

**FOUNDATION INVESTIGATION AND DESIGN REPORT  
RETAINING WALLS AND NOISE BARRIER WALLS  
HIGHWAY 417 WIDENING  
NICHOLAS STREET TO O.R.174  
OTTAWA, ONTARIO**

**G.W.P. 4091-07-00 and 4320-06-00**

**Geocres Number: 31G5-250**

**Report to**

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| Appendix I includes:            | Record of Borehole Sheets<br>Borehole Location and Soil Strata Drawings  |

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**PART 1: FACTUAL INFORMATION**

**1 INTRODUCTION**

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) at proposed retaining wall and noise barrier locations along Highway 417 from Nicholas Street to O.R.174 in Ottawa, Ontario. These retaining walls and noise barriers are part of the Highway 417 Widening project. This report addresses all retaining walls and noise barriers included in the Highway 417 Widening final design, as identified by McCormick Rankin Corporation (MRC).

Twelve retaining walls (identified as 12N, 13N, 14N, 15N, 16N, 17N, 18N, 19N, 21S, 22S, 23S, and 1M) and one section of noise barrier (at Lees Avenue North) were initially proposed and investigated. During the course of the foundation investigation, four additional retaining walls were added to the highway widening design (identified as Nicholas Street Underpass South, Lees Avenue S-E Ramp, Lees Avenue North at Robinson Avenue, and Canadian Tire Parking Lot). Six of the initially proposed walls were also eliminated from the final design after boreholes had already been drilled at these locations (17N, 18N, 19N, 21S, 22S, 1M).

The purpose of this investigation was to explore the subsurface conditions along the proposed retaining wall and noise barrier alignments and, based on the data obtained, to provide borehole location plans, record of borehole sheets, stratigraphic profiles, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions under the proposed retaining walls and noise barriers was developed from the data obtained in the course of the investigation.

Thurber carried out the investigation as a sub-consultant to McCormick Rankin Corporation, under the Ministry of Transportation Ontario (MTO) Agreement Number 4009-E-0007.

## **2 SITE DESCRIPTION**

Highway 417 is currently a 3 to 4 lane divided highway. The widening of Highway 417 from Nicholas Street to O.R.174 includes the installation of new retaining walls and noise barriers. From Nicholas Street to O.R.174 along Highway 417 is approximately 4 km. Highway 417 crosses over the Rideau River approximately 805 m east of Nicholas Street.

The lands surrounding Highway 417 between Nicholas Street and O.R.174 primarily comprise commercial and industrial developments.

The Highway 417 project area lies within the Ottawa Valley Clay Plains physiographic region, a clay plains interrupted by ridges of sand or rock. The bedrock consists of the Carlsbad Formation, comprising dark grey shale interbedded with calcareous siltstone and limestone.

## **3 SITE INVESTIGATION AND FIELD TESTING**

The site investigation and field testing for this project were carried out between July 18, 2011 and May 3, 2012 and consisted of drilling and sampling a total of fifty-four (54) boreholes for thirteen proposed retaining walls and one noise barrier wall. Subsequent to drilling, six of the proposed walls were deleted. A summary of the currently proposed retaining wall and noise barrier locations, the deleted wall designations, and corresponding boreholes is presented in Table 3.1.

The respective appendices, which include Record of Borehole sheets, laboratory test results, and Borehole Locations and Soil Strata Drawings for each wall, are also listed in Table 3.1.

The approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata Drawings included in Appendix A through I. The coordinates and elevations of the boreholes are given on the drawings and on the individual Record of Borehole sheets.

The borehole locations were marked in the field, where possible and utility clearances were obtained prior to commencement of drilling operations. Boreholes were repositioned as necessary to avoid conflicts with utilities. A City of Ottawa Road Cut Permit was obtained for the two boreholes drilled on Robinson Avenue (Boreholes LE-08 and LE-09).

The drilling was carried out using both a track-mounted and a truck-mounted drill rig. A combination of hollow-stem auger drilling techniques and NQ coring methods were used to advance the boreholes. Overburden samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). Where bedrock was encountered within the programmed exploration depth, cores of the rock were recovered. All rock cores were logged, and the Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined. The borehole depths ranged from 1.6 m to 14.6 m.

**Table 3.1 – Summary of Proposed Retaining Walls and Noise Barriers and Corresponding Boreholes**

| <b>Proposed Wall</b>                                     | <b>Approx. Station</b> | <b>Length (m)</b> | <b>Boreholes</b>                             | <b>Appendix</b> |
|--|------------------------|-------------------|--|-----------------|
| Nicholas Street Underpass (South)                        | 130+329 to 130+366     | 37                | NSW-1 and NSW-2                              | A               |
| Lees Avenue S-E Ramp                                     | 10+290 to 10+375       | 85                | LSER-01 to LSER-04                           | B               |
| Lees Avenue (North) at Robinson Avenue                   | 230+718 to 230+751     | 33                | LE-08 and LE-09                              | C               |
| Lees Avenue (North) Noise Barrier                        | 230+680 to 231+080     | 400               | 12N-01, 12N-02, 13N-01, NB8-01, 14N-01 to 03 | D               |
| Canadian Tire Parking Lot – Riverside to Belfast (North) | 210+902 to 211+000     | 98                | 15N-01, CTW-1, CTW-2, OHS-07L                | E               |
| Belfast Road (North) Wall 15N                            | 211+220 to 211+700     | 480               | 15N-01 to 15N-12                             | F               |
| Belfast Road (South) Wall 23S                            | 111+025 to 111+705     | 680               | 23S-01 to 23S-09                             | G               |
| St. Laurent Blvd. N-W Ramp Wall 16N                      | 212+000 to 212+200     | 200               | 16N-1 to 16N-3                               | H               |
| Wall 21S   | Cancelled              |                   | 21S-01 to 21S-03                             | I               |
| Wall 22S   | Cancelled              |                   | 22S-01 and 22S-02                            | I               |
| Wall 1M  | Cancelled              |                   | 1M-01 and 1M-02                              | I               |
| Wall 17N   | Cancelled              |                   | 17N-02                                       | I               |
| Wall 18N   | Cancelled              |                   | 18N-1 to 18N-3                               | I               |
| Wall 19N   | Cancelled              |                   | 19N-1 and 19N-2                              | I               |

Groundwater conditions were observed in the open boreholes throughout the drilling operations, where possible. Standpipe piezometers consisting of 19 mm diameter PVC pipe with a slotted screen were installed in selected boreholes for monitoring of stabilized groundwater levels. The installation details of the piezometers are summarized in Table 3.2. Following the final water level reading, the piezometers will be decommissioned in general accordance with MOE Regulation 903.

**Table 3.2 – Piezometer Installation Details**

| Borehole | Tip Position (m) |       | Completion Details   |
|----------|------------------|-------|--|
|          | Depth            | Elev. |  |
| NSW-1    | 11.9             | 47.2  | Sand filter from 13.9 to 10.1 m, bentonite from 10.1 to 0.3 m, then asphalt to surface. Flush-mount casing protector at surface.   |
| LSER-01  | 11.4             | 47.6  | Sand filter from 11.4 to 6.9 m, bentonite from 6.9 to surface. Flush-mount casing protector at surface.  |
| LSER-03  | 10.7             | 49.0  | Sand filter from 11.3 to 5.8 m, bentonite from 5.8 to 0.9 m, sand from 0.9 to 0.2 m, then asphalt to surface. Flush-mount casing protector at surface.                                     |
| LSER-04  | 11.8             | 48.1  | Sand filter from 11.8 to 9.0 m, bentonite from 9.0 to 3.3 m, cuttings from 3.3 to 0.9 m, sand from 0.9 to 0.2 m, then asphalt to surface. Flush-mount casing protector at surface.         |
| LE-08    | 8.9              | 51.8  | Sand filter from 8.9 to 6.9 m, bentonite from 6.9 to 1.2 m, cuttings from 1.2 to 0.3 m, sand from 0.3 to 0.2 m, then asphalt to surface. Flush-mount casing protector at surface.          |
| LE-09    | 7.6              | 52.9  | Sand filter from 7.6 to 5.5 m, bentonite from 5.5 to 1.2 m, cuttings from 1.2 to 0.3 m, sand from 0.3 to 0.2 m, then asphalt to surface. Flush-mount casing protector at surface.          |
| 12N-02   | 4.6              | 56.3  | Sand filter from 4.6 to 2.5 m, bentonite from 2.5 to 1.9 m, cuttings and bentonite mixture from 1.9 to 0.2 m, then asphalt cold patch to surface. Flush-mount casing protector at surface. |
| 13N-01   | 6.1              | 54.3  | Sand filter from 6.1 to 4.0 m, bentonite from 4.0 to 3.4 m, cuttings and bentonite mixture from 3.4 to 0.2 m, then asphalt cold patch to surface. Flush-mount casing protector at surface. |
| 14N-02   | 6.1              | 54.0  | Sand filter from 6.1 to 4.0 m, bentonite from 4.0 to 3.4m, cuttings and bentonite mixture from 3.4 to 0.2 m, then asphalt cold patch to surface. Flush-mount casing protector at surface.  |
| CTW-1    | 10.1             | 50.9  | Sand filter from 10.1 to 6.1 m, bentonite from 6.1 to 0.6 m, sand from 0.6 to 0.3 m, then asphalt to surface. Flush-mount casing protector at surface.                                     |
| 15N-01   | 4.6              | 56.5  | Sand filter from 4.6 to 1.2 m, bentonite from 1.2 to 0.2 m, then asphalt cold patch to surface. Flush-mount casing protector at surface.   |
| 15N-03   | 5.3              | 56.6  | Sand filter from 5.3 to 1.8 m, bentonite from 1.8 to 0.2 m, then asphalt cold patch to surface. Flush-mount casing protector at surface.   |
| 15N-05   | 5.3              | 57.5  | Sand filter from 5.3 to 3.1 m, bentonite from 3.1 to 0.2 m, then asphalt cold patch to surface. Flush-mount casing protector at surface.   |
| 15N-07   | 4.6              | 59.9  | Sand filter from 6.4 to 1.2 m, bentonite from 1.2 to 0.2 m, then asphalt cold patch to surface. Flush-mount casing protector at surface.   |
| 15N-09   | 3.1              | 63.1  | Sand filter from 4.3 to 0.6 m, bentonite from 0.6 to 0.2 m, then asphalt cold patch to surface. Flush-mount casing protector at surface.   |

| Borehole | Tip Position (m) |       | Completion Details   |
|----------|------------------|-------|--|
|          | Depth            | Elev. |  |
| 15N-11   | 4.6              | 63.3  | Sand filter from 4.6 to 1.2 m, bentonite from 1.2 to 0.3 m, cuttings from 0.3 to 0.2 m, then asphalt cold patch to surface. Flush-mount casing protector at surface. |
| 23S-02   | 5.5              | 57.0  | Sand filter from 5.5 to 2.1 m, bentonite from 2.1 to 0.2 m, then asphalt cold patch to surface. Flush-mount casing protector at surface.                             |
| 23S-04   | 3.7              | 60.3  | Sand filter from 8.0 to 1.8 m, bentonite from 1.8 to 0.9 m, cuttings from 0.9 to 0.2 m, then asphalt cold patch to surface. Flush-mount casing protector at surface. |
| 23S-06   | 3.1              | 62.7  | Sand filter from 4.3 to 0.9 m, bentonite from 0.9 to 0.2 m, then asphalt cold patch to surface. Flush-mount casing protector at surface.                             |
| 23S-08   | 3.1              | 64.3  | Sand filter from 4.3 to 0.9 m, bentonite from 0.9 to 0.2 m, then asphalt cold patch to surface. Flush-mount casing protector at surface.                             |
| 16N-1    | 7.6              | 62.3  | Sand filter from 7.6 to 4.3 m, bentonite from 4.3 to 2.5 m, cuttings from 2.5 to 0.1 m, then asphalt cold patch to surface. Flush-mount casing protector at surface. |
| 16N-3    | 5.2              | 63.3  | Sand filter from 5.2 to 3.4 m, bentonite from 3.4 to 2.1 m, cuttings from 2.1 to 0.1 m, then asphalt cold patch to surface. Flush-mount casing protector at surface. |
| 21S-01   | 4.6              | 55.6  | Sand filter from 4.6 to 2.8 m, bentonite from 2.8 to 2.1 m, cuttings from 2.1 to surface.  |
| 21S-03   | 4.6              | 55.8  | Sand filter from 4.6 to 2.8 m, bentonite from 2.8 to 2.1 m, cuttings from 2.1 to surface.  |
| 22S-02   | 4.6              | 55.9  | Sand filter from 4.6 to 2.8 m, bentonite from 2.8 to 2.1 m, cuttings from 2.1 to surface.  |
| 1M-02    | 3.0              | 57.8  | Sand filter from 3.0 to 1.2 m, bentonite from 1.2 to 0.3 m, then concrete to surface.  |

The drilling and sampling operations were supervised on a full time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil and bedrock samples for transport to Thurber's laboratory for further examination and testing.

#### 4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to gradation analysis (sieve and hydrometer) and Atterberg Limits testing, where appropriate. The results of this testing program are summarized on the Record of Borehole sheets and plotted on the figures included in Appendix A through Appendix I.

Point load tests were carried out on selected samples of intact bedrock core to assist in evaluation of the compressive strength of the bedrock. Results of the point load tests are included on the Record of Borehole sheets in Appendix A to I (as average per core run).

## **5 DESCRIPTION OF SUBSURFACE CONDITIONS**

Reference is made to the Record of Borehole sheets and to the Borehole Locations and Soil Strata Drawings included in Appendix A through I for the details of the encountered soil stratigraphy. An overall description of the stratigraphy encountered in the boreholes at each currently proposed retaining wall and noise barrier is given in the following paragraphs. However, the factual data presented in the borehole logs takes precedence over this general description and interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond borehole locations.

More detailed descriptions of the individual strata encountered at each of the currently proposed walls are presented below. The Record of Borehole sheets for boreholes drilled at deleted wall locations (Appendix I) are provided for information purposes only.

### **5.1 Nicholas Street Underpass (South) – Station 130+329 to 130+366 (Appendix A: Boreholes NSW-1 and NSW-2)**

Two boreholes, identified as NSW-1 and NSW-2, were drilled on the right shoulder of the Nicholas Street N-E ramp along the proposed alignment of the retaining wall under Nicholas Street at the south abutment. The stratigraphy encountered in the boreholes consisted of a pavement structure and sand fill underlain by successive layers of sand, silty clay, silt and silty sand till. Shale was encountered below the till.

#### **5.1.1 Asphalt and Concrete**

Asphalt was encountered at surface in both boreholes drilled at this location. The thickness of the asphalt ranged from 75 mm to 100 mm.

A layer of concrete was encountered below the asphalt in Borehole NSW-1, only. The concrete was 350 mm thick.

#### **5.1.2 Sand Fill**

A layer of sand fill was encountered below the asphalt in Borehole NSW-2 and below the concrete in Borehole NSW-1. The sand fill was brown and contained trace to some gravel and trace silt.

The sand fill was 1.9 m thick in Borehole NSW-1 and 2.2 m thick in Borehole NSW-2. The lower boundary of the sand fill was encountered at a depth of 2.3 m in both boreholes (Elevation 56.8).

SPT N-values recorded in the sand fill ranged from 22 to 45 blows for 0.3 m, indicating a compact to dense relative density.

The moisture content of samples of the sand fill ranged from 4% to 11%.

One sample of the sand fill was selected for laboratory grain size analysis testing. The results of this test are summarized below. These results are also presented on the corresponding Record of Borehole sheet included in Appendix A and the grain size distribution curve for this sample is plotted on Figure A1, Appendix A.

|               |    |
|---------------|----|
| Gravel %      | 14 |
| Sand %        | 80 |
| Silt & Clay % | 6  |

#### 5.1.3 Sand

Native sand was encountered below the sand fill in both boreholes. The native sand was brown to grey and contained trace to some silt, trace gravel and trace clay. The native sand encountered in Borehole NSW-1 became more coarse with increased depth.

The thickness of the native sand layer ranged from 0.7 m in Borehole NSW-2 to 1.7 m in Borehole NSW-1. The lower boundary of the native sand was encountered at depths of 3.0 m to 4.0 m (Elevation 56.1 to 55.1).

SPT N-values recorded in the native sand layer ranged from 7 to 23 blows for 0.3 m penetration, indicating a loose to compact relative density.

The moisture content of samples of the native sand ranged from 10% to 20%.

#### 5.1.4 Silty Clay

A layer of silty clay was encountered below the native sand in both boreholes. The silty clay was grey in colour and contained trace sand.

The thickness of the silty clay layer was 2.1 m and 1.6 m in Boreholes NSW-1 and NSW-2, respectively. The lower boundary of the silty clay was encountered at a depth of 6.1 m in Borehole NSW-1 and at a depth of 4.6 m in Borehole NSW-2 (Elevation 53.0 and 54.5).

SPT N-values of 4 and 6 blows for 0.3 m penetration were recorded in the silty clay. These N-values indicate that the silty clay has a soft to firm consistency.

The moisture content of two samples of the silty clay were 46% and 48%.

One sample of the silty clay underwent laboratory grain size analysis and Atterberg Limits testing, the results of which are summarized below. These results are presented on the corresponding Record of Borehole sheet in Appendix A and the lab results are plotted on Figures A2 and A5.



|                 |    |
|-----------------|----|
| Gravel %        | 0  |
| Sand %          | 2  |
| Silt %          | 48 |
| Clay %          | 50 |
| Liquid Limit%   | 44 |
| Plastic Limit % | 20 |

The Atterberg Limits indicate that the clay is of medium plasticity with a symbol of CI.

#### 5.1.5 Silt

Below the silty clay, a layer of silt was encountered in both boreholes. The silt was grey and contained trace to some sand and trace to some clay.

The layer of silt was 3.0 m thick in Borehole NSW-1 and 2.7 m thick in Borehole NSW-2. The lower boundary of the silt was encountered at depths of 9.1 m and 7.3 m (Elevation 50.0 and 51.8).

SPT N-values recorded in the silt ranged from 7 to 13 blows for 0.3 m penetration, indicating a loose to compact relative density.

The moisture content of samples of the silt ranged from 17% to 36%.

Two samples of the silt underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix A and the grain size distribution curves for these samples are plotted on Figure A3, Appendix A.

|          |          |
|----------|----------|
| Gravel % | 0        |
| Sand %   | 6 to 8   |
| Silt %   | 77 to 88 |
| Clay %   | 6 to 15  |

#### 5.1.6 Silty Sand Till

Silty sand till was encountered below the silt layer in both boreholes. The silty sand till was grey and contained trace clay to clayey and trace to some gravel.

The thickness of the silty sand till was 4.8 m in Borehole NSW-1 and 6.6 m in Borehole NSW-2. In Borehole NSW-1, the lower boundary of the silty sand till was inferred from auger refusal on probable bedrock at a depth of 13.9 m (Elevation 45.2). The lower boundary of the silty sand till was encountered at a depth of 13.9 m in Borehole NSW-2 (Elevation 45.2).

SPT N-values recorded in the silty sand till ranged from 2 blows for 0.3 m penetration to 50 blows for 0.15 m penetration, indicating that the relative density of the silty sand till

varies from very loose to very dense. Based on the recorded SPT N-values, the silty sand till generally has a compact relative density.

The moisture content of the silty sand till ranged from 7% to 13%.

Two samples of the silty sand till underwent laboratory grain size analysis testing. The results of these tests are summarized below and are also presented on the Record of Borehole sheets included in Appendix A. The grain size distribution curves for these samples are plotted on Figure A4, Appendix A.

|          |          |
|----------|----------|
| Gravel % | 10       |
| Sand %   | 39 to 53 |
| Silt %   | 27 to 29 |
| Clay %   | 10 to 23 |

It should be noted that glacial tills inherently contain cobbles and boulders.

#### 5.1.7 Bedrock

Probable bedrock was encountered below the till in both boreholes. Borehole NSW-1 was terminated at a depth of 13.9 m upon auger refusal on probable bedrock (Elevation 45.2). Borehole NSW-2 encountered bedrock at a depth of 13.9 m (Elevation 45.2) and was advanced 0.7 m into bedrock with hollow stem augers.

#### 5.1.8 Groundwater

Groundwater levels were measured in the open boreholes during drilling. One standpipe piezometer was installed along the proposed retaining wall alignment upon completion of drilling. The groundwater depths and elevations measured in the piezometer as well as in the open boreholes during drilling are shown in Table 5.1.1.

**Table 5.1.1 – Groundwater Depths and Elevations**

| Borehole | Date       | Water Level (m) |           | Comment       |
|----------|------------|-----------------|-----------|---------------|
|          |            | Depth           | Elevation |               |
| NSW-1    | 1-May-2012 | 3.3             | 55.8      | Open Borehole |
|          | 2-May-2012 | 3.4             | 55.7      | Piezometer    |
|          | 3-May-2012 | 3.4             | 55.7      | Piezometer    |
| NSW-2    | 2-May-2012 | 4.2             | 54.9      | Open Borehole |

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

## **5.2 Lees Avenue S-E Ramp – Station 10+290 to 10+375 (Appendix B: Boreholes LSER-01 to 04)**

Four boreholes, identified as LSER-01 to LSER-04, were drilled on the west side of the Lees Avenue S-E ramp adjacent to the existing crib retaining wall. The stratigraphy encountered in the boreholes generally consisted of a composite pavement (asphalt and concrete) over sand fill, underlain by silty clay, then a silt layer and sandy silt to silty sand till.

### **5.2.1 Asphalt and Concrete**

Asphalt was encountered at surface in the four boreholes drilled along the west side of the Lees Avenue S-E Ramp. The thickness of the asphalt ranged from 90 mm to 100 mm.

A layer of concrete was encountered below the asphalt in all four boreholes. The thickness of the concrete ranged from 200 mm to 250 mm.

### **5.2.2 Sand Fill**

A layer of sand fill was encountered below the concrete in all four boreholes drilled at this location. The sand fill was brown to grey and contained trace to some gravel with occasional gravelly zones, some silt and clay, occasional cobbles, and asphalt fragments locally.

The thickness of the sand fill ranged from 3.1 m to 3.9 m, with the lower boundary of the sand fill encountered at depths of 3.4 m to 4.3 m (Elevation 55.9 to 55.6).

SPT N-values recorded in the sand fill ranged from 22 blows for 0.3 m penetration to 100 blows for 0.1 m penetration, indicating a compact to very dense relative density. Generally, SPT N-values recorded in the sand fill were greater than 33 blows for 0.3 m penetration, indicating the sand fill generally has a dense to very dense relative density.

Moisture contents of samples of the sand fill ranged from 3% to 19%. In general, the moisture content of the sand fill increased with depth.

One sample of the sand fill underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix B and the grain size distribution curve for this sample is plotted on Figure B1, Appendix B. The results of this test identify one of the gravelly zones encountered in the sand fill.

|                 |    |
|-----------------|----|
| Gravel %        | 29 |
| Sand %          | 58 |
| Silt and Clay % | 13 |

### 5.2.3 Silty Clay

A layer of silty clay was encountered locally in all four boreholes, below the sand fill. The silty clay was grey and contained trace sand.

The thickness of the silty clay layer ranged from 1.8 m to 4.2 m, with the lower boundary of this layer encountered at depths of 6.1 m to 7.7 m (Elevation 53.8 to 51.4).

SPT N-values recorded in the silty clay ranged from 2 to 6 blows for 0.3 m penetration, indicating a soft to firm consistency. In situ vane shear testing carried out in the clay indicated undrained shear strengths of 40 and 54 kPa.

Moisture contents of samples of the silty clay ranged from 28% to 52%.

Three samples of the silty clay underwent laboratory grain size analysis and Atterberg Limits testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix B and the grain size distribution curves for these samples are plotted on Figure B2, Appendix B. The results of the Atterberg Limits results are plotted on Figure B5, Appendix B.

|                 | High Plasticity | Low Plasticity |
|-----------------|-----------------|----------------|
| Gravel %        | 0               | 0              |
| Sand %          | 2               | 4 to 5         |
| Silt %          | 33              | 66 to 72       |
| Clay %          | 64              | 24 to 29       |
| Liquid Limit%   | 53              | 24 to 31       |
| Plastic Limit % | 23              | 17 to 18       |

The Atterberg Limits indicate that the plasticity of the silty clay varies from low (CL) to high (CH).

### 5.2.4 Silt

A layer of silt was encountered below the silty clay in all boreholes. The silt was grey and contained trace to some clay and trace to some sand.

The thickness of the silt layer ranged from 1.1 m to 3.0 m, with the lower boundary of the silt encountered at depths of 8.7 m to 9.4 m (Elevation 50.8 to 50.0).

SPT N-values recorded in the silt layer ranged from 3 to 26 blows for 0.3 m penetration, indicating a very loose to compact relative density. In general, the silt had a loose to compact relative density.

The moisture content of samples of the silt ranged from 22% to 34%.

Three samples of the silt were selected for laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of

Borehole sheets included in Appendix B and the grain size distribution curves for these samples are plotted on Figure B3, Appendix B.

|          |          |
|----------|----------|
| Gravel % | 0        |
| Sand %   | 0 to 11  |
| Silt %   | 72 to 81 |
| Clay %   | 17 to 19 |

#### 5.2.5 Sandy Silt to Silty Sand Till

Sandy silt to silty sand till was encountered below the silt in all boreholes. The till was dark brown to dark grey and contained some clay and trace to some gravel.

The till was 2.7 m thick in Boreholes LSER-01 and LSER-04 which penetrated this layer. The lower boundary of the till was encountered at depths of 11.4 and 11.8 m (Elevation 47.6 and 48.1), where these boreholes were terminated upon probable bedrock. Boreholes LSER-02 and LSER-03 were terminated at a depth of 11.3 m (Elevation 48.1 and 48.4) in the till layer.

SPT N-values recorded in the till ranged from 5 to 35 blows for 0.3 m penetration, indicating a loose to dense relative density.

The moisture content of samples of the till ranged from 7% to 19%.

Two samples of the till were selected for laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix B and the grain size distribution curves for these samples are plotted on Figure B4, Appendix B.

|          |          |
|----------|----------|
| Gravel % | 1 to 11  |
| Sand %   | 26 to 36 |
| Silt %   | 37 to 61 |
| Clay %   | 12 to 16 |

It should be noted that glacial tills inherently contain cobbles and boulders.

#### 5.2.6 Bedrock

Boreholes LSER-01 and LSER-04 were terminated upon probable bedrock. These boreholes were terminated at depths of 11.4 m and 11.8 m, respectively (Elevation 47.6 and 48.1).

#### 5.2.7 Water Levels

Where possible, groundwater levels were measured in the open boreholes during the drilling operations. Three standpipe piezometers were installed at this location upon completion of drilling. The piezometer installed in Borehole LSER-01 was unable to be

read because the flushmount casing could not be opened. The groundwater depths and elevations measured in the piezometers and open boreholes are shown in Table 5.2.1.

**Table 5.2.1 – Groundwater Depths and Elevations**

| Borehole | Date        | Water Level (m) |           | Comment        |
|----------|-------------|-----------------|-----------|----------------|
|          |             | Depth           | Elevation |                |
| LSER-01  | 27-Mar-2012 | -               | -         | Could not open |
| LSER-02  | 06-Mar-2012 | 4.1             | 55.2      | Open Borehole  |
| LSER-03  | 27-Mar-2012 | 4.8             | 54.9      | Piezometer     |
| LSER-04  | 27-Mar-2012 | 4.4             | 55.5      | Piezometer     |

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

### **5.3 Lees Avenue (North) at Robinson Avenue – Station 230+718 to 230+751 (Appendix C: Boreholes LE-08 and LE-09)**

Two boreholes, identified as LE-08 and LE-09, were drilled on Robinson Avenue near the ends of the proposed retaining wall alignment under the Lees Avenue underpass at the north abutment. The stratigraphy encountered in the boreholes consisted of a pavement structure underlain by silty sand to sand and gravel fill, then native sand to sand and gravel, over sandy silt to silty sand till. Bedrock and probable bedrock were encountered below the silt/till.

#### **5.3.1 Asphalt**

Asphalt was encountered at surface in both boreholes drilled on Robinson Avenue in proximity of the proposed retaining wall. The thickness of the asphalt ranged from 50 mm to 100 mm.

#### **5.3.2 Sand Fill**

Brown sand fill was encountered below the asphalt in Boreholes LE-08 and LE-09. The sand fill contained trace silt to silty (in Borehole LE-09), trace gravel, and trace to some clay.

The sand fill was 0.4 m thick in Borehole LE-08 while the sand and silty sand fill in Borehole LE-09 had a total thickness of 2.2 m. The lower boundary of the sand to silty sand fill was encountered at depths of 0.5 m and 2.2 m (Elevation 60.2 and 58.3).

SPT N-values recorded in the sand to silty sand fill ranged from 15 to 19 blows for 0.3 m penetration, indicating a compact relative density.

Moisture contents of samples of the sand to silty sand fill ranged from 2% to 9%.

A sample of the silty sand fill was selected for laboratory grain size analysis testing. The results of this testing are presented on the corresponding Record of Borehole sheet in Appendix C and the grain size distribution curve for this sample is plotted on Figure C1, Appendix C. The results of this test are as follows:

|          |    |
|----------|----|
| Gravel % | 8  |
| Sand %   | 50 |
| Silt %   | 28 |
| Clay %   | 14 |

### 5.3.3 Sand and Gravel Fill

A layer of sand and gravel fill was encountered locally in Borehole LE-08, below the sand fill. The sand and gravel fill was dark brown and contained some silt.

The sand and gravel fill layer was 1.7 m thick, with the lower boundary of this layer encountered at a depth of 2.2 m (Elevation 58.5).

SPT N-values recorded in the sand and gravel fill ranged from 30 blows for 0.3 m penetration to 87 blows for 0.275 m penetration, indicating a dense to very dense relative density.

The moisture content of samples of the sand and gravel fill ranged from 9% to 10%.

### 5.3.4 Sand

Native sand was encountered below the sand and gravel fill in Borehole LE-08. The native sand was dark brown becoming grey at approximately 6 m depth and contained trace gravel to gravelly, trace silt to silty, and trace clay.

The sand was 6.6 m thick in Borehole LE-08 and the lower boundary of the sand was encountered at a depth of 8.8 m (Elevation 51.9).

SPT N-values recorded in the sand ranged from 25 to 80 blows for 0.3 m penetration, indicating a compact to very dense relative density. In general, SPT N-values recorded in the sand were greater than 50 blows for 0.3 m penetration, indicating the sand typically has a very dense relative density.

Moisture contents measured in the sand ranged from 2% to 18%.

Two samples of the sand were selected for laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix C and the grain size distribution curves for these samples are plotted on Figures C2 and C3 of Appendix C.

|                 | Silty Sand | Sand |
|-----------------|------------|------|
| Gravel %        | 16         | 0    |
| Sand %          | 54         | 90   |
| Silt %          | 23         | -    |
| Clay %          | 7          | -    |
| Silt and Clay % | -          | 10   |

#### 5.3.5 Gravelly Sand to Sand and Gravel

Native gravelly sand to sand and gravel was encountered in Borehole LE-09, below the silty sand fill. The gravelly sand to sand and gravel was brown to grey and contained some silt, occasional cobbles, and possible boulders.

The gravelly sand layer was 3.9 m thick, with the lower boundary encountered at a depth of 6.1 m (Elevation 54.4). The sand and gravel layer was encountered below the gravelly sand and was 2.4 m thick, with the lower boundary of the sand and gravel encountered at a depth of 8.5 m (Elevation 52.0).

SPT N-values recorded in the gravelly sand to sand and gravel ranged from 95 blows for 0.3 m penetration to 100 blows for no penetration, indicating a very dense relative density and the occurrence of probable cobbles and/or boulders. Coring techniques were required to advance the borehole at a depth of 2.9 m in Borehole LE-09.

The moisture content of samples of the gravelly sand to sand and gravel was measured to range from 6% to 11%.

#### 5.3.6 Sandy Silt

A layer of sandy silt was encountered locally in Borehole LE-09, below the sand and gravel. The sandy silt was grey and contained trace clay and trace gravel.

The sandy silt was 1.2 m thick, with the lower boundary of the sandy silt encountered at a depth of 9.7 m (Elevation 50.8).

A single SPT N-value, of 50 blows for 0.1 m penetration, was recorded in the sandy silt, indicating a very dense relative density.

The moisture content of one sample of the sandy silt was measured to be 15%.

One sample of the sandy silt underwent laboratory grain size analysis testing. These results are presented on the Record of Borehole sheets included in Appendix C and the grain size distribution curve for this sample is plotted on Figure C4. The results of this test are as follows:

|          |    |
|----------|----|
| Gravel % | 4  |
| Sand %   | 18 |
| Silt %   | 74 |
| Clay %   | 4  |



#### 5.3.7 Silty Sand Till

Silty sand till was encountered below the sand in Borehole LE-08. The silty sand till was dark grey and contained occasional shale fragments.

The silty sand till was 0.8 m thick, with the lower boundary of the till encountered at a depth of 9.6 m (Elevation 51.1), at which depth the borehole was terminated upon probable bedrock.

An SPT N-value of 148 blows for 0.275 m penetration was recorded in the silty sand till, indicating a very dense relative density. It is worth noting that this SPT N-value was recorded at the till-bedrock interface and may not be representative of the relative density of the till.

The moisture content of one sample of the silty sand till was measured to be 12%.

It should be noted that glacial tills inherently contain cobbles and boulders.

#### 5.3.8 Bedrock

Both boreholes were terminated upon probable bedrock, at depths of 9.6 m and 9.8 m in Boreholes LE-08 and LE-09, respectively (Elevation 51.1 and 50.7).

#### 5.3.9 Water Levels

A standpipe piezometer was installed in each borehole drilled at this location upon completion of drilling. The groundwater depths and elevations measured in the piezometers are summarized in Table 5.3.1.

**Table 5.3.1 – Groundwater Depths and Elevations**

| Borehole | Date        | Water Level (m) |           |
|----------|-------------|-----------------|-----------|
|          |             | Depth           | Elevation |
| LE-08    | 23-Mar-2012 | 1.1             | 59.6      |
| LE-09    | 23-Mar-2012 | 1.0             | 59.5      |

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

#### **5.4 Lees Avenue (North) Noise Barrier – Station 230+680 to 231+ 080 (Appendix D: Boreholes 12N-01, 12N-02, 13N-01, 14N-01 to 03, NB8-01)**

Seven boreholes were drilled along the alignment of the proposed noise barrier wall at Lees Avenue north (Boreholes 12N-01, 12N-02, NB8-01, 13N-01, 14N-01 to 14N-03). The stratigraphy encountered in the boreholes typically consisted of an asphalt or topsoil layer overlying silty sand to sand and gravel fill, underlain by sand to sand and gravel near Lees Avenue and silty sand till along the remainder of the alignment.

##### **5.4.1 Asphalt**

Asphalt was encountered at surface in five of the seven boreholes drilled along the proposed noise barrier alignment (Boreholes 12N-01, 12N-02, 13N-01, 14N-02, and 14N-03). These boreholes were drilled on the right shoulder of the westbound lanes of Highway 417. The thickness of the asphalt ranged from 150 mm to 175mm.

##### **5.4.2 Topsoil**

Topsoil was encountered at surface in the other two boreholes drilled along the proposed noise barrier alignment (Boreholes NB8-01 and 14N-01). These boreholes were drilled in the grass area north of the westbound lanes of Highway 417. The topsoil was approximately 50 mm thick in both boreholes.

##### **5.4.3 Sand Fill**

Sand fill was encountered below the asphalt in Boreholes 12N-01, 12N-02, 13N-01, 14N-02, and 14N-03 and below the topsoil in Boreholes NB8-01 and 14N-01. The sand fill was typically brown and generally contains some gravel, some silt and trace clay. In Borehole 12N-01 the fill varied to sand and gravel and in Boreholes 14N-01 to 14N-03 a layer of silty sand fill was encountered below the sand fill.

The thickness of the sand to silty sand fill ranged from 1.3 m to 3.0 m, with the lower boundary of the fill encountered at depths of 1.5 m to 3.0 m (Elevation 59.0 to 57.2).

SPT 'N' values recorded in the fill ranged from 13 blows for 0.3 m penetration to 50 blows for 0.05 m penetration, indicating variable relative density ranging from a compact to very dense.

The moisture content of samples of the sand fill ranged from 1% to 10%. In general, the higher moisture contents were measured in samples collect from Boreholes NB8-01 and 14N-01, which were located in the grass area north of the shoulder of the highway.

Two samples of the sand fill underwent laboratory grain size analysis testing. The results of these tests are plotted in Figure D1, Appendix D and summarized below. These results are also presented on the Record of Borehole sheets included in Appendix D.

|          |          |
|----------|----------|
| Gravel % | 5 to 12  |
| Sand %   | 59 to 61 |
| Silt %   | 20 to 29 |
| Clay%    | 7        |

#### 5.4.4 Sand

Native sand was encountered locally in Borehole 12N-01, below the sand fill. The sand was brown and medium grained and contained trace gravel and trace silt and clay.

