistance**

The ULS resistance and settlement for open footing and box culvert extensions/replacements are dependent on the footing size, configuration and applied loads; the geotechnical resistances should, therefore, be reviewed if the selected footing width or founding elevation differs significantly from those given in the following sections.

## Open Footing Culvert and Wing Walls/Retaining Walls

Strip footings placed on the properly prepared subgrade, at or below the design elevations given in the preceding section, should be designed based on the following factored geotechnical resistances at ULS and geotechnical resistances at SLS:

| <i>Footing Width</i> | <i>Factored Geotechnical Resistance at ULS</i> | <i>Geotechnical Resistance at SLS*</i> |
|----------------------|--|--|
| 0.6 m                | 200 kPa  | 175 kPa                                |
| 0.9 m                | 225 kPa  | 175 kPa                                |

\* For 25 mm of settlement.

The geotechnical resistances provided in this section 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 the *CHBDC*.

## Box Culvert

A factored geotechnical resistance at ULS of 150 kPa can be used for design of box culvert extensions at both the north and south ends of the culvert; for the south culvert extension, this recommendation is based on subexcavation to Elevation 225.7 m and replacement with compacted granular fill, as discussed in the preceding section. The geotechnical resistance at SLS, for 25 mm of settlement, can also be taken as 150 kPa for extensions at both ends of the culvert.

### 6.8.4 Resistance to Lateral Loads / Sliding Resistance

Resistance to lateral forces / sliding resistance between the concrete footings or base slab for the culvert extension or culvert replacement and the subgrade should be calculated in accordance with Section 6.7.5 of the *CHBDC*. For cast-in-place concrete footings constructed directly on the stiff to hard clayey silt till, the coefficient of friction,  $\tan \phi'$ , can be taken as 0.58. For pre-cast concrete box culvert sections placed on Granular "A" bedding at the north culvert extension, or on a compacted granular pad following subexcavation (as identified in Section 6.8.2) at the south culvert extension, the coefficient of friction,  $\tan \delta$ , can be taken as 0.5. These values are unfactored; in accordance with the *CHBDC*, a factor of 0.8 is to be applied in calculating the horizontal resistance.



### 6.8.5 Settlement

Some settlement will occur below the culvert extensions as a result of placement of up to approximately 2.0 m to 2.5 m of fill for the Highway 7 embankment widening. The settlement of the founding soils has been estimated using the elastic deformation moduli given below, based on correlations with the SPT “N” values.

| <i>Soil Deposit</i>            | <i>Bulk Unit Weight</i> | <i>Elastic Modulus</i> |
|--------------------------------|-------------------------|------------------------|
| Embankment fill                | 21 kN/m <sup>3</sup>    | -                      |
| Stiff clayey silt              | 20 kN/m <sup>3</sup>    | 15 MPa                 |
| Stiff to hard clayey silt till | 21 kN/m <sup>3</sup>    | 40 MPa                 |

The settlement of the foundation soils under the embankment widening is estimated to be less than 15 mm under the main widening area, decreasing to less than 5 mm at the toe of the widened embankment.

If a culvert extension is adopted for this site, the connection between the existing open footing culvert and its extension should be designed to accommodate this magnitude of settlement.

### 6.9 Culvert Bedding, Backfill and Erosion Protection

For box culvert extensions or replacements, the bedding levelling pad and backfill requirements should be in accordance with OPSS 422 for pre-cast rigid frame culverts. Box culvert extensions or replacements should be provided with at least 75 mm of OPSS 1010 Granular “A” material for bedding purposes.

Backfill and cover for concrete culverts should be completed in accordance with Ontario Provincial Standard Drawing (OPSD) 803.010. Backfill to open footing and box culvert walls should consist of granular fill meeting the requirements of OPSS 1010 Granular “A” or Granular “B” Type II, but with less than 5 per cent passing the No. 200 sieve. The backfill should be placed and compacted in accordance with MTO’s Special Provision SP105S10. The fill depth during placement should be maintained equal on both sides of the culvert walls, with one side not exceeding the other by more than 500 mm. The culvert extension should be designed for the full overburden pressure and live load, assuming an embankment fill unit weight of 22 kN/m<sup>3</sup> for Granular “A”, 21 kN/m<sup>3</sup> for Granular “B” Type II, and 21 kN/m<sup>3</sup> for earth backfill above and/or surrounding the culvert.

If the creek flow velocities are sufficiently high, provision should be made for scour and erosion protection (suitable non-woven geotextiles and/or rip-rap) in the culvert extension areas. In order to prevent surface water from flowing either beneath the culvert (potentially causing undermining and scouring) or around the culvert (creating seepage through the embankment fill, and

potentially causing erosion and loss of fine soil particles), a clay seal or concrete cut-off wall should be provided at the upstream end of any culverts that are replaced or extended at the upstream end. If a clay seal is adopted, the clay material should meet the requirements of OPSS 1205, and the seal should extend from a depth of 1 m below the scour level to a minimum horizontal distance of 2 m on either side of the culvert inlet openings, and a minimum vertical height equivalent to the high water level including treatment of adjacent side slopes. Alternatively, a clay blanket may be constructed, extending upstream to a distance equal to three times the culvert height, and extending along the adjacent side slopes to a height of two times the culvert height or the high water level, whichever is higher.

The requirements for and design of erosion protection measures for the inlet and outlet of the culvert extensions/replacements should be assessed by the hydraulic design engineer. As a minimum, rip-rap treatment for the outlet of the culvert extensions should be consistent with the standard presented in OPSD 810.010 Rip-Rap Treatment Type A. Erosion protection for the inlet of the culvert extensions should follow the standard presented in OPSD 810.010, similar to Rip-Rap Treatment Type A with the rip-rap placed up to the toe of slope level, in combination with the cut-off measures noted above. Similarly, rip-rap should be provided over the full extent of the clay blanket, including the creek side slopes and embankment fill slope adjacent to the culverts.

## **6.10 Retaining Walls – RSS Walls and Concrete Cantilever Walls**

Retaining walls may be required adjacent to the culvert extensions or replacements. Both concrete cantilever walls and retained soil system (RSS) walls are geotechnically feasible at the culvert sites. Recommendations on founding level, geotechnical resistance, resistance to lateral loads and global stability of these wall types are provided in the following subsections.

### **6.10.1 Founding Level**

Design founding elevations for concrete retaining walls are provided in Sections 6.2.2 through 6.8.2 of this report (in the subsections regarding strip footings for open footing culverts and associated wing walls/retaining walls for each of the culvert sites), and are also summarized in Table 3 following the text of this report.

For RSS walls, the facing footing and reinforced soil mass should be founded below any topsoil, existing fill or disturbed native soils. Design founding elevations for RSS walls are also summarized in Table 3 following the text of this report.

### **6.10.2 Geotechnical Resistance**

Geotechnical resistances for concrete retaining walls supported on shallow footings are provided in Sections 6.2.3 through 6.8.3 of this report (in the subsections regarding strip footings for open

footing culverts and associated wing walls/retaining walls for each of the culvert sites), and are also summarized in Table 3 following the text of this report.

For RSS walls, factored geotechnical resistances at ULS and geotechnical resistances at SLS are provided in Table 3. These design values assume that the RSS wall acts as a unit and uses the full width of the reinforced soil mass, which has been taken as 0.8 times the height of the RSS wall.

### 6.10.3 Resistance to Lateral Loads

The resistance to lateral forces / sliding resistance between concrete footings for concrete retaining walls and the subgrade should be assessed using the recommendations provided in Sections 6.2.4 through 6.8.4 of this report (in the subsections regarding strip footings for open footing culverts and associated wing walls/retaining walls for each of the culvert sites).

The resistance to lateral forces / sliding resistance between the compacted fill of the RSS wall and the subgrade should be calculated in accordance with Section 6.7.5 of the *CHBDC*. The coefficient of friction,  $\tan \phi'$ , between the compacted granular fill of the RSS wall and the properly prepared subgrade may be taken as 0.55 (based on the “worst case” subgrade conditions at the culvert sites). This represents an unfactored value; in accordance with the *CHBDC*, a factor of 0.8 is to be applied in calculating the horizontal resistance.

### 6.10.4 Global Stability

The global stability of any RSS walls or concrete cantilever walls that may be required adjacent to the culvert extensions has been analyzed using the commercially available program SLOPE/W, produced by Geo-Slope International Ltd., employing the Morgenstern-Price method of analysis. In the analyses, it has been assumed that fill for the embankment widening is “benched” into the existing embankment side slopes in accordance with OPSD 208.010.

The parameters used for the analysis of the highest wall condition – an approximately 4.5 m high RSS wall or concrete cantilever wall at the site of Culvert 4, at Station 13+884 – are summarized below:

| <i>Soil<br/>Deposit</i>           | <i>Bulk<br/>Unit Weight</i> | <i>Effective<br/>Friction Angle</i> | <i>Undrained<br/>Shear Strength</i> |
|-----------------------------------|-----------------------------|-------------------------------------|-------------------------------------|
| Embankment fill                   | 21 kN/m <sup>3</sup>        | 32°                                 | –                                   |
| Loose to dense silty sand to sand | 20 kN/m <sup>3</sup>        | 30°                                 | –                                   |
| Hard clayey silt till             | 21 kN/m <sup>3</sup>        | 35°                                 | –                                   |
| Very dense sand and gravel        | 21 kN/m <sup>3</sup>        | 37.5°                               | –                                   |

The parameters used for the analysis of a “typical” wall – a 3.0 m high RSS wall or concrete cantilever wall founded on the “worst-case” soil conditions – are summarized below:

| <i>Soil Deposit</i>           | <i>Bulk Unit Weight</i> | <i>Effective Friction Angle</i> | <i>Undrained Shear Strength</i> |
|-------------------------------|-------------------------|---------------------------------|---------------------------------|
| Embankment fill               | 21 kN/m <sup>3</sup>    | 32°                             | –                               |
| Compact sand to sand and silt | 20 kN/m <sup>3</sup>    | 30°                             | –                               |
| Stiff clayey silt             | 21 kN/m <sup>3</sup>    | –                               | 30 kPa                          |
| Hard clayey silt till         | 21 kN/m <sup>3</sup>    | 35°                             | –                               |

The results of the slope stability analyses indicate that a factor of safety greater than 1.5 is achieved with respect to global stability of RSS walls founded at nominal depth, and concrete retaining walls supported on strip footings founded at a minimum depth of 1.5 m below the lowest surrounding grade.

### 6.11 Lateral Earth Pressures for Design

The lateral earth pressures acting on the culvert walls and any associated wing walls/retaining walls will depend on the type and method of placement of the backfill materials, on the nature of the soils behind the backfill, on the magnitude of surcharge including construction loadings, on the freedom of lateral movement of the structure, and on the drainage conditions behind the walls.

The following recommendations are made concerning the design of the walls, assuming that the backfill to the culvert walls consists of free-draining granular fill meeting the requirements of OPSS Granular “A” or “B” Type II, placed and compacted in accordance with MTO’s Special Provision SP105S10, with longitudinal drains and weep holes installed as necessary to provide positive drainage of the granular backfill.

- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the walls, in accordance with *CHBDC* Section 6.9.3 and Figure 6.9.3. Other surcharge loadings should be accounted for in the design, as required.
- The granular fill may be placed either in a zone with width equal to at least 1.5 m behind the back of the wall stem (Case I in Figure C6.9.1(l) of the *Commentary to the CHBDC*) or within the wedge-shaped zone defined by a line drawn at 1.5 horizontal to 1 vertical (1.5H:1V) extending up and back from the rear face of the footing (Case II in Figure C6.9.1(l) of the *Commentary to the CHBDC*).

- For Case I, the pressures are based on the existing embankment fill materials and the following parameters (unfactored) may be used:

|  |   |
|--|---|
| Soil unit weight:                              | 21 kN/m <sup>3</sup>                      |
| Coefficients of static lateral earth pressure: |   |
| Active, $K_a$                                  | 0.33 (level ground)<br>0.53 (2H:1V slope) |
| At rest, $K_o$                                 | 0.50 (level ground)<br>0.80 (2H:1V slope) |

- For Case II, the pressures are based on granular fill and the following parameters (unfactored) may be assumed:

|  | <b>Granular "A"</b>                       | <b>Granular "B"<br/>Type II</b> |
|--|---|---------------------------------|
| Soil unit weight:                              | 22 kN/m <sup>3</sup>                      | 21 kN/m <sup>3</sup>            |
| Coefficients of static lateral earth pressure: |   |                                 |
| Active, $K_a$                                  | 0.27 (level ground)<br>0.38 (2H:1V slope) |                                 |
| At rest, $K_o$                                 | 0.43 (level ground)<br>0.61 (2H:1V slope) |                                 |

- Where the wing wall/retaining support allows lateral yielding of the stem, active earth pressures should be used in the geotechnical design of the structure. Where the wall support does not allow lateral yielding (which typically applies to a culvert or rigid frame structure), at-rest earth pressures should be assumed for the geotechnical design. The movement to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure, may be taken as follows:
  - Rotation of approximately 0.002 about the base of a vertical wall;
  - Horizontal translation of 0.001 times the height of the wall; or
  - A combination of both.

Seismic (earthquake) loading must also be taken into account in the design in accordance with Section 4.6 of the CHBDC. In this regard, the following should be included in the assessment of lateral earth pressures:

- Seismic loading will result in increased lateral earth pressures acting on the abutment stem and retaining walls. The walls should be designed to withstand the combined lateral loading for the appropriate static pressure conditions given above, plus the earthquake-induced dynamic earth pressure. According to Table A3.1.7 of the CHBDC, this site is located in Seismic Zone 1. The site-specific zonal acceleration ratio for Peterborough is 0.05. Based on experience, for the subsurface conditions at the culvert sites, a 20 per cent

amplification of the ground motion may occur, resulting in an increase in the ground surface acceleration from 0.05g to 0.06g. The seismic lateral earth pressure coefficients given below have been derived based on a design zonal acceleration ratio of  $A = 0.06$ .

- In accordance with Sections 4.6.4 and C.4.6.4 of the *CHBDC* and its *Commentary*, for structures which allow lateral yielding, the horizontal seismic coefficient,  $k_h$ , used in the calculation of the seismic active pressure coefficient, is taken as 0.5 times the zonal acceleration ratio (i.e.  $k_h = 0.03$ ). For structures that do not allow lateral yielding,  $k_h$  is taken as 1.5 times the zonal acceleration ratio (i.e.  $k_h = 0.09$ ). The seismic active earth pressure coefficient is also dependent on the vertical component of the earthquake acceleration,  $k_v$ . Three discrete values of vertical acceleration are typically selected for analysis, corresponding to  $k_v = +2/3 k_h$ ,  $k_v = 0$ , and  $k_v = -2/3 k_h$ .
- The following seismic active pressure coefficients ( $K_{AE}$ ) for the two cases (Case I and Case II) may be used in design; these coefficients reflect the maximum  $K_{AE}$  obtained using the  $k_h$  and three values of  $k_v$  as described above. It should be noted that these seismic earth pressure coefficients assume that the back of the wall is vertical and the ground surface behind the wall is flat.

#### SEISMIC ACTIVE PRESSURE COEFFICIENTS, $K_{AE}$

| Wall Condition    | Case I | Case II    |                       |
|-------------------|--------|------------|-----------------------|
|                   |        | Granular A | Granular B<br>Type II |
| Yielding wall     | 0.32   | 0.26       | 0.30                  |
| Non-yielding wall | 0.37   | 0.30       | 0.34                  |

Note: These  $K_{AE}$  values include the effect of wall friction ( $\delta=\phi'/2$ ) and are less than the static values of  $K_a$  and  $K_o$  reported above for the low zonal acceleration ratio for this site.

- The above  $K_{AE}$  values for yielding walls are applicable provided that the wall can move up to 250A (mm), where A is the design zonal acceleration ratio of 0.06. This corresponds to displacements of up to 15 mm at this site.
- The earthquake-induced dynamic pressure distribution, which is to be added to the static earth pressure distribution, is a linear distribution with maximum pressure at the top of the wall and minimum pressure at its toe (i.e. an inverted triangular pressure distribution). The total pressure distribution (static plus seismic) may be determined as follows:

$$P = K \gamma' d + (K_{AE} - K) \gamma' H$$

where  $K$  is either the static active earth pressure coefficient ( $K_a$ ) or the static at rest earth pressure coefficient ( $K_o$ ), as applicable;  
 $K_{AE}$  is the seismic active earth pressure coefficient;  
 $\gamma'$  is the effective unit weight of the soil ( $\text{kN/m}^3$ ) taken as the soil unit weight given in previous sections for fill materials;  
 $d$  is the depth below the top of the wall (m); and  
 $H$  is the height of the wall above the toe (m).

## **6.12 Construction Considerations**

### **6.12.1 Surface Water and Groundwater Control**

Control of the surface water and groundwater will be necessary at the culvert extension or replacement sites to allow for excavation and foundation construction to be carried out in dry conditions.

Depending on the creek flow at the time of construction, the surface water flow could be passed through the culvert area by means of a temporary pipe, or diverted by pumping from behind a temporary cofferdam. Surface water should be directed away from the excavation areas, to prevent ponding of water that could result in disturbance and weakening of the foundation subgrades; further discussion on this aspect is provided in Section 6.12.3.

As discussed in Sections 6.2 to 6.8, groundwater control will be required at all of the culvert extension/replacement locations, as the foundation excavations will extend below the groundwater level at all of the sites. A sample NSSP is included in Appendix A, for inclusion in the Contract Documents, to address groundwater control for the culvert sites.

Where the excavations will be advanced through existing fill and cohesive soils to terminate within cohesive soils (i.e. no excavation through water-bearing granular soils), seepage into the excavation should be adequately controlled by pumping from properly filtered sumps. Based on the borehole results, this is anticipated to be the case at the sites of Culverts 6 and 7.

For Culverts 1 through 5, appropriate dewatering of the water-bearing cohesionless soil deposits will be required to draw the water level down to at least 0.3 m below the founding level or subexcavation level for the culvert extensions/replacements and any associated retaining walls. A wellpoint or eductor system, designed and installed by a specialist dewatering contractor, is considered to be necessary and appropriate for dewatering at these sites. As discussed Section 6.12.2, an interlocking sheetpile system could also be used at the sites of Culverts 1 through 5 to control groundwater seepage through the excavation side walls (in addition to providing temporary excavation support where needed). Sheetpile systems at these sites would still have to be supplemented with wellpoints or eductors to draw the groundwater level down to below the excavation base.

### **6.12.2 Excavations and Temporary Roadway Protection**

Temporary excavations for the culvert extensions or culvert replacements will be made through the existing embankment fill, peat and surficial organic soils, loose sands/silts, and soft to firm clayey silt soils, generally terminating in loose to dense sand to silty sand or stiff to hard clayey

silt / clayey silt till soils. Excavation works must be carried out in accordance with the guidelines outlined in the Occupational Health and Safety Act and Regulations for Construction Projects. The existing fill and the weaker portions of the clayey silt or sand/silt soils would be classified as Type 3 soil, according to the OHSA, assuming that proper groundwater control is in place to dewater cohesionless soil deposits prior to excavation, where necessary. Where space permits, temporary open-cut excavations through these materials should be made with side slopes formed no steeper than 1H:1V.

Depending on the construction staging sequence and schedule, temporary roadway protection may be required to facilitate the culvert extension works; if full culvert replacements are adopted, temporary roadway protection is likely to be required. The temporary excavation support systems should be designed and constructed in accordance with MTO's Special Provision 105S19. The lateral movement of the temporary shoring system should meet Performance Level 2 as specified in SP105S19, provided that any adjacent utilities can tolerate this magnitude of deformation.

Where temporary excavation support is required, it is considered that a driven, interlocking sheetpile system would be suitable at the sites of Culverts 1 through 5, based on the subsurface soil and groundwater conditions at these locations, as a sheetpile system would contribute to both ground and groundwater control. A soldier pile and lagging system (using rakers to provide lateral support as necessary) would be suitable for temporary excavation support at the sites of Culverts 6 and 7, where groundwater seepage will be less significant. Soldier pile and lagging systems could also be adopted at the sites of Culverts 1 through 5; however, groundwater control (as discussed in Section 6.12.1) would be critical at these sites to control groundwater seepage and associated loss of soil particles through the lagging boards.

### **6.12.3 Subgrade Protection**

Where clayey or silty soils are exposed at the footing subgrade level, they will be susceptible to disturbance from construction traffic and/or ponded water. To limit this degradation, it is recommended that a working mat of lean concrete or mass concrete be placed on the subgrade within four hours after preparation, inspection and approval of the footing subgrade. Where a box culvert extension or replacement is adopted, a 75 mm thick levelling pad of Granular "A" or fine aggregate (meeting the gradation requirements set out in OPSS 1002) should be provided on top of the concrete mat. Alternatively, for a box culvert extension/replacement, the subgrade can be protected with a Granular "A" pad in lieu of the lean mix concrete/mass concrete working mat.


This requirement can be addressed either with a note on the General Arrangement drawing, or with a Non-Standard Special Provision (NSSP). A sample NSSP to address this requirement is included in Appendix A.

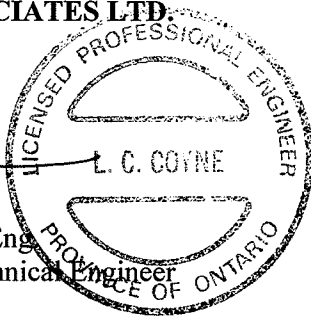



## 7.0 CLOSURE


This Foundation Design Report was prepared by Ms. Karyn Gallant, and reviewed by Ms. Lisa Coyne, P.Eng., an Associate and geotechnical engineer with Golder. Mr. Jorge Costa, a Designated MTO Contact for Golder, conducted an independent quality control review of the report.

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**TABLE 1 – COMPARISON OF CULVERT FOUNDATION ALTERNATIVES  
HIGHWAY 7 WIDENING BETWEEN DRUMMOND LINE AND 150 m EAST OF HIGHWAY 28  
PETERBOROUGH, ONTARIO  
G.W.P. 583-93-00**

| <b>Culvert No.</b> | <b><i>Advantages, Disadvantages, Risks and Consequences</i></b>  |   | <b><i>Preferred Option<br/>(from Foundations Perspective)</i></b> |
|--------------------|--|---|---|
|                    | <b><i>Open Footing</i></b>   | <b><i>Box Culvert</i></b>   |   |
| <b>1</b>           | <p>Advantages:</p> <ul style="list-style-type: none"> <li>Matches existing footing and would satisfy any fisheries requirements, if applicable</li> </ul> <p>Disadvantages:</p> <ul style="list-style-type: none"> <li>Excavation would extend about 2.3 m below groundwater level through fill and firm to hard/loose to dense clayey silt to silt and sand till; dewatering will be required</li> </ul>  | <p>Advantages:</p> <ul style="list-style-type: none"> <li>Minimizes depth of excavation and dewatering requirements compared to open footing option</li> <li>Precast box sections may allow faster construction than cast-in-place open footings, with less dewatering time</li> </ul> <p>Disadvantages:</p> <ul style="list-style-type: none"> <li>Excavation would still extend to about 1.2 m below groundwater level, and groundwater control would still be required</li> <li>Compatibility of a box culvert extension with existing open footing culvert; box culvert may not satisfy fisheries requirements</li> </ul>   | Box Culvert   |
| <b>2</b>           | <p>Advantages:</p> <ul style="list-style-type: none"> <li>Would satisfy any fisheries requirements, if applicable</li> </ul> <p>Disadvantages:</p> <ul style="list-style-type: none"> <li>Existing structure is a box culvert, so excavations for footings for an extension would extend below founding level of existing culvert base slab, with potential for undermining/loss of bedding material from below existing box culvert</li> <li>Excavation would extend about 2.5 m below groundwater level through loose to compact sand and silt, stiff clayey silt till and compact sand and gravel, therefore dewatering will be required</li> </ul> | <p>Advantages:</p> <ul style="list-style-type: none"> <li>Minimizes depth of excavation and dewatering requirements compared to open footing option</li> <li>Precast box sections may allow faster construction than cast-in-place open footings, with less dewatering time</li> <li>For extension option, would minimize potential of undermining existing culvert base slab as compared with open footing option</li> </ul> <p>Disadvantages:</p> <ul style="list-style-type: none"> <li>Excavation would still extend about 1.4 m below the groundwater level through loose to compact sand and silt; therefore, dewatering will still be required</li> </ul>  | Box Culvert   |
| <b>3</b>           | <p>Advantages:</p> <ul style="list-style-type: none"> <li>Matches existing footing and would satisfy any fisheries requirements, if applicable</li> </ul> <p>Disadvantages:</p> <ul style="list-style-type: none"> <li>Excavation would extend 1.7 m below groundwater level through compact sand or stiff clayey silt; dewatering will be required</li> </ul>   | <p>Advantages:</p> <ul style="list-style-type: none"> <li>Minimizes depth of excavation and dewatering requirements compared to open footing option</li> <li>Precast box sections may allow faster construction than cast-in-place open footings, with less dewatering time</li> </ul> <p>Disadvantages:</p> <ul style="list-style-type: none"> <li>Subexcavation required (approximately 0.4 m) due to presence of peat</li> <li>Excavation would still extend about 1 m below groundwater level through compact sand; dewatering will be required</li> <li>Compatibility of a box culvert extension with existing open footing culvert; box culvert may not satisfy fisheries requirements</li> </ul> | Box Culvert   |

**TABLE 1 (Continued) – COMPARISON OF CULVERT FOUNDATION ALTERNATIVES  
HIGHWAY 7 WIDENING BETWEEN DRUMMOND LINE AND 150 m EAST OF HIGHWAY 28  
PETERBOROUGH, ONTARIO  
G.W.P. 583-93-00**

| <i><b>Culvert<br/>No.</b></i> | <i><b>Advantages, Disadvantages, Risks and Consequences</b></i>   |   | <i><b>Preferred Option<br/>(from Foundations Perspective)</b></i> |
|-------------------------------|---|---|---|
|                               | <i><b>Open Footing</b></i>  | <i><b>Box Culvert</b></i>   |   |
| <b>4</b>                      | <p>Advantages:</p> <ul style="list-style-type: none"> <li>Matches existing open footing and would satisfy any fisheries requirements, if applicable</li> </ul> <p>Disadvantages:</p> <ul style="list-style-type: none"> <li>Excavation would extend 1.6 m below groundwater level through compact sand to silty sand; dewatering will be required</li> </ul>  | <p>Advantages:</p> <ul style="list-style-type: none"> <li>Minimizes depth of excavation and dewatering requirements compared to open footing option</li> <li>Precast box sections may allow faster construction than cast-in-place open footings, with less dewatering time</li> </ul> <p>Disadvantages:</p> <ul style="list-style-type: none"> <li>Subexcavation required (approximately 0.3 m) due to presence of organic silty sand</li> <li>Excavation would still extend about 0.8 m below groundwater level through compact sand to silty sand; dewatering will still be required</li> <li>Compatibility of a box culvert extension with existing open footing culvert; box culvert may not satisfy fisheries requirements</li> </ul> | Box Culvert   |
| <b>5</b>                      | <p>Advantages:</p> <ul style="list-style-type: none"> <li>Would satisfy any fisheries requirements, if applicable</li> </ul> <p>Disadvantages:</p> <ul style="list-style-type: none"> <li>Subexcavation required to extend below peat/organic soils; such excavation would extend 2.9 m below groundwater level, and groundwater control will be required</li> </ul>  | <p>Advantages:</p> <ul style="list-style-type: none"> <li>Precast box sections may allow faster construction than cast-in-place open footings, with less dewatering time</li> </ul> <p>Disadvantages:</p> <ul style="list-style-type: none"> <li>Subexcavation of peat/organic soils required with a similar depth of excavation to open footing option</li> <li>Subexcavation would extend about 2.9 m below groundwater level, and dewatering will be required</li> </ul>   | Box Culvert or<br>Open Footing                                    |
| <b>6</b>                      | <p>Advantages:</p> <ul style="list-style-type: none"> <li>Matches existing open footing and would satisfy any fisheries requirements, if applicable</li> </ul> <p>Disadvantages:</p> <ul style="list-style-type: none"> <li>Excavation would extend 1.7 m below groundwater level through soft to very stiff clayey silt and stiff to hard clayey silt till; however, based on presence of cohesive soils, it is anticipated that groundwater control could be handled using properly filtered sumps</li> </ul> | <p>Advantages:</p> <ul style="list-style-type: none"> <li>Minimizes depth of excavation and dewatering requirements compared to open footing option (excavation would extend only about 0.6 m below groundwater level through soft to very stiff clayey silt; therefore, it is anticipated that groundwater control could be handled using properly filtered sumps)</li> <li>Precast box sections may allow faster construction than cast-in-place open footings, with less dewatering time</li> </ul> <p>Disadvantages:</p> <ul style="list-style-type: none"> <li>Compatibility of a box culvert extension with existing open footing culvert; box culvert may not satisfy fisheries requirements</li> </ul>                              | Box Culvert   |

**TABLE 1 (Continued) – COMPARISON OF CULVERT FOUNDATION ALTERNATIVES  
HIGHWAY 7 WIDENING BETWEEN DRUMMOND LINE AND 150 m EAST OF HIGHWAY 28  
PETERBOROUGH, ONTARIO  
G.W.P. 583-93-00**

| <i><b>Culvert<br/>No.</b></i> | <i><b>Advantages, Disadvantages, Risks and Consequences</b></i>  |  | <i><b>Preferred Option<br/>(from Foundations Perspective)</b></i> |
|-------------------------------|--|--|---|
|                               | <i><b>Open Footing</b></i>   | <i><b>Box Culvert</b></i>  |   |
| <b>7</b>                      | <p>Advantages:</p> <ul style="list-style-type: none"> <li>Matches existing open footing and would satisfy any fisheries requirements, if applicable</li> </ul> <p>Disadvantages:</p> <ul style="list-style-type: none"> <li>Excavation would extend 1.5 m below groundwater level through stiff clayey silt and stiff to hard clayey silt till; however, based on presence of cohesive soils, it is anticipated that groundwater control could be handled using properly filtered sumps</li> </ul> | <p>Advantages:</p> <ul style="list-style-type: none"> <li>Minimizes depth of excavation and dewatering requirements compared to open footing option (excavation would extend only about 0.8 m below groundwater level through cohesive soils; therefore, it is anticipated that groundwater control could be handled using properly filtered sumps)</li> <li>Precast box sections may allow faster construction than cast-in-place open footings, with less dewatering time</li> </ul> <p>Disadvantages:</p> <ul style="list-style-type: none"> <li>Subexcavation required (approximately 0.4 m) due to presence of organic silty sand</li> <li>Compatibility of a box culvert extension with existing open footing culvert; box culvert may not satisfy fisheries requirements</li> </ul> | Box Culvert   |

**TABLE 2 – SUMMARY OF FOUNDATION RECOMMENDATIONS FOR CULVERT FOUNDATION ALTERNATIVES  
HIGHWAY 7 WIDENING BETWEEN DRUMMOND LINE AND 150 m EAST OF HIGHWAY 28  
PETERBOROUGH, ONTARIO  
G.W.P. 583-93-00**

| Culvert<br>Number and<br>Location | Open Footing Extension or Replacement |                    |                    |                    |                    | Box Culvert Extension or Replacement |              |                  |                  |
|-----------------------------------|---------------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------------------------|--------------|------------------|------------------|
|                                   | Founding<br>Elevation                 | Footing Width      |                    |                    |                    | Founding<br>Elevation                | Box<br>Width | ULS <sup>1</sup> | SLS <sup>2</sup> |
|                                   |                                       | 0.6 m              |                    | 0.9 m              |                    |                                      |              |                  |                  |
|                                   |                                       | ULS <sup>1</sup>   | SLS <sup>2</sup>   | ULS <sup>1</sup>   | SLS <sup>2</sup>   |                                      |              |                  |                  |
| 1<br>Station 12+402               | 200.2 m                               | 300 kPa            | 250 kPa            | 325 kPa            | 250 kPa            | 201.3 m                              | 1.8 m        | 250 kPa          | 250 kPa          |
| 2<br>Station 13+255               | 202.0 m                               | 200 kPa            | 200 kPa            | 225 kPa            | 200 kPa            | 203.1 m                              | 5.5 m        | 350 kPa          | 250 kPa          |
| 3<br>Station 13+494               | 202.8 m                               | 175 kPa            | 150 kPa            | 200 kPa            | 150 kPa            | 203.5 m*                             | 1.2 m        | 150 kPa          | 150 kPa          |
| 4<br>Station 13+884               | 204.8 m                               | 175 kPa            | 150 kPa            | 200 kPa            | 150 kPa            | 205.6 m*                             | 1.2 m        | 175 kPa          | 150 kPa          |
| 5<br>Station 14+434               | 205.2 m<br>205.8 m**                  | 175 kPa<br>225 kPa | 150 kPa<br>150 kPa | 200 kPa<br>250 kPa | 150 kPa<br>150 kPa | 205.2 m*                             | 4.1 m        | 250 kPa          | 150 kPa          |
| 6<br>Station 15+792               | 224.5 m (north)<br>224.3 m (south)    | 200 kPa            | 175 kPa            | 225 kPa            | 175 kPa            | 225.6 m (north)<br>225.4 m (south)   | 1.2 m        | 150 kPa          | 150 kPa          |
| 7<br>Station 16+129               | 225.3 m (north)<br>225.0 m (south)    | 200 kPa            | 175 kPa            | 225 kPa            | 175 kPa            | 226.4 m (north)<br>225.7 m* (south)  | 1.2 m        | 150 kPa          | 150 kPa          |

Reviewed: L.C. Coyne

**NOTES:**

1. Denotes the factored geotechnical resistance at Ultimate Limit States (ULS), in kPa.
2. Denotes the geotechnical resistance at Serviceability Limit States (SLS), for 25 mm of settlement.
- \* Indicates that subexcavation is required to this elevation (due to the presence of unsuitable soils above this level), followed by placement of compacted Granular A or Granular B Type II to the underside of the box culvert.
- \*\* Founding elevation following subexcavation down to Elevation 205.2 m and placement of a compacted granular pad.

**TABLE 3 – SUMMARY OF FOUNDATION RECOMMENDATIONS FOR RETAINING WALLS  
HIGHWAY 7 WIDENING BETWEEN DRUMMOND LINE AND 150 m EAST OF HIGHWAY 28  
PETERBOROUGH, ONTARIO  
G.W.P. 583-93-00**

| Culvert<br>Number and<br>Location | Estimated<br>Retaining Wall<br>Height | Concrete Retaining Walls on Strip Footing |                    |                    |                    |                    | RSS Walls                          |                     |                  |                  |
|-----------------------------------|---------------------------------------|---|--------------------|--------------------|--------------------|--------------------|------------------------------------|---------------------|------------------|------------------|
|                                   |                                       | Founding<br>Elevation                     | Footing Width      |                    |                    |                    | Founding<br>Elevation              | Reinforced<br>Width | ULS <sup>1</sup> | SLS <sup>2</sup> |
|                                   |                                       |   | 0.6 m              |                    | 0.9 m              |                    |                                    |                     |                  |                  |
|                                   |                                       |   | ULS <sup>1</sup>   | SLS <sup>2</sup>   | ULS <sup>1</sup>   | SLS <sup>2</sup>   |                                    |                     |                  |                  |
| 1<br>Station 12+402               | 1.5 m                                 | 200.2 m                                   | 300 kPa            | 250 kPa            | 325 kPa            | 250 kPa            | 201.6 m                            | 1.2 m               | 100 kPa          | 100 kPa          |
| 2<br>Station 13+255               | 3 m                                   | 202.0 m                                   | 200 kPa            | 200 kPa            | 225 kPa            | 200 kPa            | 203.5 m                            | 2.4 m               | 125 kPa          | 125 kPa          |
| 3<br>Station 13+494               | 3 m                                   | 202.8 m                                   | 175 kPa            | 150 kPa            | 200 kPa            | 150 kPa            | 203.5 m (north)<br>204.5 m (south) | 2.4 m               | 125 kPa          | 125 kPa          |
| 4<br>Station 13+884               | 4.5 m                                 | 204.8 m                                   | 175 kPa            | 150 kPa            | 200 kPa            | 150 kPa            | 206.1 m                            | 3.6 m               | 225 kPa          | 150 kPa          |
| 5<br>Station 14+434               | 3 m                                   | 205.2 m<br>205.8 m**                      | 175 kPa<br>225 kPa | 150 kPa<br>150 kPa | 200 kPa<br>250 kPa | 150 kPa<br>150 kPa | 205.2 m                            | 2.4 m               | 125 kPa          | 125 kPa          |
| 6<br>Station 15+792               | 2 m                                   | 224.5 m (north)<br>224.3 m (south)        | 200 kPa            | 175 kPa            | 225 kPa            | 175 kPa            | 225.9 m                            | 1.6 m               | 125 kPa          | 125 kPa          |
| 7<br>Station 16+129               | 2.5 m                                 | 225.3 m (north)<br>225.0 m (south)        | 200 kPa            | 175 kPa            | 225 kPa            | 175 kPa            | 226.8 m (north)<br>226.0 m (south) | 2.0 m               | 150 kPa          | 150 kPa          |

Reviewed: L.C. Coyne

**NOTES:**

1. Denotes the factored geotechnical resistance at Ultimate Limit States (ULS), in kPa.
2. Denotes the geotechnical resistance at Serviceability Limit States (SLS), for 25 mm of settlement.
- \* Indicates that subexcavation is required to this elevation, due to the presence of unsuitable soils above this level.
- \*\* Founding elevation following subexcavation down to Elevation 205.2 m and placement of a compacted granular pad.

## 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 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   |

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



# LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

## WEATHERING STATE

**Fresh:** no visible sign of weathering.

**Faintly weathered:** weathering limited to the surface of major discontinuities.

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

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

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

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

## BEDDING THICKNESS

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

## JOINT OR FOLIATION SPACING

| Description      | Spacing     |
|------------------|-------------|
| Very wide        | > 3 m       |
| Wide             | 1 - 3 m     |
| Moderately close | 0.3 - 1 m   |
| Close            | 50 - 300 mm |
| Very close       | < 50 mm     |

## GRAIN SIZE

| Term                | Size*             |
|---------------------|-------------------|
| Very Coarse Grained | > 60 mm           |
| Coarse Grained      | 2 - 60 mm         |
| Medium Grained      | 60 microns - 2 mm |
| Fine Grained        | 2 - 60 microns    |
| Very Fine Grained   | < 2 microns       |

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

## CORE CONDITION

### Total Core Recovery

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

### Solid Core Recovery (SCR)

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

### Rock Quality Designation (RQD)

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

## DISCONTINUITY DATA

### Fracture Index

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

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

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

### Description and Notes

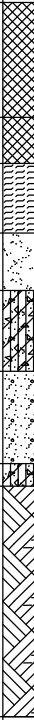
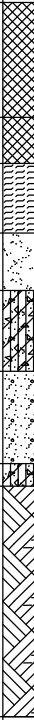
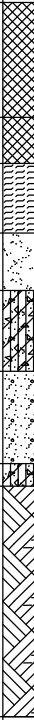
An abbreviated description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information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

### Abbreviations









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

| PROJECT            |  | RECORD OF BOREHOLE |         |         |            | No CU-1                                  |                 | 1 OF 1                                      |  | METRIC |  |  |                                    |                                     |                                   |  |  |                   |
|--------------------|--|--------------------|---------|---------|------------|--|-----------------|---|--|--------|--|--|------------------------------------|-------------------------------------|-----------------------------------|--|--|-------------------|
| W.P. WP 583-93-00  |  | LOCATION           |         |         |            | N 4907852.2 ; E 405300.8                 |                 | ORIGINATED BY GD                            |  |        |  |  |                                    |                                     |                                   |  |  |                   |
| DIST Eastern HWY 7 |  | BOREHOLE TYPE      |         |         |            | Track-Mounted CME-55, Hollow Stem Augers |                 | COMPILED BY NK                              |  |        |  |  |                                    |                                     |                                   |  |  |                   |
| DATUM Geodetic     |  | DATE               |         |         |            | April 2, 2007                            |                 | CHECKED BY LCC                              |  |        |  |  |                                    |                                     |                                   |  |  |                   |
| SOIL PROFILE       |  |                    | SAMPLES |         |            | GROUND WATER<br>CONDITIONS               | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |        |  |  | PLASTIC<br>LIMIT<br>W <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>W | LIQUID<br>LIMIT<br>W <sub>L</sub> | UNIT<br>WEIGHT<br>γ<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br>GR SA SI CL |                   |
| ELEV<br>DEPTH      | DESCRIPTION  | STRAT PLOT         | NUMBER  | TYPE    | "N" VALUES |  |                 | SHEAR STRENGTH kPa                          |  |        |  |  |                                    |                                     |                                   |  |  | WATER CONTENT (%) |
| 202.6<br>0.0       | GROUND SURFACE<br>Sand and gravel, trace to some silt (FILL)<br>Compact<br>Brown<br>Moist to wet   |                    | 1       | SS      | 24         |  | 202             |   |  |        |  |  |                                    |                                     |                                   |  |  | 37 51 10 2        |
|                    |  |                    | 2       | SS      | 13         |  | 201             |   |  |        |  |  |                                    |                                     |                                   |  |  |                   |
|                    |  |                    | 3       | SS      | 12         |  | 200             |   |  |        |  |  |                                    |                                     |                                   |  |  |                   |
| 200.3<br>2.3       | CLAYEY SILT with sand to SILT and SAND, some gravel (TILL)<br>Firm to very stiff<br>Grey<br>Wet  | 4                  | SS      | 13      | 199        |  |                 |   |  |        |  |  |                                    |                                     |                                   |  |  |                   |
|                    |  | 5                  | SS      | 3       | 198        |  |                 |   |  |        |  |  |                                    |                                     |                                   |  |  |                   |
|                    |  | 6                  | SS      | 26/0.23 | 197        |  |                 |   |  |        |  |  |                                    |                                     |                                   |  |  |                   |
| 198.5<br>4.1       | Limestone (BEDROCK) containing shale interbeds<br>Fresh<br>Medium strong<br>Thinly laminated to laminated<br>Light and dark grey   |                    | 1       | RC      | REC 33%    |  | 196             |   |  |        |  |  |                                    |                                     |                                   |  | RQD = 57%  |                   |
|                    |  |                    | 2       | RC      | REC 100%   |  | 195             |   |  |        |  |  |                                    |                                     |                                   |  |  |                   |
|                    |  |                    | 3       | RC      | REC 88%    |  |                 |   |  |        |  |  |                                    |                                     |                                   |  |  |                   |
|                    |  |                    | 4       | RC      | REC 100%   |  |                 |   |  |        |  |  |                                    |                                     |                                   |  |  |                   |
| 195.0<br>7.6       | End of Borehole<br><br>Notes:<br><br>1. Wet soils encountered during drilling at a depth of 1.5 m.<br><br>2. Water level at a depth of 1.5m (Elevation 201.1 m) upon completion of drilling. |                    |         |         |            |  |                 |   |  |        |  |  |                                    |                                     |                                   |  |  |                   |

| PROJECT <u>06-1111-044</u>       |  |            | <b>RECORD OF BOREHOLE No CU-2</b>                             |      |            | 1 OF 1 <b>METRIC</b>                     |                 |   |   |  |  |             |  |   |                                       |  |             |  |           |
|----------------------------------|--|------------|---|------|------------|--|-----------------|---|---|--|--|-------------|--|---|---------------------------------------|--|-------------|--|-----------|
| W.P. <u>WP 583-93-00</u>         |  |            | LOCATION <u>N 4907819.1 ;E 405308.2</u>                       |      |            | ORIGINATED BY <u>GD</u>                  |                 |   |   |  |  |             |  |   |                                       |  |             |  |           |
| DIST <u>Eastern</u> HWY <u>7</u> |  |            | BOREHOLE TYPE <u>Track-Mounted CME-55, Hollow Stem Augers</u> |      |            | COMPILED BY <u>NK</u>                    |                 |   |   |  |  |             |  |   |                                       |  |             |  |           |
| DATUM <u>Geodetic</u>            |  |            | DATE <u>February 27, 2007</u>                                 |      |            | CHECKED BY <u>LCC</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 CONDITIONS                  | ELEVATION SCALE | SHEAR STRENGTH kPa<br>○ UNCONFINED + FIELD VANE<br>● QUICK TRIAXIAL × REMOULDED |   |  | WATER CONTENT (%)<br>W <sub>p</sub> — W — W <sub>L</sub> |             |  | γ |                                       |  | GR SA SI CL |  |           |
| 203.2                            | GROUND SURFACE   |            |   |      |            |  |                 | 20 40 60 80 100   |   |  |  |             |  |   |                                       |  |             |  |           |
| 0.0                              | Silty sand, trace gravel, containing rootlets (FILL)   |            | 1   | SS   | 4          |  | 203             |   |   |  |  |             |  |   |                                       |  |             |  |           |
| 202.4                            | Loose Dark brown Moist   |            | 2   | SS   | 9          |  | 202             |   |   |  |  |             |  |   |                                       |  |             |  |           |
| 201.7                            | Clayey silt, some sand and gravel, containing organics (FILL)  |            | 3   | SS   | 10         |  | 201             |   |   |  |  |             |  |   |                                       |  |             |  |           |
| 1.5                              | Stiff Grey Moist   |            | 4   | SS   | 5          |  | 200             |   |   |  |  |             |  |   |                                       |  |             |  |           |
|                                  | CLAYEY SILT to SILT, some sand, trace gravel (TILL)  |            | 5   | SS   | 16         |  | 199             |   |   |  |  |             |  |   |                                       |  |             |  |           |
|                                  | Firm to hard / Loose to dense Grey Moist to wet  |            | 6   | SS   | 32         |  | 198             |   |   |  |  |             |  |   |                                       |  |             |  |           |
| 198.6                            | Limestone (BEDROCK) containing shale intervals   |            | 1   | RC   | REC 0%     |  | 198             |   |   |  |  |             |  |   |                                       |  |             |  | RQD = 0%  |
| 4.6                              | Fresh Strong Thinly laminated to laminated Light and dark grey   |            | 2   | RC   | REC 52%    |  | 197             |   |   |  |  |             |  |   |                                       |  |             |  | RQD = 27% |
|                                  |  |            | 3   | RC   | REC 87%    |  | 196             |   |   |  |  |             |  |   |                                       |  |             |  | RQD = 43% |
|                                  |  |            | 4   | RC   | REC 93%    |  | 195             |   |   |  |  |             |  |   |                                       |  |             |  | RQD = 42% |
| 194.1                            | End of Borehole  |            |   |      |            |  |                 |   |   |  |  |             |  |   |                                       |  |             |  |           |
| 9.1                              | Notes:<br><br>1. Wet soils encountered during drilling at a depth of 1.5 m.<br><br>2. Water level in piezometer measured at a depth of 0.5 m (Elevation 202.7 m) on April 11, 2007, and at a depth of 0.7 m (Elevation 202.5 m) on June 5, 2007. |            |   |      |            |  |                 |   |   |  |  |             |  |   |                                       |  |             |  |           |