The sand was 4.7 m thick in this borehole, though it was not fully penetrated. Borehole 12N-01 was terminated at a depth of 6.7 m (Elevation 54.3).

SPT N-values recorded in the sand ranged from 28 to 71 blows for 0.3 m penetration, indicating a compact to very dense condition.

The moisture content of samples of the sand ranged from 3% to 19%. In general, the moisture content of the sand increased with depth.

Two samples of the sand underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix D and the grain size distribution curves for these samples are plotted on Figure D2, Appendix D.

|                 |          |
|-----------------|----------|
| Gravel %        | 0 to 7   |
| Sand %          | 85 to 91 |
| Silt and Clay % | 8 to 9   |

#### 5.4.5 Sand and Gravel

A layer of sand and gravel was encountered below the sand fill in Boreholes 12N-02 and 14N-02. The sand and gravel was greyish brown and contained some silt. A hydrocarbon odour was noted in the sand and gravel in Borehole 14N-02.

Borehole 12N-02 was terminated upon auger refusal within the sand and gravel layer at a depth of 4.6 m (Elevation 56.3). The sand and gravel layer was 0.9 m thick in Borehole 14N-02, with a lower boundary at 3.0 m depth (Elevation 57.1).

SPT 'N' values ranging from 31 blows for 0.3 m penetration to 100 blows for 0.025 m penetration were recorded in the sand and gravel, indicating a dense to very dense relative density.

The moisture content of the sand and gravel was typically 3% in Borehole 12N-02. One moisture content of 9% was measured in Borehole 14N-02.

One sample of sand and gravel underwent grain size analysis testing, the results of which are plotted on Figure D3, Appendix D and are summarized below. This result is also presented on the corresponding Record of Borehole sheet included in Appendix D.

|                |    |
|----------------|----|
| Gravel %       | 40 |
| Sand %         | 44 |
| Silt and Clay% | 16 |

#### 5.4.6 Silty Sand Till

Brown to grey/black silty sand till was encountered below the sand fill in Boreholes NB8-01, 13N-01, 14N-01, 14N-02, and 14N-03. The silty sand till contains trace to some clay and trace to some gravel.

The silty sand till was 3.2 m to 5.2 m thick and extended to the maximum depth of exploration in these boreholes. These five boreholes were terminated at depths of 6.2 m to 6.7 m (Elevation 54.9 to 53.4).

SPT 'N' values recorded in the silty sand till ranged from 9 blows for 0.3 m penetration to 101 blows for 0.225 m penetration, indicating a loose to very dense relative density. In general, SPT N-values were greater than 14 blows for 0.3 m penetration, indicating a compact to very dense relative density.

Moisture contents of samples of the silty sand till typically ranged from 6% and 11%.

Six samples of the silty sand till were selected for laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix D and the grain size distribution curves for these samples are plotted on Figure D4, Appendix D.

|          |          |
|----------|----------|
| Gravel % | 6 to 15  |
| Sand %   | 43 to 56 |
| Silt%    | 27 to 38 |
| Clay%    | 7 to 10  |

One sample of the silty sand till exhibited sufficient plasticity for Atterberg Limits testing. The results of these tests are plotted on Figure D5, Appendix D and are as follows:

|                 |    |
|-----------------|----|
| Liquid Limit%   | 16 |
| Plastic Limit % | 11 |

The Atterberg Limits indicate that the silty sand till has some zones of low plasticity.

It should be noted that glacial tills inherently contain cobbles and boulders.

#### 5.4.7 Water Levels

Water levels were observed in the open boreholes during drilling operations. Three standpipe piezometers were installed along the proposed noise barrier alignment upon completion of drilling. The groundwater depths and elevations measured in the piezometers are shown in Table 5.4.1, along with the measurements made in the open boreholes.

**Table 5.4.1 – Groundwater Depths and Elevations**

| Borehole | Date        | Water Level (m) |       | Comments                    |
|----------|-------------|-----------------|-------|-----------------------------|
|          |             | Depth           | Elev. |                             |
| 12N-01   | 22-Aug-2011 | 5.8             | 55.2  | Open Borehole               |
| 12N-02   | 22-Aug-2011 | 3.7             | 57.2  | Open Borehole               |
|          | 12-Oct-2011 | -               | -     | Piezometer plugged at 3.0 m |
| NB8-01   | 16-Aug-2011 | DRY             |       | Open Borehole               |
| 13N-01   | 12-Oct-2011 | -               | -     | Piezometer plugged at 1.5 m |
| 14N-01   | 15-Aug-2011 | DRY             |       | Open Borehole               |
| 14N-02   | 12-Oct-2011 | 2.5             | 57.6  | Piezometer                  |
| 14N-03   | 15-Aug-2011 | DRY             |       | Open Borehole               |

Seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

### **5.5 Canadian Tire Parking Lot – Riverside Drive to Belfast Road (North) – Station 210+902 to 211+000 (Appendix E: Boreholes 15N-01, CTW-1 & 2, and OHS-7L)**

Four boreholes (15N-01, CTW-1, CTW-2, and OHS-07L) were drilled along the alignment of the proposed retaining wall at the Canadian Tire parking lot. The stratigraphy encountered in the boreholes generally consisted of pavement structure (asphalt over sand fill) overlying sandy silt to silty sand fill at the west end of the alignment, underlain by sandy silt to silty sand till which overlies shale bedrock.

#### 5.5.1 Asphalt

A layer of asphalt was encountered at surface in all four boreholes. The asphalt was 100 mm to 200 mm thick. All four boreholes were drilled on the right shoulder of the westbound lanes of Highway 417.

### 5.5.2 Sand Fill

A layer of sand fill was encountered below the asphalt in all four boreholes. The sand fill was brown and contained trace gravel to gravelly and some silt.

The thickness of the sand fill layer ranged from 0.5 m to 0.9 m, with the lower boundary of this fill layer encountered at depths of 0.6 to 1.1 m (Elevation 60.4 to 59.8).

SPT N-values recorded in the sand to gravelly sand fill ranged from 18 to 22 blows for 0.3 m penetration, indicating a compact relative density.

The moisture content of the sand to gravelly sand fill ranged from 2% to 8%.

### 5.5.3 Sandy Silt to Silty Sand Fill

Sandy silt to silty sand fill was encountered below the sand fill in Borehole CTW-1 and below a localized 0.4 m thick layer of clayey silt fill in Borehole OHS-07L, which was encountered below the sand fill. The sandy silt to silty sand till was dark grey and contained trace gravel and some clay.

The sandy silt to silty sand fill was 1.6 m thick in Borehole CTW-1 and 1.4 m thick in Borehole OHS-07L. The lower boundary of the sandy silt to silty sand fill was encountered at depths of 2.3 and 2.9 m in Boreholes CTW-1 and OHS-07L, respectively (Elevation 58.7 and 58.0).

SPT N-values recorded in the sandy silt to silty sand fill ranged from 12 to 38 blows for 0.3 m penetration, indicating a compact to dense relative density.

The moisture content of samples of the sandy silt to silty sand till generally ranged from 6% to 20%. A moisture content of 40% was measured in a sample from Borehole OHS-07L at a depth of 2.7 m.

One sample of the silty sand fill and one sample of the sandy silt fill underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix E and the grain size distribution curves for these samples are plotted on Figure E1, Appendix E.

|          |          |
|----------|----------|
| Gravel % | 0        |
| Sand %   | 30 to 53 |
| Silt %   | 31 to 53 |
| Clay %   | 16 to 17 |

One sample of the sandy silt fill had sufficient plasticity for Atterberg Limits testing. The results of these tests are summarized below and are plotted on Figure E3, Appendix E.

|                 |    |
|-----------------|----|
| Liquid Limit%   | 21 |
| Plastic Limit % | 13 |

The Atterberg Limits indicate that the sandy silt fill has some low plastic zones.

#### 5.5.4 Sandy Silt to Silty Sand Till

Sandy silt to silty sand till was encountered below the fill in all four boreholes. The sandy silt to silty sand till was brown to dark grey and contained some clay to clayey and trace gravel.

The thickness of the till ranged from 3.2 m to 3.8 m, with the lower boundary of the till encountered at depths of 4.1 to 6.1 m (Elevation 56.9 to 54.9). Borehole OHS-07L was terminated in the till at 6.1 m (Elevation 54.8).

SPT N-values recorded in the till generally ranged from 13 to 29 blows for 0.3 m penetration, indicating a compact relative density. An SPT N-value of 7 blows for 0.3 m penetration (loose) was recorded in Borehole CTW-2 at a depth of 3.5 m (Elevation 57.5). SPT N-values greater than 45 blows for 0.3 m penetration were recorded in Borehole 15N-01 near the upper boundary of the till layer.

The moisture content of samples of the till generally ranged from 8% to 17%. A moisture content of 34% was measured at a depth of 2.5 m in Borehole CTW-2.

Three samples of the till were selected for laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix E and the grain size distribution curves for these samples are plotted on Figure E2, Appendix E.

|          |          |
|----------|----------|
| Gravel % | 0 to 7   |
| Sand %   | 24 to 55 |
| Silt %   | 24 to 59 |
| Clay %   | 14 to 22 |

One sample of the till had sufficient plasticity for Atterberg Limits testing. The results of these tests are summarized below and are plotted on Figure E4, Appendix E.

|                 |    |
|-----------------|----|
| Liquid Limit%   | 25 |
| Plastic Limit % | 16 |

The Atterberg Limits indicate that the sandy silt to silty sand till has some low plastic zones.

It should be noted that glacial tills inherently contain cobbles and boulders.

#### 5.5.5 Bedrock

Bedrock was encountered below the till in Boreholes CTW-1 and CTW-2. Probable bedrock was encountered below the till in Borehole 15N-01. The depths and elevations at which bedrock and probable bedrock were encountered are summarized in Table 5.5.1.

**Table 5.5.1 – Depths and Elevations of Bedrock Surface**

| Borehole | Bedrock Surface |               | Comment          |
|----------|-----------------|---------------|------------------|
|          | Depth (m)       | Elevation (m) |                  |
| CTW-1    | 6.1             | 54.9          | Proven by coring |
| CTW-2    | 4.1             | 56.9          | Proven by coring |
| 15N-01   | 4.6             | 56.5          | Probable Bedrock |

Where proven by coring, the bedrock was described as thinly bedded grey shale with occasional limestone interbeds. The shale was generally described as slightly weathered to fresh with increased depth. Occasional horizontal joints and highly broken zones were observed in the bedrock cores. Total Core Recovery (TCR) ranged from 93% to 100% in the bedrock cores. The RQD values ranged from 87 to 100%, indicating a good to excellent rock quality. In general, RQD values increased with depth. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, was typically less than 3.

The estimated unconfined compressive strength of the rock, interpreted from point load tests conducted on intact rock cores, ranged from 15 to 21 MPa, indicating a weak rock strength classification. It should be noted that higher rock strengths may be obtained in the hard limestone interbeds.

#### 5.5.6 Water Levels

Water was not observed in Boreholes CTW-1 and CTW-2 during drilling, prior to water being introduced into the borehole for coring operations. Three standpipe piezometers were installed along the proposed retaining wall alignment upon completion of drilling. The groundwater depths and elevations measured in the piezometers as well as in the open boreholes during drilling are shown in Table 5.5.2.

**Table 5.5.2 – Groundwater Depths and Elevations**

| Borehole | Date        | Water Level (m) |           | Comment         |
|----------|-------------|-----------------|-----------|-----------------|
|          |             | Depth           | Elevation |                 |
| CTW-1    | 2-May-2012  | Dry             |           | Prior to coring |
|          | 3-May-2012  | 0.3*            | 60.7      | Piezometer      |
| CTW-2    | 3-May-2012  | Dry             |           | Prior to coring |
| OHS-07L  | 22-Mar-2012 | 2.2             | 58.7      | Piezometer      |
| 15N-01   | 26-Jul-2011 | 3.5             | 57.6      | Piezometer      |
|          | 18-Aug-2011 | 3.5             | 57.6      | Piezometer      |
|          | 12-Oct-2011 | 2.7             | 58.4      | Piezometer      |

\*Very short term reading. May indicate level of water added to borehole during coring.



The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

### **5.6 Belfast Road (North), Wall 15N – Station 211+220 to 211+700 (Appendix F: Boreholes 15N-01 to 15N-12)**

Twelve boreholes, identified as 15N-01 to 15N-12, were drilled for the proposed retaining wall near Belfast Road on the north side of the highway from Station 211+025 to 211+825. The final design for this retaining wall was shortened to Station 211+220 to 211+700, therefore only Boreholes 15N-04 to 15N-10 have been considered for the following description of the subsurface conditions. The Record of Borehole sheets for all Boreholes 15N-01 to 15N-12 are included in Appendix F.

The stratigraphy encountered in the boreholes generally consisted of a pavement structure (asphalt over gravelly sand) underlain by silt/sand fill along the west part of the alignment, overlying silty sand to sandy silt till. Shale bedrock was encountered below the till.

#### **5.6.1 Asphalt**

Asphalt was encountered at surface in the seven boreholes drilled along the proposed retaining wall alignment. These boreholes were drilled on the right shoulder of the westbound lanes of Highway 417. The thickness of the asphalt ranged from 150 mm to 300 mm.

#### **5.6.2 Gravelly Sand Fill**

A layer of gravelly sand fill was encountered below the asphalt in all seven boreholes drilled at this proposed retaining wall. The gravelly sand fill was typically brown and contained some silt.

The thickness of the gravelly sand fill ranged from 0.5 m to 0.8 m, with the lower boundary of the gravelly sand fill encountered at depths of 0.8 m to 1.1 m (Elevation 66.3 to 61.5).

One SPT N-value of 62 blows for 0.225 m penetration was recorded in the gravelly sand fill, indicating a very dense relative density. This value was measured at the fill-bedrock interface and may include resistance on the bedrock surface.

Moisture contents of samples of the sand fill typically ranged from 1% to 2%. A moisture content of 8% was measured in one sample of the gravelly sand fill in Borehole 15N-09.

One sample of the gravelly sand fill underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of

Borehole sheets included in Appendix F and the grain size distribution curve for this sample is plotted on Figure F1, Appendix F.

|          |    |
|----------|----|
| Gravel % | 27 |
| Sand %   | 50 |
| Silt %   | 17 |
| Clay %   | 6  |

#### 5.6.3 Sandy Silt to Silty Sand Fill

A layer of sandy silt to silty sand fill was encountered below the gravelly sand fill in Boreholes 15N-04, 15N-05, and 15N-06. The sandy silt to silty sand fill was brown and contained trace clay and trace to some gravel.

The thickness of the sandy silt to silty sand fill ranged from 0.6 m to 1.4 m, with the lower boundary of this fill encountered at depths of 1.4 m to 2.2 m (Elevation 62.3 to 60.1).

SPT N-values recorded in the sandy silt to silty sand fill ranged from 17 to 47 blows for 0.3 m penetration, indicating a compact to dense relative density. In general, the sandy silt to silty sand fill had a dense relative density

Moisture contents of samples of the sandy silt to silty sand fill ranged from 7% to 14%.

Two samples of the sandy silt to silty sand fill underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix F and the grain size distribution curves for these samples are plotted on Figure F2, Appendix F.

|          |          |
|----------|----------|
| Gravel % | 3 to 11  |
| Sand %   | 42 to 52 |
| Silt %   | 33 to 50 |
| Clay %   | 3 to 5   |

#### 5.6.4 Silty Sand to Sandy Silt Till

Silty sand to sandy silt till was encountered below the silty sand fill in Boreholes 15N-04 to 15N-06 and below the gravelly sand fill in Borehole 15N-07. In Borehole 15N-10 the till consisted of silt with some sand. Till was not encountered in Borehole 15N-09. The silty sand till was dark grey while the sandy silt till was grey and the silt till was brown. In general, the till contained trace gravel and trace clay. Occasional shale fragments were also observed in the till.

The thickness of the till ranged from 0.6 m in borehole 15N-08 to 3.2 m in Borehole 15N-06. The lower boundary of the till was encountered at depths of 1.4 m to 5.3 m (Elevation 65.6 to 57.4).

SPT N-values recorded in the till ranged from 32 blows for 0.3 m penetration to 50 blows for 0.025 m penetration, indicating a dense to very dense relative density.

The moisture content of samples of the till ranged from 6% to 10%.

Two samples of the till were selected for laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix F and the grain size distribution curves for these samples are plotted on Figure F3, Appendix F.

|          |          |
|----------|----------|
| Gravel % | 9 to 10  |
| Sand %   | 51 to 62 |
| Silt %   | 25 to 33 |
| Clay %   | 3 to 7   |

It should be noted that glacial tills inherently contain cobbles and boulders.

#### 5.6.5 Bedrock

Bedrock was encountered below the till in Boreholes 15N-04 to 15N-08 and 15N-10, and below the gravelly sand fill in Borehole 15N-09. The depths and elevations at which bedrock was encountered are summarized in Table 5.6.1.

**Table 5.6.1 – Depths and Elevations of Bedrock Surface**

| Borehole | Bedrock Surface |               |
|----------|-----------------|---------------|
|          | Depth (m)       | Elevation (m) |
| 15N-04   | 4.6             | 57.7          |
| 15N-05   | 5.3             | 57.4          |
| 15N-06   | 4.6             | 59.1          |
| 15N-07   | 3.0*            | 61.5          |
| 15N-08   | 1.4*            | 64.0          |
| 15N-09   | 1.1*            | 65.1          |
| 15N-10   | 1.5*            | 65.6          |

\*Bedrock proven by coring.

The bedrock was described as laminated grey shale and typically contained hard limestone interbeds up to 75 mm in thickness. The shale was generally described as slightly weathered to fresh with increased depth. Occasional moderately to highly fractured zones were observed in the bedrock cores. Total Core Recovery (TCR) was 100% in all bedrock cores. The RQD values ranged from 10 to 100%, indicating a variable rock quality ranging from very poor to excellent. In general, RQD values

increased with depth. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, was also quite variable and ranged from 0 to greater than 20.

The estimated unconfined compressive strength of the rock, interpreted from point load tests conducted on intact rock cores, ranged from 12 to 27 MPa, indicating a weak to medium strong rock strength classification. It should be noted that higher rock strengths may be obtained in the hard limestone interbeds.

#### 5.6.6 Water Levels

Three standpipe piezometers were installed along the proposed retaining wall alignment upon completion of drilling. The groundwater depths and elevations measured in the piezometers are shown in Table 5.6.2.

**Table 5.6.2 – Groundwater Depths and Elevations**

| Borehole | Date        | Water Level (m) |           | Comment    |
|----------|-------------|-----------------|-----------|------------|
|          |             | Depth           | Elevation |            |
| 15N-05   | 26-Jul-2011 | 2.9             | 59.9      | Piezometer |
|          | 18-Aug-2011 | 3.0             | 59.8      | Piezometer |
|          | 12-Oct-2011 | 3.2             | 59.6      | Piezometer |
| 15N-07   | 26-Jul-2011 | 3.6             | 60.9      | Piezometer |
|          | 18-Aug-2011 | 3.5             | 61.0      | Piezometer |
|          | 12-Oct-2011 | 4.0             | 60.5      | Piezometer |
| 15N-09   | 26-Jul-2011 | 2.2             | 64.0      | Piezometer |
|          | 18-Aug-2011 | 2.2             | 64.0      | Piezometer |
|          | 12-Oct-2011 | 2.5             | 63.5      | Piezometer |

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

#### **5.7 Belfast Road (South), Wall 23S – Station 111+090 to 111+705 (Appendix G: Boreholes 23S-01 to 23S-09)**

Nine boreholes, identified as 23S-01 to 23S-09 were drilled for the proposed retaining wall at this location. The final retaining wall alignment was shifted west and now covers Station 111+090 to 111+705, therefore only Boreholes 23S-01 to 23S-08 have been included in the description of subsurface conditions below. The Record of Borehole sheets for all nine boreholes are included in Appendix G.

The stratigraphy encountered in the boreholes consisted of a pavement structures (asphalt over gravelly sand) underlain by silty sand till then bedrock. Silty sand fill was encountered below the pavement structure at the west end of the alignment.

#### 5.7.1 Asphalt

Asphalt was encountered at surface in the eight boreholes drilled along the retaining wall alignment. These boreholes were drilled on the right shoulder of the eastbound lanes of Highway 417. The thickness of the asphalt ranged from 150 mm to 300 mm.

#### 5.7.2 Sand to Gravelly Sand Fill

A layer of sand with some gravel to gravelly sand fill was encountered below the asphalt in all the boreholes drilled along the proposed retaining wall alignment, except Borehole 23S-04. The sand to gravelly sand fill was brown and contained trace to some silt.

The thickness of the sand to gravelly sand fill ranged from 0.5 m to 0.6 m, with the lower boundary of the sand to gravelly sand fill encountered at depths of 0.8 m to 0.9 m (Elevation 66.6 to 61.1).

Samples of the sand to gravelly sand fill were collected from the augers. Moisture contents ranged from 2% to 3%.

One sample of the sand fill (from Borehole 23S-06) underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix G and the grain size distribution curve for this sample is plotted on Figure G1, Appendix G.

|          |    |
|----------|----|
| Gravel % | 16 |
| Sand %   | 59 |
| Silt %   | 18 |
| Clay %   | 7  |

#### 5.7.3 Silty Sand Fill

A layer of silty sand fill was encountered below the sand to gravelly sand fill in Boreholes 23S-01 and 23S-02, and directly below the asphalt in Borehole 23S-04. The silty sand fill was brown and contained trace clay and trace to some gravel.

The thickness of the silty sand fill ranged from 0.5 m to 1.4 m, with the lower boundary of this fill encountered at depths of 0.8 m to 2.2 m (Elevation 63.2 to 59.7).

SPT N-values recorded in the silty sand fill ranged from 16 to 39 blows for 0.3 m penetration, indicating a compact to dense relative density.

Moisture contents of samples of the silty sand fill ranged from 2% to 8%.

One sample of the silty sand fill (from Borehole 23S-01) underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix G and the grain size distribution curve for this sample is plotted on Figure G1.

|          |    |
|----------|----|
| Gravel % | 8  |
| Sand %   | 62 |
| Silt %   | 24 |
| Clay %   | 6  |

#### 5.7.4 Silty Sand Till

Silty sand till was encountered below the silty sand fill in Boreholes 23S-01, 23S-02, and 23S-04 and below the sand to gravelly sand in Boreholes 23S-03 and 23S-05 to 23S-08. The silty sand till was typically dark grey, though locally it was brown in colour. The silty sand till contained trace to some gravel, trace to some clay, and occasional shale fragments.

The thickness of the silty sand till ranged from 0.4 m to 5.0 m, with the lower boundary of the till encountered at depths of 1.2 m to 6.0 m (Elevation 66.2 to 55.9).

SPT N-values recorded in the silty sand till ranged from 26 blows for 0.3 m penetration to 84 blows for 0.02 m penetration, indicating a compact to very dense relative density. In general, SPT N-values were greater than 50 blows for 0.3 m penetration, indicating a very dense relative density.

The moisture content of samples of the silty sand till ranged from 2% to 12%. Typically, moisture contents were less than 10% in the silty sand till.

Six samples of the silty sand till were selected for laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix G and the grain size distribution curves for these samples are plotted on Figure G2, Appendix G.

|          |          |
|----------|----------|
| Gravel % | 6 to 12  |
| Sand %   | 45 to 61 |
| Silt %   | 22 to 35 |
| Clay %   | 4 to 16  |

It should be noted that glacial tills inherently contain cobbles and boulders.

#### 5.7.5 Bedrock

Bedrock was encountered below the silty sand till in all eight boreholes drilled along the retaining wall alignment. The depths and elevations at which bedrock was encountered are summarized in Table 5.7.1.

**Table 5.7.1 – Depths and Elevations of Bedrock Surface**

| Borehole | Bedrock Surface |               |
|----------|-----------------|---------------|
|          | Depth (m)       | Elevation (m) |
| 23S-01   | 6.0             | 55.9          |
| 23S-02   | 4.6             | 57.9          |
| 23S-03   | 5.8             | 57.4          |
| 23S-04   | 4.6             | 59.4          |
| 23S-05   | 2.7             | 62.2          |
| 23S-06   | 1.2             | 64.6          |
| 23S-07   | 1.2             | 65.4          |
| 23S-08   | 1.2             | 66.2          |

The bedrock was described as laminated grey shale and typically contained hard limestone interbeds up to 75 mm in thickness. The shale was generally described as slightly weathered to fresh with increased depth. Occasional highly fractured zones were observed in the bedrock cores. Total Core Recovery (TCR) was typically 100% in the bedrock cores. The RQD values ranged from 0 to 100%, indicating a variable rock quality ranging from very poor to excellent. In general, RQD values were less than 58%, indicating a fair to very poor rock quality. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, was also quite variable and ranged from 0 to greater than 10.

The estimated unconfined compressive strength of the rock, interpreted from point load tests conducted on intact rock cores, ranged from 8 to 32 MPa, indicating a weak to medium strong rock strength classification. It should be noted that higher rock strengths may be obtained in the hard limestone interbeds.

#### 5.7.6 Water Levels

Four standpipe piezometers were installed along the proposed retaining wall alignment upon completion of drilling. The groundwater depths and elevations measured in the piezometers are shown in Table 5.7.2.

**Table 5.7.2 – Groundwater Depths and Elevations**

| Borehole | Date        | Water Level (m) |           |
|----------|-------------|-----------------|-----------|
|          |             | Depth           | Elevation |
| 23S-02   | 26-Jul-2011 | 2.8             | 59.7      |
|          | 18-Aug-2011 | 2.8             | 59.7      |
|          | 12-Oct-2011 | 3.9             | 58.6      |
| 23S-04*  | 21-Jul-2011 | 2.6             | 61.4      |
|          | 26-Jul-2011 | 2.5             | 61.5      |
|          | 18-Aug-2011 | 2.5             | 61.5      |
|          | 12-Oct-2011 | 2.5             | 61.5      |
| 23S-06   | 21-Jul-2011 | 3.0             | 62.8      |
|          | 26-Jul-2011 | 3.1             | 62.7      |
|          | 18-Aug-2011 | 3.1             | 62.7      |
|          | 12-Oct-2011 | 3.2             | 62.6      |
| 23S-08   | 21-Jul-2011 | 2.8             | 64.6      |
|          | 26-Jul-2011 | 2.8             | 64.6      |
|          | 18-Aug-2011 | 2.8             | 64.6      |
|          | 12-Oct-2011 | 2.8             | 64.6      |

\*Piezometer likely plugged at 2.5 m

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

## 5.8 St. Laurent Boulevard N-W Ramp, Wall 16N – Station 212+000 to 212+200 (Appendix H: Boreholes 16N-1 to 16N-3)

Three boreholes, designated Boreholes 16N-1 to 16N-3, were drilled along the N-W Ramp at the St. Laurent Boulevard interchange. The stratigraphy encountered in the boreholes generally consisted of a pavement structure overlying various sand to clayey silt fills, underlain by silty sand, then sandy silt to silty sand till. Bedrock was encountered below the till.

### 5.8.1 Asphalt

Asphalt was encountered at surface in the three boreholes drilled along the south side of the St. Laurent Boulevard N-W ramp. The thickness of the asphalt ranged from 100 mm to 150 mm.



### 5.8.2 Gravelly Sand Fill

A layer of gravelly sand fill was encountered below the asphalt in all three boreholes drilled at this location. The gravelly sand fill was brown and contained some silt.

The thickness of the gravelly sand fill ranged from 0.7 m to 2.2 m, with the lower boundary of the gravelly sand fill encountered at depths of 0.8 m to 2.3 m (Elevation 69.1 to 67.0).

SPT N-values recorded in the gravelly sand fill ranged from 30 blows for 0.3 m penetration to 50 blows for 0.125 m penetration, indicating a dense to very dense relative density.

Moisture contents of samples of the gravelly sand fill ranged from 2% to 5%.

### 5.8.3 Silty Sand to Sand Fill

A layer of silty sand to sand fill was encountered below the gravelly sand fill in Boreholes 16N-1 and 16N-2. The fill was brown and contained some silt to silty, trace to some clay, and trace to some gravel.

The silty sand fill layer in Borehole 16N-1 was 1.5 m thick while the sand fill in Borehole 16N-2 was 0.7 m thick. The lower boundary of this fill was encountered at a depth of 2.3 m in Borehole 16N-1 and 3.0 m in Borehole 16N-2 (Elevation 67.6 and 66.3).

SPT N-values recorded in the silty sand to sand fill ranged from 7 blows for 0.3 m penetration to 50 blows for 0.125 m penetration, indicating a variable relative density, ranging from loose to very dense.

Moisture contents of samples of the silty sand to sand fill ranged from 9% to 31%.

One sample of the silty sand fill underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix H and the grain size distribution curve for this sample is plotted on Figure H1, Appendix H.

|          |    |
|----------|----|
| Gravel % | 6  |
| Sand %   | 48 |
| Silt %   | 29 |
| Clay %   | 18 |

### 5.8.4 Clayey Silt Fill

A layer of clayey silt fill was encountered locally in Borehole 16N-1, below the silty sand fill. The clayey silt fill was brown and grey and contained some sand and trace gravel.

The layer of clayey silt fill was 0.7 m thick, with the lower boundary of this layer encountered at a depth of 3.0 m (Elevation 66.9).

A single SPT N-value, of 8 blows for 0.3 m penetration, was recorded in the clayey silt fill layer. This value is indicative of a firm to stiff consistency.

The moisture content of one sample of the clayey silt fill was measured to be 38%.

#### 5.8.5 Silty Sand

A layer of native silty sand was encountered below the clayey silt fill in Borehole 16N-1, below the sand fill in Borehole 16N-2, and below the gravelly sand fill in Borehole 16N-3. The silty sand was brown to grey and contained trace gravel and trace clay.

The thickness of the silty sand layer ranged from 0.8 m to 1.6 m, with the lower boundary of the silty sand encountered at depths of 2.3 m to 4.6 m (Elevation 66.2 to 64.7).

SPT N-values recorded in the silty sand layer ranged from 11 to 39 blows for 0.3 m penetration, indicating a compact to dense relative density.

The moisture content of samples of the silty sand ranged from 12% to 23%.

One sample of the silty sand underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix H and the grain size distribution curve for this sample is plotted on Figure H2, Appendix H.

|          |    |
|----------|----|
| Gravel % | 0  |
| Sand %   | 60 |
| Silt %   | 30 |
| Clay %   | 7  |

#### 5.8.6 Sandy Silt to Silty Sand Till

Sandy silt to silty sand till was encountered below the silty sand in all three boreholes drilled at this location. The till was brown to dark grey and contained trace gravel, occasional shale fragments, and trace to some clay with occasional clayey zones.

The thickness of the till ranged from 1.2 m to 2.6 m, with the lower boundary of the till encountered at depths of 4.9 m to 5.8 m (Elevation 64.1 to 63.5).

SPT N-values recorded in the till ranged from 14 blows for 0.3 m penetration to 50 blows for 0.025 m penetration, indicating a compact to very dense relative density.

The moisture content of samples of the sandy silt to silty sand till typically ranged from 8% to 10%. A moisture content of 26% was measured in a sample collected from a clayey zone within the till in Borehole 16N-3.

Two samples of the till were selected for laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of

Borehole sheets included in Appendix H and the grain size distribution curves for these samples are plotted on Figures H3 and H4, Appendix H.

|          | Silty Sand Till | Clayey<br>Silt & Sand Till |
|----------|-----------------|----------------------------|
| Gravel % | 3               | 0                          |
| Sand %   | 54              | 26                         |
| Silt %   | 38              | 53                         |
| Clay %   | 5               | 21                         |

A sample collected from the clayey zone also underwent Atterberg Limits testing. These results are presented on the Record of Borehole sheets included in Appendix H and are plotted on Figure H5, Appendix H. These results are summarized as follows:

|                 |    |
|-----------------|----|
| Liquid Limit%   | 46 |
| Plastic Limit % | 20 |

The Atterberg Limits indicate intermediate plasticity with a group symbol of CI.

It should be noted that glacial tills inherently contain cobbles and boulders.

#### 5.8.7 Bedrock

Bedrock was encountered below the till in all three boreholes. The depths and elevations at which bedrock was encountered are summarized in Table 5.8.1.

**Table 5.8.1 – Depths and Elevations of Bedrock Surface**

| Borehole | Bedrock Surface |               |
|----------|-----------------|---------------|
|          | Depth (m)       | Elevation (m) |
| 16N-1    | 5.8             | 64.1          |
| 16N-2    | 5.8             | 63.5          |
| 16N-3    | 4.9             | 63.6          |

The bedrock was described as laminated grey shale and typically contained hard limestone interbeds up to 75 mm in thickness. The shale was generally described as slightly weathered to fresh with increased depth. Occasional vertical fractures, rubble zones, and clay seams were observed in the bedrock cores. Total Core Recovery (TCR) in the bedrock ranged from 77 % to 100%, typically 100%. The RQD values ranged from 25 to 100%, indicating a variable rock quality ranging from poor to excellent. In general, RQD values increased with depth. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, was also quite variable and ranged from 0 to greater than 10.

The estimated unconfined compressive strength of the rock, interpreted from point load tests conducted on intact rock cores, ranged from 15 to 34 MPa, indicating a weak to medium strong rock strength classification. It should be noted that higher rock strengths may be obtained in the hard limestone interbeds.

#### 5.8.8 Water Levels

Two standpipe piezometers were installed at this location upon completion of drilling. The groundwater depths and elevations measured in the piezometers are shown in Table 5.8.2.

**Table 5.8.2 – Groundwater Depths and Elevations**

| Borehole | Date        | Water Level (m) |           |
|----------|-------------|-----------------|-----------|
|          |             | Depth           | Elevation |
| 16N-1    | 20-Sep-2011 | 5.2             | 64.7      |
|          | 12-Oct-2011 | 5.8             | 64.1      |
| 16N-3    | 18-Aug-2011 | 4.7             | 63.8      |
|          | 20-Sep-2011 | 3.7             | 64.8      |
|          | 12-Oct-2011 | 3.7             | 64.8      |

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

## 6 MISCELLANEOUS

The borehole locations were selected and established in the field by Thurber Engineering Ltd. Surveyors from MMM Group determined the co-ordinates and ground surface elevations at the boreholes after completion of the site investigation.

Underground Service Locators Inc. obtained utility clearances on behalf of Thurber for the selected borehole locations prior to drilling.

Eastern Ontario Diamond Drilling Ltd. from Hawkesbury, Ontario supplied both track-mounted and truck-mounted drill rigs and conducted the drilling, sampling and in-situ testing operations.

The field investigation was supervised by Ms. Eckie Siu, Mr. George Azzopardi, Mr. Ryan Kromer, E.I.T. and Mr. Luke Gilarski, E.I.T. of Thurber. Overall planning and supervision of the field program was conducted by Ms. Lindsey Blaine, E.I.T.

Routine laboratory testing was carried out by Thurber Engineering Ltd.

Interpretation of the data and preparation of the report were carried out by Ms. Lindsey Blaine, E.I.T. and Ms. Mei Cheong, M.Phil.

The report was reviewed by Mr. M.R. Anderson, P.Eng., M.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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**FOUNDATION INVESTIGATION AND DESIGN REPORT  
RETAINING WALLS AND NOISE BARRIER WALLS  
HIGHWAY 417 WIDENING  
NICHOLAS STREET TO O.R.174  
OTTAWA, ONTARIO**

**G.W.P. 4091-07-00 and 4320-06-00**

**Geocres Number: 31G5-250**

**PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS**

**7 GENERAL**

This report presents interpretation of the geotechnical data in the factual report and presents geotechnical design recommendations to assist the design team in developing suitable methodology and foundation systems for the new retaining walls and noise barrier walls proposed along Highway 417, between Nicholas Street and O.R.174.

Geotechnical recommendations and design parameters are presented for the walls proposed at the following locations:

- Nicholas Street Underpass (South) – Station 130+329 to 130+366
- Lees Avenue S-E Ramp – Station 10+290 to 10+375 (existing crib wall)
- Lees Avenue (North) at Robinson Avenue – Station 230+718 to 230+751
- Lees Avenue (North) Noise Barrier, Wall 12N, 13N, 14N – Station 230+680 to 231+ 080
- Canadian Tire Parking Lot – Riverside Drive to Belfast Road (North) Station 210+902 to 211+000
- Belfast Road (North), Wall 15N – Station 211+220 to 211+700
- Belfast Road (South), Wall 23S – Station 111+090 to 111+705
- St. Laurent Boulevard N-W Ramp, Wall 16N – Station 212+000 to 212+200.