| PROJECT  |   | RECORD OF BOREHOLE   |        |               |            | No CU-3 |  | 1 OF 1 |  | METRIC |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
|--|---|--|--------|---------------|------------|---------|--|--------|--|--------|--|---------------|-------------|------------|--------|------|------------|-------|----------------|--|--|--|--|-----|---|--|---|----|----|--|--|---|----|----|-------|--|--|--|--|-----|---|---|----|----|-------|--|--|--|--|-----|--|---|----|---|-------|---|---|----|----|-----|--|--|--|--|-------|---|---|----|----|-----|--|--|--|--|-------|--|---|----|----|-----|--|--|--|--|-------|--|---|----|--------|-----|--|--|--|--|--|---|---|----|---------|--|--|--|--|--|--|---|---|----|---------|-------|--|--|--|--|-----|-----------------|--|--|--|--------|------|------------|---|----|----|---|----|----|---|----|----|---|----|---|---|----|----|---|----|----|---|----|----|---|----|--------|---|----|---------|---|----|---------|
| W.P.   |   | LOCATION   |        | ORIGINATED BY |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| DIST   |   | BOREHOLE TYPE  |        | COMPILED BY   |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| DATUM  |   | DATE   |        | CHECKED BY    |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 06-1111-044  |   | N 4908253.0 ; E 406056.5   |        | GD            |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| WP 583-93-00   |   | Track-Mounted CME-55, Hollow Stem Augers   |        | NK            |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| Eastern HWY 7  |   | April 2, 2007  |        | LCC           |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| <div style="display: flex; justify-content: space-between;"> <div style="width: 30%;"> <p><b>SOIL PROFILE</b></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>ELEV<br/>DEPTH</th> <th>DESCRIPTION</th> <th>STRAT PLOT</th> <th>NUMBER</th> <th>TYPE</th> <th>"N" VALUES</th> </tr> </thead> <tbody> <tr> <td>206.6</td> <td>GROUND SURFACE</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>0.0</td> <td>Gravelly sand, some silt (FILL)<br/>Dense to compact<br/>Brown<br/>Moist</td> <td rowspan="8"></td> <td>1</td> <td>SS</td> <td>39</td> </tr> <tr> <td></td> <td></td> <td>2</td> <td>SS</td> <td>29</td> </tr> <tr> <td>205.1</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>1.5</td> <td>Clayey silt, some sand and gravel (FILL)<br/>Very stiff<br/>Grey<br/>Moist</td> <td>3</td> <td>SS</td> <td>21</td> </tr> <tr> <td>204.5</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>2.1</td> <td></td> <td>4</td> <td>SS</td> <td>3</td> </tr> <tr> <td>203.6</td> <td>Organic silty SAND<br/>Very loose<br/>Dark brown<br/>Moist</td> <td>5</td> <td>SS</td> <td>15</td> </tr> <tr> <td>3.1</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>202.8</td> <td>SAND, some silt<br/>Compact<br/>Grey<br/>Wet</td> <td>6</td> <td>SS</td> <td>11</td> </tr> <tr> <td>3.8</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>201.7</td> <td>CLAYEY SILT, some sand, containing sand seams (TILL)<br/>Stiff to very stiff<br/>Grey<br/>Wet</td> <td>7</td> <td>SS</td> <td>32</td> </tr> <tr> <td>4.9</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>200.5</td> <td>SAND and GRAVEL, trace silt<br/>Dense<br/>Brown<br/>Wet</td> <td>8</td> <td>SS</td> <td>8/0.15</td> </tr> <tr> <td>6.4</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td>CLAYEY SILT, some sand and gravel (TILL)<br/>Very stiff<br/>Grey<br/>Wet</td> <td>1</td> <td>RC</td> <td>REC 95%</td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td>Limestone (BEDROCK) containing shale interbeds<br/>Fresh<br/>Strong<br/>Thinly laminated to laminated<br/>Light and dark grey</td> <td>2</td> <td>RC</td> <td>REC 95%</td> </tr> <tr> <td>197.2</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>9.5</td> <td>End of Borehole</td> <td></td> <td></td> <td></td> </tr> </tbody> </table> </div> <div style="width: 30%;"> <p><b>SAMPLES</b></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>NUMBER</th> <th>TYPE</th> <th>"N" VALUES</th> </tr> </thead> <tbody> <tr><td>1</td><td>SS</td><td>39</td></tr> <tr><td>2</td><td>SS</td><td>29</td></tr> <tr><td>3</td><td>SS</td><td>21</td></tr> <tr><td>4</td><td>SS</td><td>3</td></tr> <tr><td>5</td><td>SS</td><td>15</td></tr> <tr><td>6</td><td>SS</td><td>11</td></tr> <tr><td>7</td><td>SS</td><td>32</td></tr> <tr><td>8</td><td>SS</td><td>8/0.15</td></tr> <tr><td>1</td><td>RC</td><td>REC 95%</td></tr> <tr><td>2</td><td>RC</td><td>REC 95%</td></tr> </tbody> </table> </div> <div style="width: 30%;"> <p><b>GROUND WATER CONDITIONS</b></p> <p style="text-align: center;">▽</p> </div> <div style="width: 30%;"> <p><b>ELEVATION SCALE</b></p> <p>206<br/>205<br/>204<br/>203<br/>202<br/>201<br/>200<br/>199<br/>198</p> </div> <div style="width: 30%;"> <p><b>DYNAMIC CONE PENETRATION RESISTANCE PLOT</b></p> <p>SHEAR STRENGTH kPa</p> <p>○ UNCONFINED + FIELD VANE<br/>● QUICK TRIAXIAL × REMOULDED</p> <p>20 40 60 80 100</p> </div> <div style="width: 30%;"> <p><b>PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT</b></p> <p>W<sub>p</sub> — W — W<sub>L</sub></p> <p>10 20 30</p> </div> <div style="width: 30%;"> <p><b>UNIT WEIGHT</b></p> <p>γ</p> <p>kN/m<sup>3</sup></p> </div> <div style="width: 30%;"> <p><b>REMARKS &amp; GRAIN SIZE DISTRIBUTION (%)</b></p> <p>GR SA SI CL</p> </div> </div> |   |  |        |               |            |         |  |        |  |        |  | ELEV<br>DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | 206.6 | GROUND SURFACE |  |  |  |  | 0.0 | Gravelly sand, some silt (FILL)<br>Dense to compact<br>Brown<br>Moist |  | 1 | SS | 39 |  |  | 2 | SS | 29 | 205.1 |  |  |  |  | 1.5 | Clayey silt, some sand and gravel (FILL)<br>Very stiff<br>Grey<br>Moist | 3 | SS | 21 | 204.5 |  |  |  |  | 2.1 |  | 4 | SS | 3 | 203.6 | Organic silty SAND<br>Very loose<br>Dark brown<br>Moist | 5 | SS | 15 | 3.1 |  |  |  |  | 202.8 | SAND, some silt<br>Compact<br>Grey<br>Wet | 6 | SS | 11 | 3.8 |  |  |  |  | 201.7 | CLAYEY SILT, some sand, containing sand seams (TILL)<br>Stiff to very stiff<br>Grey<br>Wet | 7 | SS | 32 | 4.9 |  |  |  |  | 200.5 | SAND and GRAVEL, trace silt<br>Dense<br>Brown<br>Wet | 8 | SS | 8/0.15 | 6.4 |  |  |  |  |  | CLAYEY SILT, some sand and gravel (TILL)<br>Very stiff<br>Grey<br>Wet | 1 | RC | REC 95% |  |  |  |  |  |  | Limestone (BEDROCK) containing shale interbeds<br>Fresh<br>Strong<br>Thinly laminated to laminated<br>Light and dark grey | 2 | RC | REC 95% | 197.2 |  |  |  |  | 9.5 | End of Borehole |  |  |  | NUMBER | TYPE | "N" VALUES | 1 | SS | 39 | 2 | SS | 29 | 3 | SS | 21 | 4 | SS | 3 | 5 | SS | 15 | 6 | SS | 11 | 7 | SS | 32 | 8 | SS | 8/0.15 | 1 | RC | REC 95% | 2 | RC | REC 95% |
| ELEV<br>DEPTH  | DESCRIPTION   | STRAT PLOT   | NUMBER | TYPE          | "N" VALUES |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 206.6  | GROUND SURFACE  |  |        |               |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 0.0  | Gravelly sand, some silt (FILL)<br>Dense to compact<br>Brown<br>Moist   |  | 1      | SS            | 39         |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
|  |   |  | 2      | SS            | 29         |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 205.1  |   |  |        |               |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 1.5  | Clayey silt, some sand and gravel (FILL)<br>Very stiff<br>Grey<br>Moist   |  | 3      | SS            | 21         |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 204.5  |   |  |        |               |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 2.1  |   |  | 4      | SS            | 3          |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 203.6  | Organic silty SAND<br>Very loose<br>Dark brown<br>Moist   |  | 5      | SS            | 15         |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 3.1  |   |  |        |               |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 202.8  | SAND, some silt<br>Compact<br>Grey<br>Wet   | 6  | SS     | 11            |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 3.8  |   |  |        |               |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 201.7  | CLAYEY SILT, some sand, containing sand seams (TILL)<br>Stiff to very stiff<br>Grey<br>Wet                                | 7  | SS     | 32            |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 4.9  |   |  |        |               |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 200.5  | SAND and GRAVEL, trace silt<br>Dense<br>Brown<br>Wet  | 8  | SS     | 8/0.15        |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 6.4  |   |  |        |               |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
|  | CLAYEY SILT, some sand and gravel (TILL)<br>Very stiff<br>Grey<br>Wet   | 1  | RC     | REC 95%       |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
|  |   |  |        |               |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
|  | Limestone (BEDROCK) containing shale interbeds<br>Fresh<br>Strong<br>Thinly laminated to laminated<br>Light and dark grey | 2  | RC     | REC 95%       |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 197.2  |   |  |        |               |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 9.5  | End of Borehole   |  |        |               |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| NUMBER   | TYPE  | "N" VALUES   |        |               |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 1  | SS  | 39   |        |               |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 2  | SS  | 29   |        |               |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 3  | SS  | 21   |        |               |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 4  | SS  | 3  |        |               |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 5  | SS  | 15   |        |               |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 6  | SS  | 11   |        |               |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 7  | SS  | 32   |        |               |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 8  | SS  | 8/0.15   |        |               |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 1  | RC  | REC 95%  |        |               |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |
| 2  | RC  | REC 95%  |        |               |            |         |  |        |  |        |  |               |             |            |        |      |            |       |                |  |  |  |  |     |   |  |   |    |    |  |  |   |    |    |       |  |  |  |  |     |   |   |    |    |       |  |  |  |  |     |  |   |    |   |       |   |   |    |    |     |  |  |  |  |       |   |   |    |    |     |  |  |  |  |       |  |   |    |    |     |  |  |  |  |       |  |   |    |        |     |  |  |  |  |  |   |   |    |         |  |  |  |  |  |  |   |   |    |         |       |  |  |  |  |     |                 |  |  |  |        |      |            |   |    |    |   |    |    |   |    |    |   |    |   |   |    |    |   |    |    |   |    |    |   |    |        |   |    |         |   |    |         |

| PROJECT <u>06-1111-044</u>  |   |            |         | <b>RECORD OF BOREHOLE No CU-4</b>                             |             |                            |                 | 1 OF 1 <b>METRIC</b>  |  |  |  |  |                                    |                                     |                                   |   |  |
|---|---|------------|---------|---|-------------|----------------------------|-----------------|---|--|--|--|--|------------------------------------|-------------------------------------|-----------------------------------|---|--|
| W.P. <u>WP 583-93-00</u>  |   |            |         | LOCATION <u>N 4908223.5 ; E 406064.8</u>                      |             |                            |                 | ORIGINATED BY <u>GD</u>   |  |  |  |  |                                    |                                     |                                   |   |  |
| DIST <u>Eastern</u> HWY <u>7</u>  |   |            |         | BOREHOLE TYPE <u>Track-Mounted CME-55, Hollow Stem Augers</u> |             |                            |                 | COMPILED BY <u>NK</u>   |  |  |  |  |                                    |                                     |                                   |   |  |
| DATUM <u>Geodetic</u>   |   |            |         | DATE <u>February 27 to 28, 2007</u>                           |             |                            |                 | CHECKED BY <u>LCC</u>   |  |  |  |  |                                    |                                     |                                   |   |  |
| SOIL PROFILE  |   |            | SAMPLES |   |             | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT   |  |  |  |  | PLASTIC<br>LIMIT<br>W <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>W | LIQUID<br>LIMIT<br>W <sub>L</sub> | UNIT<br>WEIGHT<br>$\gamma$<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br>GR SA SI CL |
| ELEV<br>DEPTH   | DESCRIPTION   | STRAT PLOT | NUMBER  | TYPE  | "N" VALUES  |                            |                 | SHEAR STRENGTH kPa<br>○ UNCONFINED    + FIELD VANE<br>● QUICK TRIAXIAL    × REMOULDED |  |  |  |  |                                    |                                     |                                   |   |  |
| 205.3   | GROUND SURFACE  |            |         |   |             |                            |                 |   |  |  |  |  |                                    |                                     |                                   |   |  |
| 0.0   | SILT, some sand, trace gravel,<br>containing rootlets<br>Loose<br>Brown to grey<br>Moist                                |            | 1       | SS  | 5           |                            |                 |   |  |  |  |  |                                    |                                     |                                   |   |  |
|   |   |            | 2       | SS  | 5           |                            |                 |   |  |  |  |  |                                    |                                     |                                   |   |  |
| 203.8   |   |            |         |   |             |                            |                 |   |  |  |  |  |                                    |                                     |                                   |   |  |
| 1.5   | SAND and SILT<br>Compact<br>Grey<br>Wet   |            | 3       | SS  | 17          |                            |                 |   |  |  |  |  |                                    |                                     |                                   |   | 0 64 32 4  |
| 203.0   |   |            |         |   |             |                            |                 |   |  |  |  |  |                                    |                                     |                                   |   |  |
| 202.6   | CLAYEY SILT, trace to some sand<br>(TILL)<br>Stiff<br>Brown<br>Moist  |            | 4       | SS  | 14          |                            |                 |   |  |  |  |  |                                    |                                     |                                   |   |  |
| 2.7   |   |            | 5       | SS  | 31          |                            |                 |   |  |  |  |  |                                    |                                     |                                   |   |  |
|   | SAND and GRAVEL, trace silt<br>Compact to very dense<br>Brown<br>Wet  |            | 6       | SS  | 74          |                            |                 |   |  |  |  |  |                                    |                                     |                                   |   | 37 47 9 7  |
|   |   |            | 7       | SS  | 22          |                            |                 |   |  |  |  |  |                                    |                                     |                                   |   |  |
| 200.1   |   |            |         |   |             |                            |                 |   |  |  |  |  |                                    |                                     |                                   |   |  |
| 5.2   | Limestone (BEDROCK) containing<br>shale interbeds<br>Fresh<br>Weak to strong<br>Thinly laminated<br>Light and dark grey |            | 1       | RC  | REC<br>96%  |                            |                 |   |  |  |  |  |                                    |                                     |                                   |   | RQD = 54%  |
|   |   |            | 2       | RC  | REC<br>97%  |                            |                 |   |  |  |  |  |                                    |                                     |                                   |   | RQD = 55%  |
|   |   |            |         |   |             |                            |                 |   |  |  |  |  |                                    |                                     |                                   |   |  |
|   |   |            | 3       | RC  | REC<br>100% |                            |                 |   |  |  |  |  |                                    |                                     |                                   |   | RQD = 77%  |
| 196.9   |   |            |         |   |             |                            |                 |   |  |  |  |  |                                    |                                     |                                   |   |  |
| 8.4   | End of Borehole   |            |         |   |             |                            |                 |   |  |  |  |  |                                    |                                     |                                   |   |  |
| Notes:<br>1. Wet soils encountered during drilling at a depth of 0.8 m.<br>2. Water level in piezometer measured at a depth of 0.5m (Elevation 204.8 m) on April 11, 2007, and at a depth of 0.7 m (Elevation 204.6 m) on June 5, 2007. |   |            |         |   |             |                            |                 |   |  |  |  |  |                                    |                                     |                                   |   |  |

| PROJECT <u>06-1111-044</u>       |  | <b>RECORD OF BOREHOLE No CU-5</b>   |         |      |            | 1 OF 1 <b>METRIC</b>       |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
|----------------------------------|--|---|---------|------|------------|----------------------------|--------------------|---|----|----|----|-----|------------------------------------|-------------------------------------|-----------------------------------|---|--|
| W.P. <u>WP 583-93-00</u>         |  | LOCATION <u>N 4908350.3 ; E 406262.5</u>  |         |      |            | ORIGINATED BY <u>PKS</u>   |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
| DIST <u>Eastern</u> HWY <u>7</u> |  | BOREHOLE TYPE <u>Truck-Mounted CME-75, 210 mm O.D. Hollow Stem Augers</u>           |         |      |            | COMPILED BY <u>KG</u>      |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
| DATUM <u>Geodetic</u>            |  | DATE <u>April 9, 2007</u>   |         |      |            | CHECKED BY <u>LCC</u>      |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
| SOIL PROFILE                     |  |   | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION<br>SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |    |     | PLASTIC<br>LIMIT<br>W <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>W | LIQUID<br>LIMIT<br>W <sub>L</sub> | UNIT<br>WEIGHT<br>$\gamma$<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br>GR SA SI CL |
| ELEV<br>DEPTH                    | DESCRIPTION  | STRAT PLOT  | NUMBER  | TYPE | "N" VALUES |                            |                    | SHEAR STRENGTH kPa                          |    |    |    |     |                                    |                                     |                                   |   |  |
| 207.4                            | GROUND SURFACE   |   |         |      |            |                            |                    | 20  | 40 | 60 | 80 | 100 |                                    |                                     |                                   |   |  |
| 0.0                              | Sand and gravel (FILL)<br>Loose to dense<br>Grey-brown<br>Moist  |    | 1       | SS   | 38         |                            |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
|                                  |  |   | 2       | SS   | 28         |                            |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
|                                  |  |   | 3       | SS   | 7          |                            |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
| 205.1                            |  |   |         |      |            |                            |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
| 2.3                              | Silty SAND, trace gravel<br>Loose<br>Grey<br>Moist   |    | 4       | SS   | 4          |                            |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
| 204.3                            |  |   |         |      |            |                            |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
| 3.1                              | PEAT containing layers of organic<br>silty sand<br>Firm  |    | 5       | SS   | 8          |                            |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
| 203.5                            |  |   |         |      |            |                            |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
| 3.9                              | Dark brown<br>Moist  |    | 6       | SS   | 10         |                            |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
| 202.8                            |  |   |         |      |            |                            |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
| 4.6                              | SAND, some silt<br>Compact<br>Grey<br>Wet  |    | 7       | SS   | 14         |                            |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
|                                  |  |   |         |      |            |                            |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
|                                  | CLAYEY SILT, trace sand<br>Stiff<br>Grey<br>Moist  |    |         |      |            |                            |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
| 201.3                            |  |   |         |      |            |                            |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
| 6.1                              | Silty SAND to Sandy SILT, trace<br>clay<br>Loose to compact<br>Grey<br>Wet   |   | 8       | SS   | 8          |                            |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
|                                  |  |   |         |      |            |                            |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
|                                  |  |   | 9       | SS   | 10         |                            |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
|                                  |  |   |         |      |            |                            |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
|                                  |  |   | 10      | SS   | 6          |                            |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
| 197.3                            |  |   |         |      |            |                            |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
| 10.1                             | CLAYEY SILT with sand, some<br>gravel, containing cobbles (TILL)<br>Hard<br>Grey<br>Moist to wet   |  | 11      | SS   | 85         |                            |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
|                                  |  |   |         |      |            |                            |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
| 196                              |  |   |         |      |            |                            |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
| 195.2                            |  |   |         |      |            |                            |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
| 12.2                             | End of Borehole  |   |         |      |            |                            |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |
|                                  | Notes:<br><br>1. Wet soils encountered during<br>drilling at a depth of 3.1 m.<br><br>2. Water level in open borehole at a<br>depth of 7.6 m (Elevation 199.8 m)<br>on completion of drilling. |   |         |      |            |                            |                    |   |    |    |    |     |                                    |                                     |                                   |   |  |

MIS-MTO 001 06-1111-044.GPJ GAL-MISS.GDT 2/18/09 MSM/RJ/SAC

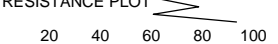
| PROJECT       |  | 06-1111-044   |         | <b>RECORD OF BOREHOLE No CU-6</b> |            | 1 OF 1 <b>METRIC</b>                     |                 |
|---------------|--|---------------|---------|-----------------------------------|------------|--|-----------------|
| W.P.          |  | WP 583-93-00  |         | LOCATION                          |            | N 4908324.5 ; E 406265.7                 |                 |
| DIST          |  | Eastern HWY 7 |         | BOREHOLE TYPE                     |            | Track-Mounted CME-55, Hollow Stem Augers |                 |
| DATUM         |  | Geodetic      |         | DATE                              |            | February 28, 2007                        |                 |
|               |  |               |         |                                   |            | ORIGINATED BY GD                         |                 |
|               |  |               |         |                                   |            | COMPILED BY NK                           |                 |
|               |  |               |         |                                   |            | CHECKED BY LCC                           |                 |
| SOIL PROFILE  |  |               | SAMPLES |                                   |            | DYNAMIC CONE PENETRATION RESISTANCE PLOT |                 |
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT    | NUMBER  | TYPE                              | "N" VALUES | GROUND WATER<br>CONDITIONS               | ELEVATION SCALE |
| 204.7         | GROUND SURFACE   |               |         |                                   |            |  |                 |
| 0.0           | Silty SAND, trace gravel, containing rootlets  |               | 1       | SS                                | 1          |  |                 |
| 203.9         | Very loose Brown Wet   |               | 2       | SS                                | 13         |  |                 |
| 0.8           | SAND, some silt  |               | 3       | SS                                | 12         |  |                 |
| 202.4         | Compact Brown Wet  |               | 4       | SS                                | 7          |  |                 |
| 2.3           | CLAYEY SILT, trace sand  |               | 5       | SS                                | 7          |  |                 |
|               | Firm to stiff Grey Wet   |               | 6       | SS                                | 13         |  |                 |
| 200.1         | Silty SAND, trace gravel   |               | 7       | SS                                | 10         |  |                 |
| 4.6           | Compact Grey Wet   |               | 8       | SS                                | 13         |  |                 |
| 197.1         | CLAYEY SILT, some sand, trace gravel (TILL)  |               | 9       | SS                                | 53         |  |                 |
| 7.6           | Hard Grey Moist  |               | 10      | SS                                | 96/0.23    |  |                 |
| 195.2         | End of Borehole  |               |         |                                   |            |  |                 |
| 9.5           | Notes:<br><br>1. Wet soils encountered immediately below ground surface during drilling.<br><br>2. Water level in piezometer was frozen at ground surface on April 11, 2007, and was measured at a depth of 0.2 m (Elevation 204.5 m) on June 5, 2007. |               |         |                                   |            |  |                 |

|                            |  |   |  |                          |  |
|----------------------------|--|---|--|--------------------------|--|
| <b>PROJECT</b> 06-1111-044 |  | <b>RECORD OF BOREHOLE No CU-7</b>   |  | 1 OF 1 <b>METRIC</b>     |  |
| <b>W.P.</b> WP 583-93-00   |  | <b>LOCATION</b> N 4908513.9 ; E 406618.4                                  |  | <b>ORIGINATED BY</b> PKS |  |
| <b>DIST</b> Eastern HWY 7  |  | <b>BOREHOLE TYPE</b> Truck-Mounted CME-75, 210 mm O.D. Hollow Stem Augers |  | <b>COMPILED BY</b> KG    |  |
| <b>DATUM</b> Geodetic      |  | <b>DATE</b> April 10, 2007  |  | <b>CHECKED BY</b> LCC    |  |

| SOIL PROFILE  |   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT               |  |  |  |  | PLASTIC LIMIT NATURAL<br>MOISTURE CONTENT LIQUID<br>LIMIT |  |  | UNIT<br>WEIGHT<br><br>$\gamma$<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br>GR SA SI CL |
|---------------|---|------------|---------|------|------------|----------------------------|-----------------|---|--|--|--|--|---|--|--|---|--|
| ELEV<br>DEPTH | DESCRIPTION   | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa  |  |  |  |  | WATER CONTENT (%)   |  |  |   |  |
|               |   |            |         |      |            |                            |                 | 20 40 60 80 100   |  |  |  |  | W <sub>p</sub> W W <sub>L</sub>                           |  |  |   |  |
|               |   |            |         |      |            |                            |                 | ○ UNCONFINED + FIELD VANE<br>● QUICK TRIAXIAL × REMOULDED |  |  |  |  |   |  |  |   |  |
| 210.9         | GROUND SURFACE  |            |         |      |            |                            |                 |   |  |  |  |  |   |  |  |   |  |
| 0.0           | Sand and gravel (FILL)<br>Dense to very dense<br>Grey-brown<br>Moist  |            | 1       | SS   | 45         | $\nabla$                   | 210             |   |  |  |  |  |   |  |  |   |  |
|               |   |            | 2       | SS   | 62         |                            | 209             |   |  |  |  |  |   |  |  |   |  |
| 209.4         |   |            |         |      |            |                            | 208             |   |  |  |  |  |   |  |  |   |  |
| 1.5           | Clayey silt, some sand and gravel (FILL)<br>Very stiff<br>Grey-brown<br>Moist   |            | 3       | SS   | 15         |                            | 207             |   |  |  |  |  |   |  |  |   |  |
| 208.8         |   |            | 4       | SS   | 4          |                            | 206             |   |  |  |  |  |   |  |  |   |  |
| 2.1           | Silty sand, trace gravel, containing organics and wood fragments (FILL)<br>Loose<br>Brown<br>Moist to wet   |            | 5       | SS   | 8          |                            | 205             |   |  |  |  |  |   |  |  |   |  |
|               |   |            | 6       | SS   | 4          |                            | 204             |   |  |  |  |  |   |  |  |   |  |
| 206.3         |   |            |         |      |            |                            | 203             |   |  |  |  |  |   |  |  |   |  |
|               | PEAT  |            | 7       | SS   | 10         |                            | 202             |   |  |  |  |  |   |  |  |   |  |
| 4.8           | SAND, trace to some silt<br>Compact<br>Brown<br>Wet   |            | 8       | SS   | 5*         |                            | 201             |   |  |  |  |  |   |  |  |   |  |
|               |   |            |         |      |            |                            | 200             |   |  |  |  |  |   |  |  |   |  |
|               |   |            | 9       | SS   | 13         |                            | 199             |   |  |  |  |  |   |  |  |   |  |
|               |   |            |         |      |            |                            | 198             |   |  |  |  |  |   |  |  |   |  |
|               |   |            | 10      | SS   | 13         |                            |                 |   |  |  |  |  |   |  |  |   |  |
| 200.2         |   |            |         |      |            |                            |                 |   |  |  |  |  |   |  |  |   |  |
| 10.7          | CLAYEY SILT, some sand and gravel (TILL)<br>Hard<br>Brown<br>Moist to wet   |            | 11      | SS   | 44         |                            |                 |   |  |  |  |  |   |  |  |   |  |
| 199.6         |   |            |         |      |            |                            |                 |   |  |  |  |  |   |  |  |   |  |
| 11.3          | SAND and GRAVEL, trace silt<br>Very dense<br>Brown<br>Wet   |            | 12      | SS   | 90/0.23    |                            |                 |   |  |  |  |  |   |  |  |   |  |
|               |   |            |         |      |            |                            |                 |   |  |  |  |  |   |  |  |   |  |
| 197.1         |   |            |         |      |            |                            |                 |   |  |  |  |  |   |  |  |   |  |
| 13.8          | End of Borehole   |            | 13      | SS   | 80/0.06    |                            |                 |   |  |  |  |  |   |  |  |   |  |
|               | Notes:<br><br>1. Wet soils encountered during drilling at a depth of 3.8 m.<br><br>2. Water level in open borehole at a depth of 6.0 m (Elevation 204.9 m) upon completion of drilling.<br><br>3. "Low SPT "N" value is the result of sample disturbance due to groundwater inflow to the borehole. |            |         |      |            |                            |                 |   |  |  |  |  |   |  |  |   |  |

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| PROJECT <u>06-1111-044</u>   |   |            | <b>RECORD OF BOREHOLE No CU-8</b>                             |      |            | 1 OF 1 <b>METRIC</b>    |   |  |           |
|--|---|------------|---|------|------------|-------------------------|---|--|-----------|
| W.P. <u>WP 583-93-00</u>   |   |            | LOCATION <u>N 4908487.7 ; E 406637.3</u>                      |      |            | ORIGINATED BY <u>GD</u> |   |  |           |
| DIST <u>Eastern</u> HWY <u>7</u>   |   |            | BOREHOLE TYPE <u>Track-Mounted CME-55, Hollow Stem Augers</u> |      |            | COMPILED BY <u>NK</u>   |   |  |           |
| DATUM <u>Geodetic</u>  |   |            | DATE <u>February 28 to March 1, 2007</u>                      |      |            | CHECKED BY <u>LCC</u>   |   |  |           |
| SOIL PROFILE   |   |            | SAMPLES   |      |            | GROUND WATER CONDITIONS |   |  |           |
| ELEV<br>DEPTH  | DESCRIPTION   | STRAT PLOT | NUMBER  | TYPE | "N" VALUES | ELEVATION SCALE         | DYNAMIC CONE PENETRATION RESISTANCE PLOT<br><br>SHEAR STRENGTH kPa<br>○ UNCONFINED + FIELD VANE<br>● QUICK TRIAXIAL × REMOULDED |  |           |
|  |   |            |   |      |            |                         | PLASTIC LIMIT $W_p$ NATURAL MOISTURE CONTENT $W$ LIQUID LIMIT $W_L$<br>WATER CONTENT (%)  |  |           |
|  |   |            |   |      |            |                         | UNIT WEIGHT $\gamma$<br>kN/m <sup>3</sup>   |  |           |
|  |   |            |   |      |            |                         | REMARKS & GRAIN SIZE DISTRIBUTION (%)<br>GR SA SI CL  |  |           |
| 206.6  | GROUND SURFACE  |            |   |      |            |                         |   |  |           |
| 0.0  | Silty SAND, some clay, containing rootlets and organics |            | 1   | SS   | 2          |                         |   |  |           |
| 205.8  | Very loose  |            | 2   | SS   | 19         |                         |   |  | 2 74 20 4 |
| 0.8  | Dark brown to brown Moist                               |            | 3   | SS   | 15         |                         |   |  |           |
|  | Silty SAND to SAND, trace silt, trace gravel            |            | 4   | SS   | 5*         |                         |   |  |           |
|  | Compact to dense  |            | 5   | SS   | 2*         |                         |   |  |           |
|  | Brown to grey   |            | 6   | SS   | 11         |                         |   |  | 0 96 4 2  |
|  | Wet   |            | 7   | SS   | 26         |                         |   |  |           |
|  |   |            | 8   | SS   | 13         |                         |   |  |           |
|  |   |            | 9   | SS   | 34         |                         |   |  |           |
| 197.5  | CLAYEY SILT, some sand and gravel (TILL)                |            | 10  | SS   | 68/0.15    |                         |   |  |           |
| 9.4  | Hard Grey Moist   |            |   |      |            |                         |   |  |           |
|  | End of Borehole   |            |   |      |            |                         |   |  |           |
| Notes:<br>1. Wet soils encountered during drilling at a depth of 0.8 m.<br>2. Water level in piezometer at a depth of 0.2 m (Elevation 206.4 m) on April 11, 2007, and June 5, 2007.<br>3. *Low SPT "N" values are the result of sample disturbance due to groundwater inflow to borehole. |   |            |   |      |            |                         |   |  |           |

|                            |  |   |  |                         |  |
|----------------------------|--|---|--|-------------------------|--|
| <b>PROJECT</b> 06-1111-044 |  | <b>RECORD OF BOREHOLE No CU-9</b>   |  | 1 OF 1 <b>METRIC</b>    |  |
| <b>W.P.</b> WP 583-93-00   |  | <b>LOCATION</b> N 4908742.9 ; E 407118.5                                  |  | <b>ORIGINATED BY</b> GD |  |
| <b>DIST</b> Eastern HWY 7  |  | <b>BOREHOLE TYPE</b> Truck-Mounted CME-75, 210 mm O.D. Hollow Stem Augers |  | <b>COMPILED BY</b> NK   |  |
| <b>DATUM</b> Geodetic      |  | <b>DATE</b> April 5, 2007   |  | <b>CHECKED BY</b> LCC   |  |

| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |    | PLASTIC LIMIT NATURAL MOISTURE LIQUID LIMIT |                |   | UNIT<br>WEIGHT<br><br>$\gamma$<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br>GR SA SI CL |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|---|----|----|----|---|----------------|---|---|--|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa                          |    |    |    | WATER CONTENT (%)                           |                |   |   |  |
|               |  |            |         |      |            |                            |                 | 20  | 40 | 60 | 80 | 100   | W <sub>p</sub> | W |   |  |
| 209.9         | GROUND SURFACE   |            |         |      |            |                            |                 |   |    |    |    |   |                |   |   |  |
| 0.0           | Sand and gravel (FILL)<br>Compact<br>Brown<br>Moist  |            | 1       | SS   | 17         |                            | 209             |   |    |    |    |   |                |   | 1 11 62 26  |  |
|               |  |            | 2       | SS   | 20         |                            | 209             |   |    |    |    |   |                |   |   |  |
| 208.4         |  |            |         |      |            |                            | 208             |   |    |    |    |   |                |   |   |  |
| 1.5           | Clayey silt, trace to some sand (FILL)<br>Firm<br>Brown  |            | 3       | SS   | 8          |                            | 208             |   |    |    |    |   |                |   |   |  |
| 207.6         |  |            |         |      |            |                            | 207             |   |    |    |    |   |                |   |   |  |
| 2.3           | Moist<br>Clayey silt, some sand and gravel,<br>containing tree roots (FILL)<br>Stiff to very stiff<br>Brown  |            | 4       | SS   | 28         |                            | 207             |   |    |    |    |   |                |   |   |  |
|               |  |            | 5       | SS   | 14         |                            | 207             |   |    |    |    |   |                |   |   |  |
| 206.1         |  |            |         |      |            |                            | 206             |   |    |    |    |   |                |   |   |  |
| 3.8           | PEAT containing organic clayey silt<br>layers<br>Firm  |            | 6       | SS   | 7          |                            | 206             |   |    |    |    |   |                |   |   |  |
| 205.3         |  |            |         |      |            |                            | 205             |   |    |    |    |   |                |   |   |  |
| 4.6           | Brown/light brown<br>Wet<br>SAND, trace gravel and silt<br>Compact<br>Grey<br>Wet  |            | 7       | SS   | 12         |                            | 205             |   |    |    |    |   |                |   |   |  |
|               |  |            |         |      |            |                            | 204             |   |    |    |    |   |                |   |   |  |
|               |  |            | 8       | SS   | 7*         |                            | 204             |   |    |    |    |   |                |   |   |  |
|               |  |            |         |      |            |                            | 203             |   |    |    |    |   |                |   |   |  |
|               |  |            | 9       | SS   | 15         | 203                        |                 |   |    |    |    |   |                |   |   |  |
|               |  |            |         |      |            | 202                        |                 |   |    |    |    |   |                |   |   |  |
|               |  |            |         |      |            | 201                        |                 |   |    |    |    |   |                |   |   |  |
|               |  |            | 10      | SS   | 20         | 201                        |                 |   |    |    |    |   |                |   |   |  |
|               |  |            |         |      |            | 200                        |                 |   |    |    |    |   |                |   |   |  |
|               |  |            |         |      |            | 199                        |                 |   |    |    |    |   |                |   |   |  |
| 199.2         |  |            |         |      |            | 199                        |                 |   |    |    |    |   |                |   |   |  |
| 10.7          | CLAYEY SILT<br>Stiff<br>Grey<br>Wet  |            | 11      | SS   | 10         | 199                        |                 |   |    |    |    |   |                |   |   |  |
| 198.3         |  |            |         |      |            | 198                        |                 |   |    |    |    |   |                |   |   |  |
| 11.6          | Silty SAND<br>Compact<br>Grey<br>Wet   |            | 12      | SS   | 13         | 198                        |                 |   |    |    |    |   |                |   |   |  |
|               |  |            |         |      |            | 197                        |                 |   |    |    |    |   |                |   |   |  |
|               |  |            | 13      | SS   | 14         | 197                        |                 |   |    |    |    |   |                |   |   |  |
|               |  |            |         |      |            | 196                        |                 |   |    |    |    |   |                |   |   |  |
|               |  |            |         |      |            | 195                        |                 |   |    |    |    |   |                |   |   |  |
| 194.1         |  |            | 14      | SS   | 20         | 195                        |                 |   |    |    |    |   |                |   |   |  |
| 15.8          | End of Borehole  |            |         |      |            |                            |                 |   |    |    |    |   |                |   |   |  |
|               | Notes:<br><br>1. Wet soils encountered during drilling at a depth of 2.3 m.<br><br>2. Water level measured in open borehole at a depth of 3.6 m (Elevation 206.3 m) on completion of drilling.<br><br>3. *Low SPT "N" value is the result of sample disturbance due to groundwater inflow to the borehole. |            |         |      |            |                            |                 |   |    |    |    |   |                |   |   |  |

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| PROJECT 06-1111-044  |   | RECORD OF BOREHOLE No CU-10A                                       |         |      |            | 1 OF 1 METRIC           |                 |  |  |                                 |                               |                                |                  |                                       |
|--|---|--|---------|------|------------|-------------------------|-----------------|--|--|---------------------------------|-------------------------------|--------------------------------|------------------|---------------------------------------|
| W.P. WP 583-93-00  |   | LOCATION N 4908733.9 ; E 407129.3                                  |         |      |            | ORIGINATED BY PKS       |                 |  |  |                                 |                               |                                |                  |                                       |
| DIST Eastern HWY 7   |   | BOREHOLE TYPE Truck-Mounted CME-75, 210 mm O.D. Hollow Stem Augers |         |      |            | COMPILED BY KG          |                 |  |  |                                 |                               |                                |                  |                                       |
| DATUM Geodetic   |   | DATE April 9, 2007   |         |      |            | CHECKED BY LCC          |                 |  |  |                                 |                               |                                |                  |                                       |
| 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<br>DEPTH  | DESCRIPTION   | STRAT PLOT   | NUMBER  | TYPE | "N" VALUES |                         |                 | SHEAR STRENGTH kPa                       |  |                                 |                               |                                |                  |                                       |
| 209.7  | GROUND SURFACE  |  |         |      |            |                         |                 |  |  |                                 |                               |                                |                  |                                       |
| 0.9  | TOPSOIL   |  | 1       | SS   | 16         |                         |                 |  |  |                                 |                               |                                |                  |                                       |
|  | Sand and gravel, some silt to silty sand, some gravel (FILL)<br>Compact to loose<br>Grey-brown<br>Moist |  | 2       | SS   | 8          |                         |                 |  |  |                                 |                               |                                |                  | 20 46 24 10                           |
| 208.2  |   |  |         |      |            |                         |                 |  |  |                                 |                               |                                |                  |                                       |
| 1.5  | Silty sand, some gravel, trace clay, containing rootlets (FILL)<br>Loose<br>Brown<br>Moist              |  | 3       | SS   | 6          |                         |                 |  |  |                                 |                               |                                |                  |                                       |
|  |   |  | 4       | SS   | 4          |                         |                 |  |  |                                 |                               |                                |                  |                                       |
| 206.7  |   |  |         |      |            |                         |                 |  |  |                                 |                               |                                |                  |                                       |
| 3.1  | CLAYEY SILT, containing shells<br>Firm<br>Light grey to grey<br>Moist                                   |  | 5       | SS   | 2          |                         |                 |  |  |                                 |                               |                                |                  |                                       |
|  |   |  | 6       | SS   | 5          |                         |                 |  |  |                                 |                               |                                |                  |                                       |
| 205.1  |   |  |         |      |            |                         |                 |  |  |                                 |                               |                                |                  |                                       |
| 4.6  | Silty SAND to Sandy SILT<br>Loose to compact<br>Brown to grey<br>Wet                                    |  | 7       | SS   | 7          |                         |                 |  |  |                                 |                               |                                |                  |                                       |
|  |   |  | 8       | SS   | 5*         |                         |                 |  |  |                                 |                               |                                |                  |                                       |
|  |   |  |         |      |            |                         |                 |  |  |                                 |                               |                                |                  |                                       |
|  |   |  | 9       | SS   | 13         |                         |                 |  |  |                                 |                               |                                |                  | 8 84 5 3                              |
|  |   |  | 10      | SS   | 20         |                         |                 |  |  |                                 |                               |                                |                  |                                       |
| 199.0  |   |  |         |      |            |                         |                 |  |  |                                 |                               |                                |                  |                                       |
| 10.7   | CLAYEY SILT, trace to some sand, trace gravel, containing sand seams<br>Stiff<br>Grey<br>Moist to wet   |  | 11      | SS   | 14         |                         |                 |  |  |                                 |                               |                                |                  |                                       |
|  |   |  | 12      | SS   | 13         |                         |                 |  |  |                                 |                               |                                |                  |                                       |
| 196.9  |   |  |         |      |            |                         |                 |  |  |                                 |                               |                                |                  |                                       |
| 12.8   | End of Borehole   |  |         |      |            |                         |                 |  |  |                                 |                               |                                |                  |                                       |
| Notes:<br>1. Wet soils encountered during drilling at a depth of 4.1 m.<br>2. Water level in piezometer measured at a depth of 1.5 m (Elevation 208.2 m) on April 11, 2007, June 5, 2007, and September 8, 2008.<br>3. "Low SPT "N" value is the result of sample disturbance due to groundwater inflow to the borehole. |   |  |         |      |            |                         |                 |  |  |                                 |                               |                                |                  |                                       |

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| PROJECT <u>06-1111-044</u>  |  | <b>RECORD OF BOREHOLE No CU-10B</b>   |         |      |            | 1 OF 1 <b>METRIC</b>       |                 |   |  |  |  |                                    |                                     |                                   |   |  |
|---|--|---|---------|------|------------|----------------------------|-----------------|---|--|--|--|------------------------------------|-------------------------------------|-----------------------------------|---|--|
| W.P. <u>WP 583-93-00</u>  |  | LOCATION <u>N 4908723.8 ; E 407119.7</u>  |         |      |            | ORIGINATED BY <u>PKS</u>   |                 |   |  |  |  |                                    |                                     |                                   |   |  |
| DIST <u>Eastern</u> HWY <u>7</u>  |  | BOREHOLE TYPE <u>Portable Drilling Equipment, Continuous 50 mm O.D. Split-Spoon Sampler</u> |         |      |            | COMPILED BY <u>KG</u>      |                 |   |  |  |  |                                    |                                     |                                   |   |  |
| DATUM <u>Geodetic</u>   |  | DATE <u>April 11, 2007</u>  |         |      |            | CHECKED BY <u>LCC</u>      |                 |   |  |  |  |                                    |                                     |                                   |   |  |
| SOIL PROFILE  |  |   | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |  |  | PLASTIC<br>LIMIT<br>W <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>W | LIQUID<br>LIMIT<br>W <sub>L</sub> | UNIT<br>WEIGHT<br>$\gamma$<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br>GR SA SI CL |
| ELEV<br>DEPTH   | DESCRIPTION  | STRAT PLOT  | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa                          |  |  |  |                                    |                                     |                                   |   |  |
| 208.1   | GROUND SURFACE   |   |         |      |            |                            |                 |   |  |  |  |                                    |                                     |                                   |   |  |
| 0.0   | PEAT   |   |         |      |            |                            |                 |   |  |  |  |                                    |                                     |                                   |   |  |
| 0.2   | CLAYEY SILT, some sand and<br>gravel, trace organics<br>Firm<br>Grey-brown<br>Moist to wet |   | 1       | SS   | 1          |                            |                 |   |  |  |  |                                    |                                     |                                   |   |  |
|   |  |   | 2       | SS   | 5          |                            |                 |   |  |  |  |                                    |                                     |                                   |   |  |
|   |  |   | 3       | SS   | 5          |                            |                 |   |  |  |  |                                    |                                     |                                   |   |  |
|   |  |   | 4       | SS   | 3          |                            |                 |   |  |  |  |                                    |                                     |                                   |   |  |
| 205.1   |  |   | 5       | SS   | 6          |                            |                 |   |  |  |  |                                    |                                     |                                   |   |  |
| 3.1   | CLAYEY SILT, trace sand,<br>containing shells in sample 6<br>Firm to stiff<br>Grey<br>Wet  |   | 6       | SS   | 3          |                            |                 |   |  |  |  |                                    |                                     |                                   |   |  |
|   |  |   | 7       | SS   | 10         |                            |                 |   |  |  |  |                                    |                                     |                                   |   |  |
| 203.2   |  |   | 8       | SS   | 7          |                            |                 |   |  |  |  |                                    |                                     |                                   |   |  |
| 4.9   | End of Borehole  |   |         |      |            |                            |                 |   |  |  |  |                                    |                                     |                                   |   |  |
| Notes:<br>1. Borehole advanced using portable drilling equipment with a half-weight hammer. SPT "N" values shown on this borehole record have been adjusted to reflect values that would be obtained using a standard-weight hammer.<br>2. Water level in open borehole at a depth of 0.1m (Elevation 208.0 m) on completion of drilling. |  |   |         |      |            |                            |                 |   |  |  |  |                                    |                                     |                                   |   |  |

| PROJECT <u>06-1111-044</u>  |  |            |         | <b>RECORD OF BOREHOLE No CU-11A</b>      |            |                            |                 | 1 OF 1 <b>METRIC</b>                        |    |    |    |     |                                    |                                     |                                   |   |  |
|---|--|------------|---------|--|------------|----------------------------|-----------------|---|----|----|----|-----|------------------------------------|-------------------------------------|-----------------------------------|---|--|
| W.P. <u>WP 583-93-00</u>  |  |            |         | LOCATION <u>N 4909175.1 ; E 408392.6</u> |            |                            |                 | ORIGINATED BY <u>PKS</u>                    |    |    |    |     |                                    |                                     |                                   |   |  |
| DIST <u>Eastern</u> HWY <u>7</u>  |  |            |         | BOREHOLE TYPE <u>Hand Dug</u>            |            |                            |                 | COMPILED BY <u>PKS</u>                      |    |    |    |     |                                    |                                     |                                   |   |  |
| DATUM <u>Geodetic</u>   |  |            |         | DATE <u>April 4, 2007</u>                |            |                            |                 | CHECKED BY <u>LCC</u>                       |    |    |    |     |                                    |                                     |                                   |   |  |
| SOIL PROFILE  |  |            | SAMPLES |  |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |    |     | PLASTIC<br>LIMIT<br>W <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>W | LIQUID<br>LIMIT<br>W <sub>L</sub> | UNIT<br>WEIGHT<br>$\gamma$<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br>GR SA SI CL |
| ELEV<br>DEPTH   | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE                                     | "N" VALUES |                            |                 | SHEAR STRENGTH kPa                          |    |    |    |     |                                    |                                     |                                   |   |  |
| 226.7   | GROUND SURFACE   |            |         |  |            |                            |                 | 20  | 40 | 60 | 80 | 100 |                                    |                                     |                                   |   |  |
| 0.0   | Organic silty SAND                                     |            |         |  |            |                            |                 |   |    |    |    |     |                                    |                                     |                                   |   |  |
| 226.2   | Loose<br>Black/brown<br>Wet                            |            |         |  |            |                            |                 |   |    |    |    |     |                                    |                                     |                                   |   |  |
| 0.6   | Silty SAND<br>Loose<br>Brown<br>Wet<br>End of Borehole |            |         |  |            |                            | 226             |   |    |    |    |     |                                    |                                     |                                   |   |  |
| <p>Note:</p> <p>Water level in hand dug hole at ground surface (Elevation 226.7 m) upon completion of excavation.</p> |  |            |         |  |            |                            |                 |   |    |    |    |     |                                    |                                     |                                   |   |  |







| PROJECT 06-1111-044 |   | RECORD OF BOREHOLE No CU-11B                                       |         |      |            | 1 OF 1 METRIC           |                 |  |                 |                                 |                               |                                |                  |                                       |
|---------------------|---|--|---------|------|------------|-------------------------|-----------------|--|-----------------|---------------------------------|-------------------------------|--------------------------------|------------------|---------------------------------------|
| W.P. WP 583-93-00   |   | LOCATION N 4909167.6 ; E 408392.6                                  |         |      |            | ORIGINATED BY PKS       |                 |  |                 |                                 |                               |                                |                  |                                       |
| DIST Eastern HWY 7  |   | BOREHOLE TYPE Truck-Mounted CME-75, 210 mm O.D. Hollow Stem Augers |         |      |            | COMPILED BY NK          |                 |  |                 |                                 |                               |                                |                  |                                       |
| DATUM Geodetic      |   | DATE April 4, 2007   |         |      |            | CHECKED BY LCC          |                 |  |                 |                                 |                               |                                |                  |                                       |
| 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<br>DEPTH       | DESCRIPTION   | STRAT PLOT   | NUMBER  | TYPE | "N" VALUES |                         |                 | SHEAR STRENGTH kPa                       |                 |                                 |                               |                                |                  |                                       |
| 228.6               | GROUND SURFACE  |  |         |      |            |                         |                 | 20 40 60 80 100                          | 20 40 60 80 100 | 10 20 30                        |                               |                                |                  |                                       |
| 0.0                 | Gravelly sand, some silt (FILL)<br>Compact<br>Brown<br>Moist  |  | 1       | SS   | 14         |                         |                 |  |                 |                                 |                               |                                |                  |                                       |
| 227.1               |   |  | 2       | SS   | 27         |                         |                 |  |                 |                                 | o                             |                                |                  | 27 47 19 7                            |
| 1.5                 | Clayey silt, some sand, trace gravel, containing organics and rootlets (FILL)   |  | 3       | SS   | 5          |                         |                 |  |                 |                                 |                               |                                |                  |                                       |
| 226.3               | Firm  |  |         |      |            |                         |                 |  |                 |                                 |                               |                                |                  |                                       |
| 2.3                 | Brown   |  | 4       | SS   | 2          |                         |                 |  |                 |                                 | o                             |                                |                  |                                       |
| 225.6               | Moist to wet  |  |         |      |            |                         |                 |  |                 |                                 |                               |                                |                  |                                       |
| 3.0                 | CLAYEY SILT containing silty sand seams   |  | 5       | SS   | 13         |                         |                 |  |                 |                                 |                               |                                |                  |                                       |
| 224.8               | Soft  |  |         |      |            |                         |                 |  |                 |                                 |                               |                                |                  |                                       |
| 3.8                 | Black/Grey  |  | 6       | SS   | 9          |                         |                 |  |                 |                                 | o                             |                                |                  | 15 39 32 14                           |
|                     | Wet   |  |         |      |            |                         |                 |  |                 |                                 |                               |                                |                  |                                       |
|                     | CLAYEY SILT, trace sand   |  | 7       | SS   | 26         |                         |                 |  |                 |                                 |                               |                                |                  |                                       |
|                     | Stiff   |  |         |      |            |                         |                 |  |                 |                                 |                               |                                |                  |                                       |
|                     | Brown   |  |         |      |            |                         |                 |  |                 |                                 |                               |                                |                  |                                       |
|                     | Wet   |  |         |      |            |                         |                 |  |                 |                                 |                               |                                |                  |                                       |
|                     | CLAYEY SILT with sand, some gravel, containing cobbles (TILL)   |  | 8       | SS   | 27         |                         |                 |  |                 |                                 |                               |                                |                  |                                       |
|                     | Stiff to hard   |  |         |      |            |                         |                 |  |                 |                                 |                               |                                |                  |                                       |
|                     | Brown becoming grey below 6.1 m depth   |  |         |      |            |                         |                 |  |                 |                                 |                               |                                |                  |                                       |
|                     | Moist   |  | 9       | SS   | 27         |                         |                 |  |                 |                                 | o                             |                                |                  |                                       |
|                     |   |  |         |      |            |                         |                 |  |                 |                                 |                               |                                |                  |                                       |
|                     |   |  | 10      | SS   | 39         |                         |                 |  |                 |                                 |                               |                                |                  |                                       |
|                     |   |  |         |      |            |                         |                 |  |                 |                                 |                               |                                |                  |                                       |
|                     |   |  |         |      |            |                         |                 |  |                 |                                 |                               |                                |                  |                                       |
|                     |   |  | 11      | SS   | 100        |                         |                 |  |                 |                                 |                               |                                |                  |                                       |
| 217.5               | End of Borehole   |  |         |      |            |                         |                 |  |                 |                                 |                               |                                |                  |                                       |
| 11.1                | Notes:<br><br>1. Wet soils encountered during drilling at a depth of 2.3 m.<br><br>2. Water level in open borehole at a depth of 3.0 m (Elevation 225.6 m) upon completion of drilling. |  |         |      |            |                         |                 |  |                 |                                 |                               |                                |                  |                                       |

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|                            |  |   |  |                          |  |
|----------------------------|--|---|--|--------------------------|--|
| <b>PROJECT</b> 06-1111-044 |  | <b>RECORD OF BOREHOLE No CU-12</b>  |  | 1 OF 1 <b>METRIC</b>     |  |
| <b>W.P.</b> WP 583-93-00   |  | <b>LOCATION</b> N 4909147.3 ; E 408396.3                                  |  | <b>ORIGINATED BY</b> PKS |  |
| <b>DIST</b> Eastern HWY 7  |  | <b>BOREHOLE TYPE</b> Truck-Mounted CME-75, 210 mm O.D. Hollow Stem Augers |  | <b>COMPILED BY</b> KG    |  |
| <b>DATUM</b> Geodetic      |  | <b>DATE</b> April 10, 2007  |  | <b>CHECKED BY</b> LCC    |  |



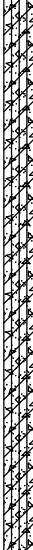
| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT                       |    |    |     |  | PLASTIC LIMIT   NATURAL<br>LIMIT   MOISTURE   LIMIT<br>CONTENT |  |  | UNIT<br>WEIGHT<br><br>$\gamma$<br><br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br><br>GR   SA   SI   CL |  |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|---|----|----|-----|--|--|--|--|---|--|--|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa  |    |    |     |  | WATER CONTENT (%)  |  |  |   |  |  |
|               |  |            |         |      |            |                            |                 |   |    |    |     |  |  |  |  |   |  |  |
|               |  |            |         |      |            |                            |                 | ○ UNCONFINED   +   FIELD VANE<br>● QUICK TRIAXIAL   ×   REMOULDED |    |    |     |  | W <sub>p</sub> W                      W <sub>L</sub>           |  |  |   |  |  |
| 228.3         | GROUND SURFACE   |            |         |      |            |                            | 20              | 40  | 60 | 80 | 100 |  |  |  |  |   |  |  |
| 0.0           | Sand and gravel (FILL)<br>Compact<br>Brown<br>Moist  |            | 1       | SS   | 14         |                            | 228             |   |    |    |     |  |  |  |  |   |  |  |
| 227.2         |  |            | 2       | SS   | 10         |                            | 227             |   |    |    |     |  |  |  |  |   |  |  |
| 1.1           | Clayey silt, some sand, trace<br>gravel, containing rootlets (FILL)<br>Stiff<br>Grey-brown<br>Moist  |            | 3       | SS   | 8          |                            | 226             |   |    |    |     |  |  |  |  |   |  |  |
| 226.0         |  | 4          | SS      | 15   | 225        |                            |                 |   |    |    |     |  |  |  |  |   |  |  |
| 2.3           | CLAYEY SILT, trace sand<br>Stiff to very stiff<br>Brown<br>Moist   | 5          | SS      | 14   | 224        |                            |                 |   |    |    |     |  |  |  |  |   |  |  |
| 224.6         |  | 6          | SS      | 17   | 223        |                            |                 |   |    |    |     |  |  |  |  |   |  |  |
| 3.7           | CLAYEY SILT with sand to some<br>sand, some gravel, containing<br>cobbles (TILL)<br>Stiff to hard<br>Brown<br>Wet  | 7          | SS      | 35   | 222        |                            |                 |   |    |    |     |  |  |  |  |   |  |  |
|               |  | 8          | SS      | 13   | 221        |                            |                 |   |    |    |     |  |  |  |  |   |  |  |
|               | Becoming grey below 7.6 m depth  | 9          | SS      | 21   | 220        |                            |                 |   |    |    |     |  |  |  |  |   |  |  |
|               |  | 10         | SS      | 30   | 219        |                            |                 |   |    |    |     |  |  |  |  |   |  |  |
|               |  | 11         | SS      | 50   | 218        |                            |                 |   |    |    |     |  |  |  |  |   |  |  |
|               |  |            |         |      | 217        |                            |                 |   |    |    |     |  |  |  |  |   |  |  |
| 215.7         |  |            |         |      | 216        |                            |                 |   |    |    |     |  |  |  |  |   |  |  |
| 12.6          | End of Borehole  |            |         |      |            |                            |                 |   |    |    |     |  |  |  |  |   |  |  |
|               | Notes:<br><br>1. Wet soils encountered during<br>drilling at a depth of 3.8 m.<br><br>2. Water level in open borehole at a<br>depth of 3.6 m (Elevation 224.7 m)<br>upon completion of drilling. |            |         |      |            |                            |                 |   |    |    |     |  |  |  |  |   |  |  |