The discussion and recommendations presented in this report are based on the information provided by McCormick Rankin Corporation and on the factual data obtained in the course of the investigation.

## 8 RETAINING WALL AND NOISE BARRIER WALL FOUNDATIONS

Selection of the preferred wall type at each proposed retaining wall location must consider the height of retained soil, the subsurface conditions along the wall alignment, and any space restrictions affecting construction of the wall. Consideration was typically given to the following wall types:

- Concrete toe wall
- Concrete cantilever wall (cast-in place) on native soil
- Concrete cantilever wall (cast-in place) on engineered soil
- Soldier pile with lagging system
- Proprietary post and panel wall
- RSS Wall

A summary of the advantages and disadvantages of the alternative wall types at each site is presented in Appendix J. Options including the use of micropiles and soil nail walls were not expected to be economically competitive in view of the low wall heights, and these options were not developed further. Recommendations and geotechnical design parameters for feasible retaining wall alternatives are provided in the following sections, and the scheme preferred from a foundations perspective is identified.

For support of noise barrier walls, conventional post foundation design comprising a single augered caisson (drilled shaft) is considered appropriate on this project. The noise barrier walls should be installed in accordance with SP 799F01. The geotechnical parameters recommended for design of the post foundations are presented below for each section of proposed noise barrier.

### 8.1 Nicholas Street Underpass (South) – Station 130+329 to 130+366

The proposed retaining wall will have a maximum height of approximately 0.6 m and will support the forward slope in front of the south abutment of the Nicholas Street structure. Existing grade on the N-E Ramp is at approximate Elev. 59.0 m and will be lowered by about 0.6 m. The wall may be temporary until replacement of the underpass.

The subsurface stratigraphy encountered at this location consisted of a pavement structure and compact to dense sand fill layer underlain by successive layers of sand, silty clay, silt and silty sand till. Shale bedrock was encountered below the till at 13.9 m depth (Elev. 45.2). Piezometer readings indicate that the groundwater level is at 3.4 m depth (Elev. 55.7).

A comparison of the various wall types is presented in Table J1 of Appendix J. From a foundations perspective, the preferred option at this location is a concrete toe wall founded on dense sand fill or possibly a soldier pile and lagging wall. Preliminary foundation

recommendations for design of these types of wall, as well as a concrete cantilever wall, are presented below.

#### 8.1.1 Concrete Toe Wall

Based on preliminary cross-sections, it is anticipated that a toe wall will be founded at approximate Elev. 58.5 m, a minimum 450 mm below finished ramp grade. The founding soil encountered at this level comprises dense sand fill to a depth of approximately 1.7 m below the wall base.

The dense sand fill is considered capable of supporting a concrete toe wall. A toe wall founded on the existing dense sand fill may be designed using the factored geotechnical resistances at ULS of 200 kPa (Type I) and 300 kPa (Types II and III) as per OPSD 3120.100.

The sliding resistance of mass concrete on dense sand fill may be computed on the basis of an unfactored coefficient of friction of 0.55. This value requires a degree of sliding movement to occur to fully mobilize the resistance.

#### 8.1.2 Soldier Pile and Lagging Wall

Installation of a soldier pile and lagging wall is considered feasible. The horizontal loads imposed on the walls will be resisted by the passive forces developed on the face of the pile within the fill and native layers of sand, silty clay, silt and silty sand till. The pile tip elevation will be governed by the embedment depth required to resist the horizontal loads.

The lateral resistance developed within the overburden soils may be calculated using a value for the coefficient of horizontal subgrade reaction ( $k_s$ ) and ultimate lateral resistance ( $p_{ult}$ ) as follows:

$$\begin{aligned} k_s &= n_h z / D && (\text{kN/m}^3) \text{ for cohesionless soils} \\ &= 67 c_u / D && (\text{kN/m}^3) \text{ for cohesive soils} \\ p_{ult} &= 3 \gamma z K_p && (\text{kPa}) \text{ for cohesionless soils} \\ &= 2c_u \text{ at the surface, increasing linearly to } 9c_u \text{ at a depth of three pile/ caisson diameters (D), and } 9 c_u \text{ below this depth (kPa) for cohesive soils} \end{aligned}$$

where

$$\begin{aligned} z &= \text{depth of embedment of pile/caisson (m)} \\ D &= \text{pile/caisson diameter (m)} \\ n_h &= \text{coefficient of horizontal subgrade reaction (kN/m}^3\text{)} \\ c_u &= \text{undrained shear strength (kPa)} \\ \gamma &= \text{bulk unit weight, use submerged unit weight below water table (kN/m}^3\text{)} \\ K_p &= \text{passive earth pressure coefficient} \end{aligned}$$



The recommended parameters for the above equations are presented in Table 8.1, Appendix K.

The equations and recommended parameters may be used to analyse the interaction between a pile and the surrounding soil. The lateral pressures obtained from the analysis should not exceed the ultimate lateral resistance.

The spring constant,  $K$ , for analysis may be obtained by the expression,  $K = k_s * L * D$  (kN/m), where  $k_s$  is the coefficient of horizontal subgrade reaction (kN/m<sup>3</sup>),  $D$  is the pile width (m) and  $L$  is the length (m) of the pile segment or element used in the analysis. The ultimate lateral resistance on any one segment of pile,  $P_{ult}$ , may be obtained from the expression,  $P_{ult} = p_{ult} * L * D$ . This represents the ultimate load at which the soil fails and will not support any additional load at greater displacements.

### 8.1.3 Concrete Cantilever Wall on Native Soil

A concrete cantilever wall should be founded on the native compact sand encountered at Elev. 56.8 m in the boreholes. Spread footings founded on the compact sand at this level should be designed using the following geotechnical resistances, assuming a footing width of 1.5 to 3.0 m:

|   |         |
|---|---------|
| Factored geotechnical resistance at ULS | 150 kPa |
| Geotechnical resistance at SLS          | 100 kPa |

The geotechnical resistances are for concentric, vertical loads. In the case of eccentric or inclined loading, the geotechnical resistances must be calculated as illustrated in the CHBDC Clause 6.7.3 and Clause 6.7.4.

The sliding resistance of mass concrete poured on native sand may be computed on the basis of an unfactored coefficient of friction of 0.50. This value requires a degree of sliding movement to occur to fully mobilize the resistance.

## 8.2 Lees Avenue S-E Ramp – Station 10+290 to 10+375

The existing S-E Ramp from Lees Avenue to Highway 417 will be lowered by up to 1.0 m and shifted slightly west towards an existing crib wall. Preliminary cross-sections of the ramp indicate that excavation for ramp realignment and pavement reconstruction will locally extend up to about 2.0 m below existing grade within about 0.5 m of the base of the wall. The base of the excavation is expected to range from Elev. 58.0 to Elev. 58.5.

The existing crib wall is approximately 385 m in length and varies from about 1.2 to 5.5 m high. Contract drawings indicate that the crib extends approximately 1.8 to 3.0 m behind the wall face, and the front of the wall is constructed on a 535 mm thick concrete footing with a design founding level at Elev. 58.9.

Boreholes drilled along the S-E ramp in front of the wall encountered a composite pavement structure overlying sand fill, underlain by soft to firm silty clay at depths of 3.4 to 4.3 m (Elev. 55.9 to 55.6). The sand fill is dense to very dense, becoming compact below 3.0 m depth. The silty clay is underlain by a layer of loose to compact silt, then loose to compact silty sand to sandy silt till. Probable bedrock was encountered at depths of 11.4 and 11.8 m (Elev. 47.63 and 48.1) in two boreholes.

Based on the borehole data, the crib wall footing is underlain by 3.0 to 3.3 m of sand fill above the native soft to firm silty clay. Excavation for ramp realignment will be carried out within the sand fill and extend up to 0.9 m below the wall founding level.

Excavation for ramp reconstruction must not undermine the existing crib wall foundation. Underpinning of the existing wall footing or installation of shoring is recommended for any sections where excavation extends below a line inclined downwards at 1.5H:1V from the front edge of the footing base.

The impact of excavation and ramp realignment on the global stability of the crib wall was assessed using the commercially available slope stability program SLOPE/W by Geo-Slope International. The Morgenstern-Price method was used for the limit equilibrium analyses, and both circular and non-circular (optimized) failure surfaces were considered. The critical wall section at Station 10+360 was selected for the analysis. The input parameters and soil model used in the stability analyses, including soil stratigraphy, engineering properties, groundwater conditions, and retaining wall geometry, are shown on the figures in Appendix L.

A factor of safety of 1.3 is considered appropriate to achieve both short and long-term stability for a wall founded on cohesionless soils. For cohesive foundation soils, the recommended factor of safety is 1.3 for short-term conditions and 1.5 for long-term conditions.

The results of the analyses were as follows:

- i. The current factor of safety for the existing wall conditions was determined to be in the order of 1.6 (effective stress analysis for long-term condition, Figures 1 and 1a, Appendix L).
- ii. For the case where temporary excavation in front of the wall extends to the proposed pavement subgrade level (approximately 1.8 m below existing grade), the resulting factor of safety is about 1.0 (total stress analysis for short term condition, Figures 2 and 2a, Appendix L).
- iii. The maximum excavation depth providing a minimum factor of safety of 1.3 is in the order of 0.6 to 0.9 m (total stress analysis for short term condition, Figures 3 and 3a, Appendix L).

Based on these results, the wall is expected to be detrimentally impacted (destablized) by the proposed ramp realignment. Excavation below a depth of 0.9 m is not recommended unless permanent measures are implemented to improve the stability of the wall prior to excavation. These may involve underpinning of the existing spread footings (implemented in short sections), installation of permanent sheet pile shoring, drilled-in H-piles in front of the wall, lowering of the wall height, and/or removal of backfill from behind the wall if space permits. The potential for disturbance of the wall during implementation of these measures must be considered during selection of the proposed method.

The lateral earth pressure parameters recommended for design of shoring are presented in Table 8.2, Appendix K.

### **8.3 Lees Avenue (North) at Robinson Avenue – Station 230+718 to 230+751**

The proposed retaining wall will have a maximum height of approximately 2.5 m and will support the forward slope in front of the north abutment of the Lees Avenue structure.

The subsurface stratigraphy encountered in the boreholes typically consisted of a pavement structure overlying compact to very dense silty sand to sand and gravel fill, underlain by very dense sand to sand and gravel and very dense sandy silt/silty sand till. The sand fill extends to approximately 2.2 m depth (Elev. 58.3 and 58.5). Cobbles and possibly boulders were encountered in the fill and native soils. Probable bedrock was contacted at depths of 9.6 and 9.7 m (Elev. 51.1 and 50.8). Groundwater was measured at depths of 1.1 and 1.0 m (Elev. 59.6 and 59.5) in piezometers installed in the boreholes.

A comparison of the various wall types is presented in Table J2 of Appendix J. From a foundations perspective, a concrete cantilever wall founded on native soil is the preferred wall type at this location. Preliminary foundation recommendations for design of a cantilever wall, soldier pile wall and post and panel wall are presented below.

#### **8.3.1 Concrete Cantilever Wall on Native Soil**

It is recommended that the concrete cantilever wall be founded on very dense native sand to gravelly sand encountered in the boreholes at 2.2 m depth (Elev. 58.3 to 58.5). Spread footings founded on the undisturbed very dense sand at this level should be designed using the following geotechnical resistances, assuming a footing width of 1.0 to 3.0 m:

|   |         |
|---|---------|
| Factored geotechnical resistance at ULS | 500 kPa |
| Geotechnical resistance at SLS          | 350 kPa |

The geotechnical resistances are for concentric, vertical loads. In the case of eccentric or inclined loading, the geotechnical resistances must be calculated as illustrated in the CHBDC Clause 6.7.3 and Clause 6.7.4.

The sliding resistance of mass concrete poured on native sand to gravelly sand may be computed on the basis of an unfactored coefficient of friction of 0.55. This value requires a degree of sliding movement to occur to fully mobilize the resistance.

The recommended founding level is 1.1 to 1.2 m below the groundwater levels measured in the piezometers. Dewatering will be required to lower the groundwater level prior to excavation for footing construction.

### 8.3.2 Soldier Pile and Lagging Wall

Installation of a soldier pile and lagging wall is considered feasible. The horizontal loads imposed on the walls will be resisted by the passive forces developed on the face of the pile within the native sand to sand and gravel. The pile tip elevation will be governed by the embedment depth required to resist the horizontal loads.

The lateral resistance developed within the overburden soils may be calculated using a value for the coefficient of horizontal subgrade reaction ( $k_s$ ) and ultimate lateral resistance ( $p_{ult}$ ) as follows:

$$\begin{aligned} k_s &= n_h \cdot z / D \quad (\text{kN/m}^3) \\ p_{ult} &= 3 \cdot \gamma' \cdot z \cdot K_p \quad (\text{kPa}) \end{aligned}$$

where

|           |   |                                       |
|-----------|---|---------------------------------------|
| $z$       | = | depth of embedment of piles in metres |
| $D$       | = | pile augerhole diameter in metres     |
| $n_h$     | = | coefficient related to soil density   |
| $\gamma'$ | = | effective unit weight                 |
| $K_p$     | = | passive earth pressure coefficient    |

The recommended parameters for the above equations are presented in Table 8.3, Appendix K.

The above equations and recommended parameters may be used to analyse the interaction between a pile and the surrounding soil. The lateral pressures obtained from the analysis should not exceed the ultimate lateral resistance.

The spring constant,  $K$ , for analysis may be obtained by the expression,  $K = k_s \cdot L \cdot D$  (kN/m), where  $k_s$  is the coefficient of horizontal subgrade reaction (kN/m<sup>3</sup>),  $D$  is the pile width (m) and  $L$  is the length (m) of the pile segment or element used in the analysis. The ultimate lateral resistance on any one segment of pile,  $P_{ult}$ , may be obtained from the expression,  $P_{ult} = p_{ult} \cdot L \cdot D$ . This represents the ultimate load at which the soil/ rock fails and will not support any additional

### 8.3.3 Post and Panel Wall

A proprietary post and panel wall supported on small diameter drilled caissons may be considered. The geotechnical design parameters recommended for design of the caissons are summarized in Table 8.4, Appendix K.

## 8.4 Lees Avenue (North) Noise Barrier – Station 230+680 to 231+080

A proprietary post and panel noise barrier wall is planned at this location. Sections of the wall will incorporate retaining wall panels to a maximum height of 1.0 m.

The subsurface stratigraphy at this location typically consisted of a pavement structure overlying compact to very dense sand fill, underlain by compact to very dense sand to sand and gravel near Lees Avenue and very dense silty sand till along the remainder of the alignment. The sand fill extends to depths of 1.3 m to 3.0 m (Elev. 59.0 to 57.2). Cobbles and possibly boulders are inherent in the native till. Groundwater was measured at depths of 2.5 to 5.8 m (Elev. 55.2 to 57.6) during drilling and in a piezometer installed in one of the boreholes.

The noise barrier wall should be installed in accordance with SP 799F01. The geotechnical design parameters recommended for design of the post foundations are summarized in Table 8.5, Appendix K.

## 8.5 Canadian Tire Parking Lot – Riverside Drive to Belfast Road (North) Station 210+902 to 211+000

Preliminary design indicated that the proposed retaining wall would have a maximum height of approximately 3.2 m and would support the north side of the Highway 417 westbound lanes. The grading was subsequently revised such that the maximum wall height is now 1.8 m.

The subsurface stratigraphy encountered in the boreholes at this site typically consisted of the highway shoulder pavement structure (asphalt over sand to gravelly sand fill) overlying a discontinuous layer of compact to dense sandy silt to silty sand fill, underlain by compact sandy silt to silty sand till. Bedrock or probable bedrock was encountered at depths of 4.1 to 6.1 m (Elev. 56.9 and 54.9) in three boreholes. Groundwater was measured at depths of 2.2 to 3.5 m (Elev. 58.7 to 57.6) in two piezometers.

A comparison of the various wall types is presented in Table J3 of Appendix J. From a foundations perspective, a concrete toe wall founded on native soil is the preferred wall type at this location. A concrete cantilever or soldier pile and lagging wall design is also feasible. Foundation recommendations for design of a toe wall, cantilever wall, soldier pile wall and post and panel wall (for retained sections less than 2.5 m high) are presented below.

#### 8.5.1 Concrete Toe Wall

Based on preliminary cross-sections, it is anticipated that a toe wall will be founded at approximate Elev. 59.0 m. The founding soil encountered at this level varies from compact silty sand to sandy silt fill to compact native sandy silt till at the east end.

To increase the geotechnical resistance and provide a more uniform bearing surface on which to found the toe wall, it is recommended that a minimum 600 mm thick layer of Granular A engineered fill be placed below the wall base. Spread footings founded on the engineered fill pad should be designed using the factored geotechnical resistances at ULS of 200 kPa (Type I) and 300 kPa (Types II and III) as per OPSD 3120.100.

The sliding resistance of mass concrete on granular engineered fill may be computed on the basis of an unfactored coefficient of friction of 0.60. This value requires a degree of sliding movement to occur to fully mobilize the resistance

#### 8.5.2 Concrete Cantilever Wall on Native Soil

It is recommended that the concrete cantilever wall be founded on compact native silty sand to sandy silt till. Based on cross-sectional information, the anticipated founding level for a wall base constructed at a frost depth of 1.8 m below finished grade ranges from Elev. 57.2 to 57.7 m. Spread footings founded on the undisturbed compact native sand/silt till at this level should be designed using the following geotechnical resistances, assuming a footing width of 1.0 to 3.0 m:

|   |         |
|---|---------|
| Factored geotechnical resistance at ULS | 400 kPa |
| Geotechnical resistance at SLS          | 200 kPa |

The depth of the wall foundation could be reduced (wall base constructed in compact sand/silt till at higher levels) if synthetic insulation is provided for frost protection in place of earth cover.

The geotechnical resistances are for concentric, vertical loads. In the case of eccentric or inclined loading, the geotechnical resistances must be calculated as illustrated in the CHBDC Clause 6.7.3 and Clause 6.7.4.

The sliding resistance of mass concrete poured on native silty sand to sandy silt till may be computed on the basis of an unfactored coefficient of friction of 0.5. This value requires a degree of sliding movement to occur to fully mobilize the resistance.

The recommended founding level is approximately 1.0 to 1.5 m below the groundwater levels measured in the piezometers. Dewatering will be required to lower the groundwater level prior to excavation for footing construction.

### 8.5.3 Soldier Pile and Lagging Wall

Installation of a soldier pile and lagging wall is considered feasible. The horizontal loads imposed on the walls will be resisted by the passive forces developed on the face of the pile within the native silty sand to sandy silt till and shale bedrock. The pile tip elevation will be governed by the embedment depth required to resist the horizontal loads. Socketing of the piles into the shale bedrock will be required depending upon the depth to bedrock.

The lateral resistance developed within the overburden soils may be calculated using a value for the coefficient of horizontal subgrade reaction ( $k_s$ ) and ultimate lateral resistance ( $p_{ult}$ ) as follows:

$$\begin{aligned} k_s &= n_h \cdot z / D \quad (\text{kN/m}^3) \\ p_{ult} &= 3 \cdot \gamma \cdot z \cdot K_p \quad (\text{kPa}) \end{aligned}$$

where

|           |   |                                       |
|-----------|---|---------------------------------------|
| $z$       | = | depth of embedment of piles in metres |
| $D$       | = | pile augerhole diameter in metres     |
| $n_h$     | = | coefficient related to soil density   |
| $\gamma'$ | = | effective unit weight                 |
| $K_p$     | = | passive earth pressure coefficient    |

The recommended parameters for the above equations are presented in Table 8.6, Appendix K.

Bedrock was contacted at Elev. 54.9 to 56.9 in Boreholes CTW-1, CTW-2 and 15N-01. The lateral resistance within the bedrock socket may be taken as:

$$\begin{aligned} k_s &= 25,000 \text{ kN/m}^3 \text{ at the bedrock surface, increasing linearly to } 50,000 \text{ kN/m}^3 \text{ at a depth of 3 caisson diameters and below} \\ p_{ult} &= 400 \text{ kPa in the upper 1.0 m of bedrock, and } 2,000 \text{ kPa in the bedrock below this depth.} \end{aligned}$$

The above equations and recommended parameters may be used to analyse the interaction between a pile and the surrounding soil/rock. The lateral pressures obtained from the analysis should not exceed the ultimate lateral resistance.

The spring constant,  $K$ , for analysis may be obtained by the expression,  $K = k_s \cdot L \cdot D$  (kN/m), where  $k_s$  is the coefficient of horizontal subgrade reaction (kN/m<sup>3</sup>),  $D$  is the pile width (m) and  $L$  is the length (m) of the pile segment or element used in the analysis. The ultimate lateral resistance on any one segment of pile,  $P_{ult}$ , may be obtained from the expression,  $P_{ult} = p_{ult} \cdot L \cdot D$ . This represents the ultimate load at which the soil/ rock fails and will not support any additional load at greater displacements.

#### 8.5.4 Post and Panel Wall

A proprietary post and panel wall supported on small diameter drilled caissons may be considered. The geotechnical design parameters recommended for design of the caissons are summarized in Table 8.7, Appendix K.

### 8.6 Belfast Road (North), Wall 15N – Station 211+220 to 211+700

The proposed retaining wall will have a maximum height of approximately 2.6 m and will support the ground adjacent to the north side of the Highway 417 westbound lanes. Design recommendations for the section of retaining wall below the Belfast Road structure were provided in the Foundation Design Report for the underpass rehabilitation.

The subsurface stratigraphy encountered in the boreholes typically consisted of the shoulder pavement structure, overlying sandy silt to silty sand fill, underlain by dense to very dense silty sand to silt till. The pavement and fill depths ranged from 0.8 to 2.2 m. Shale bedrock was encountered below the pavement structure at depths of 1.1 to 5.3 m (Elev. 65.6 to 57.4 m), generally deeper/falling towards the west. Groundwater levels measured in three piezometers installed at the site ranged from 2.2 to 4.0 m (Elev. 59.6 to 64.0 m).

A comparison of the various wall types is presented in Table J4 of Appendix J. From a foundations perspective, a concrete cantilever wall founded on native soil and bedrock is the preferred wall type at this location. A soldier pile and lagging wall is also feasible. Preliminary foundation recommendations for design of a cantilever wall, soldier pile wall and post and panel wall are presented below.

#### 8.6.1 Concrete Cantilever Wall on Native Soil and Bedrock

It is recommended that the concrete cantilever wall be founded on native, undisturbed dense to very dense silt to silty sand till or on shale bedrock at a minimum frost depth of 1.8 m.

Based on the borehole data, the west end of the wall (Boreholes 15N-04 to 15N-07) will be constructed on dense to very dense till at depths of 1.8 to 2.2 m (Elev. 60.1 to 62.7 m). Spread footings founded on the undisturbed till at this level should be designed using the following geotechnical resistances, assuming a footing width of 1.0 to 3.0 m:

|   |         |
|---|---------|
| Factored geotechnical resistance at ULS | 600 kPa |
| Geotechnical resistance at SLS          | 400 kPa |

The east end of the wall (Boreholes 15N-08 to 15N-10) will be placed on shale bedrock encountered at depths of 1.1 to 1.5 m (Elev. 64.0 to 65.6 m). The recommended resistance values for footings founded on undisturbed shale at the minimum frost depth are as follows:



|   |                 |
|---|-----------------|
| Factored geotechnical resistance at ULS | 1,000 kPa       |
| Geotechnical resistance at SLS          | Will not govern |

The geotechnical resistances are for concentric, vertical loads. In the case of eccentric or inclined loading, the geotechnical resistances must be calculated as illustrated in the CHBDC Clause 6.7.3 and Clause 6.7.4.

A construction joint is recommended at the transition between footings on bedrock and footings on native soil.

The sliding resistance of mass concrete poured on native silt/sand till and shale bedrock may be computed on the basis of unfactored coefficients of friction of 0.5 and 0.55, respectively. These values require a degree of sliding movement to occur to fully mobilize the resistance.

### 8.6.2 Soldier Pile and Lagging Wall

Installation of a soldier pile and lagging wall is considered feasible. The horizontal loads imposed on the walls will be resisted by the passive forces developed on the face of the pile within the native till and the shale bedrock. The pile tip elevation will be governed by the embedment depth required to resist the horizontal loads. Socketing of the piles into the shale bedrock will be required depending upon the depth to bedrock.

The lateral resistance developed within the overburden soils may be calculated using a value for the coefficient of horizontal subgrade reaction ( $k_s$ ) and ultimate lateral resistance ( $p_{ult}$ ) as follows:

$$k_s = n_h \cdot z / D \quad (\text{kN/m}^3)$$

$$p_{ult} = 3 \cdot \gamma \cdot z \cdot K_p \quad (\text{kPa})$$

|       |           |   |                                       |
|-------|-----------|---|---------------------------------------|
| where | $z$       | = | depth of embedment of piles in metres |
|       | $D$       | = | pile augerhole diameter in metres     |
|       | $n_h$     | = | coefficient related to soil density   |
|       | $\gamma'$ | = | effective unit weight                 |
|       | $K_p$     | = | passive earth pressure coefficient    |

The recommended parameters for the above equations are presented in Table 8.8, Appendix K. Lateral resistance within the frost penetration depth of 1.8 m has been neglected.

The lateral resistance within the bedrock socket may be taken as:

$$k_s = 25,000 \text{ kN/m}^3 \text{ at the bedrock surface, increasing linearly to } 50,000 \text{ kN/m}^3 \text{ at a depth of 3 caisson diameters and below}$$

$$p_{ult} = 400 \text{ kPa in the upper 1.0 m of bedrock, and } 2,000 \text{ kPa in the bedrock below this depth.}$$

The above equations and recommended parameters may be used to analyze the interaction between a pile and the surrounding soil/rock. The lateral pressures obtained from the analysis should not exceed the ultimate lateral resistance.

The spring constant,  $K$ , for analysis may be obtained by the expression,  $K = k_s * L * D$  (kN/m), where  $k_s$  is the coefficient of horizontal subgrade reaction (kN/m<sup>3</sup>),  $D$  is the pile width (m) and  $L$  is the length (m) of the pile segment or element used in the analysis. The ultimate lateral resistance on any one segment of pile,  $P_{ult}$ , may be obtained from the expression,  $P_{ult} = p_{ult} * L * D$ . This represents the ultimate load at which the soil/ rock fails and will not support any additional load at greater displacements.

### 8.6.3 Post and Panel Wall

A proprietary post and panel wall supported on small diameter drilled caissons may be considered. The geotechnical design parameters recommended for design of the caissons are summarized in Table 8.9, Appendix K.

## 8.7 Belfast Road (South), Wall 23S – Station 111+090 to 111+705

A proprietary post and panel noise barrier wall is planned at this location. Design recommendations for the section of retaining wall below the Belfast Road structure were provided in the Foundation Design Report for the underpass rehabilitation.

The subsurface stratigraphy at this location typically consists of a pavement structure overlying compact to very dense silty sand till, underlain by bedrock encountered at depths of 1.2 to 6.0 m (Elev. 66.2 to 55.9). Silty sand fill was encountered below the pavement at the west end. Groundwater was measured at depths of 2.8 to 3.9 m (Elev. 64.6 to 58.6) in piezometers installed in the boreholes.

The noise barrier wall should be installed in accordance with SP 799F01. The geotechnical design parameters recommended for design of the post foundations are summarized in Table 8.10, Appendix K.

## 8.8 St. Laurent Boulevard N-W Ramp, Wall 16N – Station 212+000 to 212+200

The N-W ramp at the retaining wall location is situated parallel to and immediately adjacent to the westbound lanes of Highway 417 north of the St. Laurent Boulevard overpass. The ramp ascends from the lower level of St. Laurent Boulevard to the higher level of Highway 417. The maximum grade difference between the ramp and highway will be approximately 5.5 m.

The proposed retaining wall will be constructed along the south side of the ramp to support the adjacent Highway 417 embankment, and accordingly the wall height is expected to decrease as the ramp rises towards the west. The wall will have a maximum height of approximately 2.3 m and support a sloped surface (max. 2H:1V) up to Highway 417.

The subsurface stratigraphy encountered in boreholes drilled at the site typically consisted of the ramp pavement structure overlying fill (gravelly sand, silty sand, sand and localized clayey silt), underlain by compact native silty sand and compact to very dense silty sand/sandy silt till. The native silty sand was encountered below the fill at depths of 1.5 to 3.0 m (Elev. 66.3 to 67.0 m). Shale bedrock was encountered below the till at depths of 4.9 to 5.8 m (Elev. 63.5 to 64.1 m). Groundwater levels measured in piezometers installed at the site ranged from 3.7 to 5.8 m below the ramp grade (Elev. 63.8 to 64.8 m).

A comparison of the various wall types is presented in Table J5 of Appendix J. From a foundations perspective, a concrete cantilever wall founded on native soil is the preferred wall type at this location. Preliminary foundation recommendations for design of a cantilever wall, as well as a soldier pile and lagging wall and a post and panel wall, are presented below.

#### 8.8.1 Concrete Cantilever Wall on Native Soil

It is recommended that the concrete cantilever wall be founded on compact native silty sand encountered at depths of 1.5 to 3.0 m (Elev. 66.3 to 67.0 m) in the boreholes. Spread footings founded on the undisturbed compact silty sand at this level should be designed using the following geotechnical resistances, assuming a footing width of 1.0 to 3.0 m:

|   |         |
|---|---------|
| Factored geotechnical resistance at ULS | 350 kPa |
| Geotechnical resistance at SLS          | 175 kPa |

Higher resistance values may be achieved by extending the wall base down to dense to very dense silty sand/sandy silt till encountered at 4.6 m depth (Elev. 63.9 to 65.3 m) in each borehole. The recommended resistance values at this level are as follows:

|   |         |
|---|---------|
| Factored geotechnical resistance at ULS | 600 kPa |
| Geotechnical resistance at SLS          | 400 kPa |

The founding level required to achieve the higher geotechnical resistance at the west end of the wall is approximately 0.9 m below the groundwater level measured in the piezometer. Dewatering will be required to lower the groundwater level prior to excavation for footing construction at this level. For this reason, use of the higher founding level (Elev. 66.3 to 67.0 m) is preferred from a geotechnical perspective.

The geotechnical resistances are for concentric, vertical loads. In the case of eccentric or inclined loading, the geotechnical resistances must be calculated as illustrated in the CHBDC Clause 6.7.3 and Clause 6.7.4.

The sliding resistance of mass concrete poured on native silty sand may be computed on the basis of an unfactored coefficient of friction of 0.5. This value requires a degree of sliding movement to occur to fully mobilize the resistance.

### 8.8.2 Soldier Pile and Lagging Wall

Installation of a soldier pile and lagging wall is considered feasible. The horizontal loads imposed on the walls will be resisted by the passive forces developed on the face of the pile within the native silty sand, till and shale bedrock. The pile tip elevation will be governed by the embedment depth required to resist the horizontal loads. For the higher sections of wall, it is anticipated that the soldier piles will require socketing into the shale bedrock to achieve adequate lateral resistance.

The lateral resistance developed within the overburden soils may be calculated using a value for the coefficient of horizontal subgrade reaction ( $k_s$ ) and ultimate lateral resistance ( $p_{ult}$ ) as follows:

$$k_s = n_h \cdot z / D \quad (\text{kN/m}^3)$$

$$p_{ult} = 3 \cdot \gamma' \cdot z \cdot K_p \quad (\text{kPa})$$

where

|           |   |                                       |
|-----------|---|---------------------------------------|
| $z$       | = | depth of embedment of piles in metres |
| $D$       | = | pile augerhole diameter in metres     |
| $n_h$     | = | coefficient related to soil density   |
| $\gamma'$ | = | effective unit weight                 |
| $K_p$     | = | passive earth pressure coefficient    |

The recommended parameters for the above equations are presented in Table 8.11, Appendix K. Lateral resistance within the frost penetration depth of 1.8 m has been neglected.

The lateral resistance within the bedrock socket may be taken as:

$$k_s = \begin{array}{l} 25,000 \text{ kN/m}^3 \text{ at the bedrock surface, increasing linearly to} \\ 50,000 \text{ kN/m}^3 \text{ at a depth of 3 caisson diameters and below} \end{array}$$

$$p_{ult} = \begin{array}{l} 400 \text{ kPa in the upper 1.0 m of bedrock, and} \\ 2,000 \text{ kPa in the bedrock below this depth.} \end{array}$$

The above equations and recommended parameters may be used to analyse the interaction between a pile and the surrounding soil/rock. The lateral pressures obtained from the analysis should not exceed the ultimate lateral resistance.

The spring constant,  $K$ , for analysis may be obtained by the expression,  $K = k_s \cdot L \cdot D$  ( $\text{kN/m}$ ), where  $k_s$  is the coefficient of horizontal subgrade reaction ( $\text{kN/m}^3$ ),  $D$  is the pile width (m) and  $L$  is the length (m) of the pile segment or element used in the analysis. The ultimate lateral resistance on any one segment of pile,  $P_{ult}$ , may be obtained from the expression,  $P_{ult} = p_{ult} \cdot L \cdot D$ . This represents the ultimate load at which the soil/ rock fails and will not support any additional load at greater displacements.

### 8.8.3 Tiebacks

If additional resistance to lateral loads is required, installation of rock anchors may be considered. Installation of anchors within the fill and native silty sand is not recommended due to the low bond strength available in these deposits and the potential for long term creep. Further, the underlying till deposit is of inadequate thickness for anchor installation. It is therefore recommended that all anchors be developed within the bedrock.

The factored rock-grout bond strength at ULS recommended for design of the anchors in shale bedrock is 400 kPa. This value includes a geotechnical resistance factor of 0.4 as per Table 6.1 of the CHBDC.

Installation of the anchors should be carried out in accordance with OPSS 942. The minimum bond length in shale should be 3.0 m for a rock anchor. The length of the unbonded zone should be at least 3.0 m for a steel bar anchor and 4.5 m for a strand anchor.

### 8.8.4 Post and Panel Wall

A proprietary post and panel wall supported on small diameter drilled caissons may be considered. The geotechnical design parameters recommended for design of the caissons are summarized in Table 8.12, Appendix K.

## 8.9 Frost Cover

The design depth of frost penetration at this site is 1.8 m.

It is recommended that all footings and pile caps be provided with a minimum of 1.8 m of earth cover above the underside of the footing. Frost protection is required for the shale bedrock.

## 8.10 Permanent Soldier Pile and Lagging Walls - General

Where construction of a permanent soldier pile and lagging wall does not include installation of a wall subdrain and granular backfill behind the wall as per OPSD specifications, the design must incorporate measures to prevent freezing of the retained soils and seepage of groundwater onto the wall face. In this case, the wall face should be covered with prefabricated vertical drainage sheets draining to a suitable frost-free outlet, overlain by synthetic insulation equivalent to 1.8 m of earth cover, protected by a durable concrete facing. Alternatively, proprietary insulating facing elements providing equivalent protection against frost penetration may be employed over the drainage sheet.

## 9 RETAINING WALL BACKFILL AND LATERAL EARTH PRESSURES

Backfill to the retaining walls should be in accordance with OPSS 902 and placed to the extents shown in OPSD 3121.150. The design of the retaining wall must incorporate a subdrain as shown in OPSD 3190.100.

Backfill to the retaining walls should consist of Granular A or Granular B Type II material meeting the requirements of Special Provision 110S13. Compaction equipment to be used adjacent to retaining structures should be restricted in accordance with OPSS 501.

The earth pressures acting on the retaining walls may be assumed to be triangular and to be governed by the characteristics of the retaining wall backfill. For a fully drained condition, the pressures should be computed by the expression given below:

$$p_h = K(\gamma h + q)$$

where:  $p_h$  = horizontal pressure on the wall at depth  $h$  (kPa)

$K$  = earth pressure coefficient (see Table 9.1)

$\gamma$  = unit weight of retained soil (see Table 9.1)

$h$  = depth below top of fill where pressure is computed (m)

$q$  = value of any surcharge (kPa)

Earth pressure coefficients for backfill to the retaining wall are dependent on the material used as backfill. Typical values are given in Table 9.1.

**Table 9.1 - Earth Pressure Coefficients (K)**

| Condition                               | Earth Pressure Coefficient (K)  |                                |  |                                |
|---|---|--------------------------------|--|--------------------------------|
|   | OPSS Granular A or<br>Granular B Type II<br>$\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$ |                                | OPSS Granular B<br>Type I<br>$\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$ |                                |
|   | Horizontal<br>Surface<br>Behind Wall  | Sloping<br>Backfill<br>(2H:1V) | Horizontal<br>Surface<br>Behind Wall   | Sloping<br>Backfill<br>(2H:1V) |
| Active<br>(Unrestrained Wall)           | 0.27  | 0.4                            | 0.31   | 0.43                           |
| At Rest<br>(Restrained Wall)            | 0.43  | -                              | 0.47   | -                              |
| Passive (Movement<br>towards soil mass) | 3.7   | 2.1*                           | 3.3  | 1.7*                           |

\* where applicable.