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| PROJECT 06-1111-044  |   | <b>RECORD OF BOREHOLE No CU-13</b>   |         |      |            | 1 OF 1 <b>METRIC</b>  |                 |   |    |    |    |     |                                    |                                     |                                   |   |  |  |
|--|---|--|---------|------|------------|---|-----------------|---|----|----|----|-----|------------------------------------|-------------------------------------|-----------------------------------|---|--|--|
| W.P. WP 583-93-00  |   | LOCATION N 4909138.1 ; E 408394.8  |         |      |            | ORIGINATED BY PKS   |                 |   |    |    |    |     |                                    |                                     |                                   |   |  |  |
| DIST Eastern HWY 7   |   | BOREHOLE TYPE Portable Drilling Equipment, Continuous 50 mm O.D. Split-Spoon Sampler |         |      |            | COMPILED BY NK  |                 |   |    |    |    |     |                                    |                                     |                                   |   |  |  |
| DATUM Geodetic   |   | DATE April 11, 2007  |         |      |            | CHECKED BY LCC  |                 |   |    |    |    |     |                                    |                                     |                                   |   |  |  |
| SOIL PROFILE   |   |  | SAMPLES |      |            | GROUND WATER<br>CONDITIONS  | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |    |     | PLASTIC<br>LIMIT<br>W <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>W | LIQUID<br>LIMIT<br>W <sub>L</sub> | UNIT<br>WEIGHT<br>$\gamma$<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br>GR SA SI CL |  |
| ELEV<br>DEPTH  | DESCRIPTION   | STRAT PLOT   | NUMBER  | TYPE | "N" VALUES |   |                 | SHEAR STRENGTH kPa                          |    |    |    |     |                                    |                                     |                                   |   |  |  |
| 226.5  | GROUND SURFACE  |  |         |      |            |   |                 | 20  | 40 | 60 | 80 | 100 |                                    |                                     |                                   |   |  |  |
| 0.0  | PEAT  |     | 1       | SS   | 4          |  | 226             |   |    |    |    |     |                                    |                                     |                                   |   |  |  |
| 225.9  |   |  | 2       | SS   | 2          |   |                 |   |    |    |    |     |                                    |                                     |                                   |   |  |  |
| 0.6  | CLAYEY SILT, some sand, trace gravel, containing rootlets                     |     |         |      |            |   |                 |   |    |    |    |     |                                    |                                     |                                   |   |  |  |
| 225.3  | Soft to firm  |  | 3       | SS   | 20         |   |                 |   |    |    |    |     |                                    |                                     |                                   |   |  |  |
| 1.2  | Brown Wet   |     |         |      |            |   | 225             |   |    |    |    |     |                                    |                                     |                                   |   |  |  |
| 224.2  | CLAYEY SILT with sand to some sand, some gravel, containing sand seams (TILL) |     | 4       | SS   | 45         |   |                 |   |    |    |    |     |                                    |                                     |                                   |   | 29 34 27 10  |  |
| 2.3  | Very stiff to hard Brown Moist to wet End of Borehole                         |     |         |      |            |   |                 |   |    |    |    |     |                                    |                                     |                                   |   |  |  |
| <p>Notes:</p> <p>1. Borehole advanced using portable drilling equipment with a half-weight hammer. SPT "N" values shown on this borehole record have been adjusted to reflect values that would be obtained using a standard hammer.</p> <p>2. Water level in open borehole at a depth of 0.3 m (Elevation 226.2 m) on completion of drilling.</p> |   |  |         |      |            |   |                 |   |    |    |    |     |                                    |                                     |                                   |   |  |  |



|                                  |  |   |  |                          |  |
|----------------------------------|--|---|--|--------------------------|--|
| PROJECT <u>06-1111-044</u>       |  | <b>RECORD OF BOREHOLE No CU-14</b>  |  | 1 OF 1 <b>METRIC</b>     |  |
| W.P. <u>WP 583-93-00</u>         |  | LOCATION <u>N 4909113.5 ; E 408724.2</u>                                  |  | ORIGINATED BY <u>PKS</u> |  |
| DIST <u>Eastern</u> HWY <u>7</u> |  | BOREHOLE TYPE <u>Truck-Mounted CME-75, 210 mm O.D. Hollow Stem Augers</u> |  | COMPILED BY <u>NK</u>    |  |
| DATUM <u>Geodetic</u>            |  | DATE <u>April 3, 2007</u>   |  | CHECKED BY <u>LCC</u>    |  |




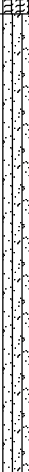

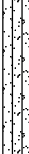
| SOIL PROFILE  |  |  | SAMPLES |      |            | GROUND WATER<br>CONDITIONS  | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |    |     | PLASTIC NATURAL LIQUID<br>LIMIT MOISTURE LIMIT<br>CONTENT |   |                | UNIT<br>WEIGHT<br>$\gamma$<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br>GR SA SI CL |
|---------------|--|--|---------|------|------------|---|-----------------|---|----|----|----|-----|---|---|----------------|---|--|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT   | NUMBER  | TYPE | "N" VALUES |   |                 | SHEAR STRENGTH kPa                          |    |    |    |     | WATER CONTENT (%)   |   |                |   |  |
|               |  |  |         |      |            |   |                 | 20  | 40 | 60 | 80 | 100 | W <sub>p</sub>  | W | W <sub>L</sub> |   |  |
| 229.0         | GROUND SURFACE   |  |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |  |
| 0.0           | Gravelly sand, some silt (FILL)<br>Dense to loose<br>Brown<br>Moist  |   | 1       | SS   | 38         |  | 228             |   |    |    |    |     |   |   |                | 28 41 23 8                                      |  |
|               |  |  | 2       | SS   | 32         |   | 227             |   |    |    |    |     |   |   |                |   |  |
| 226.9         |  |  | 3       | SS   | 9          |   | 226             |   |    |    |    |     |   |   |                |   |  |
| 2.1           | CLAYEY SILT, some sand, trace<br>gravel<br>Stiff<br>Brown<br>Moist   | 4  | SS      | 4    | 225        |   |                 |   |    |    |    |     |   |   |                |   |  |
|               |  |  |         |      | 224        |   |                 |   |    |    |    |     |   |   |                |   |  |
|               |  |  |         |      | 223        |   |                 |   |    |    |    |     |   |   |                |   |  |
|               |  |  |         |      | 222        |   |                 |   |    |    |    |     |   |   |                |   |  |
|               |  |  |         |      | 221        |   |                 |   |    |    |    |     |   |   |                |   |  |
|               |  |  |         |      | 220        |   |                 |   |    |    |    |     |   |   |                |   |  |
|               |  |  |         |      | 219        |   |                 |   |    |    |    |     |   |   |                |   |  |
| 225.2         | CLAYEY SILT, some sand, trace to<br>some gravel, containing cobbles<br>(TILL)<br>Very stiff to hard<br>Brown<br>Wet  |  | 6       | SS   | 42         | 218   |                 |   |    |    |    |     |   |   |                |   |  |
| 3.8           |  |  | 7       | SS   | 19         |   |                 |   |    |    |    |     |   |   |                |   |  |
|               |  |  | 8       | SS   | 17         |   |                 |   |    |    |    |     |   |   |                |   |  |
|               |  |  |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |  |
|               |  |  |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |  |
|               |  |  |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |  |
|               |  |  |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |  |
|               |  |  |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |  |
|               | Boulder cored between 7.6 m and<br>8.5 m   |  | -       | NQ   | -          |   |                 |   |    |    |    |     |   |   |                |   |  |
|               |  |  |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |  |
|               |  |  | 9       | SS   | 34         |   |                 |   |    |    |    |     |   |   |                |   |  |
|               |  |  |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |  |
|               |  |  |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |  |
|               |  |  | 10      | SS   | 42         |   |                 |   |    |    |    |     |   |   |                |   |  |
| 217.7         | End of Borehole  |  |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |  |
| 11.3          | Notes:<br><br>1. Wet soils encountered during<br>drilling at a depth of 3.8 m.<br><br>2. Water level in open borehole at a<br>depth of 3.0 m (Elevation 226.0 m)<br>upon completion of drilling. |  |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |  |

MIS-MTO 001 06-1111-044.GPJ GAL-MISS.GDT 2/18/09 MSM/RJ/SAC

| PROJECT 06-1111-044 |   | RECORD OF BOREHOLE No CU-15                            |         |      |            | 1 OF 1 METRIC                            |                 |   |                                 |                   |   |                                       |  |
|---------------------|---|--|---------|------|------------|--|-----------------|---|---------------------------------|-------------------|---|---------------------------------------|--|
| W.P. WP 583-93-00   |   | LOCATION N 4909106.0 ; E 408726.4                      |         |      |            | ORIGINATED BY GD                         |                 |   |                                 |                   |   |                                       |  |
| DIST Eastern HWY 7  |   | BOREHOLE TYPE Track-Mounted CME-55, Hollow Stem Augers |         |      |            | COMPILED BY NK                           |                 |   |                                 |                   |   |                                       |  |
| DATUM Geodetic      |   | DATE March 1, 2007                                     |         |      |            | CHECKED BY LCC                           |                 |   |                                 |                   |   |                                       |  |
| 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 CONDITIONS                  | ELEVATION SCALE | 20 40 60 80 100                                     | W <sub>p</sub> W W <sub>L</sub> | WATER CONTENT (%) | γ | GR SA SI CL                           |  |
| 226.7               | GROUND SURFACE  |  |         |      |            |  |                 |   |                                 |                   |   |                                       |  |
| 0.0                 | Organic Silty SAND, some gravel, containing peat layers   |  | 1       | SS   | 2          |  | 226             |   |                                 |                   |   |                                       |  |
| 226.0               | Very loose  |  | 2       | SS   | 8          |  |                 |   |                                 |                   |   |                                       |  |
| 0.8                 | Dark brown to brown   |  |         |      |            |  |                 |   |                                 |                   |   |                                       |  |
| 225.2               | Moist   |  | 3       | SS   | 15         |  | 225             |   |                                 |                   |   |                                       |  |
| 1.5                 | CLAYEY SILT, some sand, trace gravel  |  | 4       | SS   | 12         |  | 224             |   |                                 |                   |   |                                       |  |
|                     | Stiff   |  | 5       | SS   | 30         |  | 223             |   |                                 |                   |   |                                       |  |
|                     | Brown   |  | 6       | SS   | 26         |  | 222             |   |                                 |                   |   |                                       |  |
|                     | Moist   |  | 7       | SS   | 31         |  | 221             |   |                                 |                   |   |                                       |  |
|                     | CLAYEY SILT with sand, some gravel, containing cobbles (TILL)   |  | 1       | RC   | REC 25%    |  | 220             |   |                                 |                   |   |                                       |  |
|                     | Stiff to hard   |  | 2       | RC   | REC 23%    |  | 219             |   |                                 |                   |   |                                       |  |
|                     | Brown to grey   |  | 3       | RC   | REC 12%    |  | 218             |   |                                 |                   |   |                                       |  |
|                     | Moist   |  |         |      |            |  |                 |   |                                 |                   |   |                                       |  |
|                     | Containing Limestone and Granite cobbles and boulders below a depth of 5.7 m  |  |         |      |            |  |                 |   |                                 |                   |   |                                       |  |
| 217.6               | End of Borehole   |  |         |      |            |  |                 |   |                                 |                   |   |                                       |  |
| 9.1                 | Notes:  |  |         |      |            |  |                 |   |                                 |                   |   |                                       |  |
|                     | 1. Wet soils encountered during drilling at a depth of 0.8 m.   |  |         |      |            |  |                 |   |                                 |                   |   |                                       |  |
|                     | 2. Water level in piezometer measured at a depth of 0.3 m (Elevation 226.4 m) on April 11, 2007, and at a depth of 0.2 m (Elevation 226.5 m) on June 5, 2007. |  |         |      |            |  |                 |   |                                 |                   |   |                                       |  |


| PROJECT <u>06-1111-044</u>  |   | <b>RECORD OF BOREHOLE No 08-08</b>                                      |         | 1 OF 1 <b>METRIC</b>     |            |                            |                 |   |  |  |  |  |  |  |  |   |   |
|---|---|---|---------|--------------------------|------------|----------------------------|-----------------|---|--|--|--|--|--|--|--|---|---|
| W.P. <u>WP 583-93-00</u>  |   | LOCATION <u>N 4908729.0 ; E 407140.7</u>                                |         | ORIGINATED BY <u>PKS</u> |            |                            |                 |   |  |  |  |  |  |  |  |   |   |
| DIST <u>Eastern</u> HWY <u>7</u>  |   | BOREHOLE TYPE <u>Portable Equipment, 57 mm Internal Diameter Casing</u> |         | COMPILED BY <u>JB</u>    |            |                            |                 |   |  |  |  |  |  |  |  |   |   |
| DATUM <u>Geodetic</u>   |   | DATE <u>August 21, 2008</u>   |         | CHECKED BY <u>LCC</u>    |            |                            |                 |   |  |  |  |  |  |  |  |   |   |
| SOIL PROFILE  |   |   | SAMPLES |                          |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |  |  |  | PLASTIC NATURAL LIQUID<br>LIMIT MOISTURE CONTENT LIMIT |  |  | UNIT<br>WEIGHT<br>$\gamma$<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |
| ELEV<br>DEPTH   | DESCRIPTION                                   | STRAT PLOT  | NUMBER  | TYPE                     | "N" VALUES |                            |                 | SHEAR STRENGTH kPa                          |  |  |  |  | WATER CONTENT (%)                                      |  |  |   |   |
| 207.8   | GROUND SURFACE                                |   |         |                          |            |                            |                 |   |  |  |  |  |  |  |  |   |   |
| 8.9   | TOPSOIL/Root Mat                              |   | 1       | SS                       | 4          |                            |                 |   |  |  |  |  |  |  |  |   |   |
| 207.0   | CLAYEY SILT, trace sand, trace gravel         |   |         |                          |            |                            |                 |   |  |  |  |  |  |  |  |   |   |
| 0.8   | Firm Brown Wet                                |   | 2       | SS                       | 8          |                            |                 |   |  |  |  |  |  |  |  |   |   |
|   | PEAT and Organic SILT, containing sand layers |   |         |                          |            |                            |                 |   |  |  |  |  |  |  |  |   |   |
| 205.5   | Firm Brown Wet                                |   |         |                          |            |                            |                 |   |  |  |  |  |  |  |  |   |   |
| 2.3   | SILT, trace sand, to Sandy SILT, trace clay   |   | 3       | SS                       | 3*         |                            |                 |   |  |  |  |  |  |  |  |   |   |
|   | Compact to dense Grey Wet                     |   |         |                          |            |                            |                 |   |  |  |  |  |  |  |  |   |   |
|   |   |   | 4       | SS                       | 3*         |                            |                 |   |  |  |  |  |  |  |  |   |   |
|   |   |   |         |                          |            |                            |                 |   |  |  |  |  |  |  |  |   |   |
|   |   |   | 5       | SS                       | 30         |                            |                 |   |  |  |  |  |  |  |  |   |   |
|   |   |   |         |                          |            |                            |                 |   |  |  |  |  |  |  |  |   |   |
|   |   |   | 6       | SS                       | 25         |                            |                 |   |  |  |  |  |  |  |  |   |   |
|   |   |   |         |                          |            |                            |                 |   |  |  |  |  |  |  |  |   |   |
| 200.2   | CLAYEY SILT, trace sand                       |   |         |                          |            |                            |                 |   |  |  |  |  |  |  |  |   |   |
| 7.6   | Stiff to very stiff Grey Moist                |   | 7       | SS                       | 15         |                            |                 |   |  |  |  |  |  |  |  |   |   |
| 199.6   |   |   |         |                          |            |                            |                 |   |  |  |  |  |  |  |  |   |   |
| 8.2   | END OF BOREHOLE                               |   |         |                          |            |                            |                 |   |  |  |  |  |  |  |  |   |   |
| NOTE:   |   |   |         |                          |            |                            |                 |   |  |  |  |  |  |  |  |   |   |
| 1. Water level in open borehole at a depth of 0.2 m (Elevation 207.6) m) upon completion of drilling.         |   |   |         |                          |            |                            |                 |   |  |  |  |  |  |  |  |   |   |
| * SPT "N" values considered to be the result of sample disturbance due to groundwater inflow to the borehole. |   |   |         |                          |            |                            |                 |   |  |  |  |  |  |  |  |   |   |



|                                  |  |  |  |                          |  |
|----------------------------------|--|--|--|--------------------------|--|
| PROJECT <u>06-1111-044</u>       |  | <b>RECORD OF BOREHOLE No 08-08A</b>  |  | 1 OF 1 <b>METRIC</b>     |  |
| W.P. <u>WP 583-93-00</u>         |  | LOCATION <u>N 4908740.0 ; E 407137.3</u>                                   |  | ORIGINATED BY <u>PKS</u> |  |
| DIST <u>Eastern</u> HWY <u>7</u> |  | BOREHOLE TYPE <u>Truck-Mounted D-25, 108 mm Diameter Solid Stem Augers</u> |  | COMPILED BY <u>JB</u>    |  |
| DATUM <u>Geodetic</u>            |  | DATE <u>September 9, 2008</u>  |  | CHECKED BY <u>LCC</u>    |  |

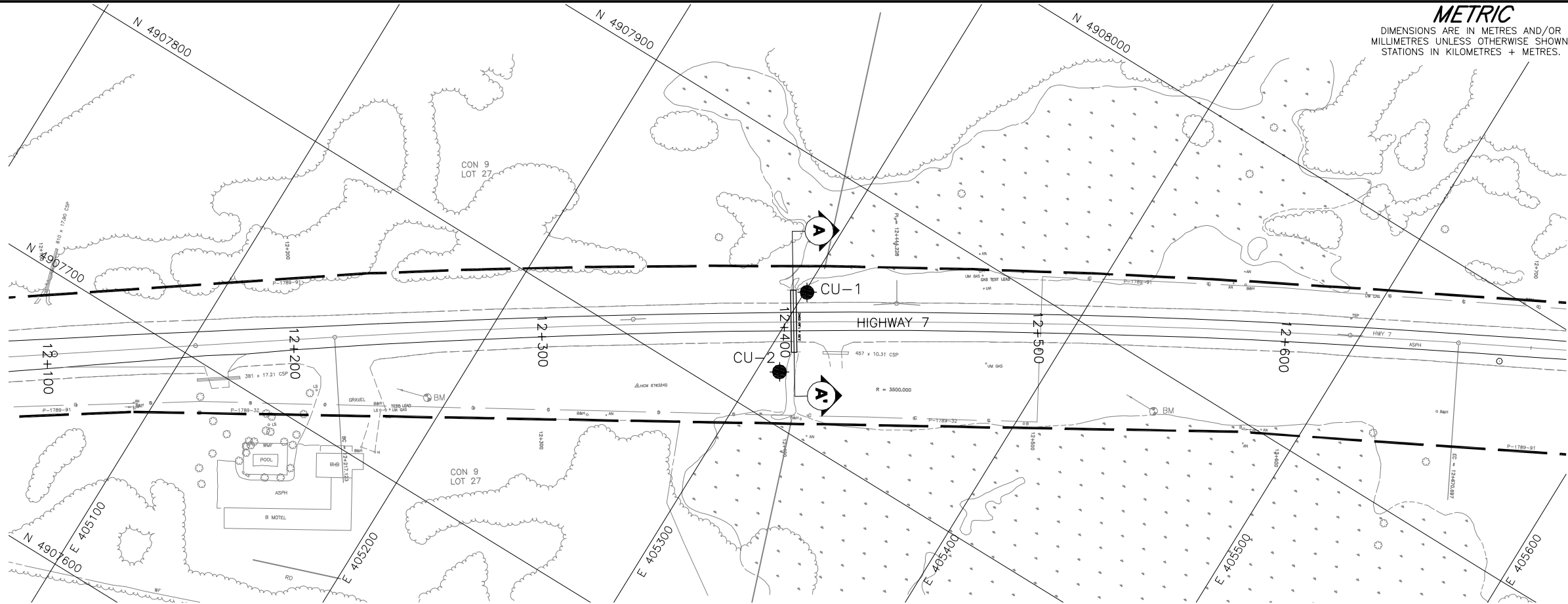
| SOIL PROFILE  |  |   | SAMPLES |      |            | GROUND WATER<br>CONDITIONS  | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT   |  |  |  |  | PLASTIC NATURAL LIQUID<br>LIMIT MOISTURE CONTENT  |  |  | UNIT<br>WEIGHT<br><br>$\gamma$<br><br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br><br>GR SA SI CL |
|---------------|--|---|---------|------|------------|---|-----------------|---|--|--|--|--|---|--|--|---|--|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT  | NUMBER  | TYPE | "N" VALUES |   |                 | SHEAR STRENGTH kPa  |  |  |  |  | WATER CONTENT (%)   |  |  |   |  |
|               |  |   |         |      |            |   |                 | <div><div><div></div><div></div><div></div><div></div><div></div></div><div>20 40 60 80 100</div></div> |  |  |  |  | <div><div><div></div><div></div><div></div></div><div>W<sub>p</sub> W W<sub>L</sub></div></div> |  |  |   |  |
| 209.8         | GROUND SURFACE   |   |         |      |            |   |                 |   |  |  |  |  |   |  |  |   |  |
| 0.0           | Silty SAND, some gravel (FILL)<br>Compact<br>Brown<br>Moist  |    | 1       | SS   | 15         |  | 209             |   |  |  |  |  |   |  |  |   |  |
|               |  |   | 2       | SS   | 27         |   | 208             |   |  |  |  |  |   |  |  |   |  |
| 208.0         |  |   | 3       | SS   | 11         |   | 207             |   |  |  |  |  |   |  |  |   |  |
| 1.8           | Organic SILT, layered with peat,<br>sand and marl, containing shells<br>Soft to firm<br>Grey, brown and white<br>Wet |    | 4       | SS   | 6          |   | 206             |   |  |  |  |  |   |  |  |   |  |
|               |  |   | 5       | SS   | 2          |   | 205             |   |  |  |  |  |   |  |  |   |  |
|               |  |   | 6       | SS   | 8          |   | 204             |   |  |  |  |  |   |  |  |   |  |
| 205.3         |  |   | 7       | SS   | 24         |   | 203             |   |  |  |  |  |   |  |  |   |  |
| 4.6           | SAND and SILT, containing clayey<br>silt seams<br>Compact<br>Grey<br>Wet   |   | 8       | SS   | 14         |   | 202             |   |  |  |  |  |   |  |  |   |  |
|               |  |   | 9       | SS   | 16         |   | 201             |   |  |  |  |  |   |  |  |   |  |
|               |  |   | 10      | SS   | 25         |   | 200             |   |  |  |  |  |   |  |  |   |  |
| 199.2         |  |   | 11      | SS   | 21         |   | 199             |   |  |  |  |  |   |  |  |   |  |
| 10.7          | CLAYEY SILT, trace sand<br>Very stiff<br>Grey<br>Wet   |  | 12      | SS   | 25         |   | 198             |   |  |  |  |  |   |  |  |   |  |
| 196.1         |  |   | 13      | SS   | 26         |   | 197             |   |  |  |  |  |   |  |  |   |  |
| 13.7          | Silty SAND, trace gravel<br>Compact<br>Grey<br>Wet   |  | 14      | SS   | 30         |   | 196             |   |  |  |  |  |   |  |  |   |  |
| 194.0         |  |   |         |      |            | 195   |                 |   |  |  |  |  |   |  |  |   |  |
| 15.9          | END OF BOREHOLE  |   |         |      |            | 194   |                 |   |  |  |  |  |   |  |  |   |  |
|               | NOTE:<br><br>1. Wet soil encountered at a depth<br>of 1.8 m (Elevation 208.0 m) during<br>drilling.                  |   |         |      |            |   |                 |   |  |  |  |  |   |  |  |   |  |

MIS-MTO 001 06-1111-044.GPJ GAL-MISS.GDT 2/18/09 MSM/RJ/SAC

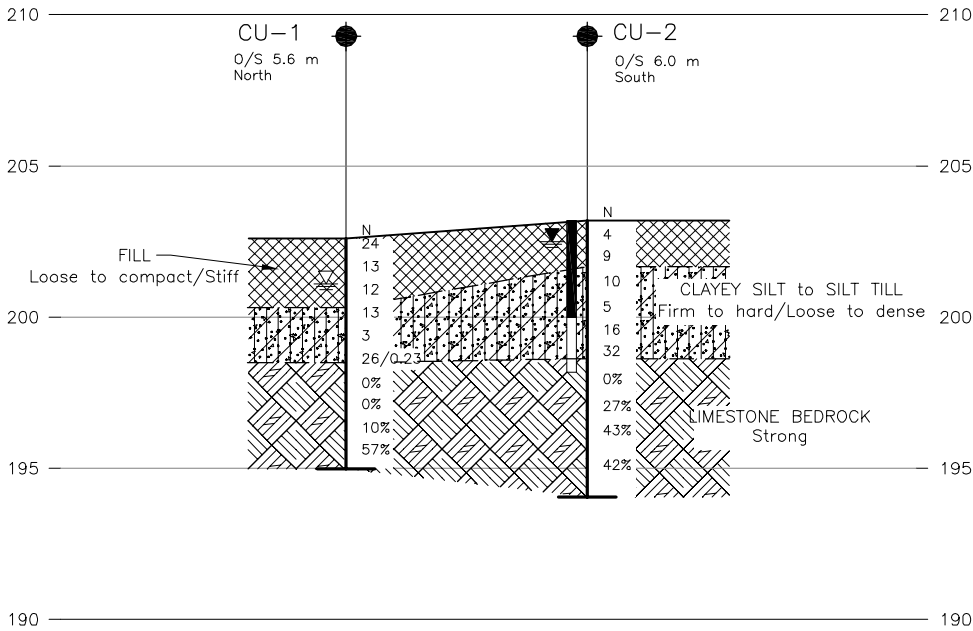
|                                  |  |   |  |                          |  |
|----------------------------------|--|---|--|--------------------------|--|
| PROJECT <u>06-1111-044</u>       |  | <b>RECORD OF BOREHOLE No 08-22</b>                                      |  | 1 OF 1 <b>METRIC</b>     |  |
| W.P. <u>WP 583-93-00</u>         |  | LOCATION <u>N 4909135.0 ; E 408733.0</u>                                |  | ORIGINATED BY <u>PKS</u> |  |
| DIST <u>Eastern</u> HWY <u>7</u> |  | BOREHOLE TYPE <u>Portable Equipment, 57 mm Internal Diameter Casing</u> |  | COMPILED BY <u>JB</u>    |  |
| DATUM <u>Geodetic</u>            |  | DATE <u>August 26, 2008</u>   |  | CHECKED BY <u>LCC</u>    |  |

| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS  | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |  |  |  | PLASTIC LIMIT NATURAL MOISTURE LIQUID LIMIT<br>LIMIT CONTENT LIMIT |  |  | UNIT<br>WEIGHT<br><br>$\gamma$<br><br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br><br>GR SA SI CL |
|---------------|--|------------|---------|------|------------|---|-----------------|---|--|--|--|--|--|--|--|---|--|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |   |                 | SHEAR STRENGTH kPa                          |  |  |  |  | WATER CONTENT (%)  |  |  |   |  |
|               |  |            |         |      |            |   |                 | 20 40 60 80 100                             |  |  |  |  | W <sub>p</sub> W W <sub>L</sub>                                    |  |  |   |  |
| 227.0         | GROUND SURFACE   |            |         |      |            |   |                 |   |  |  |  |  |  |  |  |   |  |
| 0.9           | TOPSOIL/Root Mat   |            | 1       | SS   | 4          |  |                 |   |  |  |  |  |  |  |  |   |  |
| 226.2         | CLAYEY SILT, some sand, trace gravel   |            | 2       | SS   | 15         |   |                 |   |  |  |  |  |  |  |  |   |  |
| 0.8           | Firm   |            |         |      |            |   |                 |   |  |  |  |  |  |  |  |   |  |
|               | Brown  |            | 3       | SS   | 15         |   |                 |   |  |  |  |  |  |  |  |   |  |
|               | Wet  |            | 4       | SS   | 42         |   |                 |   |  |  |  |  |  |  |  |   |  |
|               | CLAYEY SILT with sand, trace to some gravel (TILL)   |            |         |      |            |   |                 |   |  |  |  |  |  |  |  |   |  |
|               | Very stiff to hard   |            |         |      |            |   |                 |   |  |  |  |  |  |  |  |   |  |
|               | Brown  |            | 5       | SS   | 75/0.18    |   |                 |   |  |  |  |  |  |  |  |   |  |
|               | Moist  |            |         |      |            |   |                 |   |  |  |  |  |  |  |  |   |  |
| 223.7         | END OF BOREHOLE  |            |         |      |            |   |                 |   |  |  |  |  |  |  |  |   |  |
| 3.2           | NOTES:<br><br>1. Standing water present at site.<br><br>2. Water level in open borehole at a depth of 0.9 m (Elevation 226.1 m) upon completion of drilling. |            |         |      |            |   |                 |   |  |  |  |  |  |  |  |   |  |

| PROJECT 06-1111-044 |   |  |         | RECORD OF BOREHOLE No 08-22A  |            |                         |                 | 1 OF 1 METRIC                            |  |  |  |  |                                 |                               |                                |                  |                                       |
|---------------------|---|--|---------|---|------------|-------------------------|-----------------|--|--|--|--|--|---------------------------------|-------------------------------|--------------------------------|------------------|---------------------------------------|
| W.P. WP 583-93-00   |   |  |         | LOCATION N 4909124.0 ; E 408734.2                                   |            |                         |                 | ORIGINATED BY PKS                        |  |  |  |  |                                 |                               |                                |                  |                                       |
| DIST Eastern HWY 7  |   |  |         | BOREHOLE TYPE Truck-Mounted D-25, 108 mm Diameter Solid Stem Augers |            |                         |                 | COMPILED BY JB                           |  |  |  |  |                                 |                               |                                |                  |                                       |
| DATUM Geodetic      |   |  |         | DATE September 9, 2008  |            |                         |                 | CHECKED BY LCC                           |  |  |  |  |                                 |                               |                                |                  |                                       |
| 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<br>DEPTH       | DESCRIPTION   | STRAT PLOT   | NUMBER  | TYPE  | "N" VALUES |                         |                 | SHEAR STRENGTH kPa                       |  |  |  |  |                                 |                               |                                |                  |                                       |
| 229.2               | GROUND SURFACE  |  |         |   |            |                         |                 |  |  |  |  |  |                                 |                               |                                |                  |                                       |
| 0.0                 | Silty sand, some gravel (FILL)<br>Compact<br>Brown<br>Moist   |   | 1       | SS  | 18         |                         |                 |  |  |  |  |  |                                 |                               |                                |                  |                                       |
| 228.5               | Clayey silt, some sand, trace gravel (FILL)<br>Stiff to very stiff<br>Brown<br>Moist                              |  | 2       | SS  | 28         |                         |                 |  |  |  |  |  |                                 |                               |                                |                  |                                       |
| 0.8                 |   |  | 3       | SS  | 11         |                         |                 |  |  |  |  |  |                                 |                               |                                |                  |                                       |
| 226.9               | CLAYEY SILT with sand, trace to some gravel, trace organics<br>Stiff<br>Brown / grey<br>Moist                     |  | 4       | SS  | 14         |                         |                 |  |  |  |  |  |                                 |                               |                                |                  |                                       |
| 2.3                 |   |  | 5       | SS  | 37         |                         |                 |  |  |  |  |  |                                 |                               |                                |                  |                                       |
| 226.3               | CLAYEY SILT with sand, some gravel, containing cobbles (TILL)<br>Very stiff to hard<br>Brown<br>Moist to wet      |  | 6       | SS  | 23         |                         |                 |  |  |  |  |  |                                 |                               |                                |                  |                                       |
| 2.9                 |   |  | 7       | SS  | 36         |                         |                 |  |  |  |  |  |                                 |                               |                                |                  |                                       |
|                     |   |  | 8       | SS  | 100/0.20   |                         |                 |  |  |  |  |  |                                 |                               |                                |                  |                                       |
|                     |   |  | 9       | SS  | 91         |                         |                 |  |  |  |  |  |                                 |                               |                                |                  |                                       |
|                     |   |  | 10      | SS  | 71         |                         |                 |  |  |  |  |  |                                 |                               |                                |                  |                                       |
| 219.5               | END OF BOREHOLE   |  |         |   |            |                         |                 |  |  |  |  |  |                                 |                               |                                |                  |                                       |
| 9.8                 | NOTE:<br><br>1. Water level in open borehole at a depth of 7.6 m (Elevation 221.6) m upon completion of drilling. |  |         |   |            |                         |                 |  |  |  |  |  |                                 |                               |                                |                  |                                       |

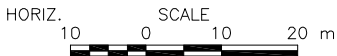


PLAN



A-A'

SECTION A-A'  
CULVERT AT STATION 12+402



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

CONT No.  
WP No. 583-93-00

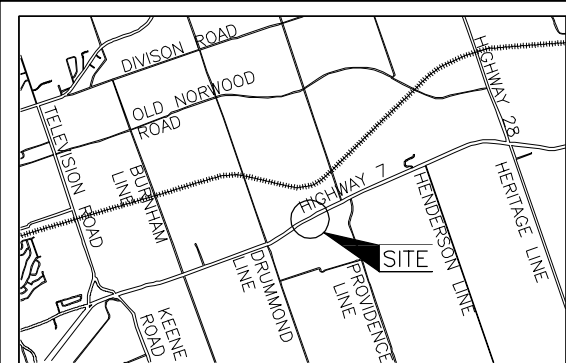
HIGHWAY 7  
CULVERT AT STATION 12+402  
BOREHOLE LOCATIONS  
AND SOIL STRATA



SHEET



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



KEY PLAN  
SCALE  
1.2 0 1.2 2.4 km

LEGEND

- Borehole - Current Investigation
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- WL in piezometer
- WL upon completion of drilling

| No.  | ELEVATION | CO-ORDINATES |          |
|------|-----------|--------------|----------|
|      |           | NORTHING     | EASTING  |
| CU-1 | 202.6     | 4907852.2    | 405300.8 |
| CU-2 | 203.2     | 4907819.1    | 405308.2 |

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.

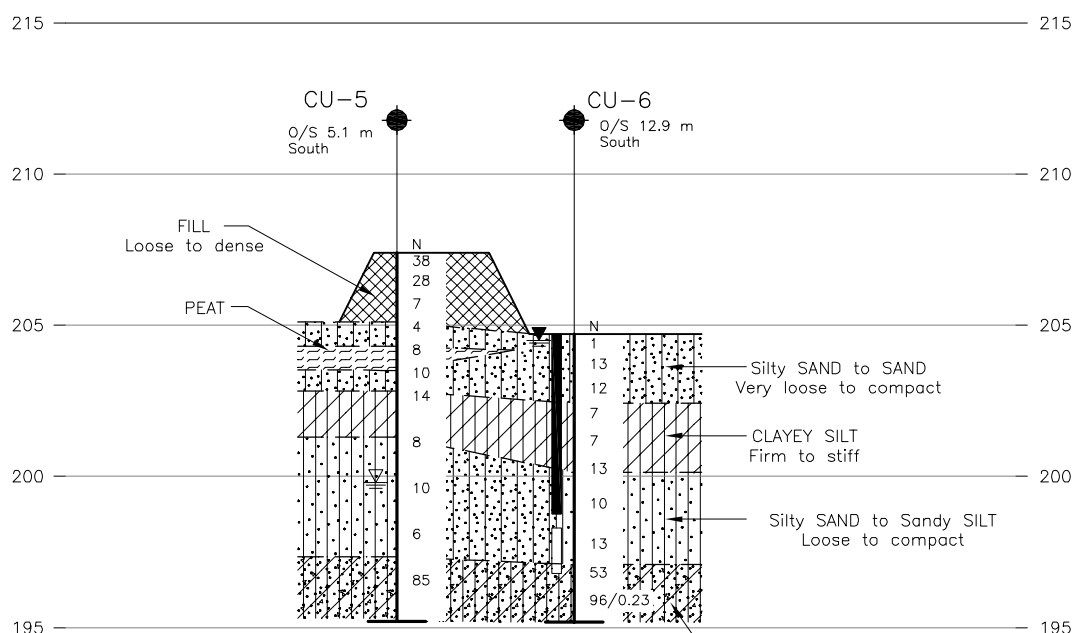
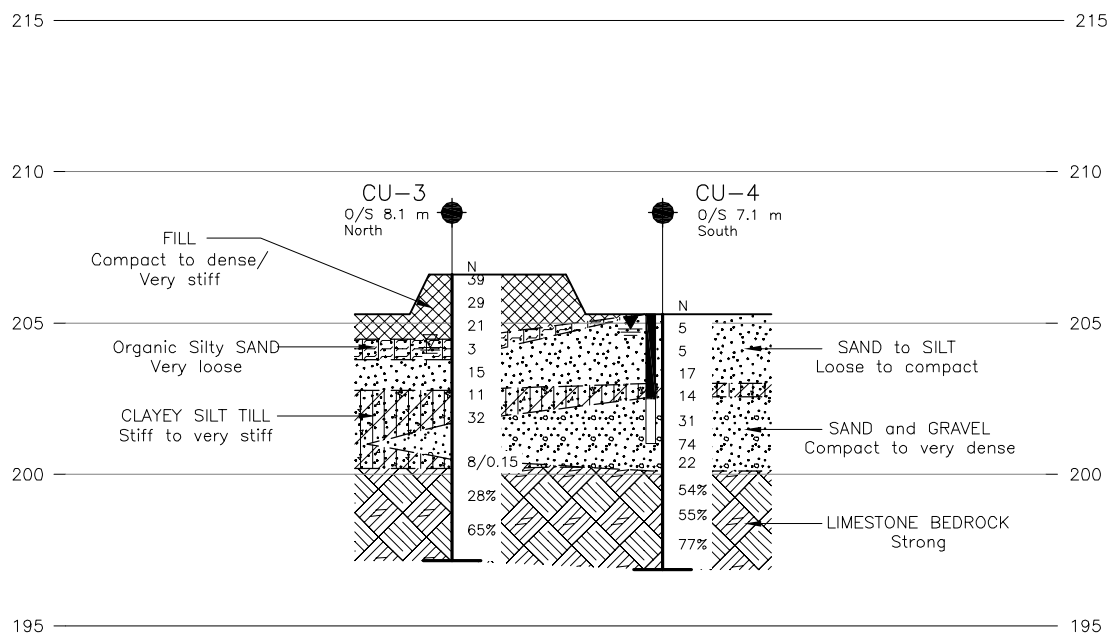
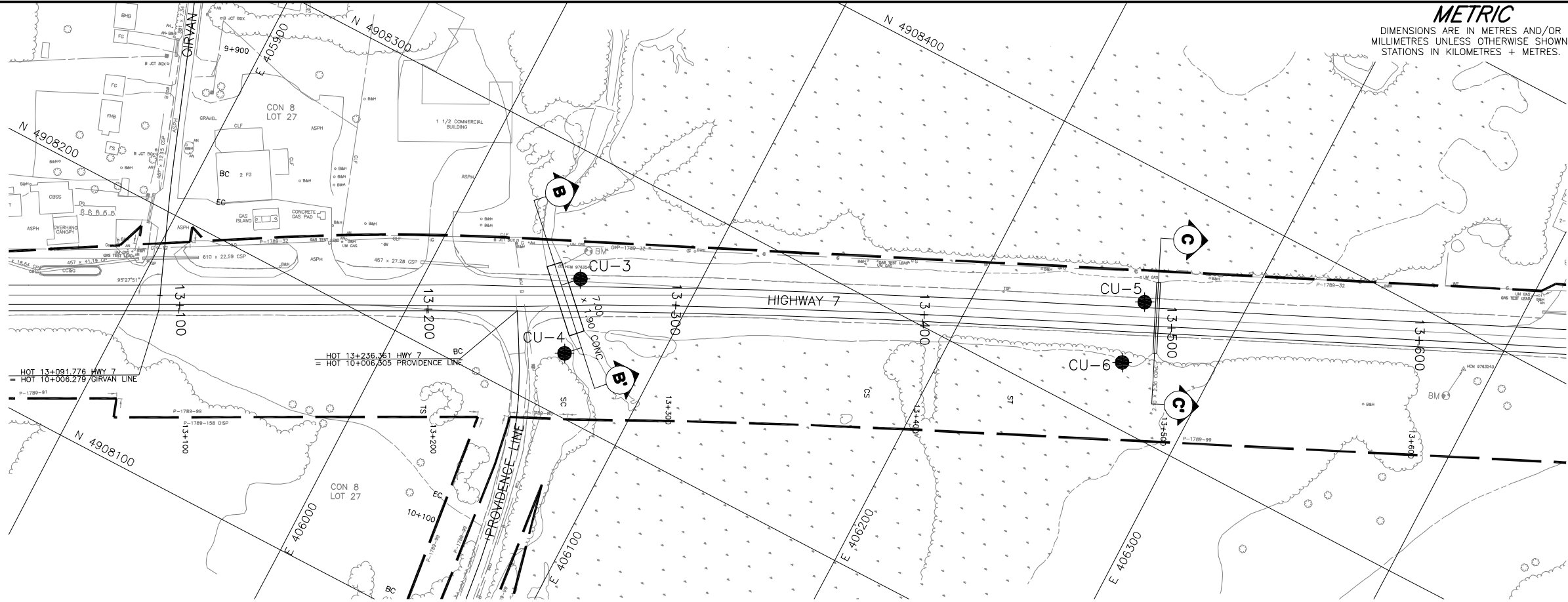
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

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REFERENCE

Base plan provided in digital format by Transenco Engineering (drawing file "Plan Existing.dwg", received May 24, 2007).

| NO.                 | DATE                    | BY                | REVISION |
|---------------------|-------------------------|-------------------|----------|
| Geocres No. 31D-432 |                         |                   |          |
| HWY. HIGHWAY 7      | PROJECT NO. 06-1111-044 |                   | DIST.    |
| SUBM'D. PKS         | CHKD. LCC               | DATE: 27-Feb-2009 | SITE:    |
| DRAWN: JFC          | CHKD. PKS               | APPD. LCC         | DWG. 1   |



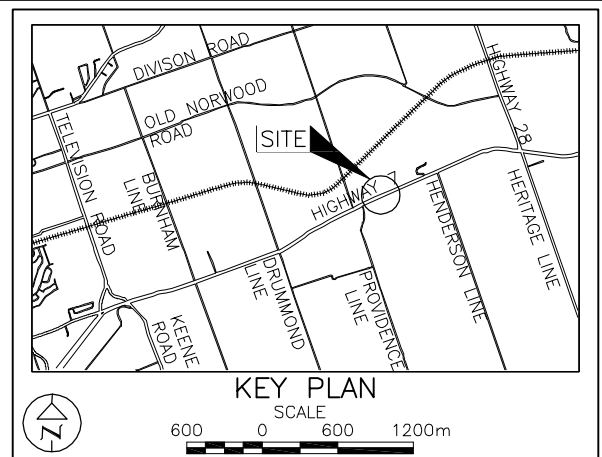
CONT No.  
WP No. 583-93-00

HIGHWAY 7  
CULVERTS AT STATIONS 13+255 AND 13+494

BOREHOLE LOCATIONS  
AND SOIL STRATA

Golder Associates

Golder Associates Ltd.  
MISSISSAUGA, ONTARIO, CANADA



| LEGEND |  |              |          |
|--------|--|--------------|----------|
|        | Borehole - Current Investigation                                   |              |          |
|        | Seal   |              |          |
|        | Piezometer   |              |          |
|        | Standard Penetration Test Value                                    |              |          |
|        | Blows/0.3m unless otherwise stated<br>(Std. Pen. Test, 475 j/blow) |              |          |
|        | 100% Rock Quality Designation (RQD)                                |              |          |
|        | WL in piezometer   |              |          |
|        | WL upon completion of drilling                                     |              |          |
| No.    | ELEVATION  | CO-ORDINATES |          |
|        |  | NORTHING     | EASTING  |
| CU-3   | 206.6  | 4908253.0    | 406056.5 |
| CU-4   | 205.3  | 4908223.5    | 406064.8 |
| CU-5   | 207.4  | 4908350.3    | 406262.5 |
| CU-6   | 204.7  | 4908324.5    | 406265.7 |

**NOTES**

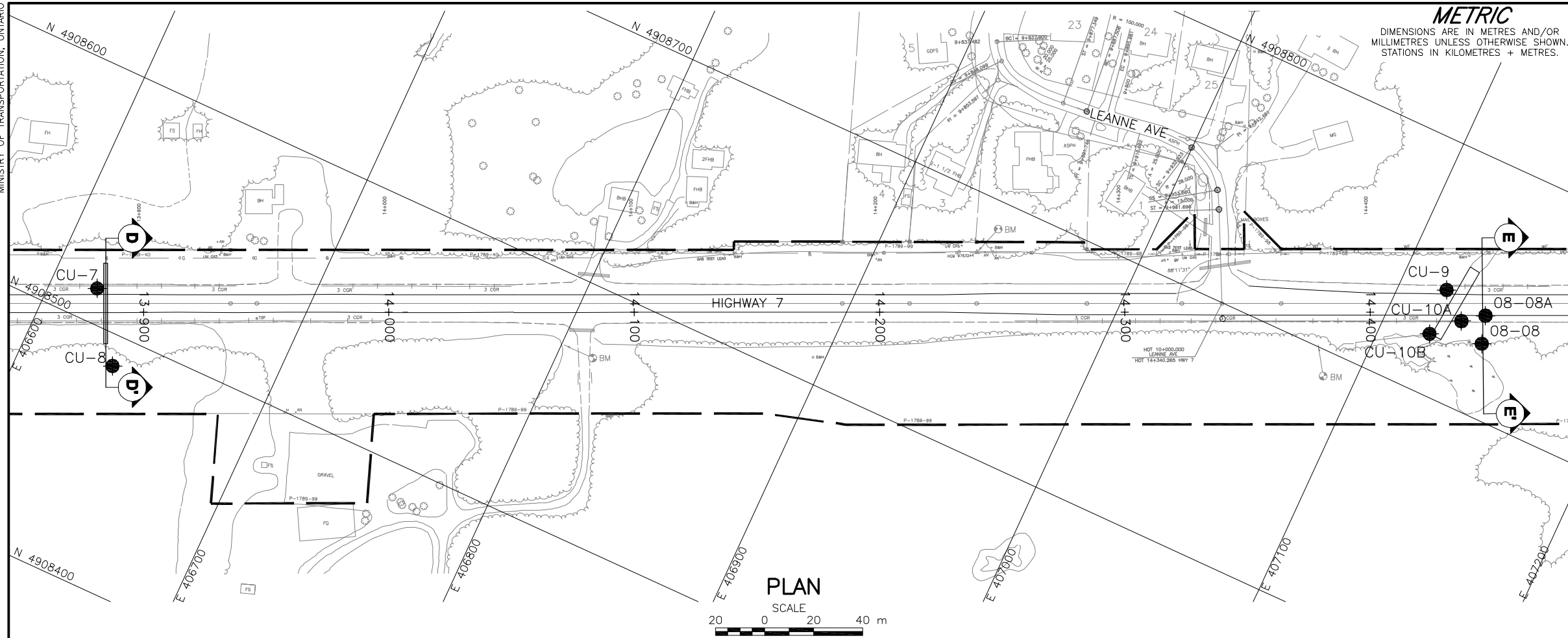
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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| REFERENCE  |                         |                   |          |
|--|-------------------------|-------------------|----------|
| Base plan provided in digital format by Transenco Engineering (drawing file "Plan Existing.dwg", received May 24, 2007). |                         |                   |          |
| NO.  | DATE                    | BY                | REVISION |
| Geocres No. 31D-432  |                         |                   |          |
| HWY. HIGHWAY 7   | PROJECT NO. 06-1111-044 |                   | DIST.    |
| SUBM'D. PKS  | CHKD. LCC               | DATE: 27-Feb-2009 | SITE:    |
| DRAWN: JFC   | CHKD. PKS               | APPD. LCC         | DWG. 2   |



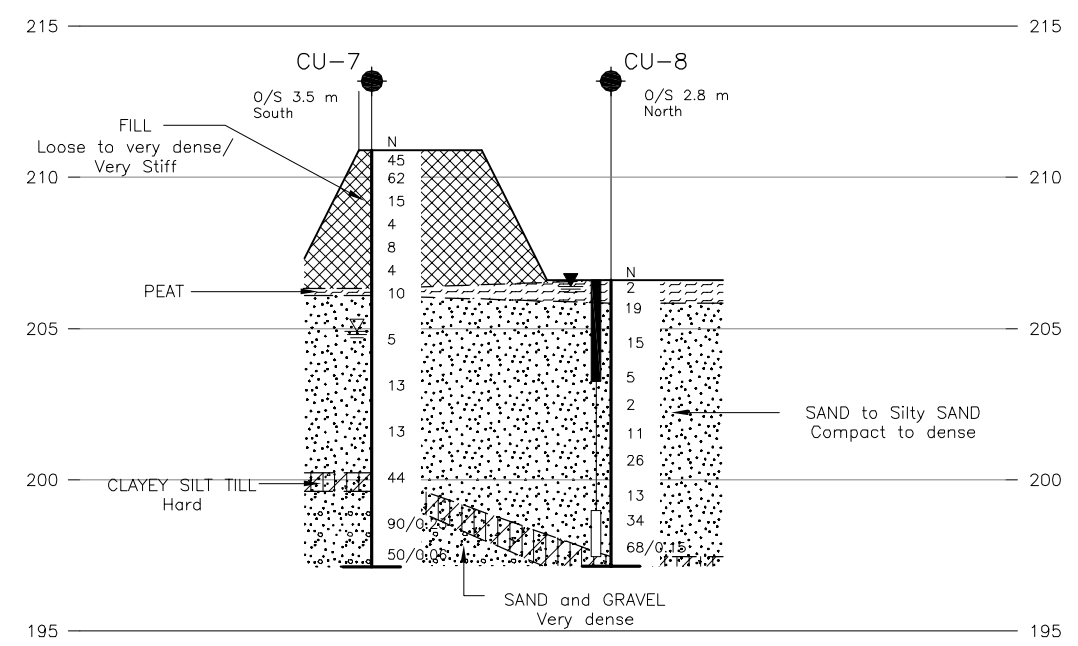
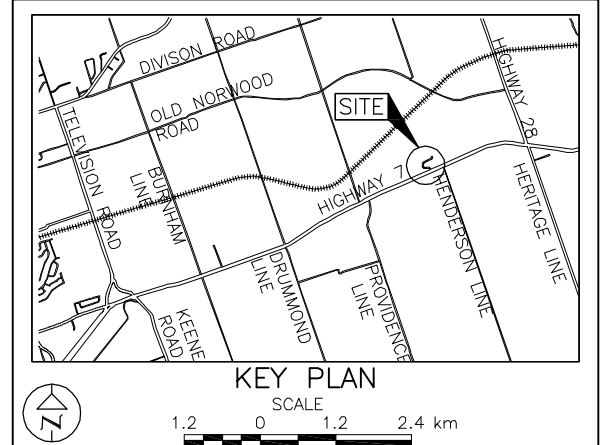


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WP No. 583-93-00

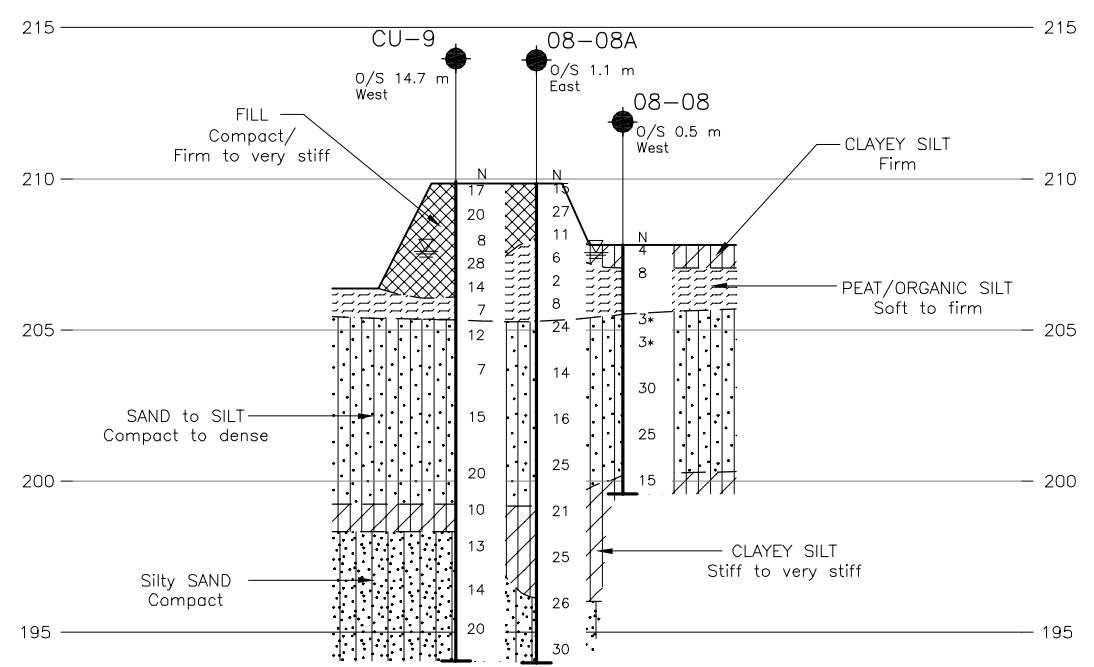
HIGHWAY 7  
CULVERTS AT STATIONS 13+884 AND 14+434