In conventional design, the use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) is preferred as it results in lower earth pressures acting on the wall.

The values in Table 9.1 require certain movements for the respective conditions to be mobilized. The values to use in design can be estimated from Figure C6.16 in the Commentary to the Canadian Highway Bridge Design Code.

In accordance with Clause 6.9.3 of the CHBDC, a compaction surcharge should be added. The magnitude should be 12 kPa at the top of fill and decreasing to 0 kPa at a depth of 2.0 m for Granular B Type I or at a depth of 1.7 m for Granular A or Granular B Type II.

## **10 EXCAVATION AND GROUNDWATER CONTROL**

Excavation for construction of the retaining walls is generally expected to encounter existing pavement structures, cohesionless silty to gravely sand fill, and silty sand to sandy silt till. Layers of silt to silty clay and sand and gravel may be encountered locally. Localized excavation into shale bedrock may be required at Belfast Road (North) Wall 15N.

All excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the fill and native soils within the probable depth of excavation may be classed as Type 3 soils above the groundwater level and Type 4 below the water level.

The excavation and backfilling for foundations must be carried out in accordance with OPSS 902. Soldier pile and caisson installation must be in accordance with OPSS 903.

The construction methodology and design of excavation shoring is the responsibility of the Contractor. Equipment suitable for excavating dense silt/sand till with possible cobbles, boulders and shale slabs must be provided. Subject to founding levels, excavation into the shale bedrock may be required and equipment suitable for excavating below the shale surface must also be supplied.

Excavation is expected to extend below the groundwater level within cohesionless sand fill and sand/silt till in some areas. Excavation below the groundwater level without prior dewatering is not recommended due to the potential for base and sidewall instability. Caisson/soldier pile installation procedures that deal with potential instability due to the presence of a high groundwater table and cohesionless soil deposits must be employed. Selection of the appropriate construction methodology and dewatering system is the responsibility of the Contractor.

The contract documents should contain an NSSP alerting the contract bidders of the specific aspects relating to soldier pile and caisson construction for retaining walls and noise barriers at the site. Suggested wording for this NSSP are provided in Appendix M.

## 11 ROADWAY PROTECTION

Roadway protection, where required, must be supplied in accordance with OPSS 539 and designed for Performance Level 2. The protection systems must be designed by a licensed Professional Engineer experienced in design of shoring with consideration of adjacent traffic loads and any sloping retained surfaces.

It is the Contractor's responsibility to select a suitable roadway protection system based on his evaluation of the data presented in the Foundation Investigation report. Installation of sheet piles or driven H-piles for a soldier pile and lagging system is expected to be feasible. In locations of limited headroom, a soldier pile and lagging system with piles set in pre-drilled holes should be feasible.

The Contractor is responsible for the design of the roadway protection system and any dewatering system required.

Soil parameters for design of the roadway protection systems are provided in Sections 8 and 9.

## 12 SEISMIC CONSIDERATIONS

The following seismic parameters should be used for design:

- Velocity Related Seismic Zone 2
- Zonal Velocity Ratio 0.1
- Acceleration Related Seismic Zone 4
- Zonal Acceleration Ratio 0.2
- Peak Horizontal Acceleration 0.16g

The soil profile type at this site has been classified as Type I. Therefore, according to Table 4.4.6.1 of the CHBDC, a Site Coefficient "S" (ground motion amplification factor) of 1.0 should be used in seismic design.

In accordance with Clause 4.6.4 of the CHBDC, retaining structures should be designed using earth pressure coefficients that incorporate the effects of earthquake loading. The seismic component of the earth pressure distribution is additional to the static earth pressure distribution and may be taken as an inverted triangle with the maximum pressure at the top of the wall and the minimum pressure at the toe. The seismic earth pressure parameters ( $\Delta K_E$ ) recommended for determining the seismic component are presented in Table 12.1.



**Table 12.1 - Earth Pressure Coefficients for Earthquake Loading**

| Condition                     | Seismic Earth Pressure Coefficient ( $\Delta K_E$ ) |   |   |   |
|-------------------------------|---|---|---|---|
|                               | OPSS Granular A or<br>OPSS Granular B Type II       |   | OPSS Granular B<br>Type I                       |   |
|                               | $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$     |   | $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$ |   |
|                               | Horizontal<br>Surface<br>Behind Wall                | Sloping Surface<br>Behind Wall<br>(2H:1V) | Horizontal<br>Surface<br>Behind Wall            | Sloping Surface<br>Behind Wall<br>(2H:1V) |
| Active ( $\Delta K_{AE}$ )*   | 0.07  | 0.22                                      | 0.07  | 0.23                                      |
| At Rest ( $\Delta K_{OE}$ )** | 0.21  | -   | 0.21  | -   |

\* After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall.

\*\* After Woods

The foundation soils at the site are not in danger of liquefaction under earthquake loading.

### 13 CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to the following:

- The soils at the wall locations include cohesionless silty to gravelly sand fill and glacial till consisting of silty sand to sandy silt. Non-cohesive soil is susceptible to disturbance under conditions of unbalanced hydrostatic head, and dewatering or other methods will be required to construct stable excavations below the water level.
- The glacial till is dense to very dense and may contain cobbles, boulders and shale slabs. Excavation of the till may prove arduous and equipment capable of excavating very dense material and removing cobbles, boulders and shale slabs may be required.
- The underlying shale contains hard limestone layers and suitable equipment must be provided if excavation or caisson/pile installation extends into bedrock.

## 14 CLOSURE

Engineering analysis and preparation of the foundation design report were carried out by Ms Mei Cheong. The report was reviewed by Mr. Murray Anderson, P.Eng., M.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

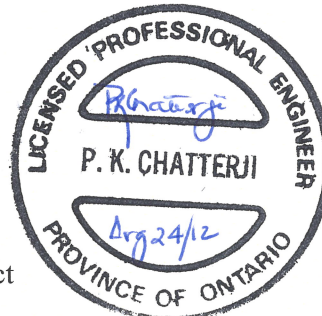
**Thurber Engineering Ltd.**

  
24 Aug, 12

Mei T. Cheong, M.Phil.  
Geotechnical Specialist



Murray R. Anderson, P.Eng., M.Eng.  
Senior Foundations Engineer



P.K. Chatterji, P.Eng., Ph.D.  
Review Principal, Designated MTO Contact

## **Appendix A**

### **Nicholas Street Underpass (South)**

#### **Boreholes NSW-1 and NSW-2**

# RECORD OF BOREHOLE No NSW-1

1 OF 2

METRIC

W.P. 4091-07-00 LOCATION N 5 031 020.7 E 369 459.8 ORIGINATED BY GA  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2012 04 30 - 2012 05 01 CHECKED BY LRB

| SOIL PROFILE  |   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT                                    |                                    |                                     | 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 |                            |                 | 20 40 60 80 100  | PLASTIC<br>LIMIT<br>w <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>w | LIQUID<br>LIMIT<br>w <sub>L</sub>               |   |
| 59.1          |   |            |         |      |            |                            |                 | SHEAR STRENGTH kPa<br>○ UNCONFINED + FIELD VANE<br>● QUICK TRIAXIAL × LAB VANE |                                    |                                     |   |   |
| 0.0           | ASPHALT: (75mm)   |            |         |      |            |                            | 59              |  |                                    |                                     |   |   |
| 0.1           |   |            |         |      |            |                            |                 |  |                                    |                                     |   |   |
| 58.7          | CONCRETE: (350mm)   |            | 1       | GS   |            |                            |                 |  |                                    |                                     |   |   |
| 0.4           |   |            |         |      |            |                            |                 |  |                                    |                                     |   |   |
|               | SAND, trace to some gravel, trace silt<br>Dense<br>Brown<br>Dry<br>(FILL)                   |            | 2       | SS   | 38         |                            | 58              |  |                                    |                                     |   |   |
|               |   |            |         |      |            |                            |                 |  |                                    |                                     |   |   |
|               |   |            | 3       | SS   | 37         |                            | 57              |  |                                    |                                     |   |   |
| 56.8          |   |            |         |      |            |                            |                 |  |                                    |                                     |   |   |
| 2.3           | SAND, some silt, trace gravel, trace<br>clay<br>Compact<br>Brown<br>Dry                     |            | 4       | SS   | 23         |                            |                 |  |                                    |                                     |   |   |
| 56.1          |   |            |         |      |            |                            |                 |  |                                    |                                     |   |   |
| 3.0           | SAND, medium to coarse grained<br>Loose<br>Grey<br>Wet                                      |            | 5       | SS   | 7          |                            | 56              |  |                                    |                                     |   |   |
| 55.1          |   |            |         |      |            |                            |                 |  |                                    |                                     |   |   |
| 4.0           | Silty CLAY, trace sand<br>Soft<br>Grey  |            | 6       | SS   | 4          |                            | 55              |  |                                    |                                     |   |   |
|               |   |            |         |      |            |                            |                 |  |                                    |                                     |   |   |
|               |   |            |         |      |            |                            | 54              |  |                                    |                                     |   | 0 2 48 50   |
| 53.0          |   |            |         |      |            |                            |                 |  |                                    |                                     |   |   |
| 6.1           | SILT, trace to some sand, trace clay<br>Compact<br>Grey<br>Wet                              |            | 7       | SS   | 12         |                            | 53              |  |                                    |                                     |   |   |
|               |   |            |         |      |            |                            |                 |  |                                    |                                     |   |   |
|               |   |            | 8       | SS   | 13         |                            | 52              |  |                                    |                                     |   |   |
|               |   |            |         |      |            |                            |                 |  |                                    |                                     |   |   |
|               |   |            |         |      |            |                            | 51              |  |                                    |                                     |   | 0 6 88 6  |
| 50.0          |   |            |         |      |            |                            |                 |  |                                    |                                     |   |   |
| 9.1           | Silty SAND, trace to some gravel,<br>trace to some clay<br>Compact<br>Grey<br>Wet<br>(FILL) |            | 9       | SS   | 19         |                            | 50              |  |                                    |                                     |   |   |

Continued Next Page

+<sup>3</sup> ×<sup>3</sup> Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No NSW-1

2 OF 2

METRIC

W.P. 4091-07-00 LOCATION N 5 031 020.7 E 369 459.8 ORIGINATED BY GA  
HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2012 04 30 - 2012 05 01 CHECKED BY LRB

| SOIL PROFILE  |   | SAMPLES    |        |      | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |                    | PLASTIC<br>LIMIT | NATURAL<br>MOISTURE<br>CONTENT | LIQUID<br>LIMIT | 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 |                  |                                |                 |   |  |
|               | Continued From Previous Page  |            |        |      |                            |                 |   |                    |                  |                                |                 |   |  |
|               | Silty SAND, trace to some gravel,<br>trace to some clay<br>Compact<br>Grey<br>Wet<br>(TILL)   |            | 10     | SS   | 15                         |                 |   |                    |                  |                                |                 |   | 10 53 27 10  |
|               |   |            | 11     | SS   | 26                         |                 |   |                    |                  |                                |                 |   |  |
| 45.2          |   |            | 12     | SS   | 50/                        |                 |   |                    |                  |                                |                 |   |  |
| 13.9          | END OF BOREHOLE AT 13.9m<br>UPON AUGER REFUSAL ON<br>PROBABLE BEDROCK.<br>BOREHOLE OPEN TO 13.9m AND<br>WATER LEVEL AT 3.3m UPON<br>COMPLETION.<br>Piezometer installation consists of<br>19mm diameter Schedule 40 PVC pipe<br>with a 1.52m slotted screen.<br><br>WATER LEVEL READINGS:<br>DATE DEPTH (m) ELEV. (m)<br>May 02/12 3.4 55.7<br>May 03/12 3.4 55.7 |            |        |      | 0.150                      |                 |   |                    |                  |                                |                 |   |  |

# RECORD OF BOREHOLE No NSW-2

1 OF 2

METRIC

W.P. 4091-07-00 LOCATION N 5 031 041 6 E 369 492 2 ORIGINATED BY GA  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2012.05.01 - 2012.05.01 CHECKED BY LRB

| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |                  |                                | 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 |                            |                 | 20 40 60 80 100                             | PLASTIC<br>LIMIT | NATURAL<br>MOISTURE<br>CONTENT | LIQUID<br>LIMIT                                 |   |
| 59.1          |  |            |         |      |            |                            |                 | SHEAR STRENGTH kPa                          | W <sub>P</sub>   | W                              | W <sub>L</sub>                                  |   |
| 0.0           | ASPHALT: (100mm)   |            |         |      |            |                            |                 | ○ UNCONFINED + FIELD VANE                   |                  |                                |   |   |
| 0.1           | SAND, trace to some gravel, trace silt<br>Compact to Dense<br>Brown<br>Dry<br>(FILL)               |            | 1       | SS   | 22         |                            | 59              | ● QUICK TRIAXIAL x LAB VANE                 |                  |                                |   |   |
|               |  |            | 2       | SS   | 32         |                            | 58              |   |                  |                                |   | 14 80 6<br>(SI+CL)                                |
|               |  |            | 3       | SS   | 45         |                            | 57              |   |                  |                                |   |   |
| 56.8          |  |            |         |      |            |                            |                 |   |                  |                                |   |   |
| 2.3           | SAND, trace silt, trace gravel<br>Compact<br>Brown<br>Damp   |            | 4       | SS   | 13         |                            | 56              |   |                  |                                |   |   |
| 56.1          |  |            |         |      |            |                            | 55              |   |                  |                                |   |   |
| 3.0           | Silty CLAY<br>Firm<br>Grey   |            | 5       | SS   | 6          |                            | 54              |   |                  |                                |   |   |
|               |  |            |         |      |            |                            | 53              |   |                  |                                |   |   |
| 54.5          |  |            |         |      |            |                            | 52              |   |                  |                                |   |   |
| 4.6           | SILT, some clay, trace sand<br>Compact to Loose<br>Grey<br>Wet                                     |            | 6       | SS   | 11         |                            | 51              |   |                  |                                |   |   |
|               |  |            |         |      |            |                            | 50              |   |                  |                                |   |   |
|               |  |            | 7       | SS   | 7          |                            |                 |   |                  |                                |   | 0 8 77 15   |
|               |  |            |         |      |            |                            |                 |   |                  |                                |   |   |
| 51.8          |  |            |         |      |            |                            |                 |   |                  |                                |   |   |
| 7.3           | Silty SAND, some clay to clayey,<br>trace gravel<br>Very Loose to Compact<br>Grey<br>Wet<br>(TILL) |            | 8       | SS   | 2          |                            |                 |   |                  |                                |   |   |
|               |  |            |         |      |            |                            |                 |   |                  |                                |   |   |
|               |  |            | 9       | SS   | 12         |                            |                 |   |                  |                                |   |   |
|               |  |            |         |      |            |                            |                 |   |                  |                                |   |   |

Continued Next Page

+<sup>3</sup> . X<sup>3</sup> : Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No NSW-2

2 OF 2

METRIC

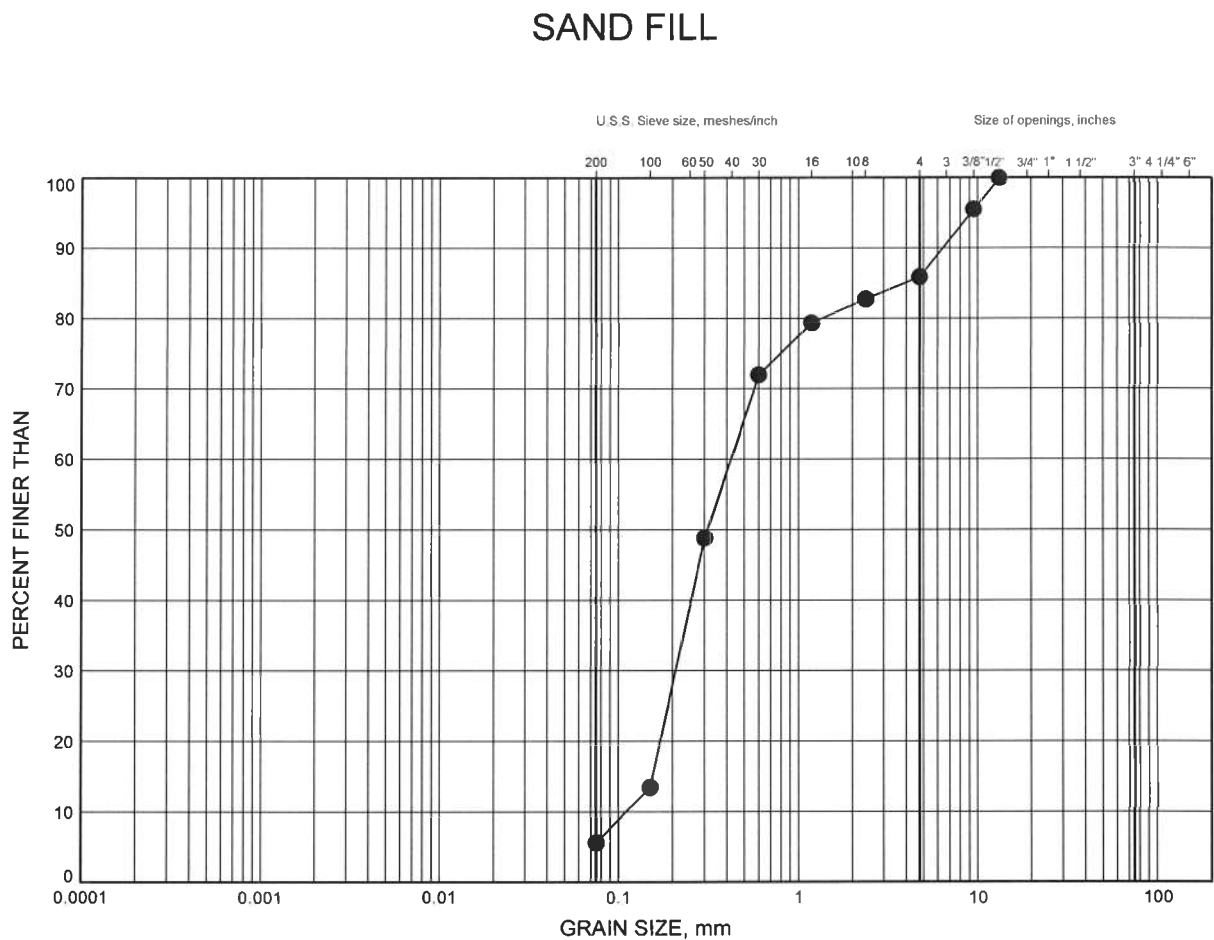
W.P. 4091-07-00 LOCATION N 5 031 041.6 E 369 492.2 ORIGINATED BY GA  
HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2012 05 01 - 2012 05 01 CHECKED BY LRB

| SOIL PROFILE  |  |            | SAMPLES |      |              | GROUND WATER<br>CONDITIONS   | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |  |  | PLASTIC<br>LIMIT | NATURAL<br>MOISTURE<br>CONTENT | LIQUID<br>LIMIT | 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                          |  |  |  |                  |                                |                 |   |  |
|               |  |            |         |      |              | 20 40 60 80 100<br>○ UNCONFINED + FIELD VANE<br>● QUICK TRIAXIAL × LAB VANE<br>20 40 60 80 100 |                 |   |  | w <sub>p</sub> — w — w <sub>L</sub><br>WATER CONTENT (%)<br>20 40 60 |  |                  |                                |                 |   |  |
|               | Continued From Previous Page   |            |         |      |              |  |                 |   |  |  |  |                  |                                |                 |   |  |
|               | Silly <b>SAND</b> , some clay to clayey,<br>trace gravel<br>Compact to Very Dense<br>Grey<br>Wet<br>(TILL)   |            | 10      | SS   | 14           |  |                 |   |  |  |  |                  |                                |                 |   |  |
|               |  |            |         |      |              |  |                 |   |  |  |  |                  |                                |                 |   |  |
|               |  |            | 11      | SS   | 50/<br>0.150 |  |                 |   |  |  |  |                  |                                |                 |   |  |
|               |  |            |         |      |              |  |                 |   |  |  |  |                  |                                |                 |   |  |
| 45.2          |  |            |         |      |              |  |                 |   |  |  |  |                  |                                |                 |   |  |
| 13.9          | <b>SHALE</b> , highly weathered, grey  |            | 12      | SS   | 100          |  |                 |   |  |  |  |                  |                                |                 |   |  |
|               |  |            |         |      |              |  |                 |   |  |  |  |                  |                                |                 |   |  |
| 44.5          |  |            |         |      |              |  |                 |   |  |  |  |                  |                                |                 |   |  |
| 14.6          | END OF BOREHOLE AT 14.6m<br>UPON AUGER REFUSAL.<br>BOREHOLE OPEN TO 14.6m AND<br>WATER LEVEL AT 4.2m UPON<br>COMPLETION.<br>BOREHOLE BACKFILLED WITH<br>BENTONITE HOLEPLUG FROM<br>14.6m TO 0.3m, CONCRETE FROM<br>0.3m TO 0.1m, THEN ASPHALT TO<br>SURFACE. |            |         |      |              |  |                 |   |  |  |  |                  |                                |                 |   |  |

ONTMT4S 1201A GPJ 5/9/12

Highway 417 Ottawa: Nicholas to Vanier  
GRAIN SIZE DISTRIBUTION

FIGURE A1



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

LEGEND

|        |          |           |           |
|--------|----------|-----------|-----------|
| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
| ●      | NSW-2    | 1.07      | 58.03     |

GRAIN SIZE DISTRIBUTION - THURBER 1201A.GPJ 5/9/12

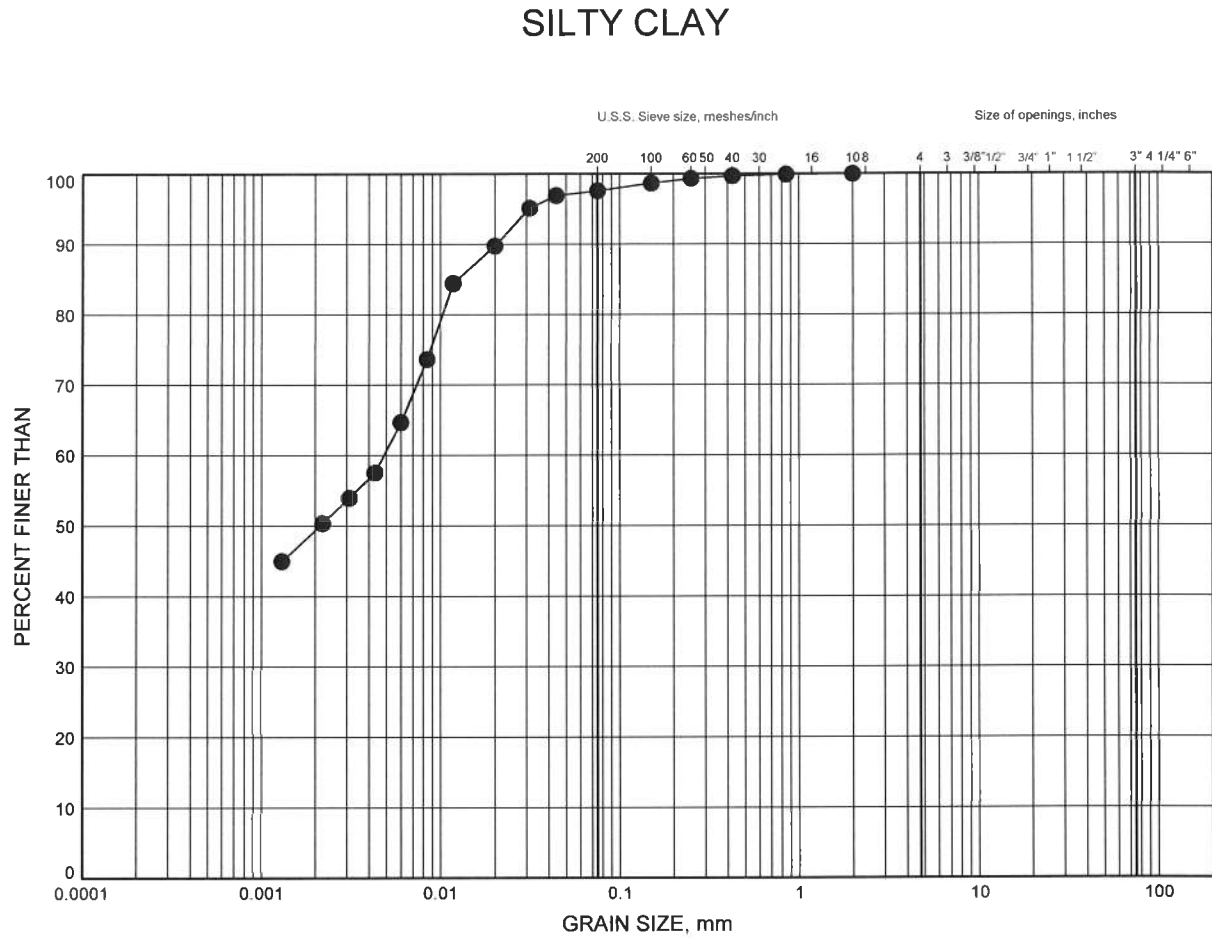
W.P.# 4091-07-00  
Prepared By AN  
Checked By LRB





# Highway 417 Ottawa: Nicholas to Vanier GRAIN SIZE DISTRIBUTION

FIGURE A2



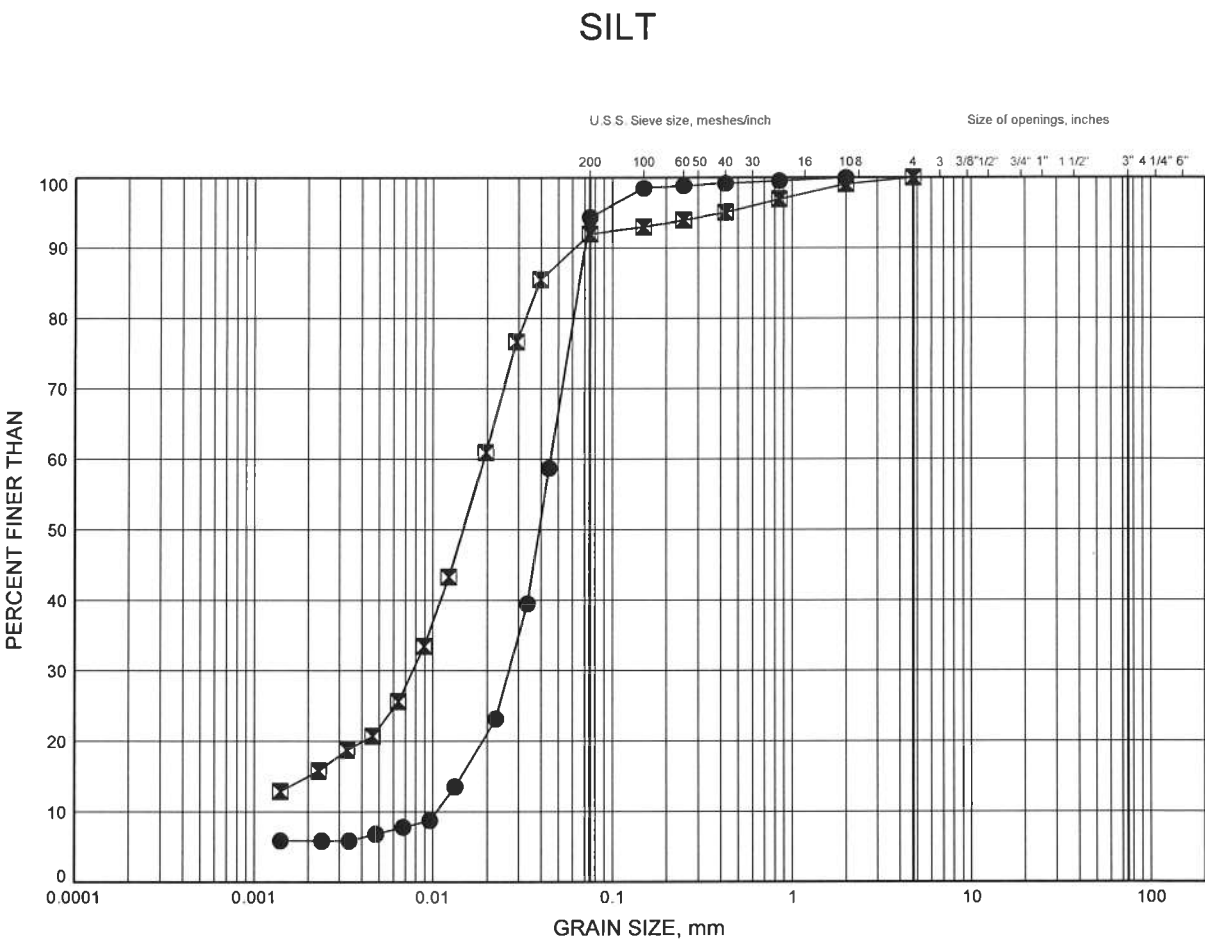
|               |      |        |        |        |        |             |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE   | COARSE | COBBLE SIZE |
| FINE GRAINED  | SAND |        |        | GRAVEL |        |             |

## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | NSW-1    | 4.88      | 54.22     |

Highway 417 Ottawa: Nicholas to Vanier  
GRAIN SIZE DISTRIBUTION

FIGURE A3



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

**LEGEND**

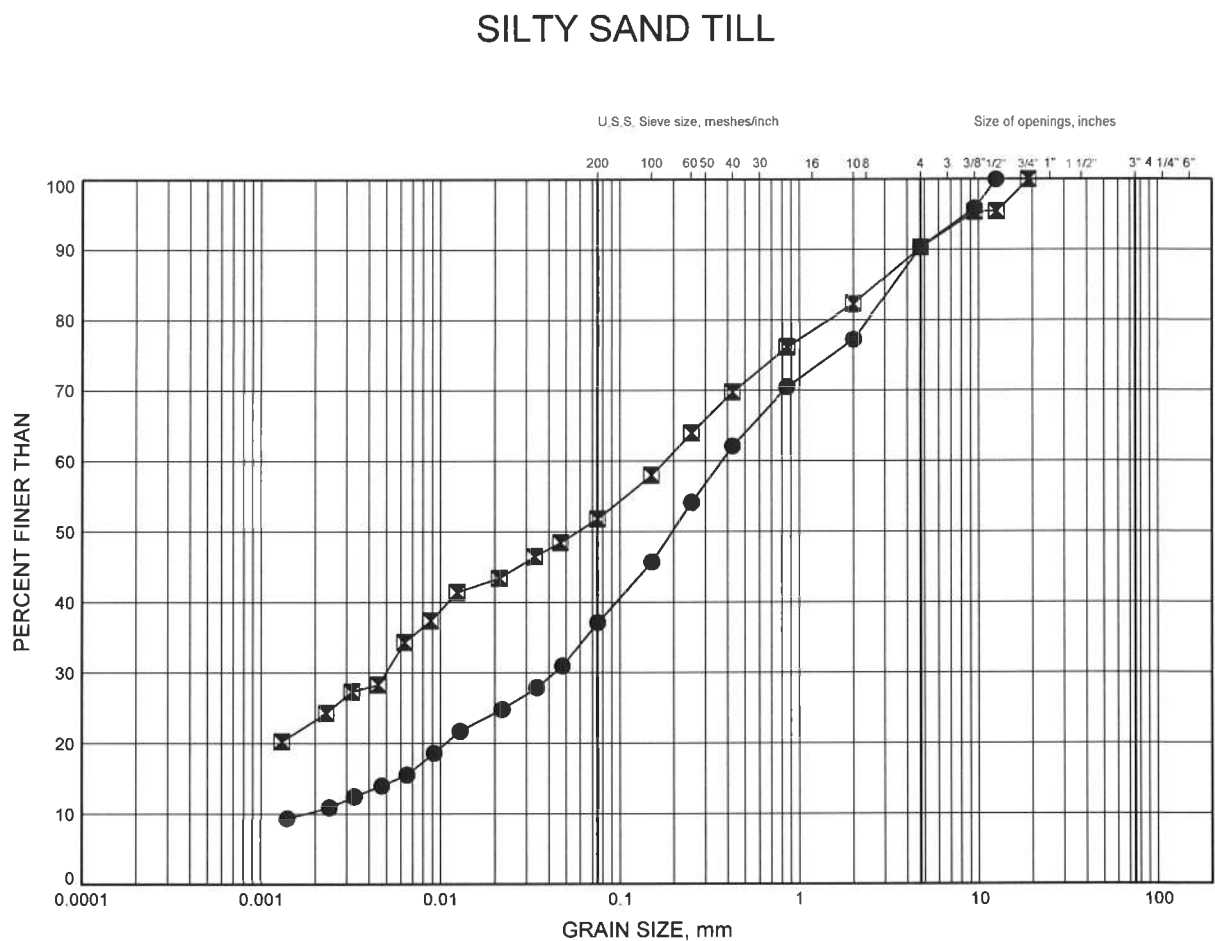
| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | NSW-1    | 7.92      | 51.18     |
| ■      | NSW-2    | 6.40      | 52.70     |



W.P.# 4091-07-00  
Prepared By AN  
Checked By LRB

Highway 417 Ottawa: Nicholas to Vanier  
GRAIN SIZE DISTRIBUTION

FIGURE A4



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

LEGEND

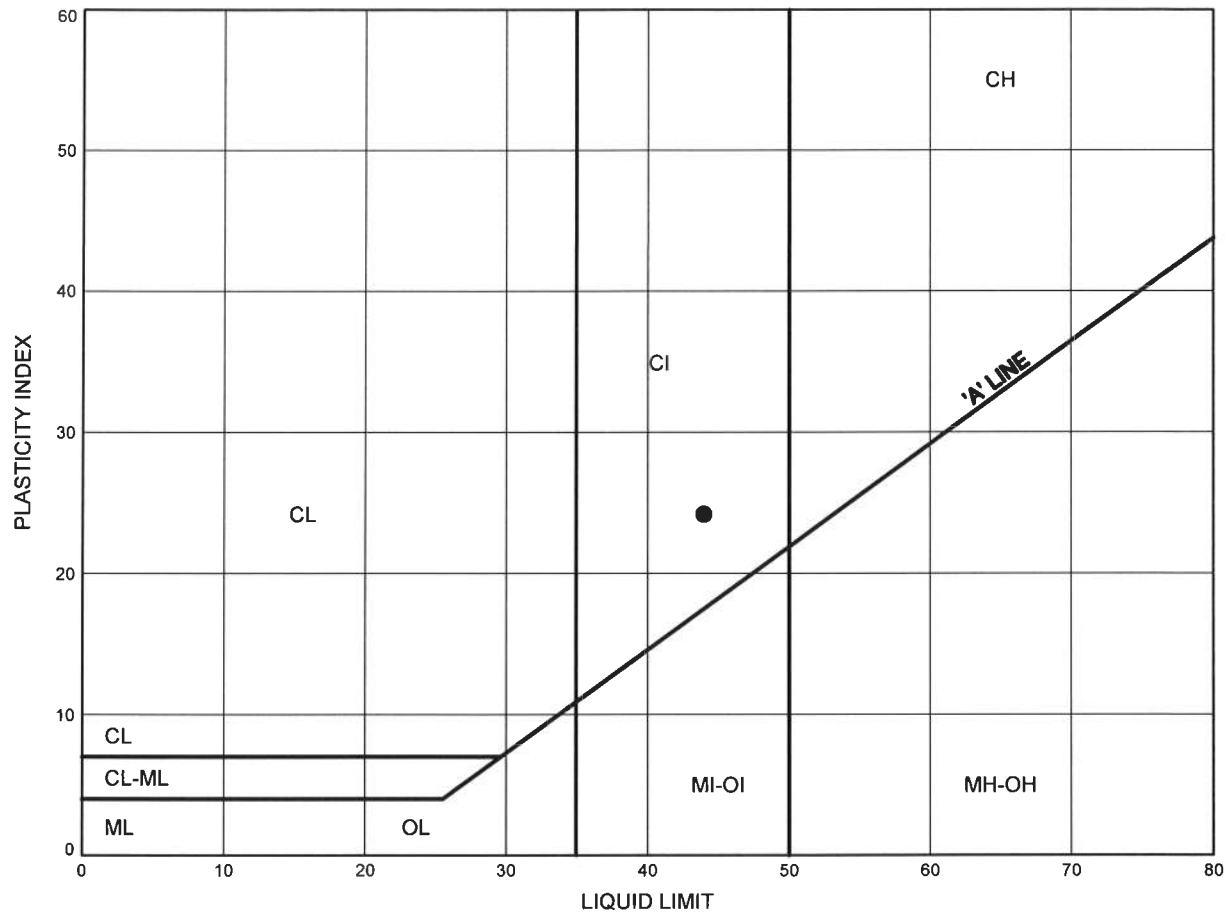
| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | NSW-1    | 10.97     | 48.13     |
| ■      | NSW-2    | 12.50     | 46.60     |



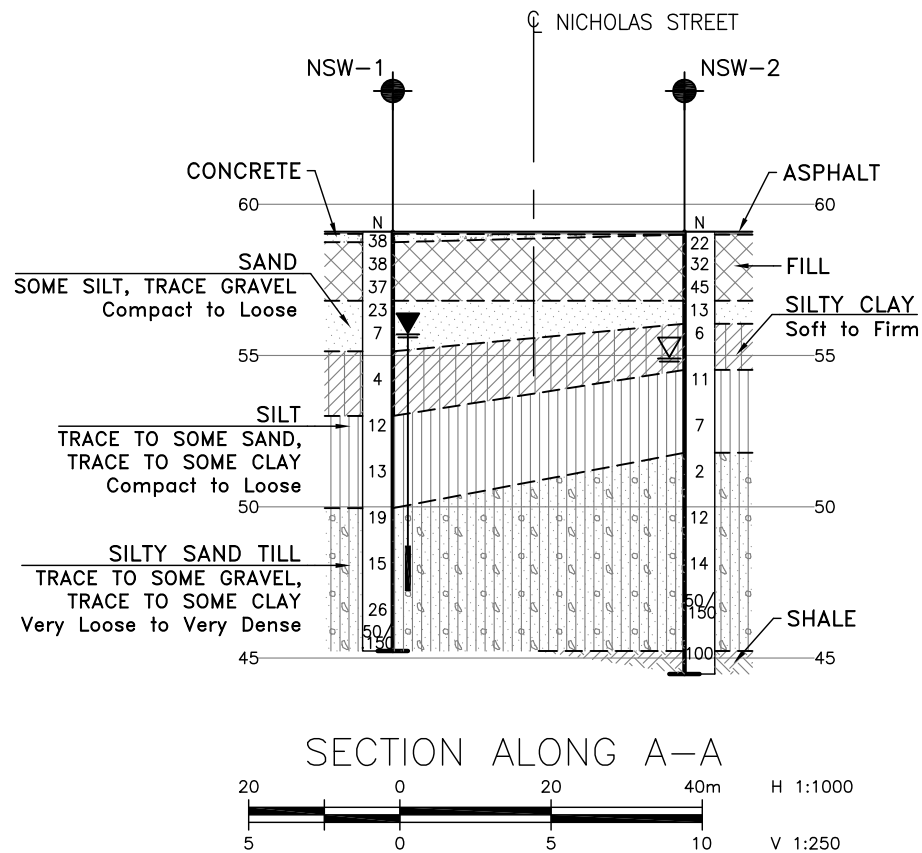
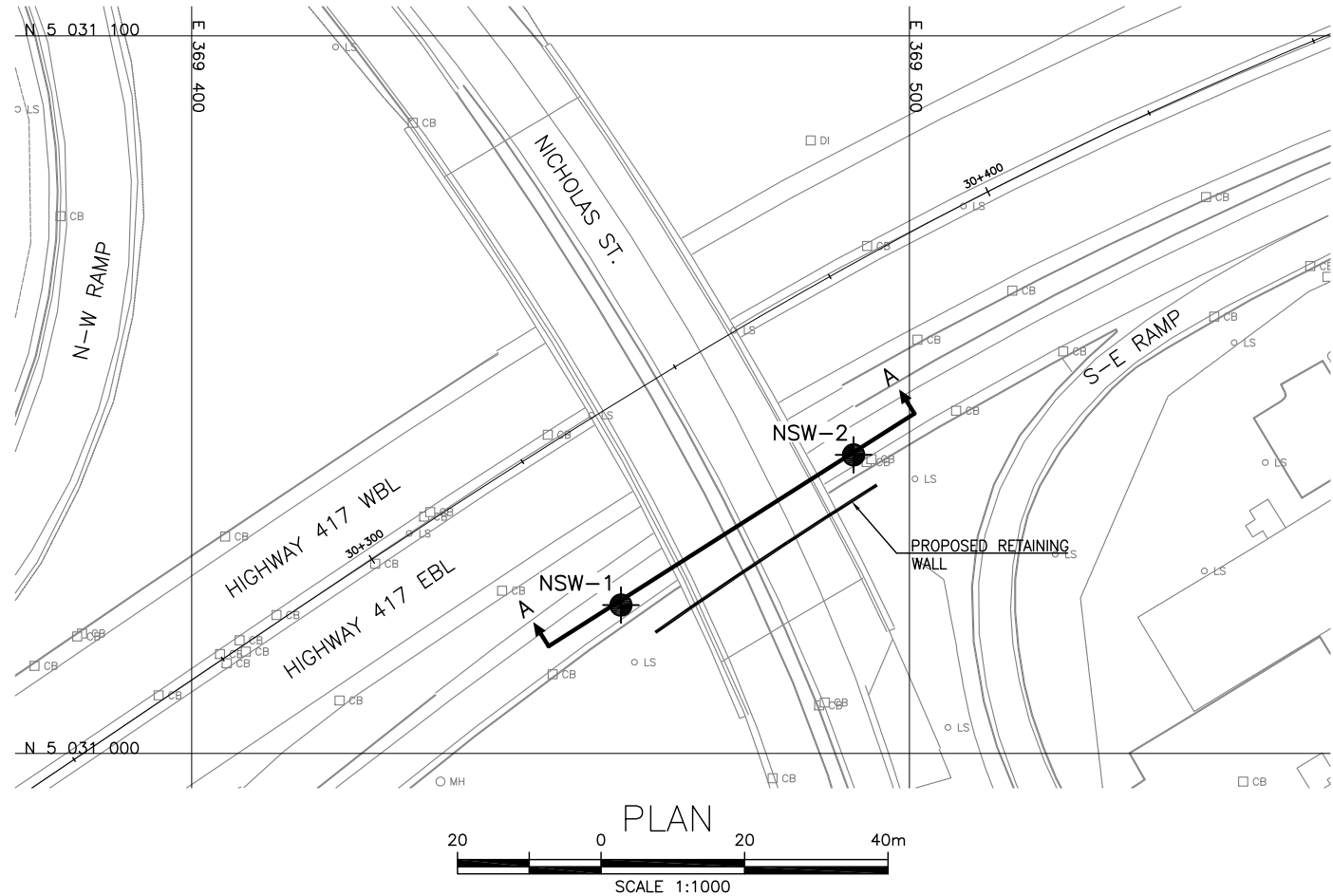
Highway 417 Ottawa: Nicholas to Vanier  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE A5

**SILTY CLAY**



| SYMBOL | BH    | DEPTH (m) | ELEV. (m) |
|--------|-------|-----------|-----------|
| ●      | NSW-1 | 4.88      | 54.22     |



**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No  
WP No 4091-07-00

HIGHWAY 417  
NICHOLAS STREET (SOUTH)  
BOREHOLE LOCATION PLAN & SOIL STRATA



KEYPLAN

LEGEND

|      |                                       |
|------|---------------------------------------|
|      | Borehole                              |
|      | Borehole and Cone                     |
| N    | Blows /0.3m (Std Pen Test, 475J/blow) |
| CONE | Blows /0.3m (60' Cone, 475J/blow)     |
| PH   | Pressure, Hydraulic                   |
|      | Water Level                           |
|      | Head Artesian Water                   |
|      | Piezometer                            |
| 90%  | Rock Quality Designation (RQD)        |
| A/R  | Auger Refusal                         |

| NO    | ELEVATION | NORTHING    | EASTING   |
|-------|-----------|-------------|-----------|
| NSW-1 | 59.1      | 5 031 020.7 | 369 459.8 |
| NSW-2 | 59.1      | 5 031 041.6 | 369 492.2 |

-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 31G5-250

| REVISIONS | DATE | BY        | DESCRIPTION |
|-----------|------|-----------|-------------|
| DESIGN    | LRB  | CHK       | LRB         |
| DRAWN     | AN   | CHK       | SITE        |
| LOAD      | DATE | AUG. 2012 |             |
| STRUCT    | DWG  | 1         |             |

## **Appendix B**

### **Lees Avenue S-E Ramp**

#### **Boreholes LSER-01 to LSER-04**

# RECORD OF BOREHOLE No LSER-01

1 OF 2

METRIC

W.P. 4091-07-00 LOCATION N 5 030 931.3 E 369 549.9 ORIGINATED BY RK  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.11.26 - 2011.11.26 CHECKED BY LRB

| 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><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 (%)                                      |  |  |   |   |
| 59.0          |   |            |         |      |              |                            |                 | 20 40 60 80 100                             |  |  |  |  |   |   |
| 0.0           | ASPHALT: (90mm)   |            |         |      |              |                            |                 |   |  |  |  |  |   |   |
| 0.1           |   |            |         |      |              |                            |                 |   |  |  |  |  |   |   |
| 58.7          | CONCRETE, with rebar  |            |         |      |              |                            |                 |   |  |  |  |  |   |   |
| 0.3           | SAND, trace to some gravel, trace silt<br>Very Dense<br>Brown<br>Moist<br>(FILL)      |            | 1       | SS   | 88           |                            |                 |   |  |  |  |  |   |   |
|               |   |            | 2       | SS   | 58/<br>0.075 |                            |                 |   |  |  |  |  |   |   |
|               | Grey  |            | 3       | SS   | 53/<br>0.100 |                            |                 |   |  |  |  |  |   |   |
| 55.6          |   |            | 4       | SS   | 13           |                            |                 |   |  |  |  |  |   |   |
| 3.4           | Silty CLAY, trace sand<br>Soft<br>Grey  |            | 5       | SS   | 2            |                            |                 |   |  |  |  |  |   |   |
|               |   |            | 6       | SS   | 2            |                            |                 |   |  |  |  |  |   |   |
| 51.4          |   |            | 7       | SS   | 9            |                            |                 |   |  |  |  |  |   |   |
| 7.6           | SILT, some clay, trace sand<br>Loose<br>Grey<br>Wet                                   |            |         |      |              |                            |                 |   |  |  |  |  |   |   |
| 50.3          |   |            | 8       | SS   | 26           |                            |                 |   |  |  |  |  |   |   |
| 8.7           | SILT and SAND, some clay, some<br>gravel<br>Compact<br>Grey<br>Moist to Wet<br>(TILL) |            |         |      |              |                            |                 |   |  |  |  |  |   |   |

Continued Next Page

+ 3 x 3 : Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No LSER-01

2 OF 2

METRIC

W.P. 4091-07-00 LOCATION N 5 030 931.3 E 369 549.9 ORIGINATED BY RK  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.11.26 - 2011.11.26 CHECKED BY LRB

| 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 |                            |                 | 20  | 40 | 60 | 80 | 100 |                                    |                                     |                                   |  |  |
|               | Continued From Previous Page   |            |         |      |            |                            |                 |   |    |    |    |     |                                    |                                     |                                   |  |  |
| 47.6          | Shale fragments  |            | 9       | SS   | 10         |                            |                 |   |    |    |    |     |                                    |                                     |                                   |  |  |
| 11.4          | END OF BOREHOLE AT 11.4m<br>UPON AUGER REFUSAL ON<br>PROBABLE BEDROCK.<br>Piezometer installation consists of<br>19mm diameter Schedule 40 PVC pipe<br>with a 3.0m slotted screen.<br><br>WATER LEVEL READINGS:<br>DATE      DEPTH (m)      ELEV (m)<br><br>Flushmount casing could not be<br>opened |            |         |      |            |                            |                 |   |    |    |    |     |                                    |                                     |                                   |  |  |



# RECORD OF BOREHOLE No LSER-02

1 OF 2

METRIC

W.P. 4091-07-00 LOCATION N 5 030 952.8 E 369 538.3 ORIGINATED BY ES  
HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2012.03.06 - 2012.03.06 CHECKED BY LRB

| SOIL PROFILE  |   |            | SAMPLES |      |               | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |   | PLASTIC LIMIT<br>NATURAL MOISTURE<br>CONTENT<br>LIQUID LIMIT |  |  | UNIT<br>WEIGHT<br><br>γ<br><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 (%)  |  |  |  |   |
| 59.3          |   |            |         |      |               |                            | 20 40 60 80 100 | ○ UNCONFINED + FIELD VANE                   | ○ | 20 40 60   |  |  |  |   |
| 0.0           | ASPHALT: (100mm)  |            |         |      |               |                            | 20 40 60 80 100 | ● QUICK TRIAXIAL × LAB VANE                 |   |  |  |  |  |   |
| 59.0          | CONCRETE: (200mm)   |            |         |      |               |                            |                 |   |   |  |  |  |  |   |
| 0.3           | SAND, some gravel, some silt and clay<br>Dense to Very Dense<br>Brown<br>Damp<br>(FILL) |            | 1       | GS   |               |                            |                 |   |   |  |  |  |  |   |
|               |   |            | 1       | SS   | 48            |                            |                 |   |   |  |  |  |  |   |
|               | Gravelly, occasional cobble   |            | 2       | SS   | 79            |                            |                 |   |   |  |  |  |  | 29 58 13<br>(SI+CL)                               |
|               | No recovery   |            | 3       | SS   | 100/<br>0.100 |                            |                 |   |   |  |  |  |  |   |
| 55.9          |   |            | 4       | SS   | 33            |                            |                 |   |   |  |  |  |  |   |
| 3.5           | Silty CLAY, trace sand<br>Soft to Firm<br>Grey  |            |         |      |               |                            |                 |   |   |  |  |  |  |   |
|               |   |            | 5       | SS   | 3             |                            |                 |   |   |  |  |  |  |   |
|               |   |            |         |      |               |                            |                 |   |   |  |  |  |  |   |
|               |   |            | 6       | SS   | 6             |                            |                 |   |   |  |  |  |  | 0 4 72 24   |
|               |   |            |         |      |               |                            |                 |   |   |  |  |  |  |   |
| 51.6          |   |            |         |      |               |                            |                 |   |   |  |  |  |  |   |
| 7.7           | SILT, trace clay, trace sand<br>Compact<br>Grey<br>Wet                                  |            | 7       | SS   | 26            |                            |                 |   |   |  |  |  |  |   |
|               |   |            |         |      |               |                            |                 |   |   |  |  |  |  |   |
| 50.0          |   |            |         |      |               |                            |                 |   |   |  |  |  |  |   |
| 9.4           | Sandy SILT, some clay, trace gravel<br>Compact<br>Dark Grey                             |            | 8       | SS   | 18            |                            |                 |   |   |  |  |  |  |   |
|               |   |            |         |      |               |                            |                 |   |   |  |  |  |  |   |

Continued Next Page


+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No LSER-02

2 OF 2

METRIC

W.P. 4091-07-00 LOCATION N 5 030 952.8 E 369 538.3 ORIGINATED BY ES  
HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2012.03.06 - 2012.03.06 CHECKED BY LRB

| SOIL PROFILE  |   |   | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT                                    |    |    |    |     | UNIT<br>WEIGHT<br><br>γ<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<br>○ UNCONFINED + FIELD VANE<br>● QUICK TRIAXIAL × LAB VANE |    |    |    |     |  |  | PLASTIC LIMIT<br>NATURAL MOISTURE<br>CONTENT<br>LIQUID LIMIT<br><br>w <sub>p</sub> w w <sub>L</sub><br>WATER CONTENT (%) |   |  |
|               | Continued From Previous Page  |   |         |      |            |                            |                 | 20   | 40 | 60 | 80 | 100 | 20   | 40   | 60   |   |  |
| 48.1          | Sandy SILT, some clay, trace gravel<br>Compact<br>Dark Grey<br>Moist<br>(TILL)  |  | 9       | SS   | 35         |                            | 49              |  |    |    |    |     |  |  |  | ○ |  |
| 11.3          | END OF BOREHOLE AT 11.3m.<br>WATER LEVEL AT 4.1m UPON<br>COMPLETION.<br>BOREHOLE BACKFILLED WITH<br>BENTONITE HOLEPLUG TO 1.2m,<br>CUTTINGS TO 0.1m THEN ASPHALT<br>TO SURFACE. |   |         |      |            |                            |                 |  |    |    |    |     |  |  |  |   |  |

RECORD OF BOREHOLE No LSER-03

1 OF 2

METRIC

W.P. 4091-07-00 LOCATION N 5 030 976 4 E 369 525 6 ORIGINATED BY ES  
HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2012.03.06 - 2012.03.06 CHECKED BY LRB

| SOIL PROFILE  |   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |                 |                 | 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 |                            |                 | 20 40 60 80 100                             | 20 40 60 80 100 | 20 40 60 80 100 |   |   |
| 59.7          |   |            |         |      |            |                            |                 |   |                 |                 |   |   |
| 0.0           | ASPHALT: (100mm)  |            |         |      |            |                            |                 |   |                 |                 |   |   |
| 59.4          | CONCRETE: (200mm)   |            |         |      |            |                            |                 |   |                 |                 |   |   |
| 0.3           | SAND, some gravel, some silt and clay<br>Very Dense<br>Brown<br>Damp to Moist<br>(FILL) |            | 1       | GS   |            |                            | 59              |   |                 |                 |   |   |
|               |   |            | 1       | SS   | 59         |                            |                 |   |                 |                 |   |   |
|               |   |            | 2       | SS   | 55         |                            | 58              |   |                 |                 |   |   |
|               | Faint odour<br>Occasional cobbles, occasional<br>asphalt fragments                      |            | 3       | SS   | 106        |                            | 57              |   |                 |                 |   |   |
|               | Compact<br>Dark Grey  |            | 4       | SS   | 22         |                            | 56              |   |                 |                 |   |   |
| 55.6          |   |            |         |      |            |                            |                 |   |                 |                 |   |   |
| 4.1           | Silty CLAY, trace sand<br>Soft<br>Grey  |            | 5       | SS   | 3          |                            | 55              |   |                 |                 |   |   |
|               |   |            |         |      |            |                            | 54              |   |                 |                 |   |   |
| 53.3          |   |            | 6       | SS   | 3          |                            |                 |   |                 |                 |   |   |
| 6.4           | SILT, some clay, trace sand<br>Loose<br>Grey<br>Wet                                     |            |         |      |            |                            | 53              |   |                 |                 |   |   |
|               |   |            | 7       | SS   | 6          |                            | 52              |   |                 |                 |   |   |
|               |   |            |         |      |            |                            | 51              |   |                 |                 |   |   |
| 50.3          |   |            |         |      |            |                            |                 |   |                 |                 |   |   |
| 9.4           | Sandy SILT, some clay, trace gravel<br>Compact<br>Grey to Dark Brown                    |            | 8       | SS   | 14         |                            | 50              |   |                 |                 |   |   |

ONTMT4S 1201A GPJ 5/14/12

Continued Next Page

+<sup>3</sup> ×<sup>3</sup> Numbers refer to  
Sensitivity 20  
15 10 5 0  
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No LSER-03

2 OF 2

METRIC

W.P. 4091-07-00 LOCATION N 5 030 976.4 E 369 525.6 ORIGINATED BY ES  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2012.03.06 - 2012.03.06 CHECKED BY LRB

| SOIL PROFILE  |   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |                 | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT |          |  | 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 |                            |                 | 20 40 60 80 100                             | 20 40 60 80 100 | W <sub>P</sub> W W <sub>L</sub>                     | 20 40 60 |  |   |  |
| 48.4          | Continued From Previous Page<br>Sandy SILT, some clay, trace gravel<br>Compact<br>Grey to Dark Brown<br>Wet<br>(TILL)   |            | 9       | SS   | 18         |                            | 49              |   |                 |   |          |  |   |  |
| 11.3          | END OF BOREHOLE AT 11.3m.<br>Piezometer installation consists of<br>19mm diameter Schedule 40 PVC pipe<br>with a 1.52m slotted screen.<br><br>WATER LEVEL READINGS:<br>DATE DEPTH (m) ELEV. (m)<br>Mar.27/12 4.8 54.9 |            |         |      |            |                            |                 |   |                 |   |          |  |   |  |

## METRIC

[illegible]

+ 3, x 3: Numbers refer to Sensitivity

RECORD OF BOREHOLE No LSER-04

2 OF 2

METRIC

W.P. 4091-07-00 LOCATION N 5 030 996 6 E 369 515 8 ORIGINATED BY ES  
HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2012.03.07 - 2012.03.07 CHECKED BY LRB

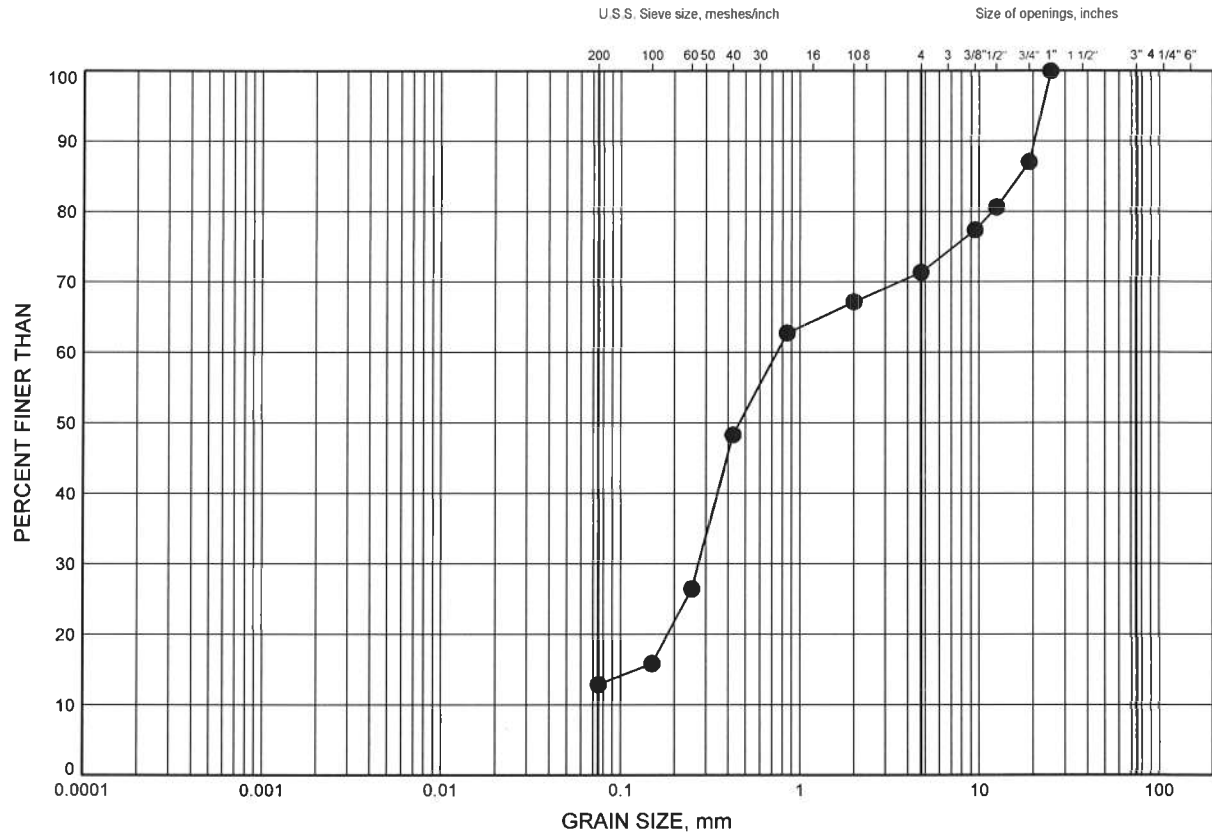
| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |  |  |  | PLASTIC<br>LIMIT<br>W <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>W | LIQUID<br>LIMIT<br>W <sub>L</sub> | UNIT<br>WEIGHT<br>γ<br>kN/m <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                          |  |  |  |  |                                    |                                     |                                   |  |  |
|               | Continued From Previous Page   |            | 9       | SS   | 15         |                            | 49              |   |  |  |  |  |                                    |                                     |                                   |  |  |
| 48.1          |  |            |         |      |            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |  |  |
| 11.8          | <p>END OF BOREHOLE AT 11.8m<br/>UPON AUGER REFUSAL ON<br/>PROBABLE BEDROCK.<br/>Piezometer installation consists of<br/>19mm diameter Schedule 40 PVC pipe<br/>with a 1.52m slotted screen.</p> <p>WATER LEVEL READINGS:<br/>DATE DEPTH (m) ELEV. (m)<br/>Mar.27/12 4.4 55.5</p> |            |         |      |            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |  |  |

ONTMT4S 1201A.GPJ 5/14/12

Highway 417 Ottawa: Nicholas to Vanier  
**GRAIN SIZE DISTRIBUTION**

**FIGURE B1**

**Gravelly Sand Fill**



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

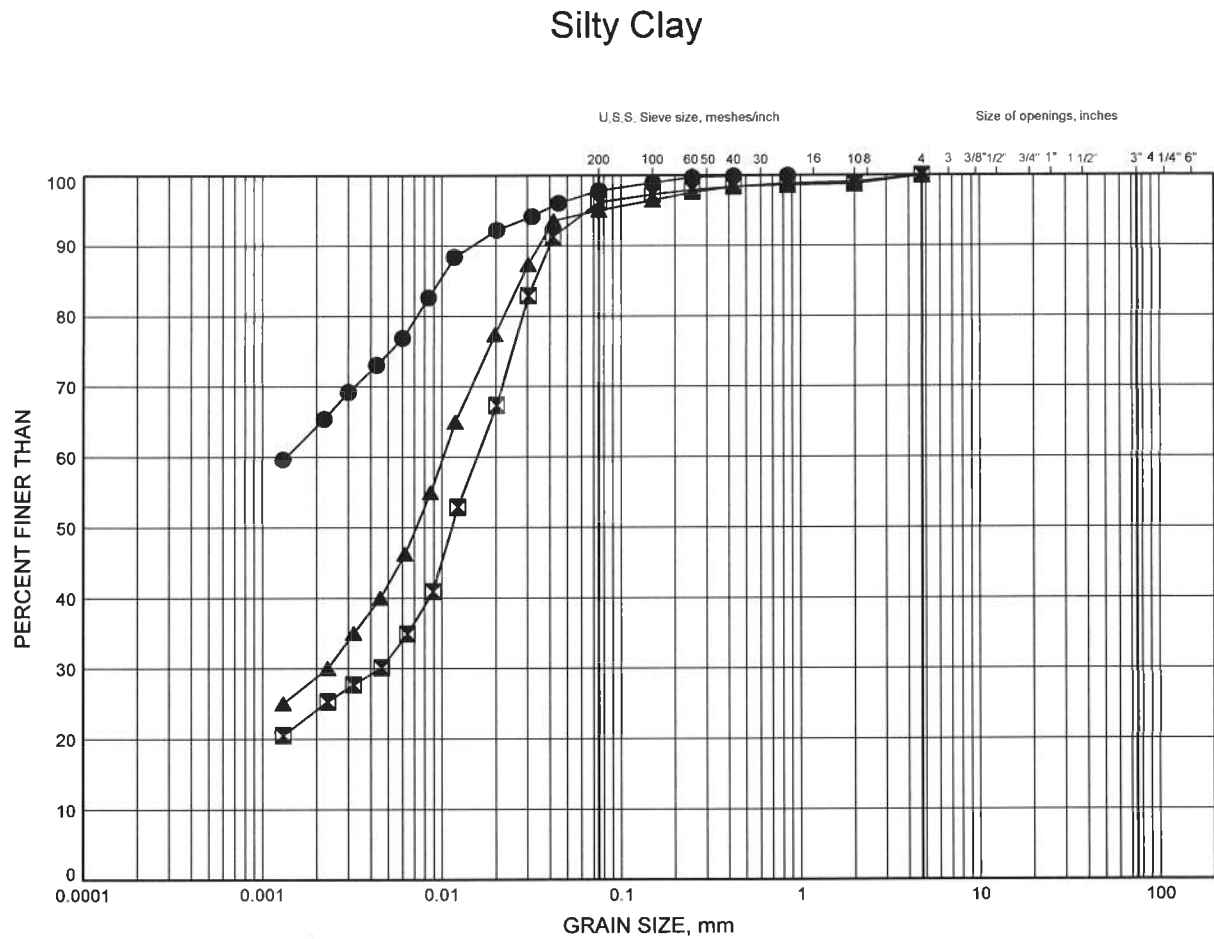
**LEGEND**

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | LSER-02  | 1.75      | 57.59     |

# Highway 417 Ottawa: Nicholas to Vanier

## GRAIN SIZE DISTRIBUTION

FIGURE B2



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

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | LSER-01  | 4.88      | 54.12     |
| ⊠      | LSER-02  | 6.40      | 52.94     |
| ▲      | LSER-04  | 4.88      | 55.05     |

Date May 2012  
W.P.# 4091-07-00



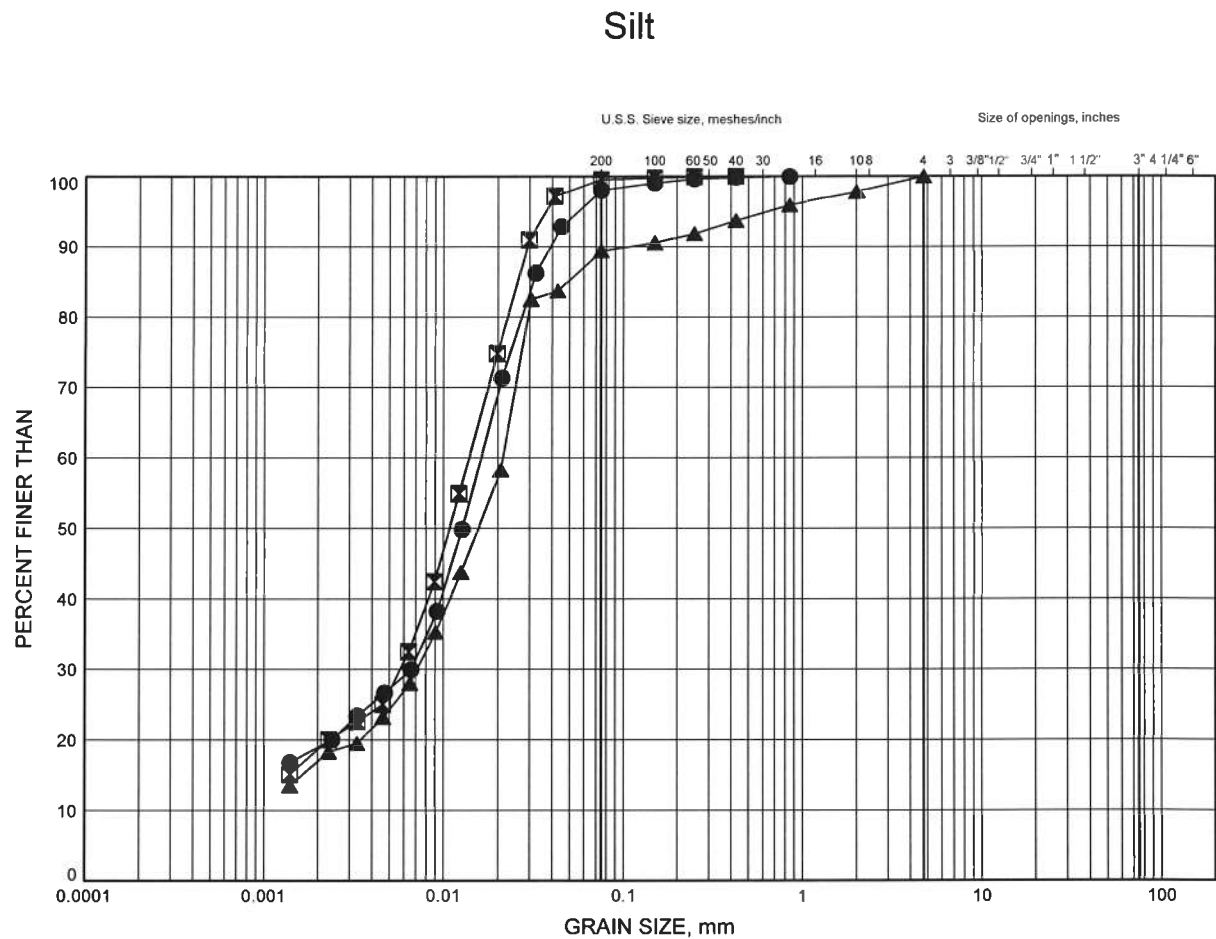
Prep'd MFA  
Chkd. LRB



# Highway 417 Ottawa: Nicholas to Vanier

## GRAIN SIZE DISTRIBUTION

FIGURE B3



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

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | LSER-01  | 7.92      | 51.08     |
| ■      | LSER-03  | 6.40      | 53.31     |
| ▲      | LSER-04  | 6.40      | 53.53     |

Date May 2012  
W.P.# 4091-07-00



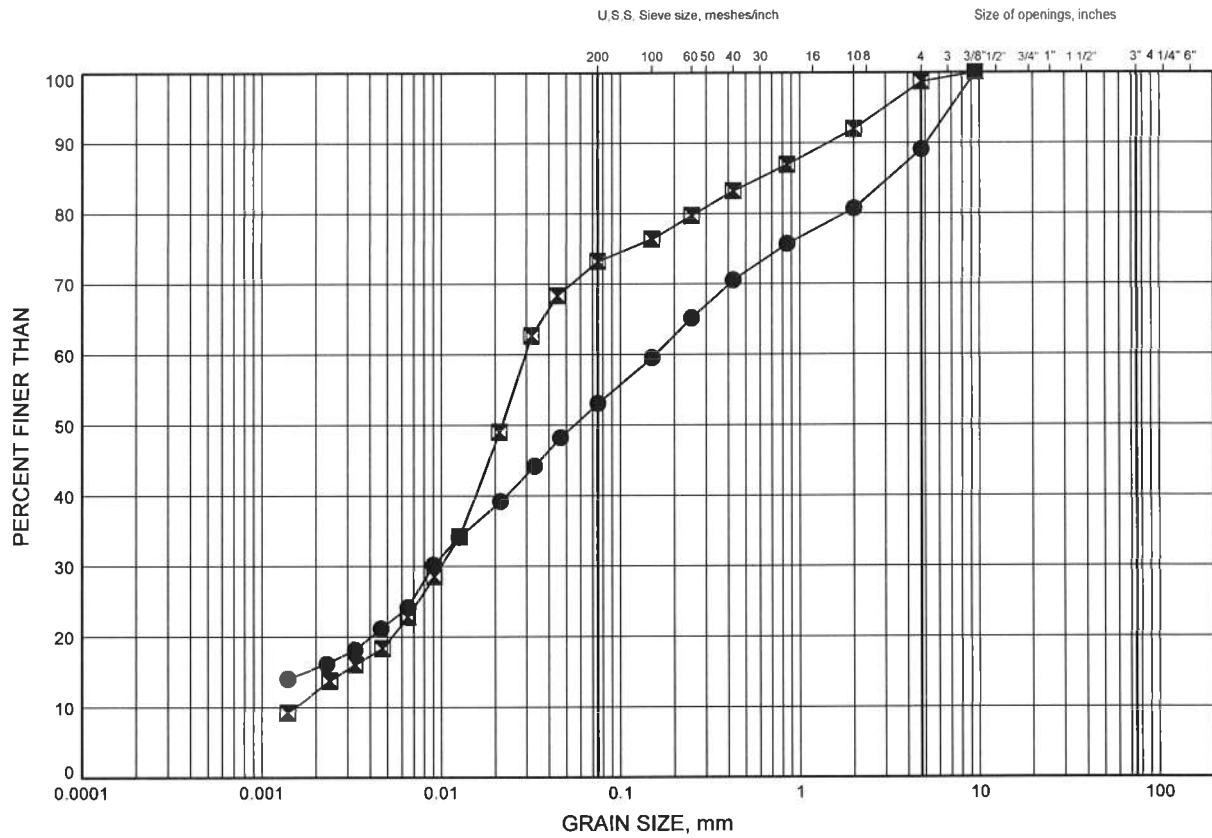
Prep'd MFA  
Chkd. LRB

# Highway 417 Ottawa: Nicholas to Vanier

## GRAIN SIZE DISTRIBUTION

FIGURE B4

### Sandy Silt to Silty Sand Till



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

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | LSER-01  | 9.45      | 49.55     |
| ⊠      | LSER-03  | 9.45      | 50.27     |