BOREHOLE LOCATIONS  
AND SOIL STRATA

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



**D-D'**  
**SECTION D-D'**  
**CULVERT AT STATION 13+884**



**E-E'**  
**SECTION E-E'**  
**CULVERT AT STATION 14+434**

**LEGEND**

- Borehole - Current Investigation
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- WL in piezometer
- WL upon completion of drilling

| No.    | ELEVATION | CO-ORDINATES |          |
|--------|-----------|--------------|----------|
|        |           | NORTHING     | EASTING  |
| CU-7   | 210.9     | 4908513.9    | 406618.4 |
| CU-8   | 206.6     | 4908487.7    | 406637.3 |
| CU-9   | 209.9     | 4908742.9    | 407118.5 |
| CU-10A | 209.7     | 4908733.9    | 407129.3 |
| CU-10B | 208.1     | 4908723.8    | 407119.7 |
| 08-08  | 207.8     | 4908729.0    | 407140.7 |
| 08-08A | 209.8     | 4908740.0    | 407137.3 |

**NOTES**

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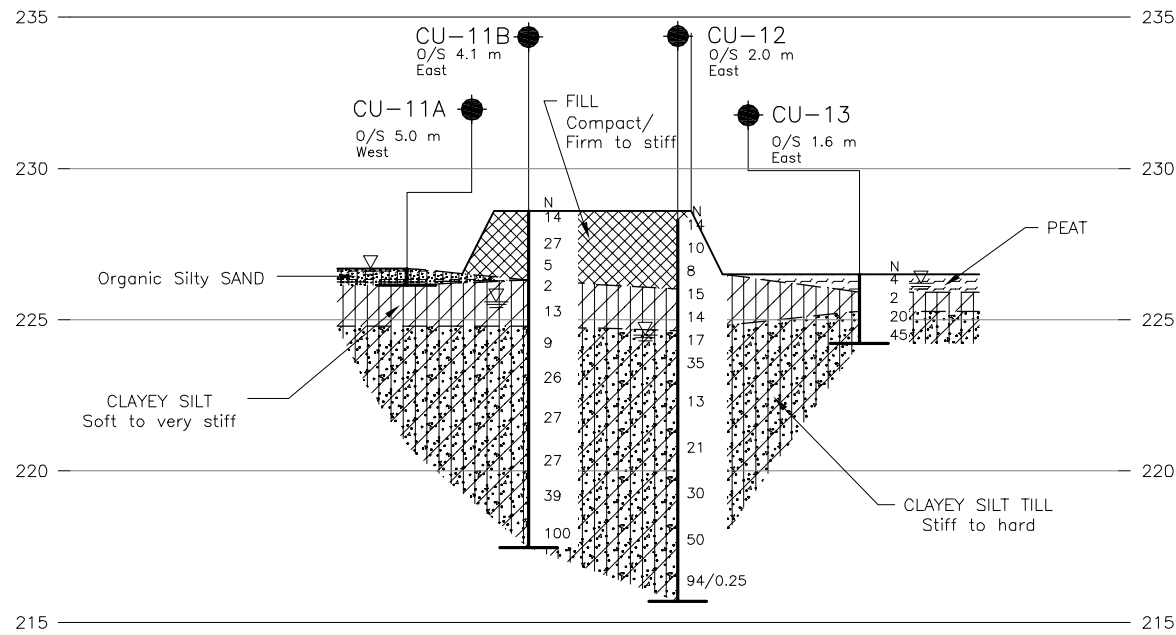
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Base plan provided in digital format by Transenco Engineering (drawing file "Plan Existing.dwg", received May 24, 2007).

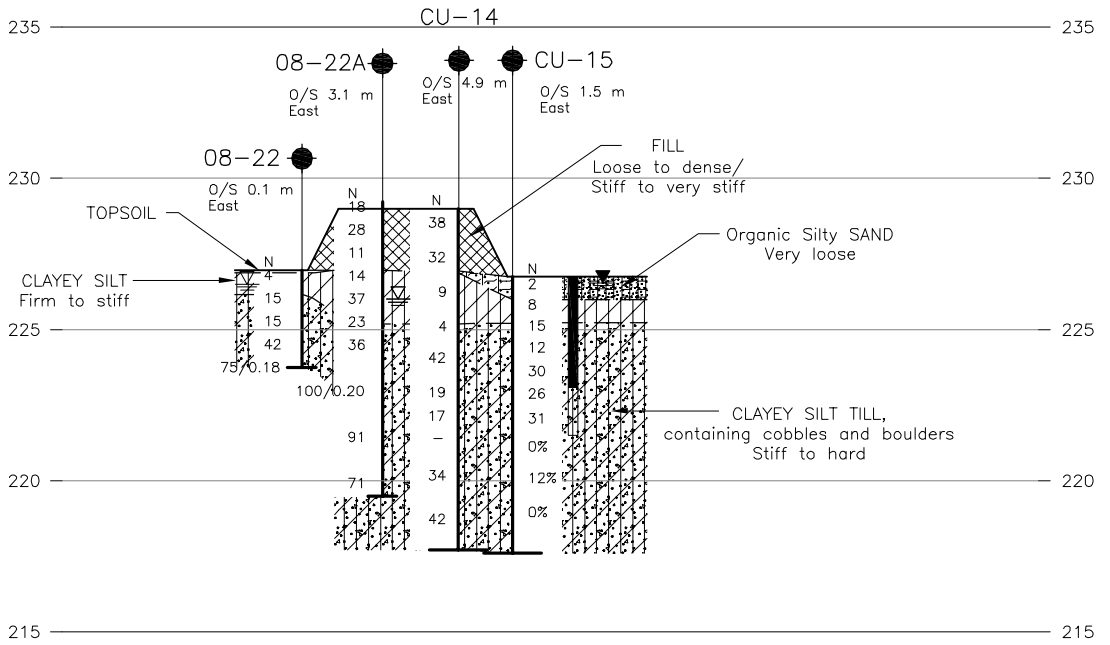
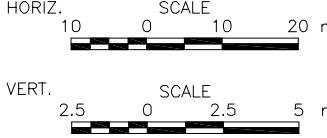
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|---------------------|-----------|-------------------------|----------|
| Geocres No. 31D-432 |           |                         |          |
| HWY. HIGHWAY 7      |           | PROJECT NO. 06-1111-044 | DIST.    |
| SUBM'D. PKS         | CHKD. LCC | DATE: 27-Feb-2009       | SITE:    |
| DRAWN: JFC          | CHKD. PKS | APPD. LCC               | DWG. 3   |



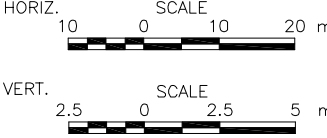
PLAN



**F-F'**  
 SECTION F-F'  
 CULVERT AT STATION 15+792



**G-G'**  
 SECTION G-G'  
 CULVERT AT STATION 16+129



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

CONT No.  
 WP No. 583-93-00

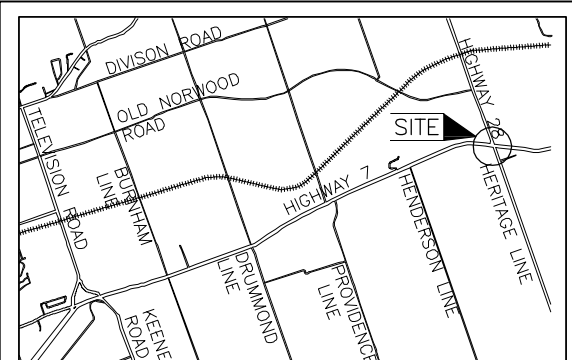


HIGHWAY 7  
 CULVERT STATIONS AT 15+792 AND 16+129  
 BOREHOLE LOCATIONS  
 AND SOIL STRATA

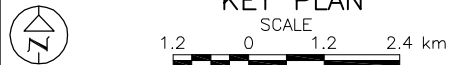
SHEET



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



KEY PLAN



LEGEND

- Borehole - Current Investigation
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- WL in piezometer
- WL upon completion of drilling

| No.    | ELEVATION | CO-ORDINATES |          |
|--------|-----------|--------------|----------|
|        |           | NORTHING     | EASTING  |
| CU-11A | 226.7     | 4909175.1    | 408392.6 |
| CU-11B | 228.6     | 4909167.6    | 408392.6 |
| CU-12  | 228.3     | 4909147.3    | 408396.3 |
| CU-13  | 226.5     | 4909138.1    | 408394.8 |
| CU-14  | 229.0     | 4909113.5    | 408724.2 |
| CU-15  | 226.7     | 4909106.0    | 408726.4 |
| 08-22  | 227.0     | 4909135.0    | 408733.0 |
| 08-22A | 229.2     | 4909124.0    | 408734.2 |

NOTES

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REFERENCE

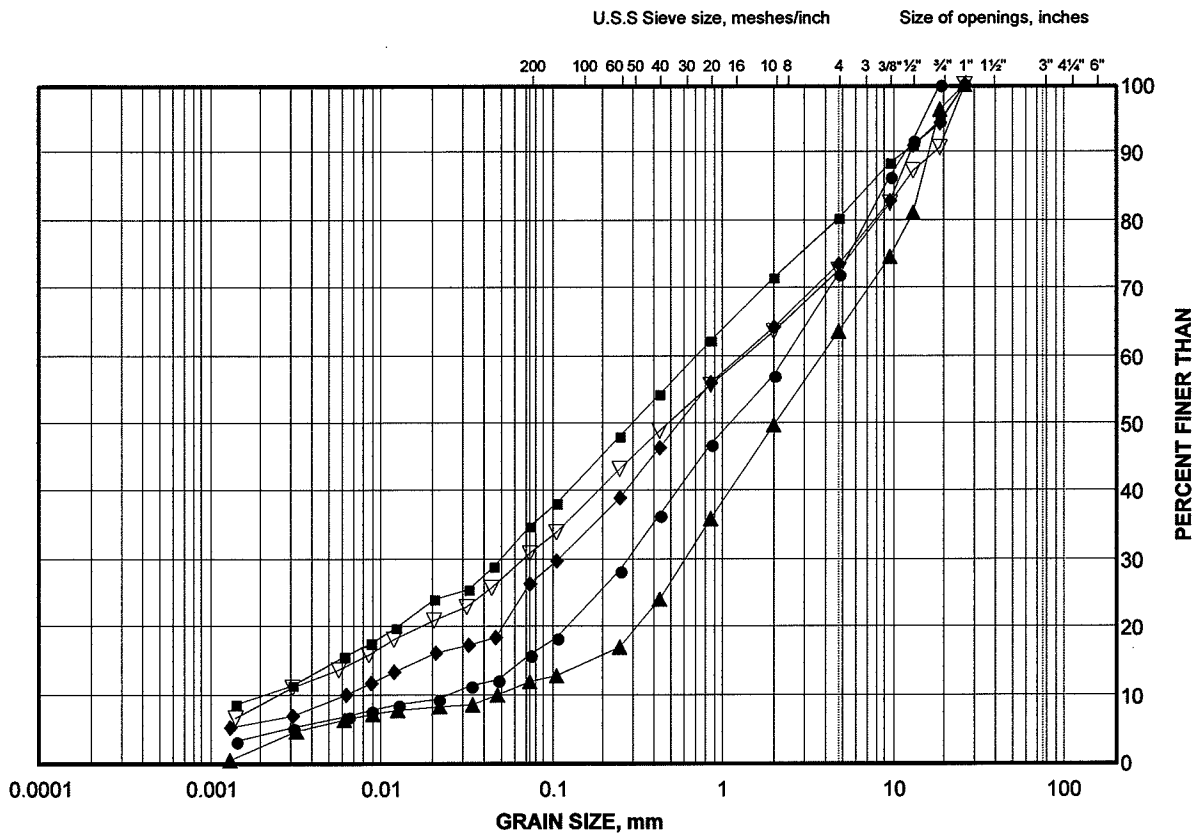
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| NO.                 | DATE                    | BY                | REVISION |
|---------------------|-------------------------|-------------------|----------|
|                     |                         |                   |          |
| Geocres No. 31D-432 |                         |                   |          |
| HWY. HIGHWAY 7      | PROJECT NO. 06-1111-044 | DIST.             |          |
| SUBM'D. PKS         | CHKD. LCC               | DATE: 27-Feb-2009 | SITE:    |
| DRAWN: JFC          | CHKD. PKS               | APPD. LCC         | DWG. 4   |

# GRAIN SIZE DISTRIBUTION TEST RESULTS

Sand and Gravel to Silty Sand Fill

FIGURE 1A



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

## LEGEND

| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|--------|----------|--------|--------------|
| ●      | CU-3     | 1      | 206.3        |
| ■      | CU-10A   | 2      | 208.7        |
| ◆      | CU-11B   | 2      | 227.6        |
| ▲      | CU-1     | 2      | 201.6        |
| ▽      | CU-14    | 3      | 227.2        |

Project Number: 06-1111-044

Checked By: *[Signature]*

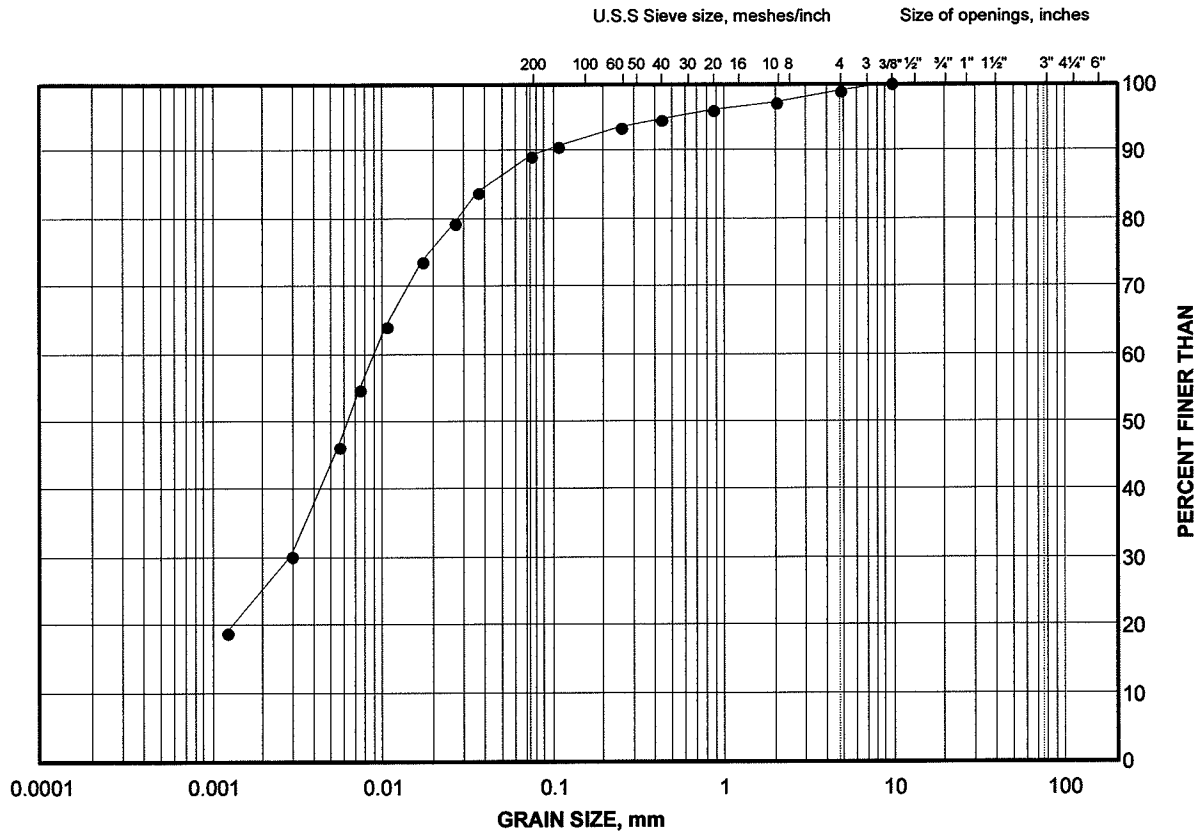
Golder Associates

Date: 20-Feb-09

# GRAIN SIZE DISTRIBUTION TEST RESULT

Clayey Silt Fill

FIGURE 1B



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

## LEGEND

| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|--------|----------|--------|--------------|
| •      | CU-9     | 3      | 208.1        |

Project Number: 06-1111-044

Checked By: *[Signature]*

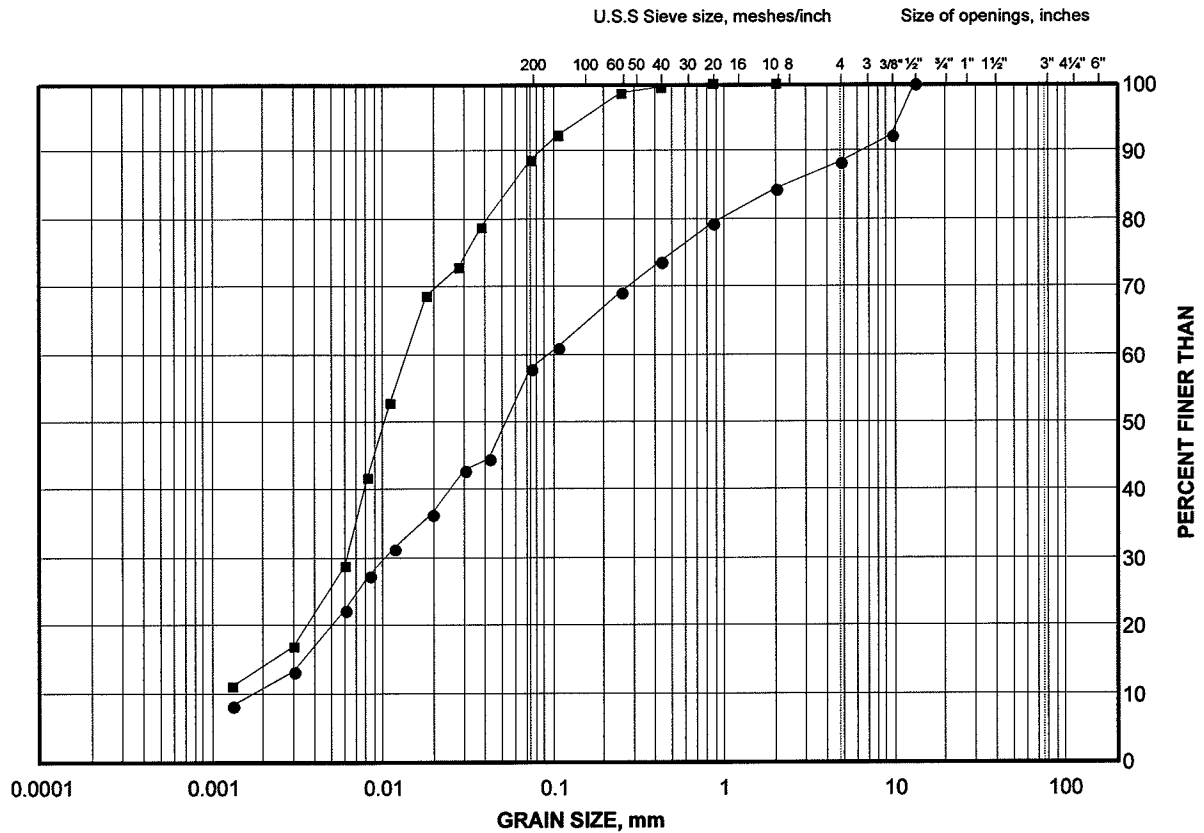
Golder Associates

Date: 20-Feb-09

# GRAIN SIZE DISTRIBUTION TEST RESULTS

Organic Silt / Clayey Silt

FIGURE 2



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

## LEGEND

| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|--------|----------|--------|--------------|
| ●      | 08-08    | 2      | 206.7        |
| ■      | 08-08A   | 5      | 206.5        |

Project Number: 06-1111-044

Checked By: *[Signature]*

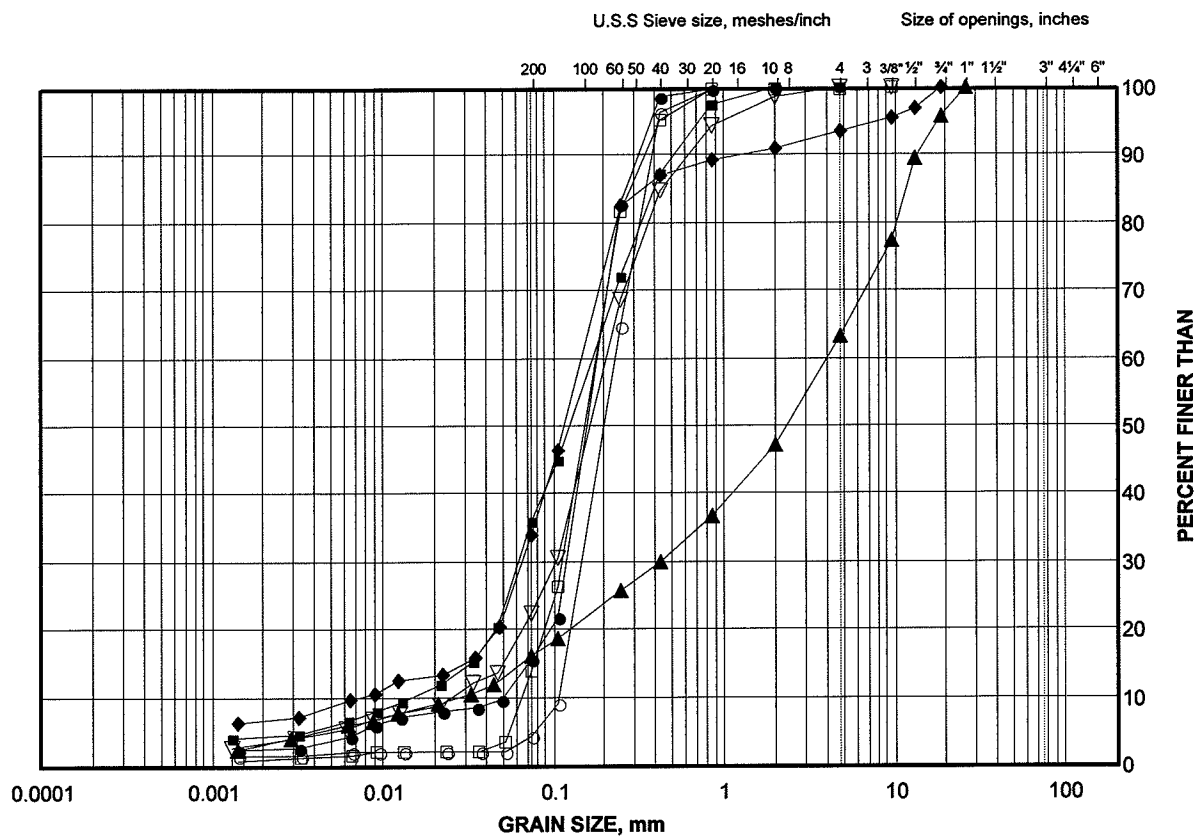
Golder Associates

Date: 20-Feb-09

# GRAIN SIZE DISTRIBUTION TEST RESULTS

Sand and Gravel to Silt

FIGURE 3A



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

## LEGEND

| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|--------|----------|--------|--------------|
| ●      | CU-6     | 2      | 203.7        |
| ■      | CU-4     | 3      | 203.5        |
| ◆      | CU-5     | 4      | 205.1        |
| ▲      | CU-4     | 5      | 201.9        |
| ▽      | CU-3     | 5      | 203.2        |
| ○      | CU-8     | 6      | 202.5        |
| □      | CU-7     | 9      | 203.0        |

Project Number: 06-1111-044

Checked By: *[Signature]*

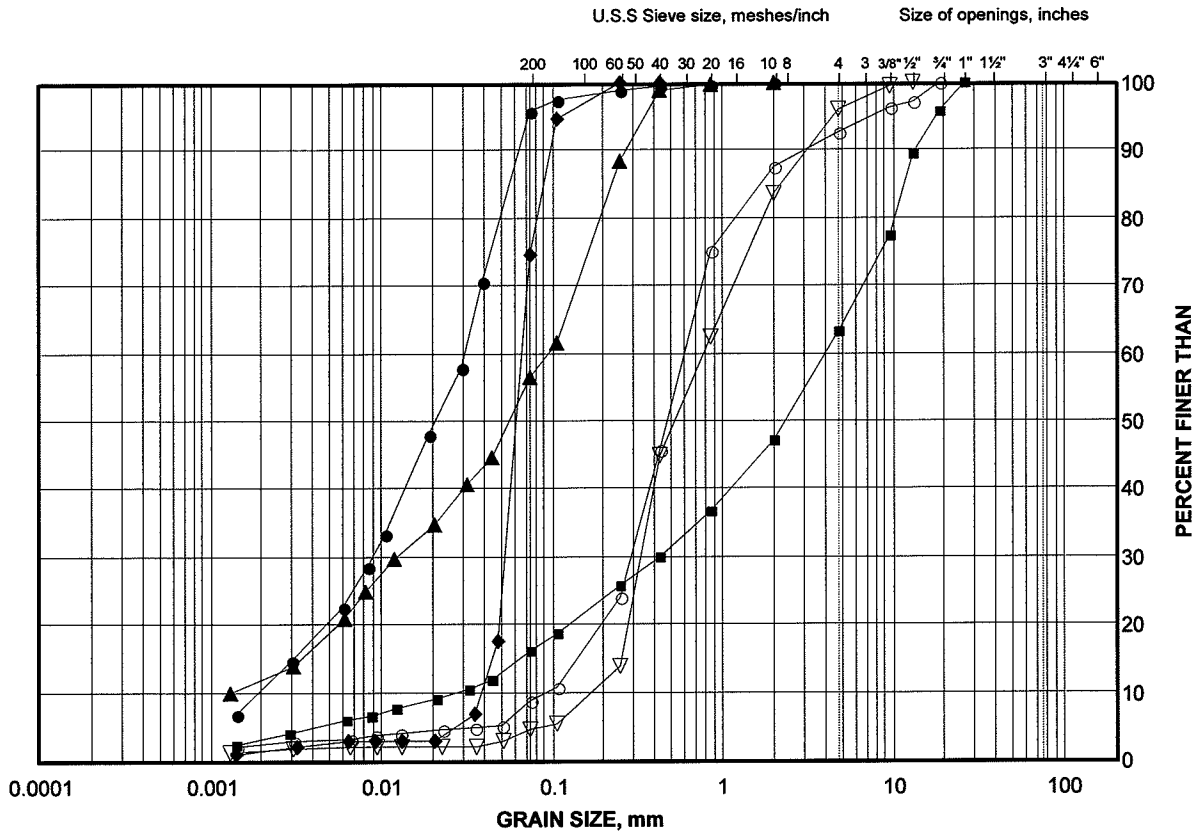
Golder Associates

Date: 20-Feb-09

# GRAIN SIZE DISTRIBUTION TEST RESULTS

Sand and Gravel to Silt

FIGURE 3B



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

## LEGEND

| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|--------|----------|--------|--------------|
| ●      | 08-08    | 3      | 205.2        |
| ■      | CU-4     | 5      | 201.9        |
| ◆      | 08-08    | 6      | 201.4        |
| ▲      | 08-08A   | 7      | 205.0        |
| ▽      | CU-9     | 8      | 203.5        |
| ○      | CU-10A   | 9      | 201.8        |