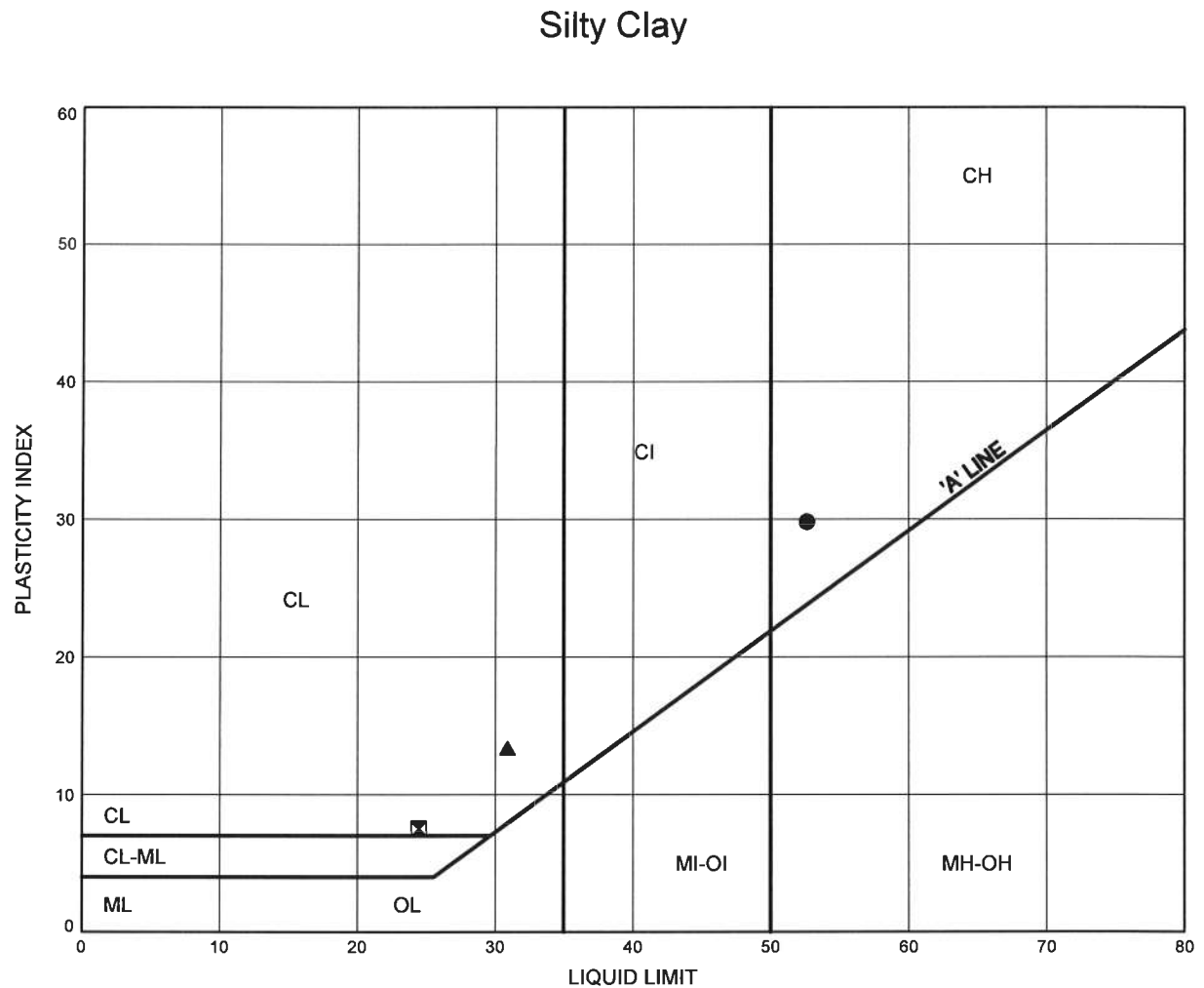
Date May 2012  
W.P.# 4091-07-00



Prep'd MFA  
Chkd. LRB

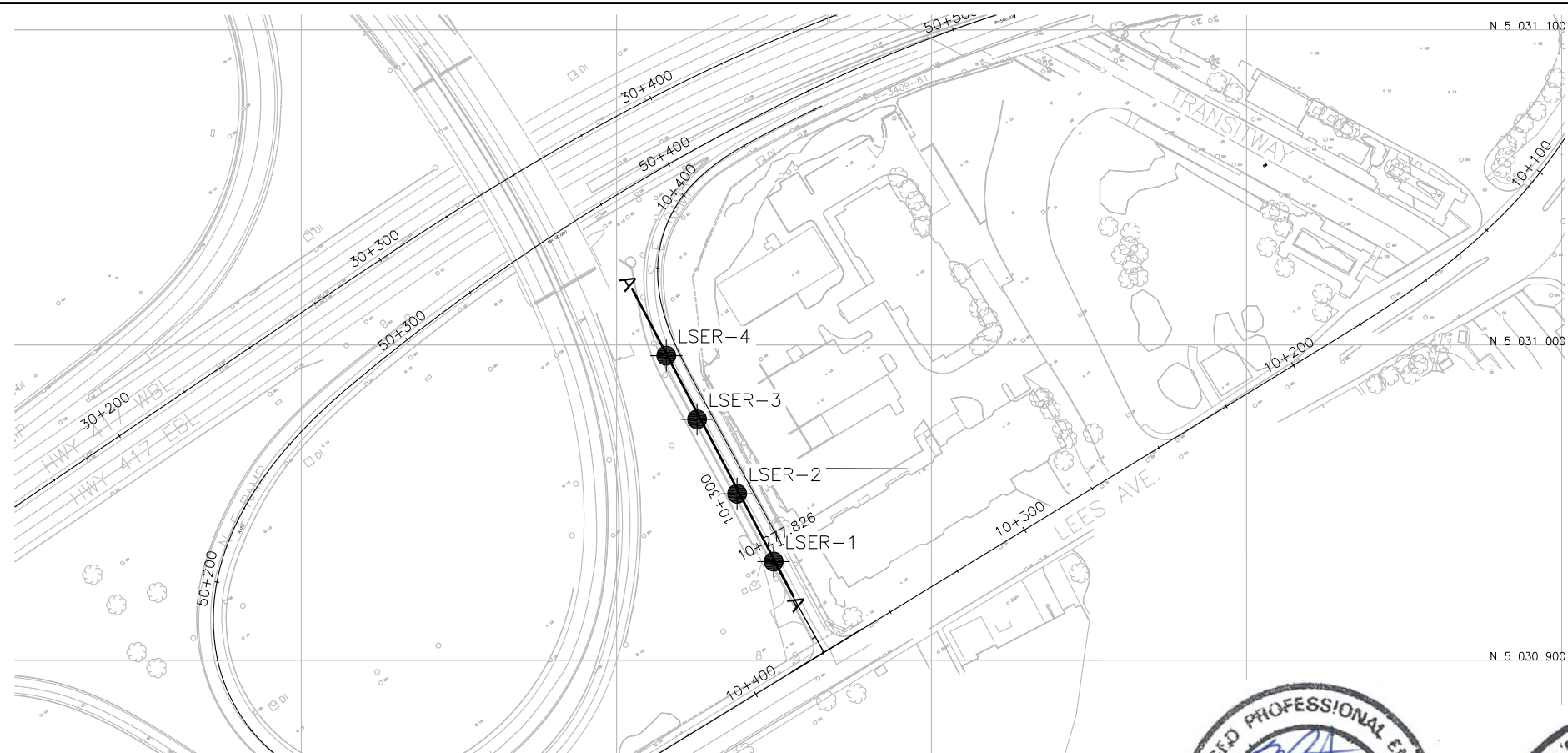
Highway 417 Ottawa: Nicholas to Vanier  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B5



**LEGEND**

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | LSER-01  | 4.88      | 54.12     |
| ⊠      | LSER-02  | 6.40      | 52.94     |
| ▲      | LSER-04  | 4.88      | 55.05     |



**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

|         |
|---------|
| CONT No |
| WP No   |

HIGHWAY 417  
LEES AVENUE S-E RAMP  
BOREHOLE LOCATIONS & SOIL STRATA








**THURBER** ENGINEERING LTD



## KEYPLAN

## LEGEND

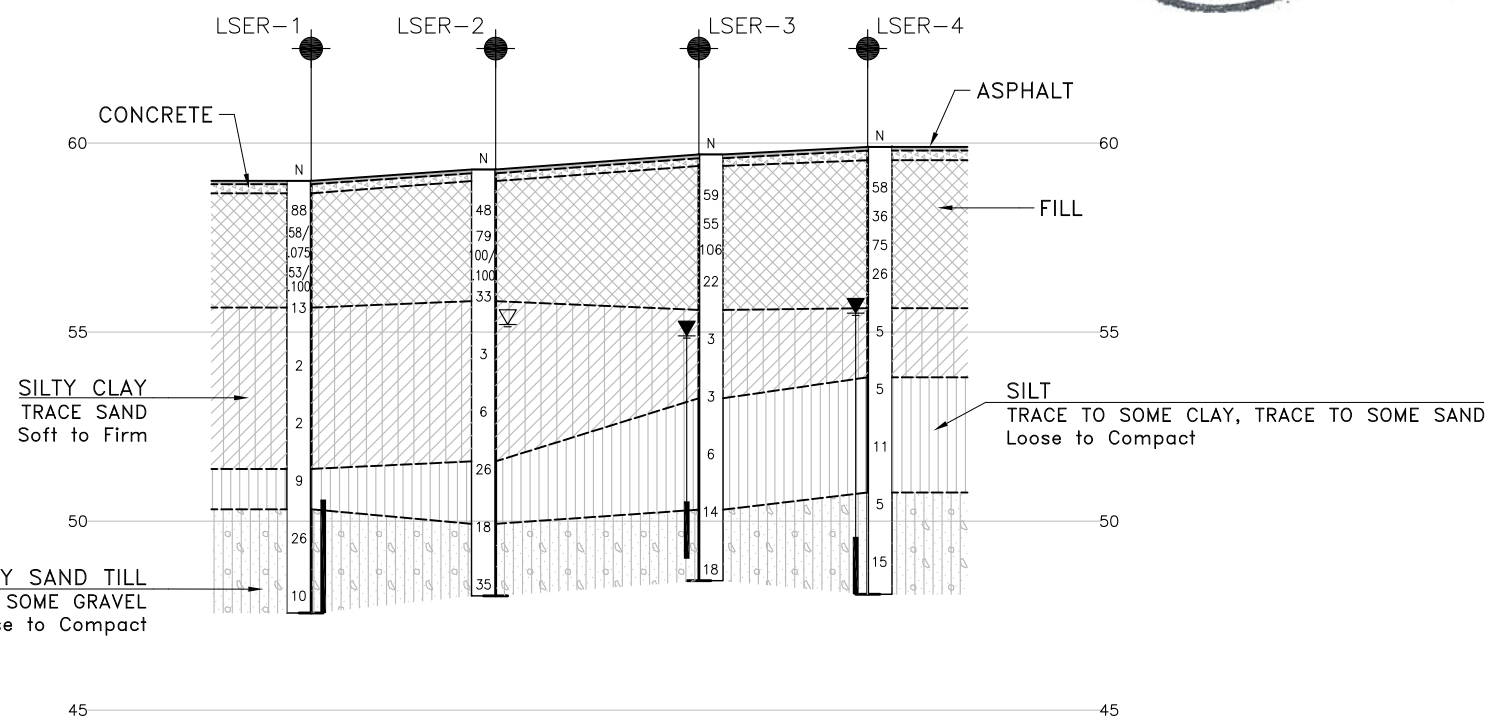
|   |                                       |
|---|---------------------------------------|
|  | Borehole                              |
|  | Borehole and Cone                     |
| N   | Blows /0.3m (Std Pen Test, 475J/blow) |
| CONE  | Blows /0.3m (60° Cone, 475J/blow)     |
| PH  | Pressure, Hydraulic                   |
|  | Water Level                           |
|  | Head Artesian Water                   |
|  | Piezometer                            |
| 90%   | Rock Quality Designation (RQD)        |
| A/R   | Auger Refusal                         |

[illegible]

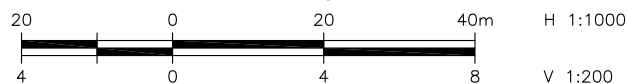
-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

**GEOCRES No. 31G5-250**



### PROFILE ALONG A-A



|           |        |     |     |      |  |        |             |      |           |
|-----------|--------|-----|-----|------|--|--------|-------------|------|-----------|
| REVISIONS |        |     |     |      |  |        |             |      |           |
|           |        |     |     |      |  |        |             |      |           |
|           |        |     |     |      |  |        |             |      |           |
|           |        |     |     |      |  |        |             |      |           |
|           |        |     |     |      |  |        |             |      |           |
|           | DATE   | BY  |     |      |  |        | DESCRIPTION |      |           |
| DESIGN    | LRB    | CHK | MRA | CODE |  | LOAD   |             | DATE | AUG. 2012 |
| DRAWN     | MFA/AN | CHK | PKC | SITE |  | STRUCT |             | DWG  | 1         |

## **Appendix C**

**Lees Avenue (North) at Robinson Avenue**

**Boreholes LE-08 and LE-09**

# RECORD OF BOREHOLE No LE-08

1 OF 2

METRIC

W.P. 4091-07-00 LOCATION N 5 031 173 5 E 369 820 5 Lees Avenue ORIGINATED BY RK/ES  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2012.03.12 - 2012.03.22 CHECKED BY LRB

| SOIL PROFILE  |   |            | SAMPLES |      |               | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |                  | UNIT<br>WEIGHT<br><br>γ<br><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                          |  |                  |  |   |                    |
| 60.7          |   |            |         |      |               |                            |                 | 20 40 60 80 100                             |  | PLASTIC<br>LIMIT | NATURAL<br>MOISTURE<br>CONTENT                   | LIQUID<br>LIMIT                                   |                    |
| 0.0           | ASPHALT: (100mm)  |            |         |      |               |                            |                 |   |  | w <sub>p</sub>   | w  | w <sub>L</sub>                                    |                    |
| 0.1           | SAND, medium grained  |            |         |      |               |                            |                 |   |  |                  |  |   |                    |
| 60.2          | Brown   |            |         |      |               |                            |                 |   |  |                  |  |   |                    |
| 0.5           | Moist<br>(FILL)   |            |         |      |               |                            |                 |   |  |                  |  |   |                    |
|               | SAND and GRAVEL, some silt  |            | 1       | SS   | 87/<br>0.275  |                            |                 |   |  |                  |  |   |                    |
|               | Very Dense to Dense   |            |         |      |               |                            |                 |   |  |                  |  |   |                    |
|               | Dark Brown  |            |         |      |               |                            |                 |   |  |                  |  |   |                    |
|               | Moist<br>(FILL)   |            | 2       | SS   | 30            |                            |                 |   |  |                  |  |   |                    |
| 58.5          |   |            |         |      |               |                            |                 |   |  |                  |  |   |                    |
| 2.2           | SAND, some gravel to gravelly, some<br>silt to silty, occasional cobble |            | 3       | SS   | 51            |                            |                 |   |  |                  |  |   | 16 54 23 7         |
|               | Very Dense  |            |         |      |               |                            |                 |   |  |                  |  |   |                    |
|               | Dark Brown  |            | 4       | SS   | 51            |                            |                 |   |  |                  |  |   |                    |
|               | Moist   |            |         |      |               |                            |                 |   |  |                  |  |   |                    |
| 56.0          |   |            |         |      |               |                            |                 |   |  |                  |  |   |                    |
| 4.7           | SAND, fine to medium grained, trace<br>gravel, trace silt, trace clay   |            | 5       | SS   | 80            |                            |                 |   |  |                  |  |   |                    |
|               | Very Dense to Compact   |            |         |      |               |                            |                 |   |  |                  |  |   |                    |
|               | Brown   |            |         |      |               |                            |                 |   |  |                  |  |   |                    |
|               | Damp to Moist   |            |         |      |               |                            |                 |   |  |                  |  |   |                    |
|               |   |            |         |      |               |                            |                 |   |  |                  |  |   |                    |
|               | Grey  |            | 6       | SS   | 75            |                            |                 |   |  |                  |  |   |                    |
|               | Wet   |            |         |      |               |                            |                 |   |  |                  |  |   |                    |
|               |   |            |         |      |               |                            |                 |   |  |                  |  |   |                    |
|               |   |            |         |      |               |                            |                 |   |  |                  |  |   |                    |
|               |   |            | 7       | SS   | 25            |                            |                 |   |  |                  |  |   | 0 90 10<br>(SI+CL) |
|               |   |            |         |      |               |                            |                 |   |  |                  |  |   |                    |
| 51.9          |   |            |         |      |               |                            |                 |   |  |                  |  |   |                    |
| 8.8           | Silty SAND, occasional shale<br>fragments                               |            | 8       | SS   | 148/<br>0.275 |                            |                 |   |  |                  |  |   |                    |
|               | Very Dense  |            |         |      |               |                            |                 |   |  |                  |  |   |                    |
|               | Dark Grey   |            |         |      |               |                            |                 |   |  |                  |  |   |                    |
| 51.1          | Moist   |            |         |      |               |                            |                 |   |  |                  |  |   |                    |
| 9.6           | (TILL)  |            |         |      |               |                            |                 |   |  |                  |  |   |                    |
|               | END OF BOREHOLE AT 9.6m UPON  |            |         |      |               |                            |                 |   |  |                  |  |   |                    |

Continued Next Page

+<sup>3</sup> ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No LE-08

2 OF 2

METRIC

W.P. 4091-07-00 LOCATION N 5 031 173.5 E 369 820.5 Lees Avenue ORIGINATED BY RK/ES  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2012 03 12 - 2012 03 22 CHECKED BY LRB

| SOIL PROFILE  |   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |     |    | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT |    |  | UNIT 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 (%)                                   |    |  |                                       |  |
|               |   |            |         |      |            |                            | 20              | 40  | 60 | 80 | 100 | 20 | 40  | 60 |  |                                       |  |
|               | Continued From Previous Page  |            |         |      |            |                            |                 |   |    |    |     |    |   |    |  |                                       |  |
|               | PROBABLE BEDROCK.<br>Piezometer installation consists of<br>19mm diameter Schedule 40 PVC pipe<br>with a 1.52m slotted screen.<br>WATER LEVEL READINGS:<br><br>DATE DEPTH (m) ELEV. (m)<br>Mar 23/12 1.1 59.6 |            |         |      |            |                            |                 |   |    |    |     |    |   |    |  |                                       |  |

ONTMT4S 1201A.GPJ 5/15/12

+<sup>3</sup> ×<sup>3</sup>

Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No LE-09

1 OF 2

METRIC

W.P. 4091-07-00 LOCATION N 5 031 173.0 E 369 843.4 Lees Avenue ORIGINATED BY ES  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN  
 DATUM Geodetic DATE 2012.03.13 - 2012.03.13 CHECKED BY LRB

| SOIL PROFILE  |  |            | SAMPLES |      |               | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT                        |  | PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT |  |  | UNIT<br>WEIGHT<br><br>γ<br><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 (%)   |  |  |  |   |
|               |  |            |         |      |               |                            |                 | 20 40 60 80 100  |  | 20 40 60  |  |  |  |   |
|               |  |            |         |      |               |                            |                 | ○ UNCONFINED      + FIELD VANE<br>● QUICK TRIAXIAL      x LAB VANE |  |   |  |  |  |   |
| 60.5          | ASPHALT: (50mm)  |            |         |      |               |                            |                 | 20 40 60 80 100  |  | 20 40 60  |  |  |  |   |
| 59.4          | SAND, trace gravel, trace silt<br>Compact<br>Brown<br>Damp<br>(FILL)   |            | 1       | GS   |               |                            |                 |  |  |   |  |  |  |   |
| 1.1           | Silty SAND, some clay, trace gravel<br>Compact to Very Dense<br>Brown<br>Moist<br>(FILL)   |            | 1       | SS   | 15            |                            |                 |  |  |   |  |  |  | 8 50 28 14  |
|               |  |            |         |      |               |                            |                 |  |  |   |  |  |  |   |
|               |  |            | 2       | SS   | 19            |                            |                 |  |  |   |  |  |  |   |
| 58.3          | Cobbles  |            |         |      |               |                            |                 |  |  |   |  |  |  |   |
| 2.2           | Gravelly SAND, some silt<br>Very Dense<br>Brown<br>Moist<br><br>Auger refusal at 2.9m, switch to casing<br>and coring<br>Occasional cobbles and boulders from<br>2.9m to 4.5m<br><br>No recovery |            | 3       | SS   | 50/<br>0.150  |                            |                 |  |  |   |  |  |  |   |
|               |  |            |         |      |               |                            |                 |  |  |   |  |  |  |   |
|               |  |            | 4       | SS   | 100/<br>0.0   |                            |                 |  |  |   |  |  |  |   |
| 54.4          |  |            |         |      |               |                            |                 |  |  |   |  |  |  |   |
| 6.1           | SAND and GRAVEL, occasional<br>cobbles<br>Very Dense<br>Grey<br>Wet  |            | 5       | SS   | 95            |                            |                 |  |  |   |  |  |  |   |
|               |  |            |         |      |               |                            |                 |  |  |   |  |  |  |   |
|               |  |            | 6       | SS   | 55/<br>0.150  |                            |                 |  |  |   |  |  |  |   |
|               |  |            |         |      |               |                            |                 |  |  |   |  |  |  |   |
| 52.0          |  |            |         |      |               |                            |                 |  |  |   |  |  |  |   |
| 8.5           | Sandy SILT, trace clay, trace gravel<br>Very Dense<br>Grey<br>Moist  |            | 7       | SS   | 50/<br>0.100  |                            |                 |  |  |   |  |  |  | 4 18 74 4   |
| 50.8          |  |            |         |      |               |                            |                 |  |  |   |  |  |  |   |
| 50.7          | SHALE, weathered, grey   |            | 8       | SS   | 100/<br>0.075 |                            |                 |  |  |   |  |  |  |   |
| 50.7          |  |            |         |      |               |                            |                 |  |  |   |  |  |  |   |
| 9.8           |  |            |         |      |               |                            |                 |  |  |   |  |  |  |   |

Continued Next Page

+<sup>3</sup> ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

ONTMT4S 1201A.GPJ 5/15/12



RECORD OF BOREHOLE No LE-09

2 OF 2

METRIC

W.P. 4091-07-00 LOCATION N 5 031 173.0 E 369 843.4 Lees Avenue ORIGINATED BY ES  
HWY 417 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN  
DATUM Geodetic DATE 2012.03.13 - 2012.03.13 CHECKED BY LRB

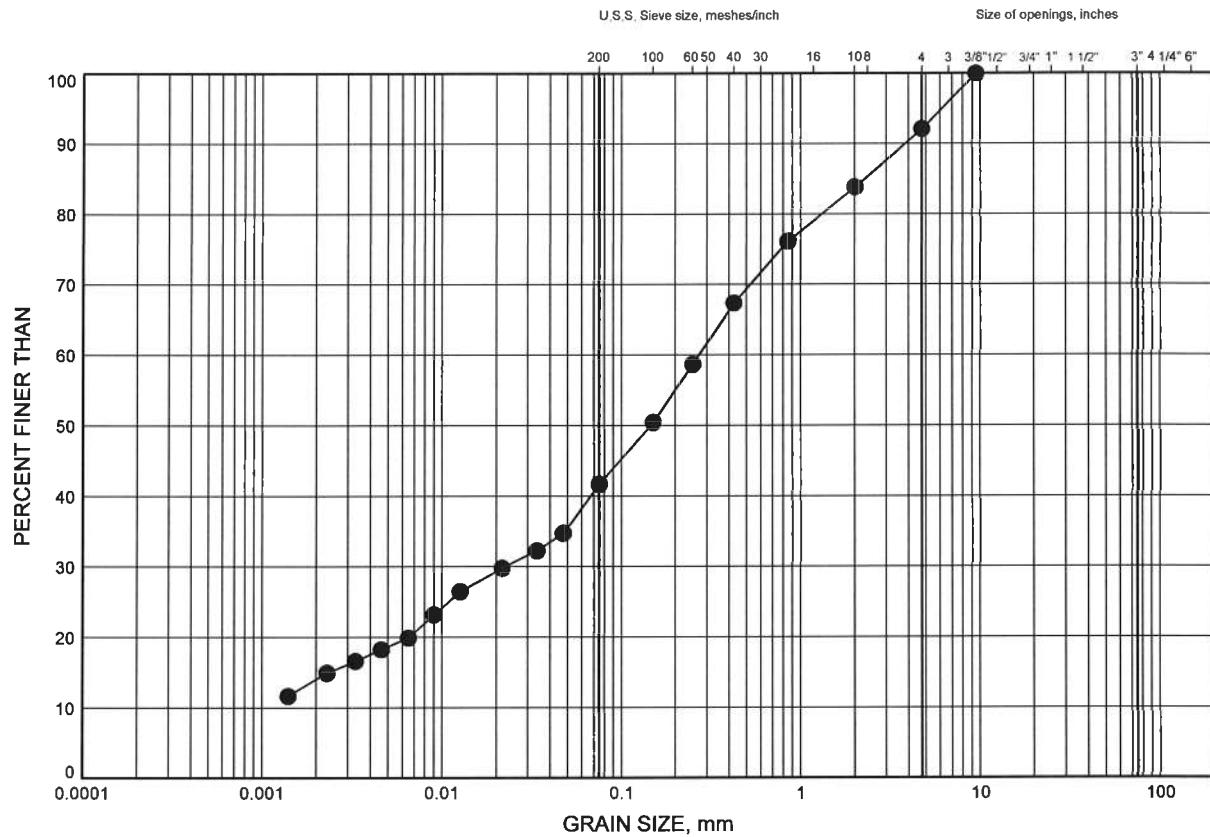
| SOIL PROFILE  |  | SAMPLES    |        |      | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |                    |    |    |     | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT |                   |    | UNIT<br>WEIGHT<br>$\gamma$<br>kN/m <sup>3</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 | 20  | 40                | 60 |   |  |
|               | Continued From Previous Page   |            |        |      |                            |                 |   |                    |    |    |     |   |                   |    |   |  |
|               | END OF BOREHOLE AT 9.8m UPON<br>PROBABLE BEDROCK.<br>Piezometer installation consists of<br>19mm diameter Schedule 40 PVC pipe<br>with a 1.52m slotted screen. |            |        |      |                            |                 |   |                    |    |    |     |   |                   |    |   |  |
|               | WATER LEVEL READINGS:<br>DATE DEPTH (m) ELEV. (m)<br>Mar.23/12 1.0 59.5  |            |        |      |                            |                 |   |                    |    |    |     |   |                   |    |   |  |

ONTMT4S 1201A.GPJ 5/15/12

Highway 417 Ottawa: Nicholas Street to OR 174  
GRAIN SIZE DISTRIBUTION

FIGURE C1

SILTY SAND FILL



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

LEGEND

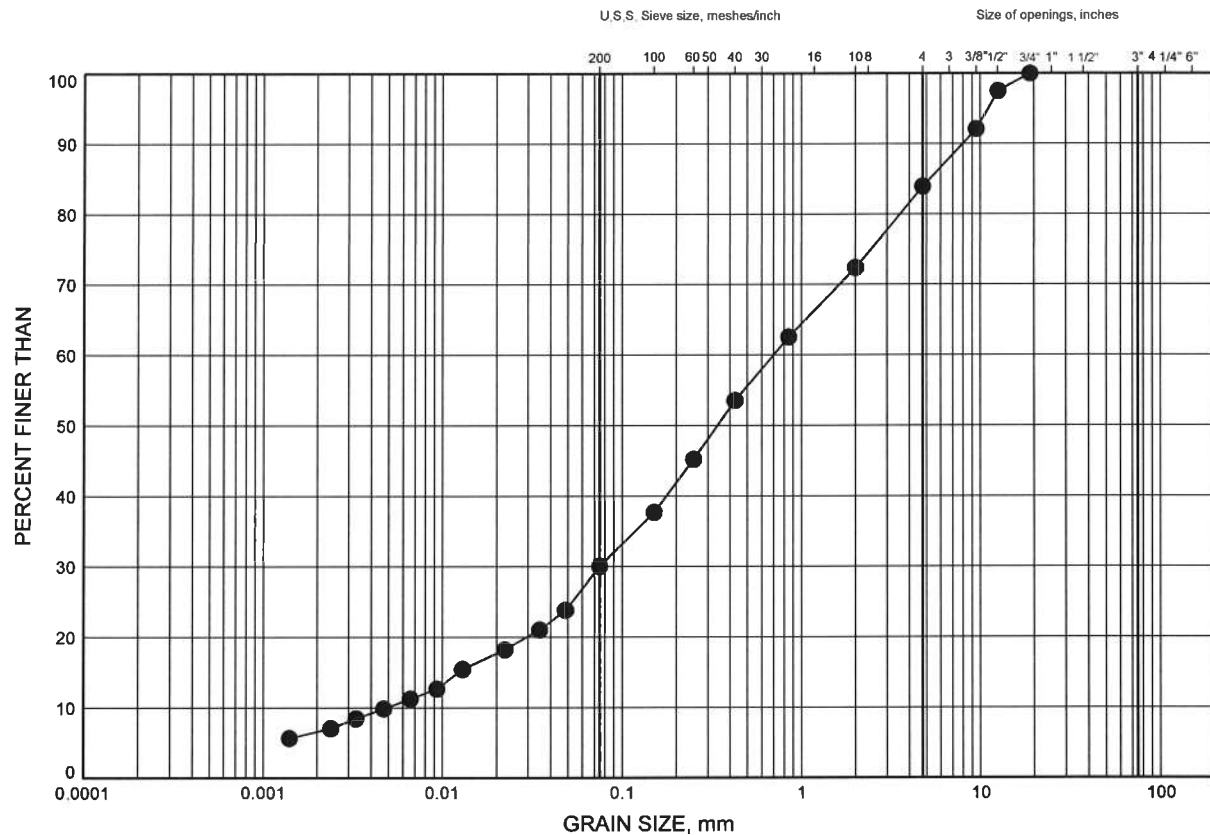
| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | LE-09    | 1.07      | 59.43     |

# Highway 417 Ottawa: Nicholas Street to OR 174

## GRAIN SIZE DISTRIBUTION

FIGURE C2

### SILTY SAND



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

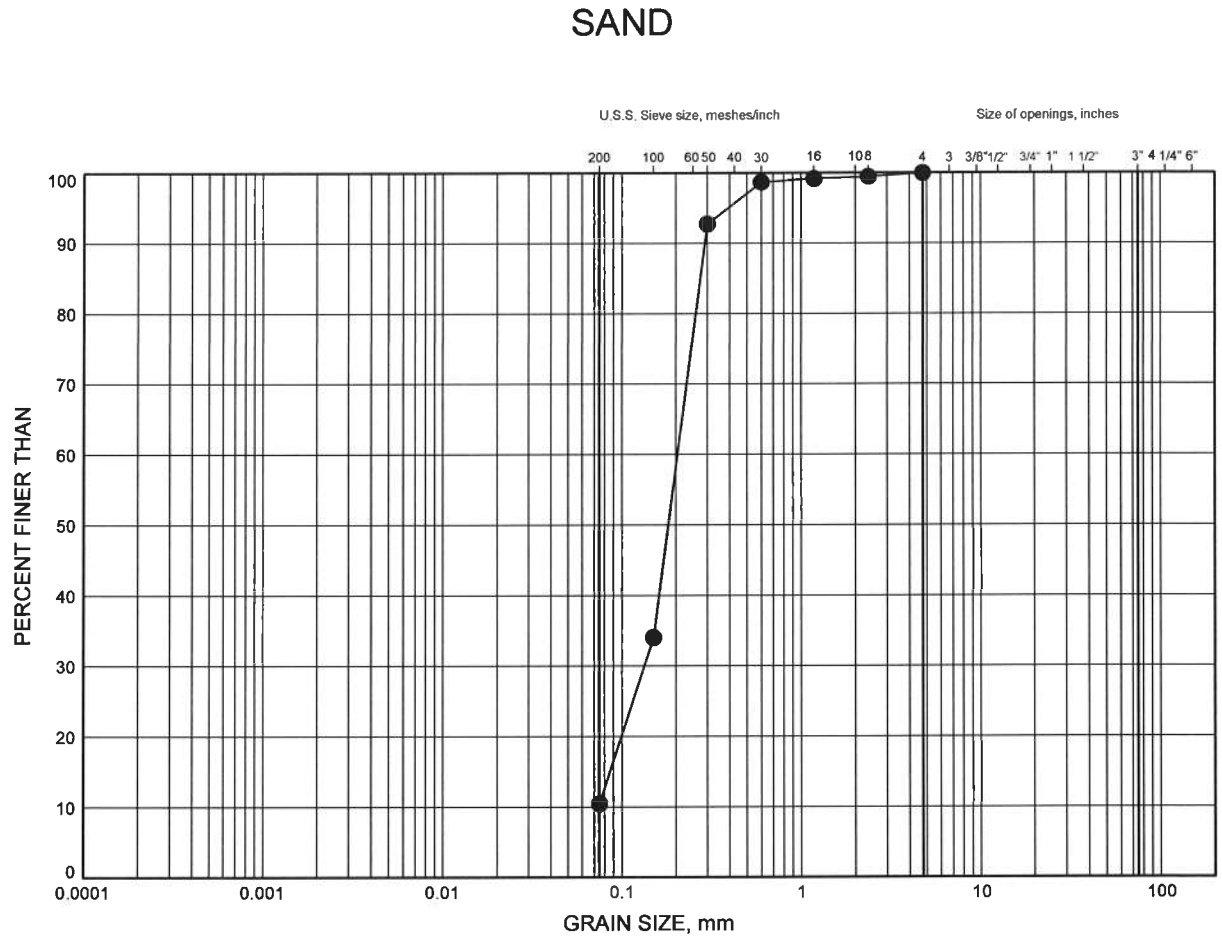
### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | LE-08    | 2.59      | 58.11     |

# Highway 417 Ottawa: Nicholas Street to OR 174

## GRAIN SIZE DISTRIBUTION

FIGURE C3



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

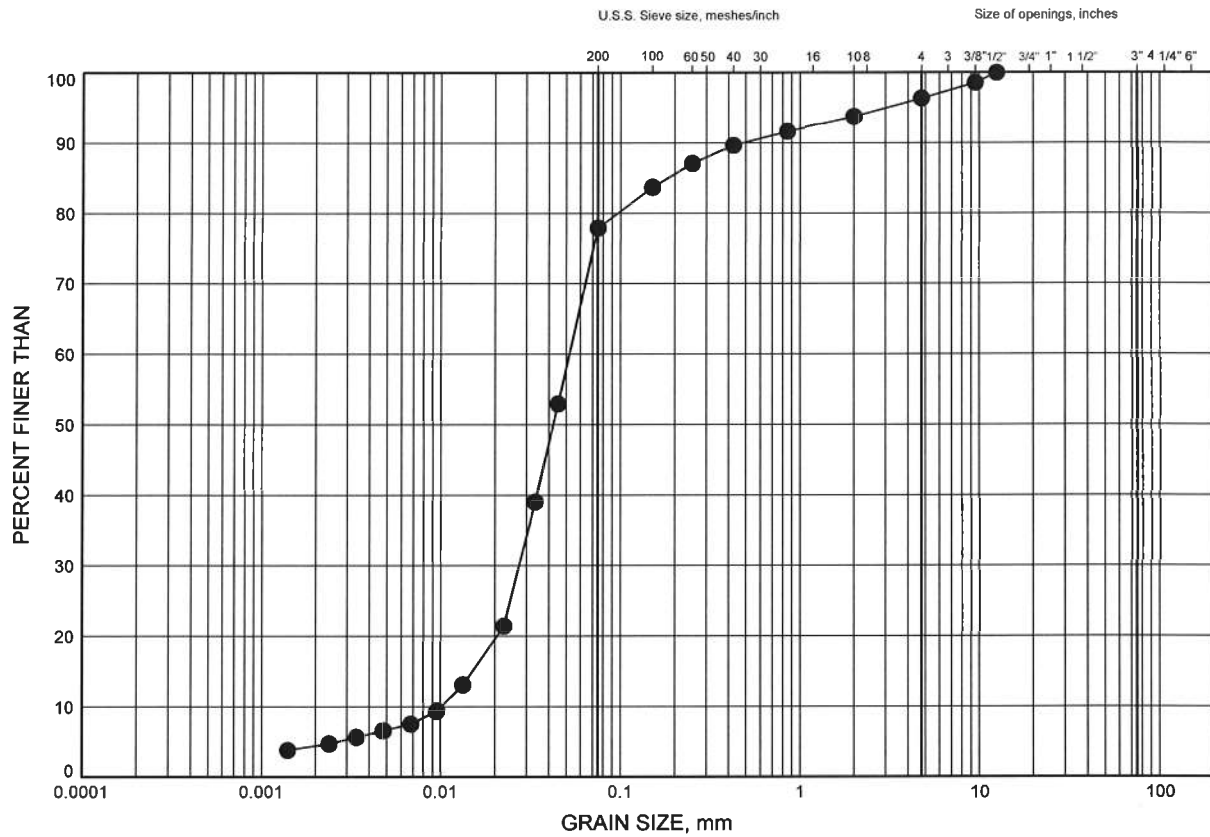
### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | LE-08    | 7.92      | 52.78     |

Highway 417 Ottawa: Nicholas Street to OR 174  
GRAIN SIZE DISTRIBUTION

FIGURE C4

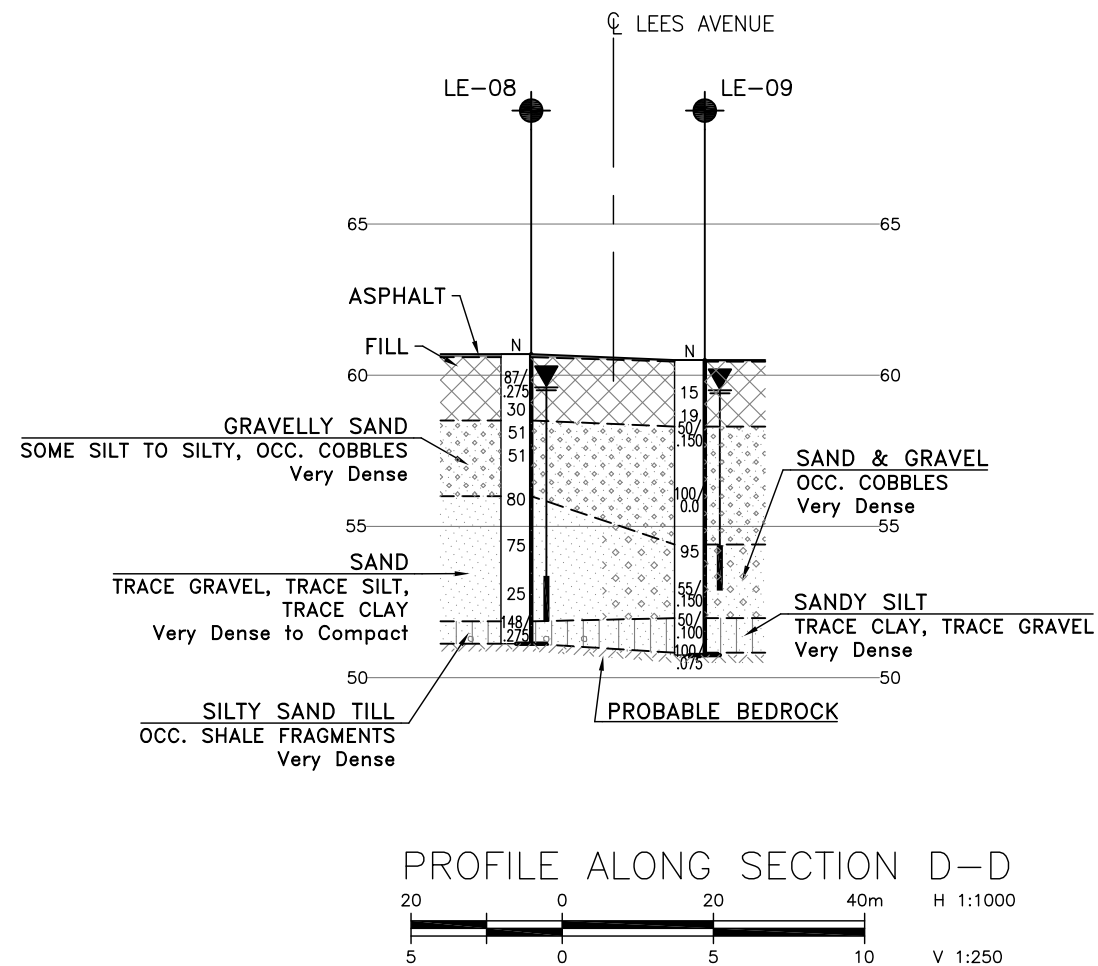
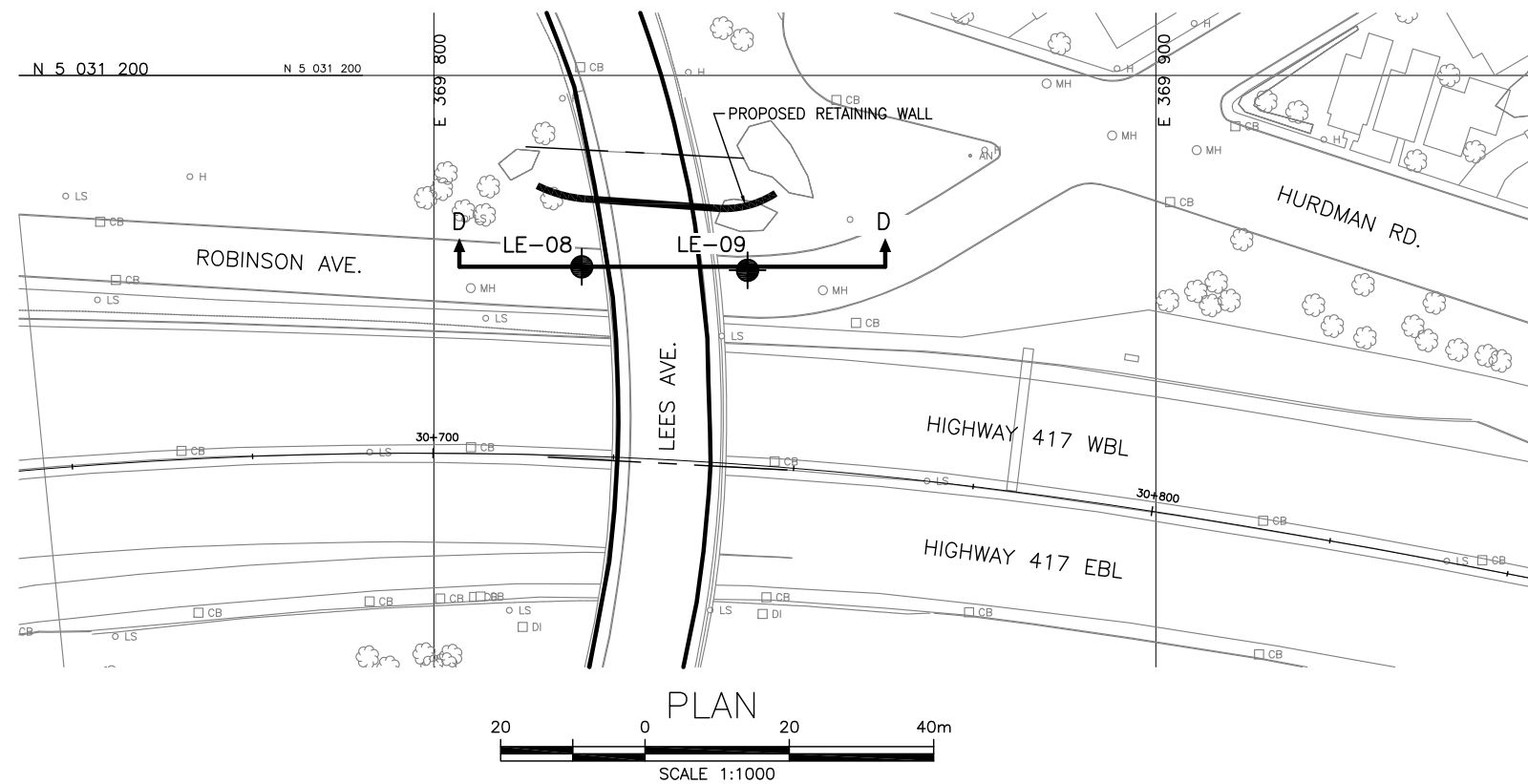
SANDY SILT



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

LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | LE-09    | 9.27      | 51.23     |



**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No  
WP No 4091-07-00








SHEET  
1



## KEYPLAN

## LEGEND

|   |                                       |
|---|---------------------------------------|
|  | Borehole                              |
|  | Borehole and Cone                     |
| N   | Blows /0.3m (Std Pen Test, 475J/blow) |
| CONE  | Blows /0.3m (60' Cone, 475J/blow)     |
| PH  | Pressure, Hydraulic                   |
|  | Water Level                           |
|  | Head Artesian Water                   |
|  | Piezometer                            |
| 90%   | Rock Quality Designation (RQD)        |
| A/R   | Auger Refusal                         |

| NO    | ELEVATION | NORTHING    | EASTING   |
|-------|-----------|-------------|-----------|
| LE-08 | 60.7      | 5 031 173.5 | 369 820.5 |
| LE-09 | 60.5      | 5 031 173.0 | 369 843.4 |

-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

**GEOCRES No. 31G5-250**

|           |      |     |             |      |        |  |  |      |           |
|-----------|------|-----|-------------|------|--------|--|--|------|-----------|
| REVISIONS |      |     |             |      |        |  |  |      |           |
|           |      |     |             |      |        |  |  |      |           |
|           |      |     |             |      |        |  |  |      |           |
|           |      |     |             |      |        |  |  |      |           |
|           |      |     |             |      |        |  |  |      |           |
|           | DATE | BY  | DESCRIPTION |      |        |  |  |      |           |
| DESIGN    | MC   | CHK | MRA         | CODE | LOAD   |  |  | DATE | AUG. 2012 |
| DRAWN     | AN   | CHK |             | SITE | STRUCT |  |  | DWG  | 1         |

## **Appendix D**

### **Lees Avenue (North) Noise Barrier**

**Boreholes 12N-01 & 02, 13N-01, 14N-01 to 03, NB8-01**

RECORD OF BOREHOLE No 12N-01

1 OF 1

METRIC

W.P. 4091-07-00 LOCATION N 5 031 163 6 E 369 769 5 ORIGINATED BY RK  
HWY 417 BOREHOLE TYPE Hollow Stem Augers - CME-75 COMPILED BY AN  
DATUM Geodetic DATE 2011.08.22 - 2011.08.22 CHECKED BY LRB

| 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><br>γ<br><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<br>○ UNCONFINED      + FIELD VANE<br>● QUICK TRIAXIAL    x LAB VANE |    |    |                                    |                                     |                                   |  |   | WATER CONTENT (%) |                   |
| 61.0          |  |            |         |      |               |                            |                 | 20   | 40 | 60 | 80                                 | 100                                 |                                   |  |   |                   |                   |
| 0.0           | ASPHALT: (175mm)   |            |         |      |               |                            |                 |  |    |    |                                    |                                     |                                   |  |   |                   |                   |
| 0.2           | SAND and GRAVEL to SAND, some gravel<br>Very Dense<br>Brown<br>Dry to Damp<br>(FILL)   |            | 1       | SS   | 100/<br>0.280 |                            |                 |  |    |    |                                    |                                     |                                   |  |   |                   |                   |
| 59.0          | Trace rootlets   |            | 2       | SS   | 100/<br>0.280 |                            |                 |  |    |    |                                    |                                     |                                   |  |   |                   |                   |
| 2.0           | SAND, medium grained, trace gravel,<br>trace silt<br>Very Dense<br>Brown<br>Damp   |            | 3       | SS   | 56            |                            |                 |  |    |    |                                    |                                     |                                   |  |   |                   | 7 85 8<br>(SI+CL) |
|               |  |            | 4       | SS   | 57            |                            |                 |  |    |    |                                    |                                     |                                   |  |   |                   |                   |
|               |  |            | 5       | SS   | 71            |                            |                 |  |    |    |                                    |                                     |                                   |  |   |                   |                   |
|               |  |            | 6       | SS   | 28            |                            |                 |  |    |    |                                    |                                     |                                   |  |   |                   | 0 91 9<br>(SI+CL) |
| 54.3          | Becoming compact   |            |         |      |               |                            |                 |  |    |    |                                    |                                     |                                   |  |   |                   |                   |
| 6.7           | END OF BOREHOLE AT 6.7m.<br>WATER LEVEL AT 5.8m UPON<br>COMPLETION.<br>BOREHOLE BACKFILLED WITH<br>BENTONITE AND CUTTINGS TO<br>SURFACE. |            |         |      |               |                            |                 |  |    |    |                                    |                                     |                                   |  |   |                   |                   |

+<sup>3</sup>, X<sup>3</sup>; Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No 12N-02

1 OF 1

METRIC

W.P. 4091-07-00 LOCATION N 5 031 158.6 E 369 879.9 ORIGINATED BY RK  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers - CME-75 COMPILED BY AN  
 DATUM Geodetic DATE 2011.08.22 - 2011.08.22 CHECKED BY LRB

| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |    |     | UNIT<br>WEIGHT<br>γ<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|---|----|----|----|-----|--|---|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | 20  | 40 | 60 | 80 | 100 |  |   |
| 60.9          |  |            |         |      |            |                            |                 |   |    |    |    |     |  |   |
| 0.0           | ASPHALT: (175mm)   |            |         |      |            |                            |                 |   |    |    |    |     |  |   |
| 0.2           | SAND, medium grained, trace to<br>some gravel<br>Dense to Compact<br>Brown<br>Damp<br>(FILL)   |            | 1       | SS   | 48         |                            | 60              |   |    |    |    |     |  |   |
|               |  |            | 2       | SS   | 18         |                            | 59              |   |    |    |    |     |  |   |
| 58.6          |  |            |         |      |            |                            |                 |   |    |    |    |     |  |   |
| 2.3           | SAND and GRAVEL, some silt<br>Very Dense to Dense<br>Greyish Brown<br>Damp   |            | 3       | SS   | 65         |                            | 58              |   |    |    |    |     |  |   |
|               |  |            | 4       | SS   | 31         |                            | 57              |   |    |    |    |     |  |   |
| 56.3          | No recovery  |            | 5       | SS   | 100/       |                            |                 |   |    |    |    |     |  |   |
| 4.6           | END OF BOREHOLE AT 4.6m UPON<br>AUGER REFUSAL.<br>WATER LEVEL AT 3.7m UPON<br>COMPLETION.<br>Piezometer installation consists of<br>19mm diameter Schedule 40 PVC pipe<br>with a 1.52m slotted screen.<br><br>WATER LEVEL READINGS:<br>DATE DEPTH (m) ELEV. (m)<br>Oct.12/11 Plugged at 3.0m |            |         |      | 0.025      |                            |                 |   |    |    |    |     |  | 40 44 16<br>(SI+CL)                               |

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 13N-01

1 OF 1

METRIC

W.P. 4091-07-00 LOCATION N 5 031 135.7 E 369 994.1 ORIGINATED BY RK  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers - CME-55 COMPILED BY AN  
 DATUM Geodetic DATE 2011.08.23 - 2011.08.23 CHECKED BY LRB

| SOIL PROFILE  |   |            | SAMPLES |      |             | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  | PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT |  |  | UNIT<br>WEIGHT<br><br>γ<br><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 (%)                                       |  |  |  |   |
| 60.4          |   |            |         |      |             |                            |                 | 20 40 60 80 100                             |  |   |  |  |  |   |
| 0.0           | ASPHALT: (175mm)  |            |         |      |             |                            |                 | 20 40 60 80 100                             |  |   |  |  |  |   |
| 0.2           | SAND, gravelly to trace gravel<br>Very Dense<br>Brown<br>Damp<br>(FILL)   |            | 1       | SS   | 63          |                            |                 |   |  |   |  |  |  |   |
| 58.9          |   |            |         |      |             |                            |                 |   |  |   |  |  |  |   |
| 1.5           | Silty SAND, some gravel, trace clay<br>Dense to Loose<br>Brown<br>Moist to Wet<br>(TILL)  |            | 2       | SS   | 42          |                            |                 |   |  |   |  |  |  |   |
|               |   |            | 3       | SS   | 14          |                            |                 |   |  |   |  |  |  | 6 56 30 8   |
|               |   |            | 4       | SS   | 11          |                            |                 |   |  |   |  |  |  |   |
|               |   |            | 5       | SS   | 9           |                            |                 |   |  |   |  |  |  |   |
|               |   |            | 6       | SS   | 64/<br>0.23 |                            |                 |   |  |   |  |  |  |   |
| 53.9          |   |            |         |      |             |                            |                 |   |  |   |  |  |  |   |
| 6.5           | END OF BOREHOLE AT 6.5m.<br>Piezometer installation consists of<br>19mm diameter Schedule 40 PVC pipe<br>with a 1.52m slotted screen.<br><br>WATER LEVEL READINGS:<br>DATE      DEPTH (m)      ELEV. (m)<br>Oct. 12/11      Plugged at 1.5m |            |         |      |             |                            |                 |   |  |   |  |  |  |   |

ONTMT4S 1201A.GPJ 4/23/12

# RECORD OF BOREHOLE No 14N-01

1 OF 1

METRIC

W.P. 4091-07-00 LOCATION N 5 031 124.5 E 370 108.6 ORIGINATED BY GA  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers - CME-55 COMPILED BY AN  
 DATUM Geodetic DATE 2011.08.15 - 2011.08.15 CHECKED BY LRB

| SOIL PROFILE  |   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |                                  |    | UNIT<br>WEIGHT<br><br>γ<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              |    | ● QUICK TRIAXIAL      × LAB VANE |    |  |  | W <sub>P</sub> W      W <sub>L</sub> |  | PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT |  |
| 60.4          |   |            |         |      |            | 20                         | 40              | 60  | 80 | 100                              | 20 | 40   | 60   |                                      |  |   |  |
| 0.0           | TOPSOIL: (50mm)   |            | 1       | SS   | 22         |                            |                 |   |    |                                  | ○  |  |  |                                      |  |   |  |
| 59.6          | SAND, some silt, trace gravel,<br>occasional rootlets<br>Compact<br>Brown   |            |         |      |            |                            |                 |   |    |                                  |    |  |  |                                      |  |   |  |
| 0.8           | Dry<br>(FILL)   |            | 2       | SS   | 29         |                            |                 |   |    |                                  | ○  |  |  |                                      |  |   |  |
| 58.9          | Silty SAND, trace gravel, trace clay<br>Compact<br>Brown to Grey  |            |         |      |            |                            |                 |   |    |                                  |    |  |  |                                      |  |   |  |
| 1.5           | Dry to Damp<br>(FILL)   |            | 3       | SS   | 30         |                            |                 |   |    |                                  | ○  |  |  | 7 55 29 9                            |  |   |  |
|               | Silty SAND, some clay, trace gravel<br>Compact to Dense<br>Brown to Grey<br>Moist to Wet<br>(TILL)  |            | 4       | SS   | 13         |                            |                 |   |    |                                  | ○  |  |  |                                      |  |   |  |
|               | Poor recovery   |            | 5       | SS   | 10         |                            |                 |   |    |                                  | ○  |  |  |                                      |  |   |  |
|               |   |            |         |      |            |                            |                 |   |    |                                  |    |  |  |                                      |  |   |  |
|               |   |            | 6       | SS   | 32         |                            |                 |   |    |                                  | ○  |  |  | 9 43 38 10                           |  |   |  |
|               |   |            |         |      |            |                            |                 |   |    |                                  |    |  |  |                                      |  |   |  |
|               |   |            |         |      |            |                            |                 |   |    |                                  |    |  |  |                                      |  |   |  |
|               |   |            | 7       | SS   | 23         |                            |                 |   |    |                                  | ○  |  |  |                                      |  |   |  |
| 53.7          |   |            |         |      |            |                            |                 |   |    |                                  |    |  |  |                                      |  |   |  |
| 6.7           | END OF BOREHOLE AT 6.7m.<br>BOREHOLE OPEN TO 6.7m AND<br>DRY UPON COMPLETION.<br>BOREHOLE BACKFILLED WITH<br>BENTONITE HOLEPLUG AND<br>CUTTINGS TO SURFACE. |            |         |      |            |                            |                 |   |    |                                  |    |  |  |                                      |  |   |  |

ONTMT4S 1201A.GPJ 4/23/12

+<sup>3</sup> ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 14N-02

1 OF 1

METRIC

W.P. 4091-07-00 LOCATION N 5 031 120.1 E 370 121.9 ORIGINATED BY RK  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.08.23 - 2011.08.23 CHECKED BY LRB

| SOIL PROFILE  |   |            | SAMPLES |      |               | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    | UNIT<br>WEIGHT<br><br>γ<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 (%) |    |  |            |  |
| 60.1          |   |            |         |      |               |                            | 20              | 40  | 60 | 80 | 100  | 20   | 40                | 60 |  |            |  |
| 0.0           | ASPHALT: (175mm)  |            |         |      |               |                            |                 |   |    |    |  |  |                   |    |  |            |  |
| 0.2           | SAND, some gravel<br>Very Dense<br>Brown<br>Dry<br>(FILL)   |            | 1       | SS   | 100/<br>0.280 |                            |                 |   |    |    |  |  |                   |    |  |            |  |
| 58.6          |   |            |         |      |               |                            |                 |   |    |    |  |  |                   |    |  |            |  |
| 1.5           | Silty SAND, some gravel<br>Very Dense<br>Brown<br>Moist<br>(FILL)   |            | 2       | SS   | 67/<br>0.280  |                            |                 |   |    |    |  |  |                   |    |  |            |  |
| 58.0          |   |            |         |      |               |                            |                 |   |    |    |  |  |                   |    |  |            |  |
| 2.1           | Augers grinding   |            |         |      |               |                            |                 |   |    |    |  |  |                   |    |  |            |  |
|               | SAND and GRAVEL, some silt, shale<br>fragments<br>Dense<br>Brown  |            | 3       | SS   | 38            |                            |                 |   |    |    |  |  |                   |    |  |            |  |
| 57.1          |   |            |         |      |               |                            |                 |   |    |    |  |  |                   |    |  |            |  |
| 3.0           | Moist to Wet<br>Hydrocarbon odour   |            | 4       | SS   | 15            |                            |                 |   |    |    |  |  |                   |    |  |            |  |
|               | Silty SAND, some gravel, trace clay<br>Compact to Very Dense<br>Brown<br>Wet<br>(TILL)  |            |         |      |               |                            |                 |   |    |    |  |  |                   |    |  |            |  |
|               |   |            | 5       | SS   | 57            |                            |                 |   |    |    |  |  |                   |    |  | 15 46 33 7 |  |
|               |   |            |         |      |               |                            |                 |   |    |    |  |  |                   |    |  |            |  |
|               |   |            | 6       | SS   | 36            |                            |                 |   |    |    |  |  |                   |    |  |            |  |
| 53.4          |   |            |         |      |               |                            |                 |   |    |    |  |  |                   |    |  |            |  |
| 6.7           | END OF BOREHOLE AT 6.7m.<br>WATER LEVEL AT 3.9m UPON<br>COMPLETION.<br>Piezometer installation consists of<br>19mm diameter Schedule 40 PVC pipe<br>with a 1.52m slotted screen.<br><br>WATER LEVEL READINGS:<br>DATE      DEPTH (m)    ELEV. (m)<br>Oct.12/11    2.5            57.6 |            |         |      |               |                            |                 |   |    |    |  |  |                   |    |  |            |  |

ONTWT4S 1201A.GPJ 4/23/12

## METRIC

| SOIL PROFILE |             |            | SAMPLES |      |            | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT                                       |  | PLASTIC LIMIT<br>NATURAL MOISTURE CONTENT<br>LIQUID LIMIT | UNIT WEIGHT | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|--------------|-------------|------------|---------|------|------------|-------------------------|-----------------|--|--|---|-------------|---------------------------------------|
| ELEV. DEPTH  | DESCRIPTION | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                         |                 |  |  |   |             |                                       |
|              |             |            |         |      |            |                         |                 | SHEAR STRENGTH kPa<br>○ UNCONFINED + FIELD VANE<br>● QUICK TRIAXIAL × LAB VANE |  |   |             |                                       |
| 60.2         |             |            |         |      |            |                         |                 |  |  |   |             |                                       |

[illegible]
















END OF BOREHOLE AT 6.5m.  
BOREHOLE BACKFILLED WITH  
BENTONITE HOLEPLUG AND  
CUTTINGS TO 0.1m, THEN  
ASPHALT COLD PATCH TO  
SURFACE

RECORD OF BOREHOLE No NB8-01

1 OF 1

METRIC

W.P. 4091-07-00 LOCATION N 5 031 154.6 E 369 929.6 ORIGINATED BY GA  
HWY 417 BOREHOLE TYPE Hollow Stem Augers - CME-55 COMPILED BY AN  
DATUM Geodetic DATE 2011.08.16 - 2011.08.16 CHECKED BY LRB

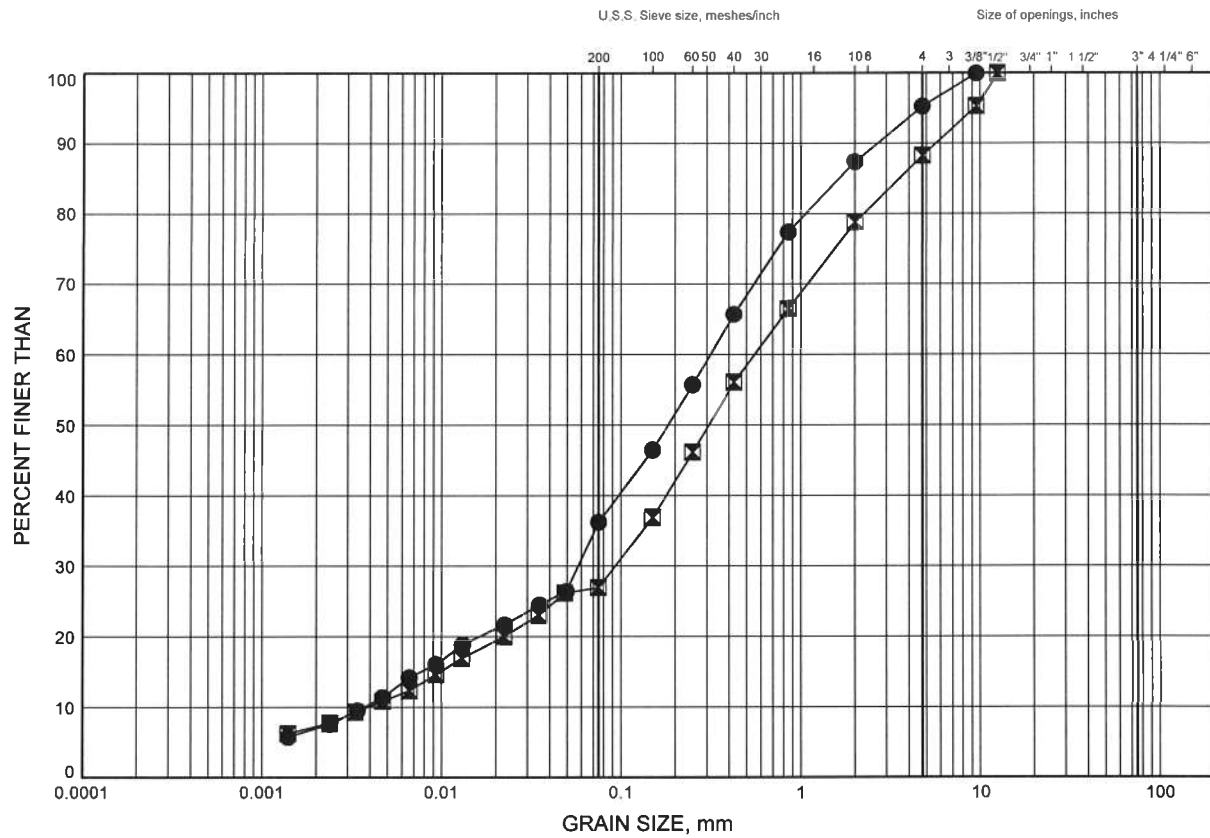
| SOIL PROFILE  |  |   | SAMPLES |      |              | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT                  |    |    | PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT |    |    | UNIT<br>WEIGHT<br><br>γ<br><br>kN/m <sup>3</sup> | REMARKS<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   × LAB VANE |    |    |   |    |    |  |  |
| 61.1          |  |   |         |      |              |                            | 20              | 40   | 60 | 80 | 100   | 20 | 40 | 60   |  |
| 0.0           | TOPSOIL: (50mm)  |  |         |      |              |                            |                 |  |    |    |   |    |    |  |  |
|               | SAND, some silt, some gravel, trace clay, occasional rootlets<br>Dense to Compact<br>Brown/Black<br>Dry (FILL)<br>Poor recovery                    |  | 1       | SS   | 38           |                            |                 |  |    |    |   | ○  |    |  |  |
|               |  |  | 2       | SS   | 28           |                            |                 |  |    |    |   | ○  |    |  |  |
|               |  |  | 3       | SS   | 16           |                            |                 |  |    |    |   | ○  |    |  | 12   61   20   7   |
|               | Poor recovery  |  | 4       | SS   | 13           |                            |                 |  |    |    |   | ○  |    |  |  |
| 58.1          |  |  |         |      |              |                            |                 |  |    |    |   |    |    |  |  |
| 3.0           | Silty SAND, some clay, some gravel<br>Compact to Very Dense<br>Grey/Black<br>Damp (TILL)   |  | 5       | SS   | 50/<br>0.150 |                            |                 |  |    |    |   | ○  |    |  | 13   48   29   10  |
|               |  |  |         |      |              |                            |                 |  |    |    |   |    |    |  |  |
|               |  |  |         |      |              |                            |                 |  |    |    |   |    |    |  |  |
|               |  |  |         |      |              |                            |                 |  |    |    |   |    |    |  |  |
|               |  |  |         |      |              |                            |                 |  |    |    |   |    |    |  |  |
|               |  |  | 6       | SS   | 26           |                            |                 |  |    |    |   | ○  |    |  |  |
|               |  |  |         |      |              |                            |                 |  |    |    |   |    |    |  |  |
|               |  |  |         |      |              |                            |                 |  |    |    |   |    |    |  |  |
| 54.9          |  |  | 7       | SS   | 50/<br>0.150 |                            |                 |  |    |    |   | ○  |    |  |  |
| 6.2           | END OF BOREHOLE AT 6.2m.<br>BOREHOLE OPEN TO 6.2m AND DRY UPON COMPLETION.<br>BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE. |   |         |      | 0.150        |                            |                 |  |    |    |   |    |    |  |  |

# Highway 417 Ottawa: Nicholas to Vanier

## GRAIN SIZE DISTRIBUTION

FIGURE D1

### SILTY SAND FILL



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

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 14N-03   | 1.78      | 58.42     |
| ⊠      | NB8-01   | 1.83      | 59.27     |

GRAIN SIZE DISTRIBUTION - THURBER 1201A.GPJ 5/14/12

Date May 2012  
W.P.# 4091-07-00

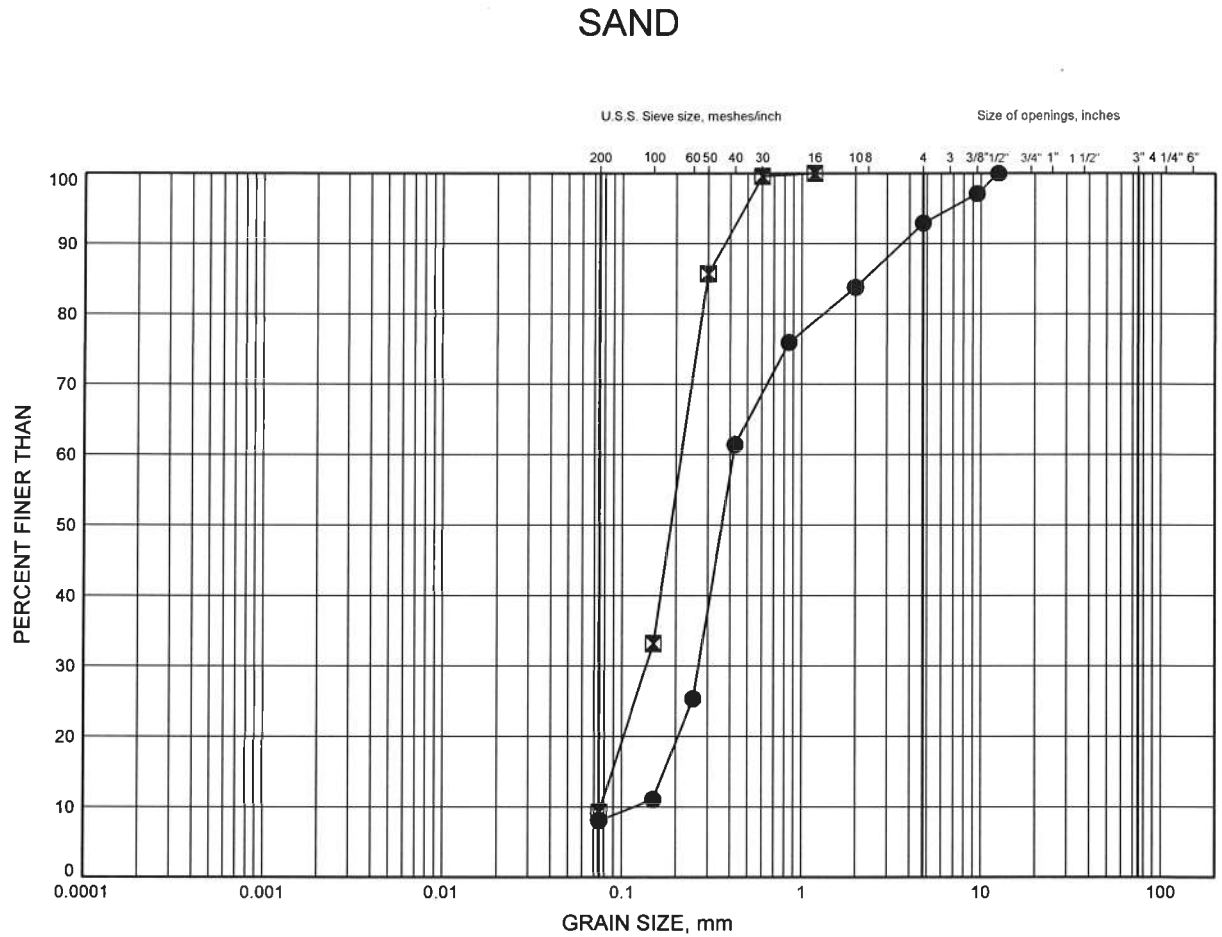


Prep'd MFA  
Chkd. LRB

# Highway 417 Ottawa: Nicholas Street to OR 174

## GRAIN SIZE DISTRIBUTION

FIGURE D2



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

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 12N-01   | 2.59      | 58.42     |
| ⊠      | 12N-01   | 6.40      | 54.61     |

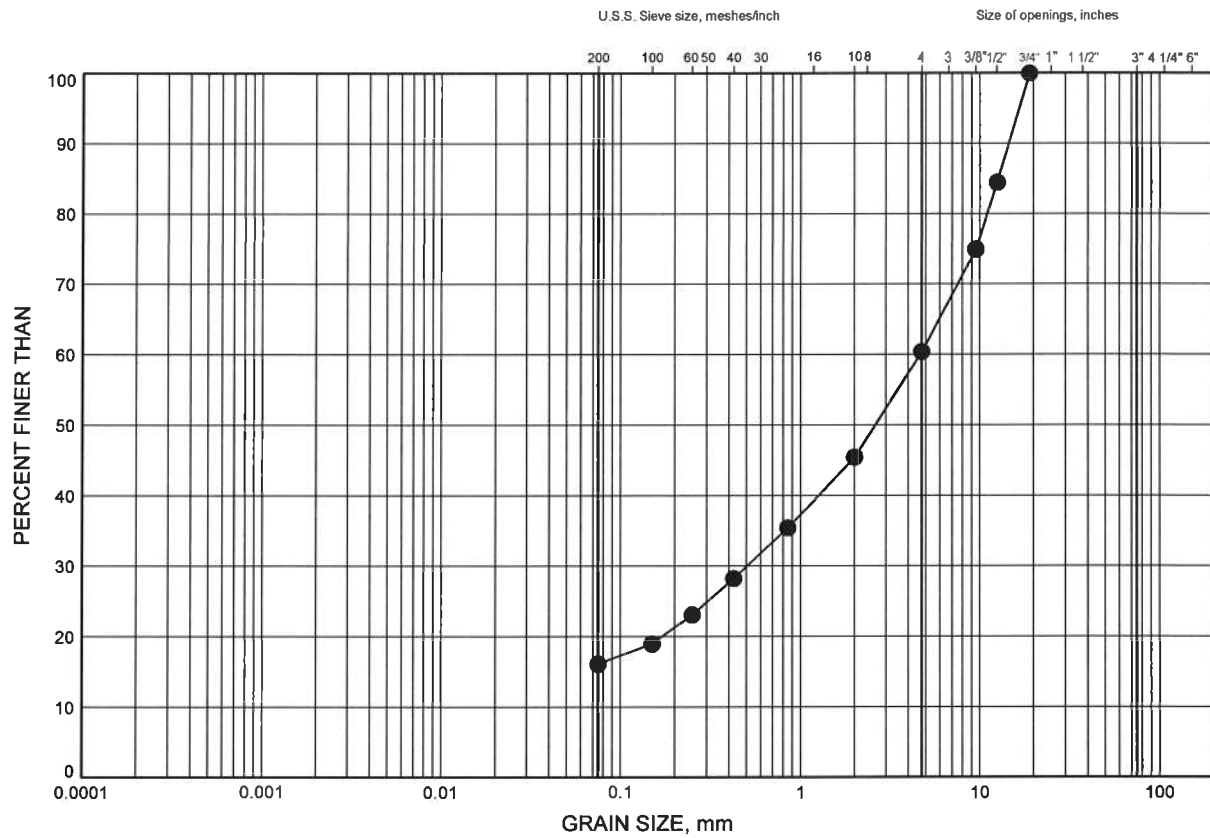


# Highway 417 Ottawa: Nicholas Street to OR 174

## GRAIN SIZE DISTRIBUTION

FIGURE D3

### SAND & GRAVEL



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

### LEGEND

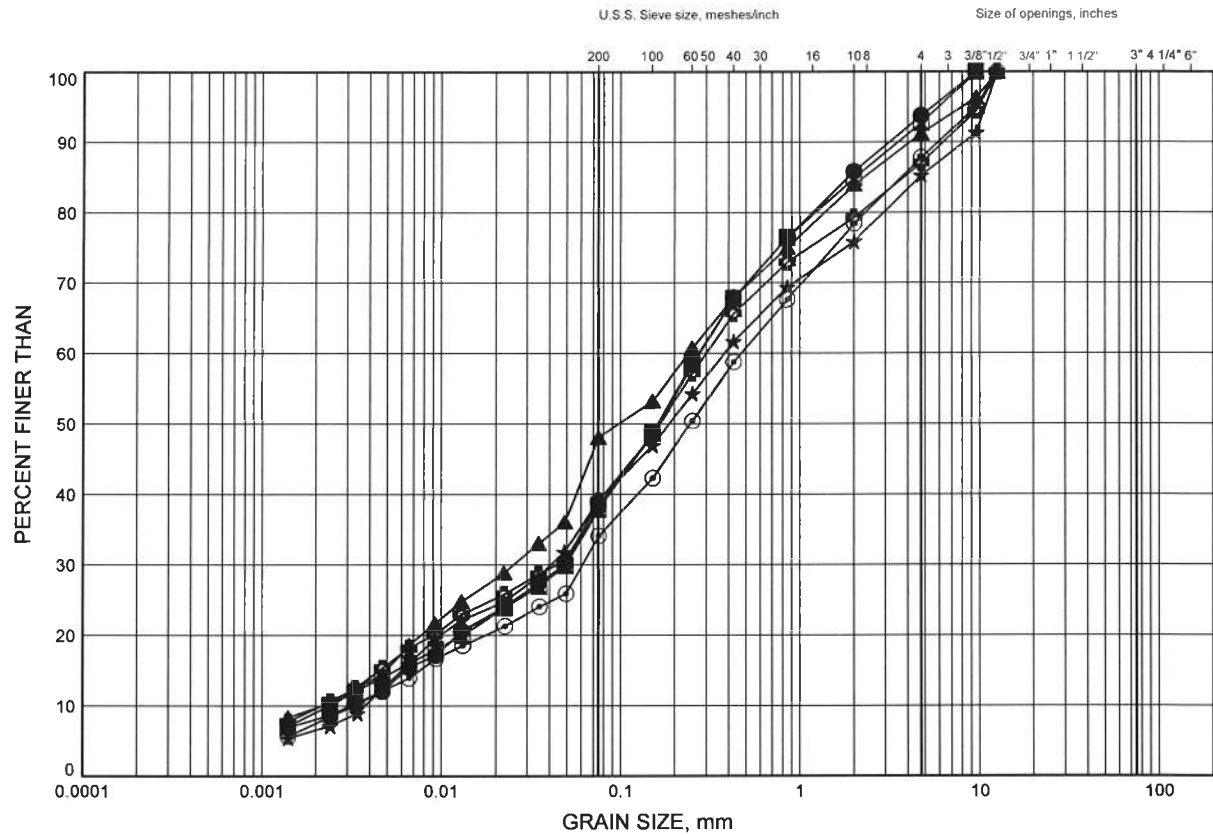
| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 12N-02   | 3.35      | 57.57     |

# Highway 417 Ottawa: Nicholas to Vanier

## GRAIN SIZE DISTRIBUTION

FIGURE D4

### SILTY SAND TILL



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

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 13N-01   | 2.59      | 57.81     |
| ⊠      | 14N-01   | 1.83      | 58.57     |
| ▲      | 14N-01   | 4.88      | 55.52     |
| ★      | 14N-02   | 4.88      | 55.22     |
| ⊙      | 14N-03   | 3.35      | 56.85     |
| ⊕      | NB8-01   | 3.35      | 57.75     |

Date May 2012

W.P.# 4091-07-00



Prep'd MFA

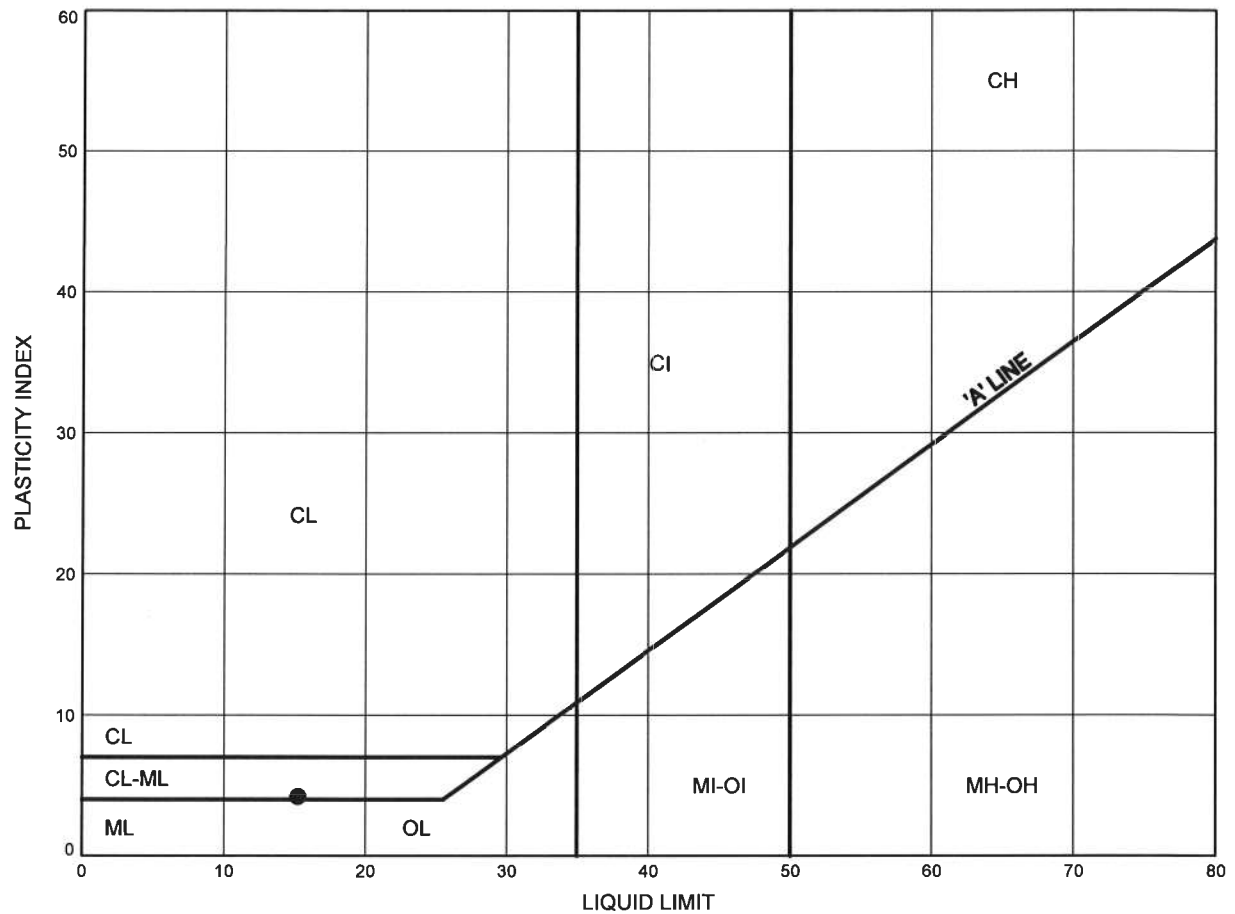
Chkd. LRB

Highway 417 Ottawa: Nicholas Street to OR 174

# ATTERBERG LIMITS TEST RESULTS

FIGURE D5

## SILTY SAND TILL



| SYMBOL | BH     | DEPTH (m) | ELEV. (m) |
|--------|--------|-----------|-----------|
| ●      | 14N-01 | 4.88      | 55.52     |

Date April 2012  
Project 4091-07-00



Prep'd AN  
Chkd. LRB

## METRIC

DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWNCONT No  
WP No 4091-07-00HIGHWAY 417  
NOISE BARRIER  
LEES AVENUE (NORTH)  
BOREHOLE LOCATIONS AND SOIL STRATA

THURBER ENGINEERING LTD.



## KEYPLAN

## LEGEND

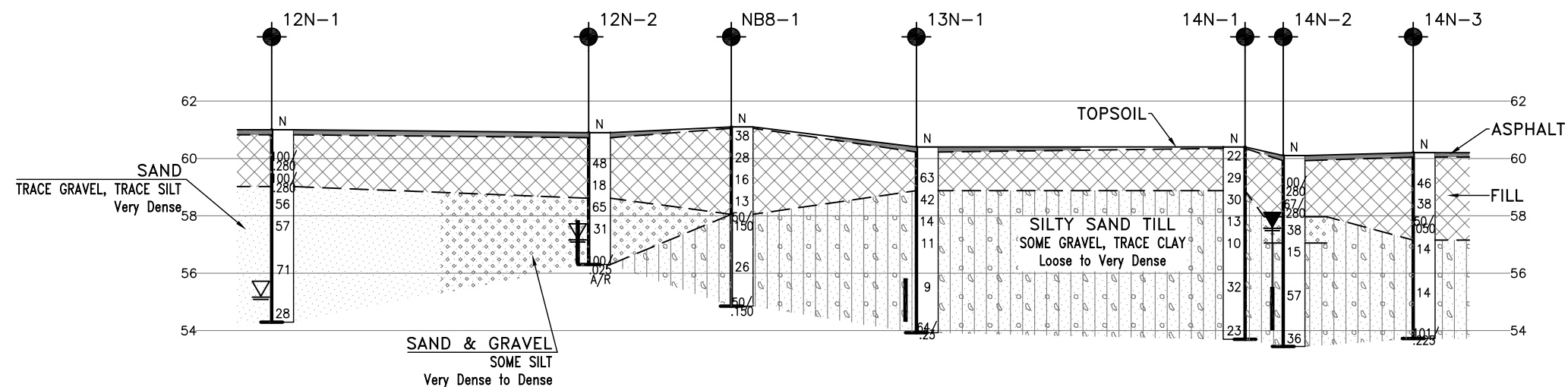
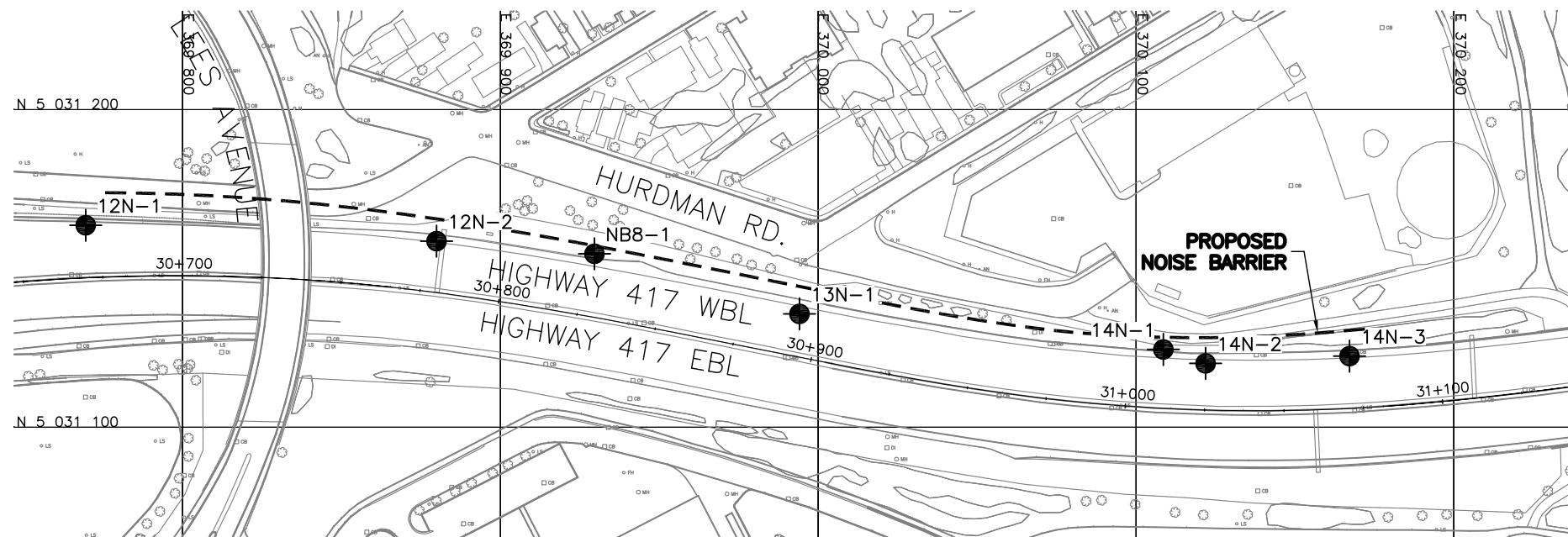
|      |                                       |
|------|---------------------------------------|
|      | Borehole                              |
|      | Borehole and Cone                     |
| N    | Blows /0.3m (Std Pen Test, 475J/blow) |
| CONE | Blows /0.3m (60° Cone, 475J/blow)     |
| PH   | Pressure, Hydraulic                   |
|      | Water Level                           |
|      | Head Artesian Water                   |
|      | Piezometer                            |
| 90%  | Rock Quality Designation (RQD)        |
| A/R  | Auger Refusal                         |

| NO    | ELEVATION | NORTHING    | EASTING   |
|-------|-----------|-------------|-----------|
| 12N-1 | 61.0      | 5 031 163.6 | 369 769.5 |
| 12N-2 | 60.9      | 5 031 158.6 | 369 879.9 |
| NB8-1 | 61.1      | 5 031 154.6 | 369 929.6 |
| 13N-1 | 60.4      | 5 031 135.7 | 369 994.1 |
| 14N-1 | 60.4      | 5 031 124.5 | 370 108.6 |
| 14N-2 | 60.1      | 5 031 120.1 | 370 121.9 |
| 14N-3 | 60.2      | 5 031 122.4 | 370 167.2 |

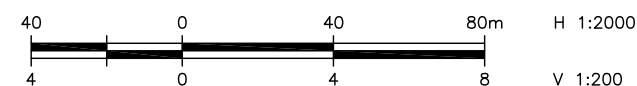
## -NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 31G5-250



## PROFILE ALONG HWY. 417 WBL



| REVISIONS | DATE    | BY   | DESCRIPTION |
|-----------|---------|------|-------------|
| DESIGN MC | CHK MC  | CODE | LOAD        |
| DRAWN AN  | CHK PKC | SITE | STRUCT      |
|           |         |      | DWG 1       |

## **Appendix E**

**Canadian Tire Parking Lot – Riverside Drive to Belfast Road (North)**

**Boreholes 15N-01, CTW-1 & 2, OHS-07L**

RECORD OF BOREHOLE No 15N-01

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 400 9 E 371 304 1 ORIGINATED BY LPG  
HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2011.07.25 - 2011.07.25 CHECKED BY LRB

| SOIL PROFILE  |  |            | SAMPLES |      |              | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT  |  |          | UNIT<br>WEIGHT<br><br>γ<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<br>○ UNCONFINED      + FIELD VANE<br>● QUICK TRIAXIAL    × LAB VANE |  |          |  |  |
| 61.1          |  |            |         |      |              |                            |                 | 20 40 60 80 100  |  | 20 40 60 |  |  |
| 0.0           | ASPHALT: (200mm)   |            |         |      |              |                            | 61              |  |  |          |  |  |
| 0.2           | Gravelly SAND, some silt<br>Brown<br>Moist<br>(FILL)   |            | 1       | AS   |              |                            |                 |  |  |          |  |  |
| 60.3          |  |            |         |      |              |                            |                 |  |  |          |  |  |
| 0.8           | Sandy SILT, some clay, trace gravel<br>Compact to Very Dense<br>Brown to Grey<br>Moist<br>(TILL)   |            | 2       | SS   | 45           |                            | 60              |  |  |          |  |  |
|               |  |            | 3       | SS   | 64/<br>0.275 |                            |                 |  |  |          |  | 0 24 59 17   |
|               |  |            | 4       | SS   | 27           |                            |                 |  |  |          |  |  |
|               |  |            | 5       | SS   | 19           |                            |                 |  |  |          |  |  |
|               | Difficult augering from 4.0m   |            |         |      |              |                            |                 |  |  |          |  |  |
| 56.5          | Shale fragments  |            | 6       | SS   | 50/<br>0.00  |                            |                 |  |  |          |  |  |
| 4.6           | END OF BOREHOLE AT 4.6m ON<br>PROBABLE BEDROCK.<br>Piezometer installation consists of<br>19mm diameter Schedule 40 PVC pipe<br>with a 3.05m slotted screen.<br><br>WATER LEVEL READINGS:<br>DATE      DEPTH (m)      ELEV. (m)<br>Jul. 26/11      3.5      57.6<br>Aug. 18/11      3.5      57.6<br>Oct. 12/11      2.7      58.4 |            |         |      |              |                            |                 |  |  |          |  |  |

+<sup>3</sup> ×<sup>3</sup>: Numbers refer to  
Sensitivity 20  
15 10 5 0 (%) STRAIN AT FAILURE

## METRIC

[illegible]

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CTW-1

2 OF 2

METRIC

W.P. 4320-06-00 LOCATION N 5 031 386.6 E 371 185.5 ORIGINATED BY GA  
HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2012.05.02 - 2012.05.02 CHECKED BY LRB

| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |                   | PLASTIC<br>LIMIT | NATURAL<br>MOISTURE<br>CONTENT | LIQUID<br>LIMIT | 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 (%) |                  |                                |                 |   |  |
| 50.9          | Continued From Previous Page   |            |         |      |            |                            |                 |   |                   |                  |                                |                 |   |  |
| 10.1          | END OF BOREHOLE AT 10.1m.<br>BOREHOLE OPEN AND DRY PRIOR<br>TO CORING.<br>Piezometer installation consists of<br>19mm diameter Schedule 40 PVC pipe<br>with a 1.52m slotted screen.<br><br>WATER LEVEL READINGS:<br>DATE DEPTH (m) ELEV. (m)<br>May03/ 12 0.3 60.7 |            |         |      |            |                            |                 |   |                   |                  |                                |                 |   |  |



# RECORD OF BOREHOLE No CTW-2

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 395.1 E 371 258.6 ORIGINATED BY GA  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2012.05.02 - 2012.05.03 CHECKED BY LRB

| 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<br>○ UNCONFINED    + FIELD VANE<br>● QUICK TRIAXIAL    × LAB VANE |  |                                    |                                     |                                   |  |  |
| 61.0          |   |            |         |      |            |                            |                 | 20 40 60 80 100  |  |                                    |                                     |                                   |  |  |
| 0.0           | ASPHALT: (100mm)  |            |         |      |            |                            |                 |  |  |                                    |                                     |                                   |  |  |
| 0.1           | SAND, some silt, trace gravel<br>Compact<br>Brown   |            | 1       | SS   | 22         |                            |                 |  |  |                                    |                                     |                                   |  |  |
| 60.4          | Dry<br>(FILL)   |            |         |      |            |                            |                 |  |  |                                    |                                     |                                   |  |  |
| 0.6           | Sandy SILT, some clay to clayey,<br>trace gravel<br>Compact to Loose<br>Grey<br>(TILL)  |            | 2       | SS   | 21         |                            |                 |  |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |            |                            |                 |  |  |                                    |                                     |                                   |  |  |
|               |   |            | 3       | SS   | 24         |                            |                 |  |  |                                    |                                     |                                   |  | 1 26 51 22   |
|               |   |            |         |      |            |                            |                 |  |  |                                    |                                     |                                   |  |  |
|               |   |            | 4       | SS   | 14         |                            |                 |  |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |            |                            |                 |  |  |                                    |                                     |                                   |  |  |
|               |   |            | 5       | SS   | 7          |                            |                 |  |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |            |                            |                 |  |  |                                    |                                     |                                   |  |  |
| 56.9          |   |            |         |      |            |                            |                 |  |  |                                    |                                     |                                   |  |  |
| 4.1           | SHALE, fresh, thinly bedded, grey,<br>occasional limestone interbeds  |            |         |      |            |                            |                 |  |  |                                    |                                     |                                   | FI                                       |  |
|               | Limestone interbed at 4.3m, 4.5m,<br>4.7m, 5.1m, 5.4m, 5.6m   |            | 1       | RUN  |            |                            |                 |  |  |                                    |                                     |                                   | 2  | RUN #1<br>TCR=93%<br>SCR=87%<br>RQD=87%<br>UCS=20MPa<br>(average)    |
|               | Horizontal joint at 4.3m, 4.4m  |            |         |      |            |                            |                 |  |  |                                    |                                     |                                   | 2  |  |
|               | Highly broken zone at 4.9m, 5.0m  |            |         |      |            |                            |                 |  |  |                                    |                                     |                                   | 0  |  |
|               |   |            |         |      |            |                            |                 |  |  |                                    |                                     |                                   | 0  |  |
|               | Limestone interbed at 6.0m, 6.2m,<br>6.3m, 6.8m, 6.9m   |            | 2       | RUN  |            |                            |                 |  |  |                                    |                                     |                                   | 0  | RUN #2<br>TCR=100%<br>SCR=100%<br>RQD=100%<br>UCS=15MPa<br>(average) |
|               |   |            |         |      |            |                            |                 |  |  |                                    |                                     |                                   | 0  |  |
|               |   |            |         |      |            |                            |                 |  |  |                                    |                                     |                                   | 0  |  |
| 53.9          |   |            |         |      |            |                            |                 |  |  |                                    |                                     |                                   | 0  |  |
| 7.1           | END OF BOREHOLE AT 7.1m.<br>BOREHOLE OPEN AND DRY PRIOR<br>TO CORING.<br>BOREHOLE BACKFILLED WITH<br>BENTONITE HOLEPLUG FROM 7.0m<br>TO 0.3m, CONCRETE FROM 0.3m<br>TO 0.15m, THEN ASPHALT TO<br>SURFACE. |            |         |      |            |                            |                 |  |  |                                    |                                     |                                   |  |  |

ONTMT4S 1201B.GPJ 5/15/12

# RECORD OF BOREHOLE No OHS-07L

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 391.4 E 371 216.4 ORIGINATED BY RK  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2012 03 14 - 2012 03 14 CHECKED BY LRB

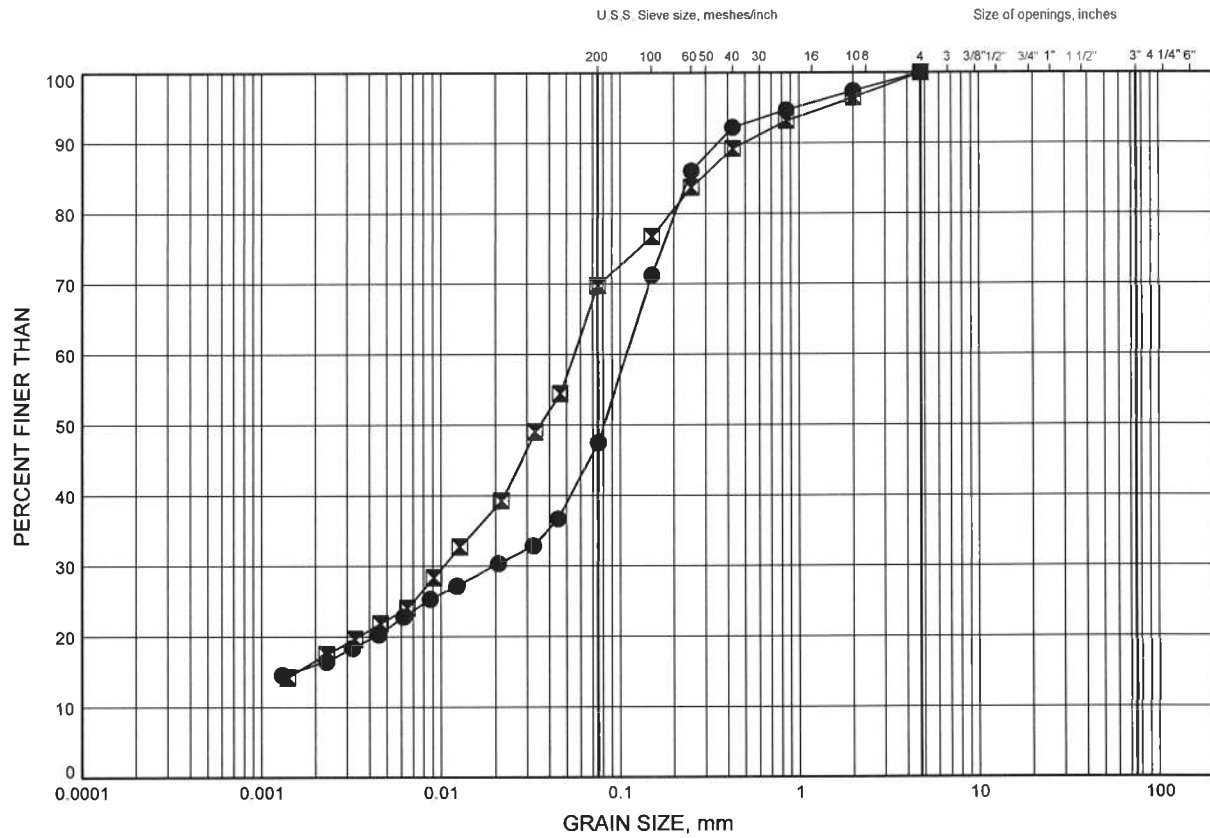
| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |                                   | PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT |              |                   | UNIT<br>WEIGHT<br><br>γ | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|---|-----------------------------------|---|--------------|-------------------|-------------------------|---|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | 20   40   60   80   100                     | W <sub>P</sub> W   W <sub>L</sub> | WATER CONTENT (%)                                       | 20   40   60 | kN/m <sup>3</sup> |                         |   |
| 60.9          |  |            |         |      |            |                            |                 |   |                                   |   |              |                   |                         |   |
| 0.0           | ASPHALT: (150mm)   |            |         |      |            |                            |                 |   |                                   |   |              |                   |                         |   |
| 0.2           | Gravelly SAND<br>Brown<br>Moist<br>(FILL)  |            |         |      |            |                            |                 |   |                                   |   |              |                   |                         |   |
| 59.8          |  |            | 1       | SS   | 10         |                            |                 |   |                                   |   |              |                   |                         |   |
| 1.1           | Clayey SILT, some sand, some gravel<br>Stiff<br>Dark Grey<br>(FILL)  |            |         |      |            |                            |                 |   |                                   |   |              |                   |                         |   |
| 59.4          |  |            | 2       | SS   | 38         |                            |                 |   |                                   |   |              |                   |                         | 0   30   53   17                                  |
| 1.5           | Sandy SILT, some clay<br>Dense to Compact<br>Dark Grey<br>Damp<br>(FILL)   |            |         |      |            |                            |                 |   |                                   |   |              |                   |                         |   |
|               |  |            | 3       | SS   | 13         |                            |                 |   |                                   |   |              |                   |                         |   |
| 58.0          |  |            |         |      |            |                            |                 |   |                                   |   |              |                   |                         |   |
| 2.9           | Sandy SILT, some clay, trace gravel<br>Compact<br>Dark Grey<br>Damp to Moist<br>(TILL)   |            | 4       | SS   | 20         |                            |                 |   |                                   |   |              |                   |                         |   |
|               |  |            |         |      |            |                            |                 |   |                                   |   |              |                   |                         |   |
|               |  |            |         |      |            |                            |                 |   |                                   |   |              |                   |                         |   |
|               |  |            | 5       | SS   | 14         |                            |                 |   |                                   |   |              |                   |                         |   |
|               |  |            |         |      |            |                            |                 |   |                                   |   |              |                   |                         |   |
| 54.8          |  |            |         |      |            |                            |                 |   |                                   |   |              |                   |                         |   |
| 6.1           | END OF BOREHOLE AT 6.1m.<br>Piezometer installation consists of<br>19mm diameter Schedule 40 PVC pipe<br>with a 1.52m slotted screen.<br><br>WATER LEVEL READINGS:<br>DATE      DEPTH (m)    ELEV. (m)<br>Mar 22/12    2.2        58.7 |            | 6       | SS   | 50/<br>150 |                            |                 |   |                                   |   |              |                   |                         |   |

+ 3 x 3 Numbers refer to  
Sensitivity 20  
15 5  
10 (%) STRAIN AT FAILURE

# Highway 417 Ottawa: Vanier to OR 174 GRAIN SIZE DISTRIBUTION

FIGURE E1

## Sandy Silt to Silty Sand Fill



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

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | CTW-1    | 1.07      | 59.93     |
| ⊠      | OHS-07L  | 1.83      | 59.07     |

Date May 2012  
W.P.# 4320-06-00

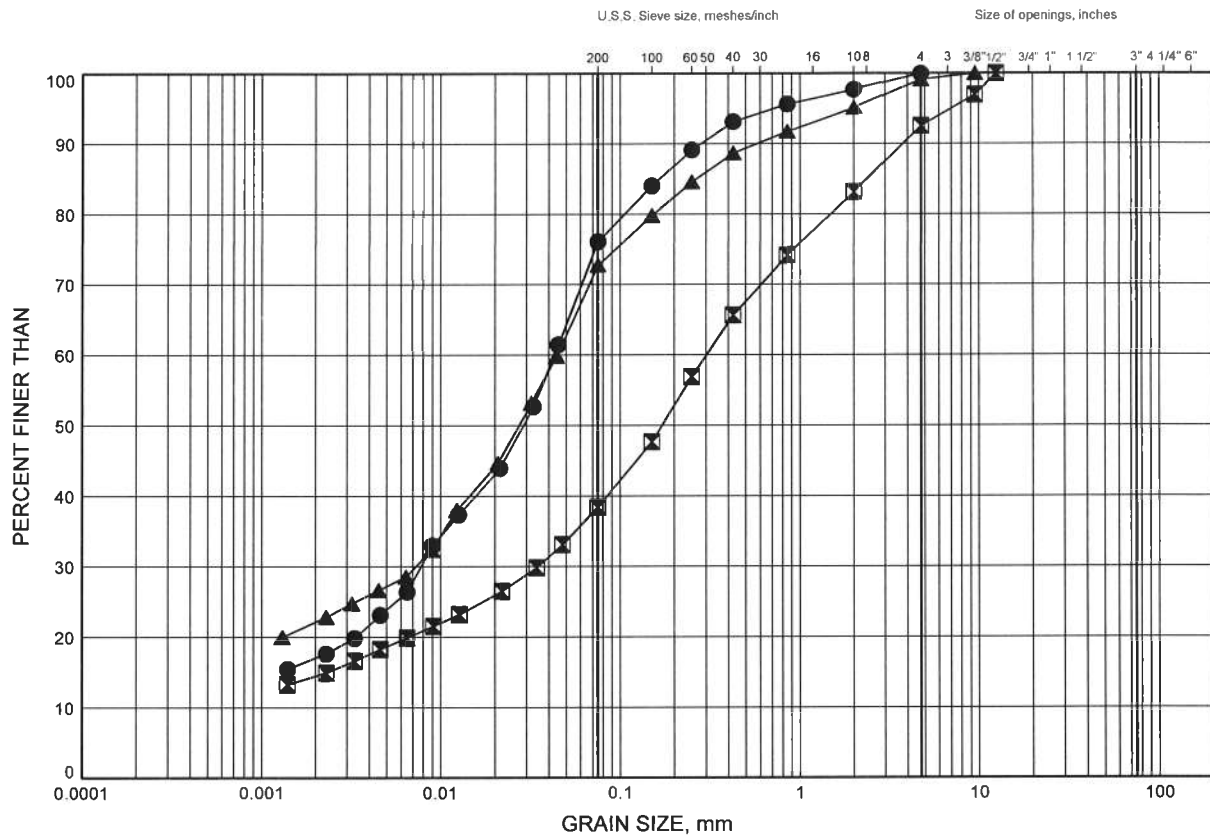


Prep'd MFA  
Chkd. LRB

# Highway 417 Ottawa: Vanier to OR 174 GRAIN SIZE DISTRIBUTION

FIGURE E2

## Sandy Silt to Silty Sand Till



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

### LEGEND

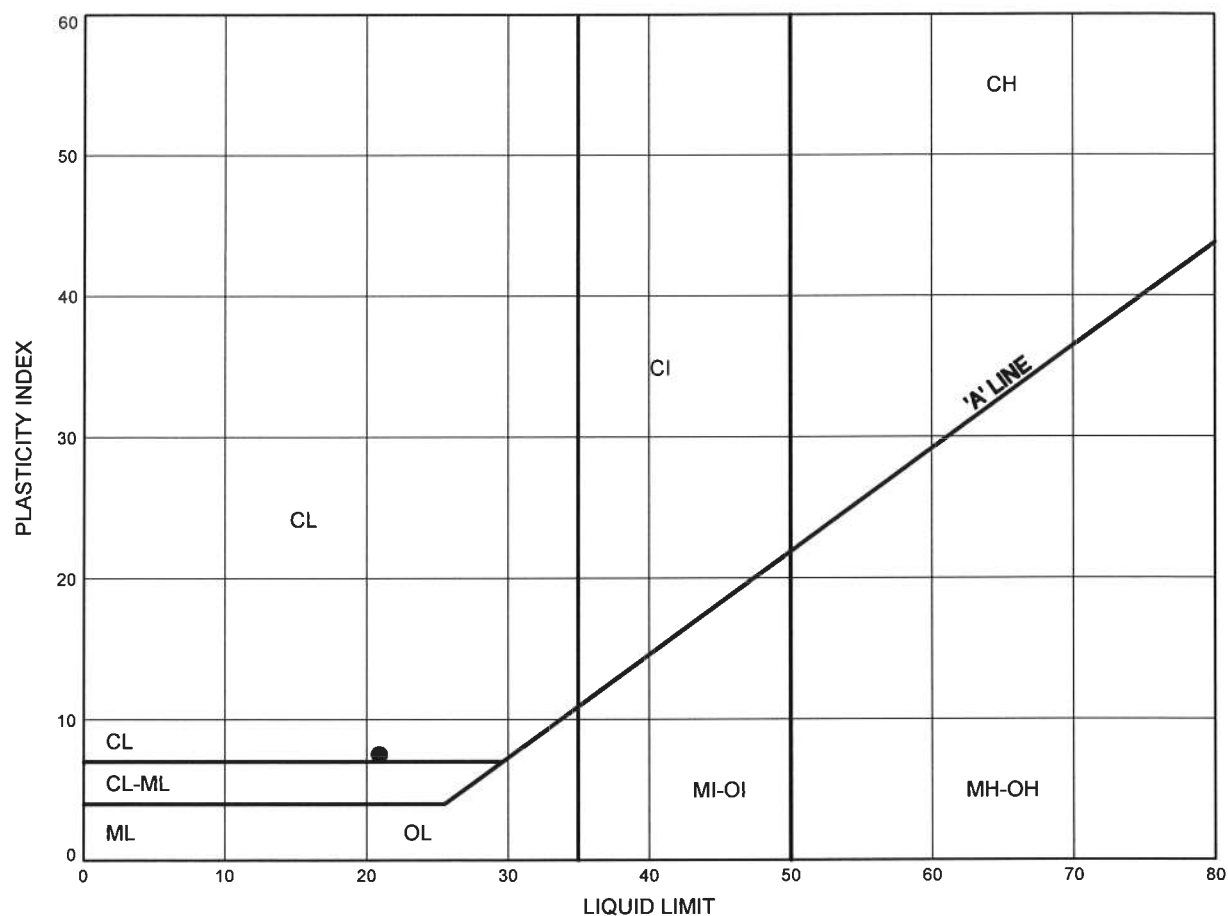
| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 15N-01   | 1.74      | 59.36     |
| ■      | CTW-1    | 4.88      | 56.12     |
| ▲      | CTW-2    | 1.83      | 59.17     |

Highway 417 Ottawa: Vanier to OR 174

# ATTERBERG LIMITS TEST RESULTS

FIGURE E3

Sandy Silt Fill



## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | OHS-07L  | 1.83      | 59.07     |

Date May 2012  
W.P.# 4320-06-00