Project Number: 06-1111-044

Checked By: *W. H. H. H.*

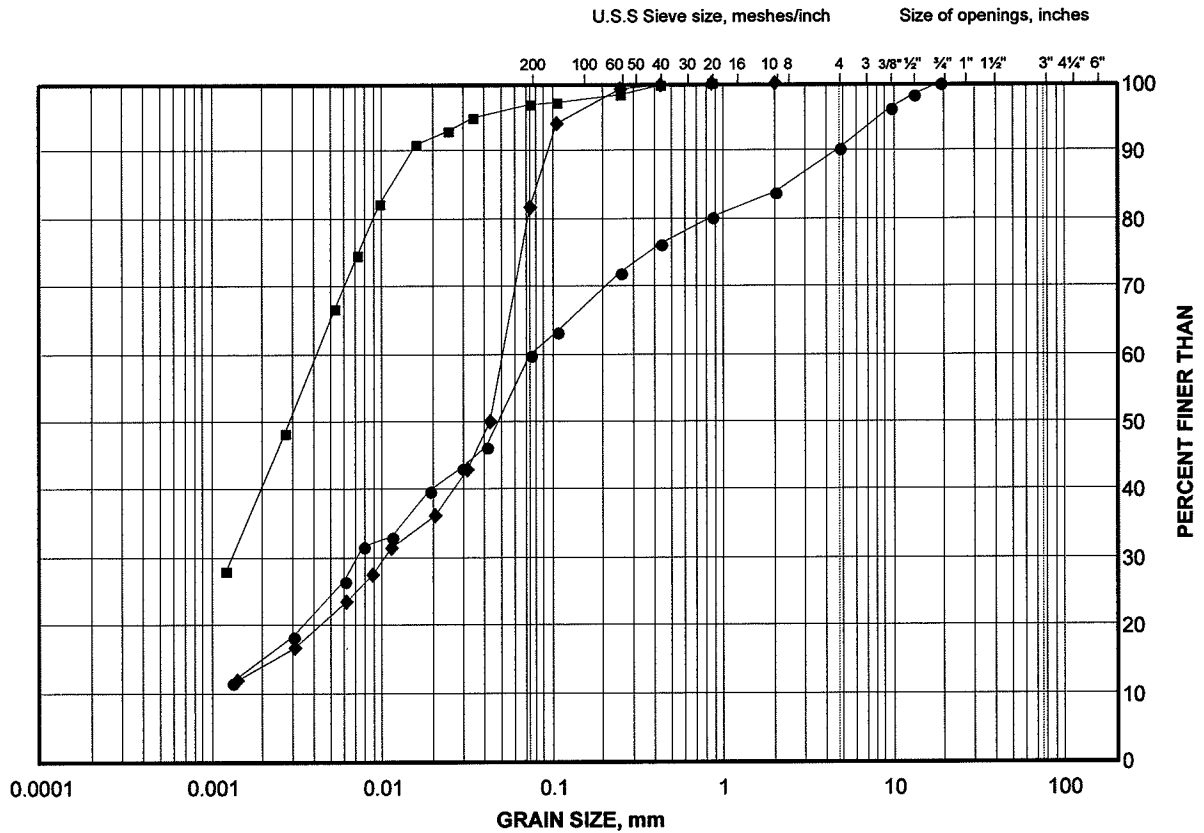
**Golder Associates**

Date: 20-Feb-09

# GRAIN SIZE DISTRIBUTION TEST RESULTS

Clayey Silt

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) |
|--------|----------|--------|--------------|
| ●      | 08-22A   | 4      | 226.6        |
| ■      | CU-6     | 5      | 201.3        |
| ◆      | CU-10B   | 8      | 203.5        |

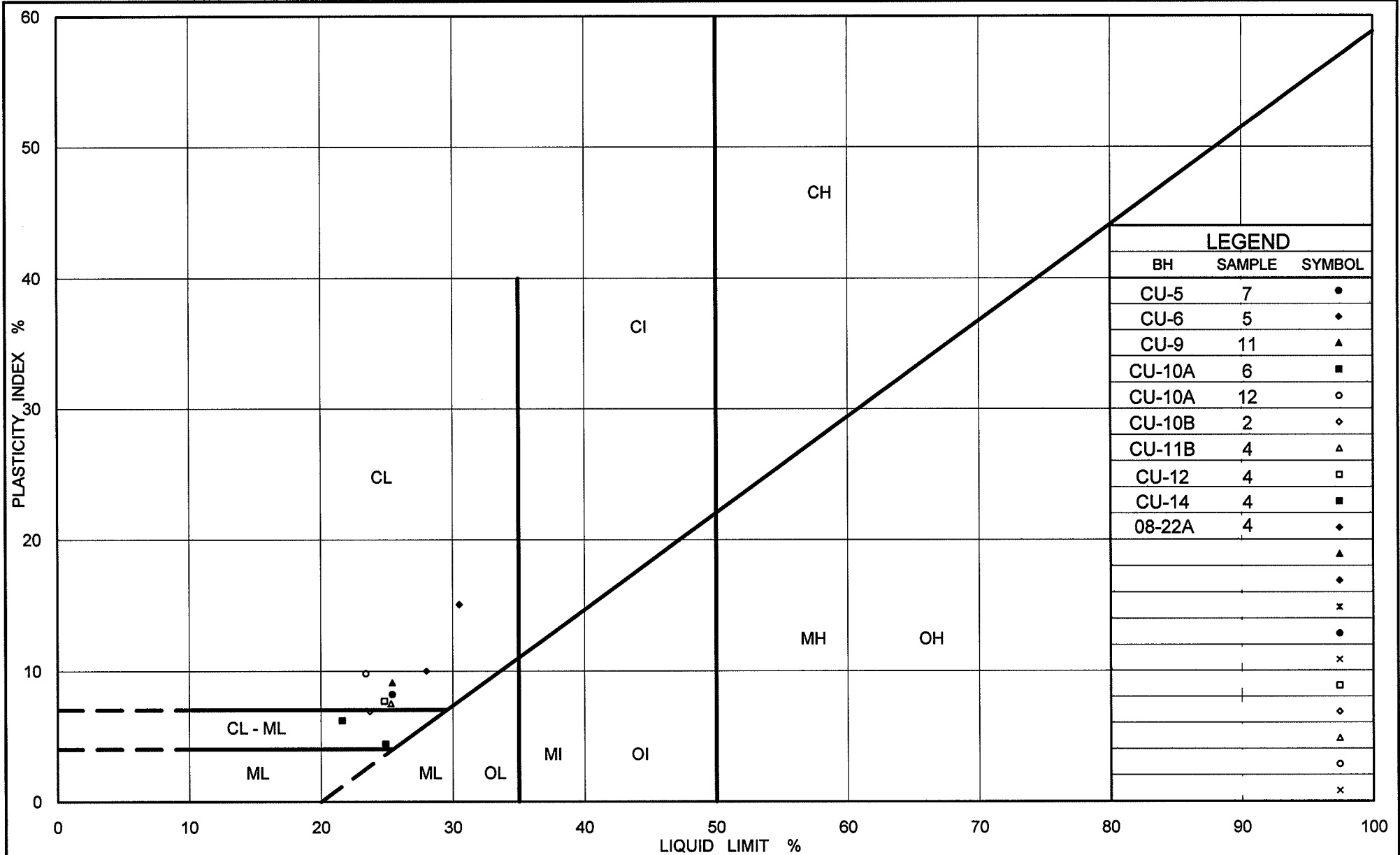
Project Number: 06-1111-044

Checked By: *Wozze*

Golder Associates

Date: 20-Feb-09





Ministry of Transportation

Ontario

# PLASTICITY CHART Clayey Silt

Figure No. 5

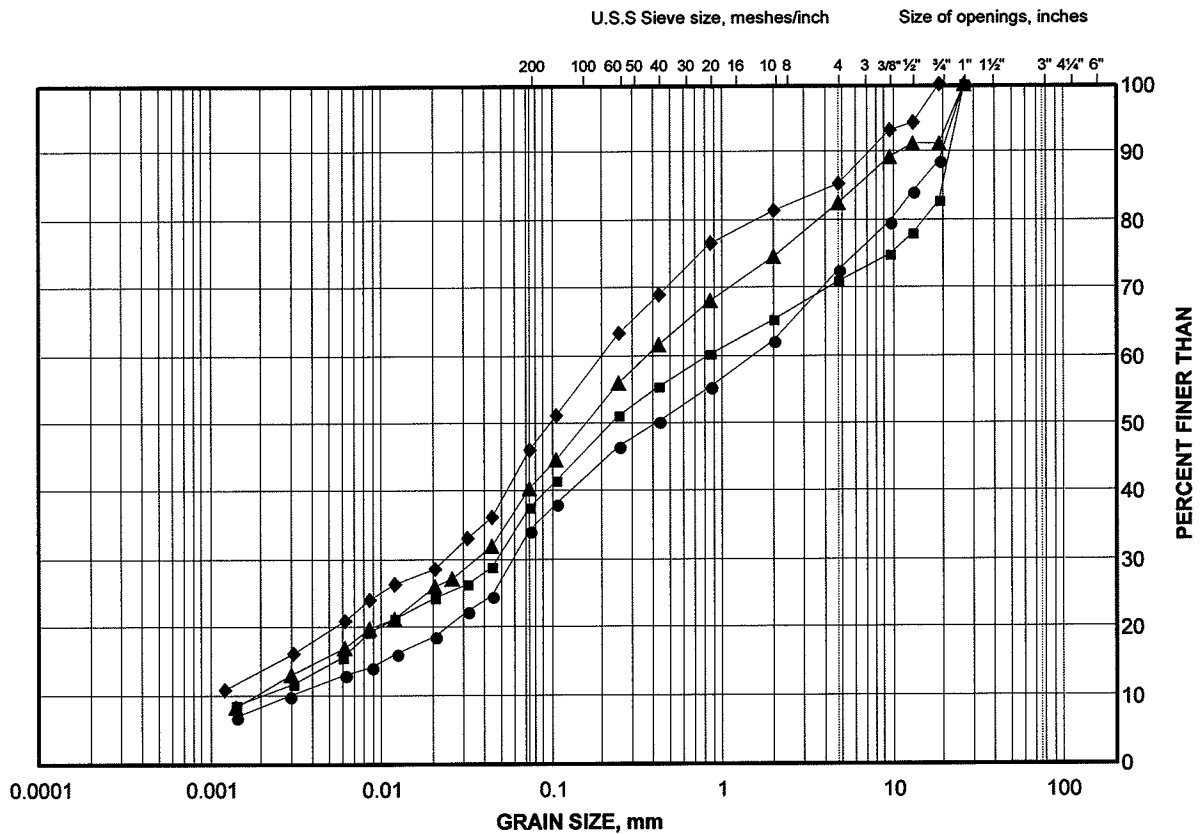
Project No. 06-1111-044

Checked By: *[Signature]*

# GRAIN SIZE DISTRIBUTION TEST RESULTS

Clayey Silt Till

FIGURE 6A



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

## LEGEND

| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|--------|----------|--------|--------------|
| ●      | CU-5     | 11     | 196.4        |
| ■      | CU-13    | 4      | 224.4        |
| ◆      | CU-11B   | 6      | 224.5        |
| ▲      | CU-1     | 6      | 198.7        |

Project Number: 06-1111-044

Checked By: *Wazye*

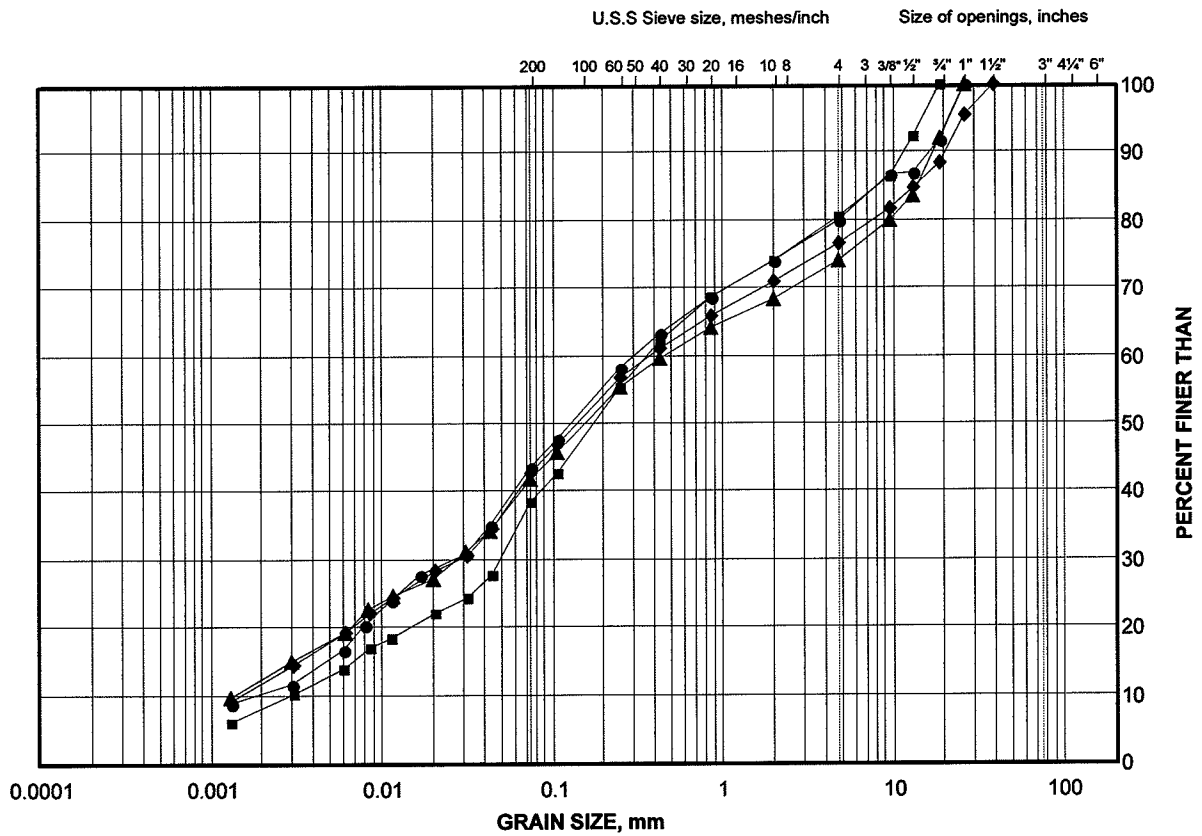
Golder Associates

Date: 20-Feb-09

# GRAIN SIZE DISTRIBUTION TEST RESULTS

Clayey Silt Till

FIGURE 6B



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

## LEGEND

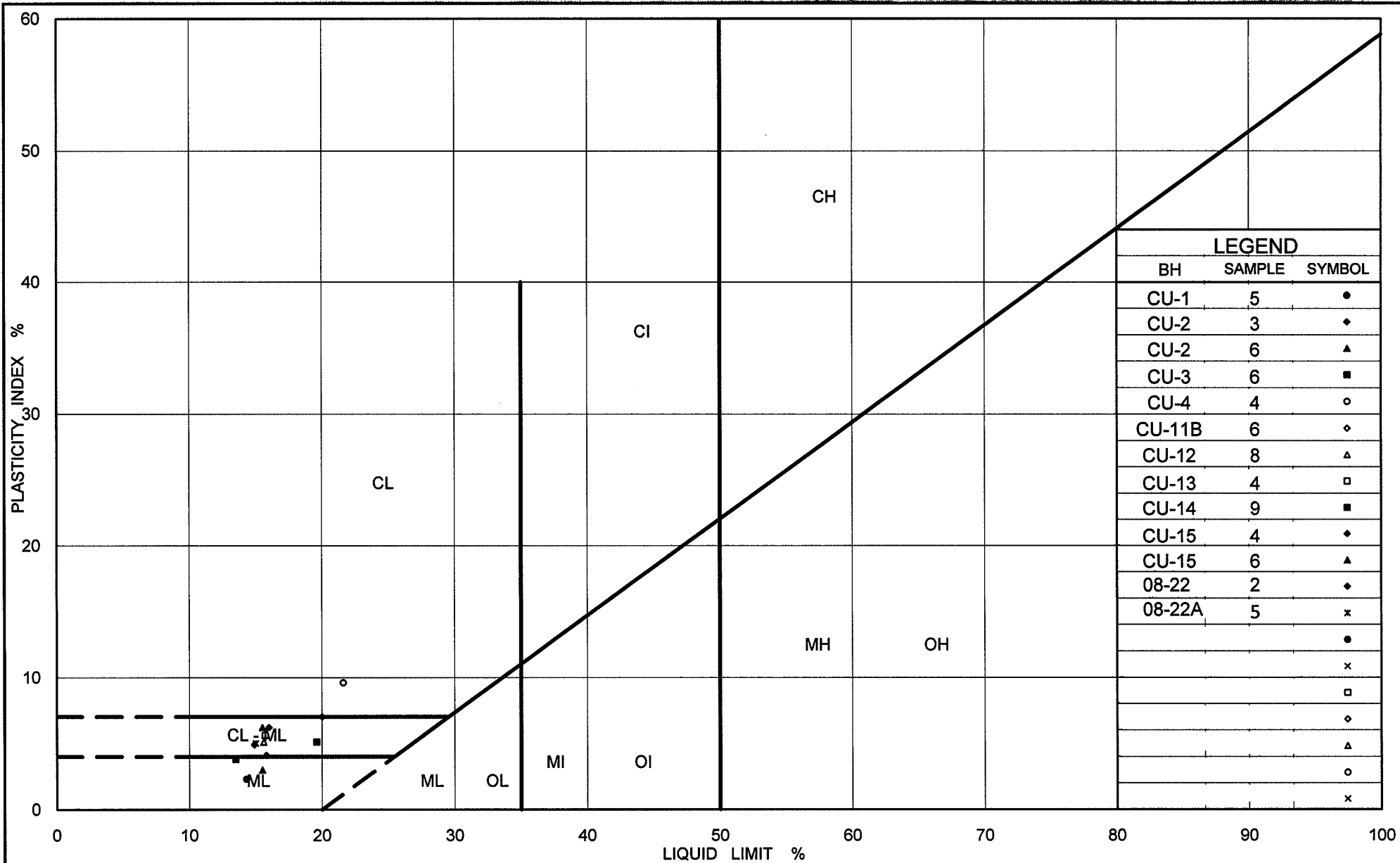
| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|--------|----------|--------|--------------|
| ●      | 08-22    | 2      | 225.9        |
| ■      | 08-22A   | 5      | 225.9        |
| ◆      | CU-15    | 5      | 223.4        |
| ▲      | CU-12    | 8      | 221.9        |

Project Number: 06-1111-044

Checked By: *W. H. H. H.*

Golder Associates

Date: 20-Feb-09



Ministry of Transportation

Ontario

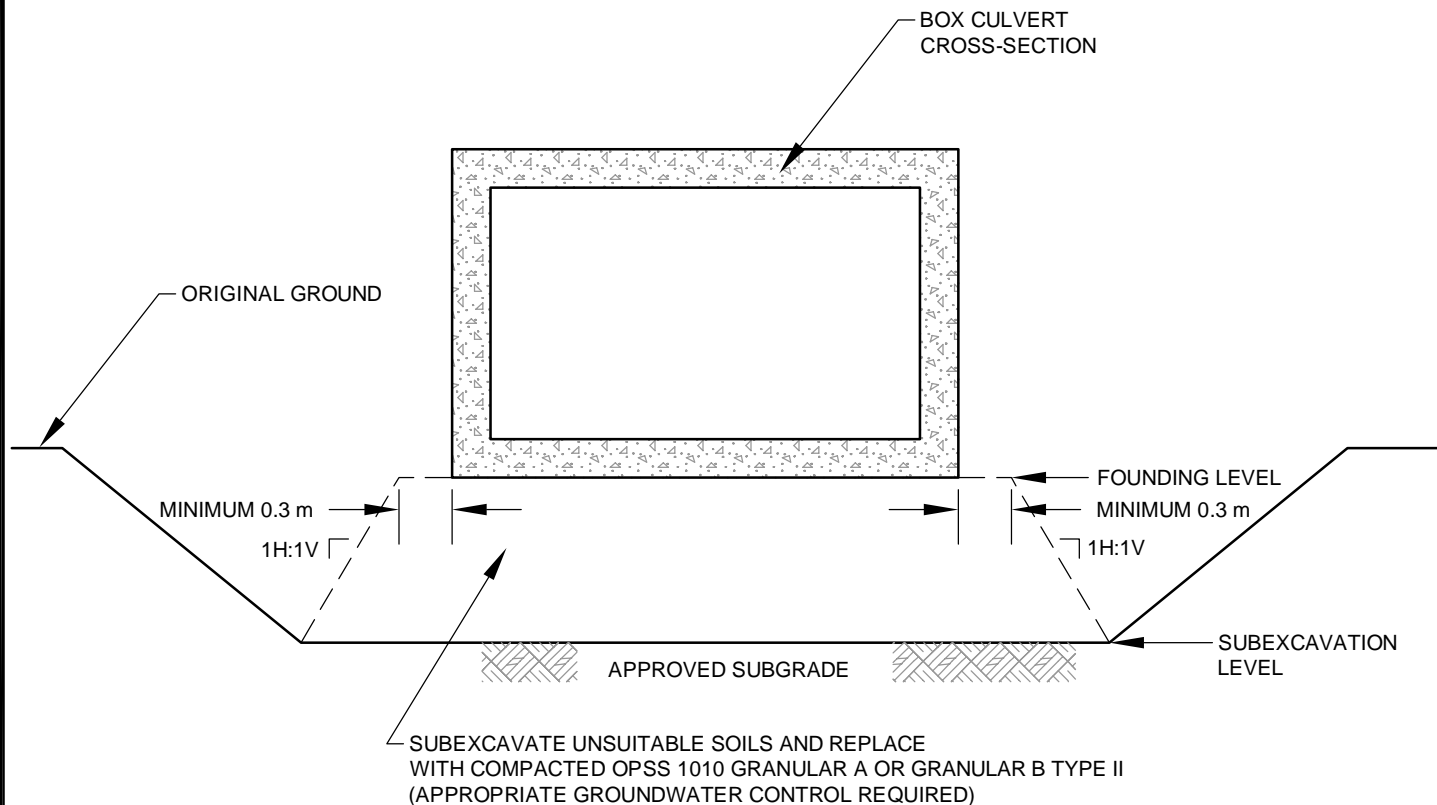
# PLASTICITY CHART Clayey Silt to Silt and Sand Till

Figure No. 7

Project No. 06-1111-044

Checked By: *W. J. [Signature]*

PLOT DATE: February 24, 2009  
 FILENAME: T:\Projects\2006\06-1111-044 (Transenco, Peterborough)\-AD-061111044AD008.dwg



**NOT TO SCALE**



|        |               |
|--------|---------------|
| SCALE  | N.T.S.        |
| DATE   | Feb. 24, 2009 |
| DESIGN |               |
| CAD    | DD            |
| CHECK  | LCC           |
| REVIEW | JMAC          |

TITLE  
**SUBEXCAVATION BELOW  
 CULVERT FOUNDING LEVEL**

FILE No. 061111044AD008.dwg

PROJECT No. 06-1111-044-1

REV.

HIGHWAY 7 WIDENING

FIGURE

**8**

**APPENDIX A**  
**NON-STANDARD SPECIAL PROVISIONS**

**GROUNDWATER CONTROL – Item No.**

---

**Non-Standard Special Provision**

---

Foundations for the new culverts or culvert extensions will require excavation below the groundwater level through cohesionless and cohesive soils at the site. Excavations through cohesionless soils submerged below the groundwater table are subjected to conditions of unbalanced head and hence can boil, cave-in and slough under these conditions. Appropriate groundwater control systems will have to be designed and installed to allow excavation and foundation subgrade preparation in the water-bearing silt to silty sand deposit, clayey silt and clayey silt till deposit. The existing footings for the culvert shall not be undermined for any culvert extension.

**Basis of Payment**

Payment at the contract price for the above tender item shall include full compensation for all labour and materials to complete the work.

END OF SECTION

**SUBGRADE PROTECTION - Item No.**

---

Non-Standard Special Provision

---

The subgrade soils for the retaining wall footing will be susceptible to disturbance and loosening from construction traffic and ponded water. If the concrete for the footing cannot be poured within four hours after inspection and approval of the prepared subgrade, a working mat of lean concrete or mass concrete, with a minimum thickness of 100 mm, should be placed on the foundation subgrade.

**Basis of Payment**

Payment at the contract price for this tender item shall include full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION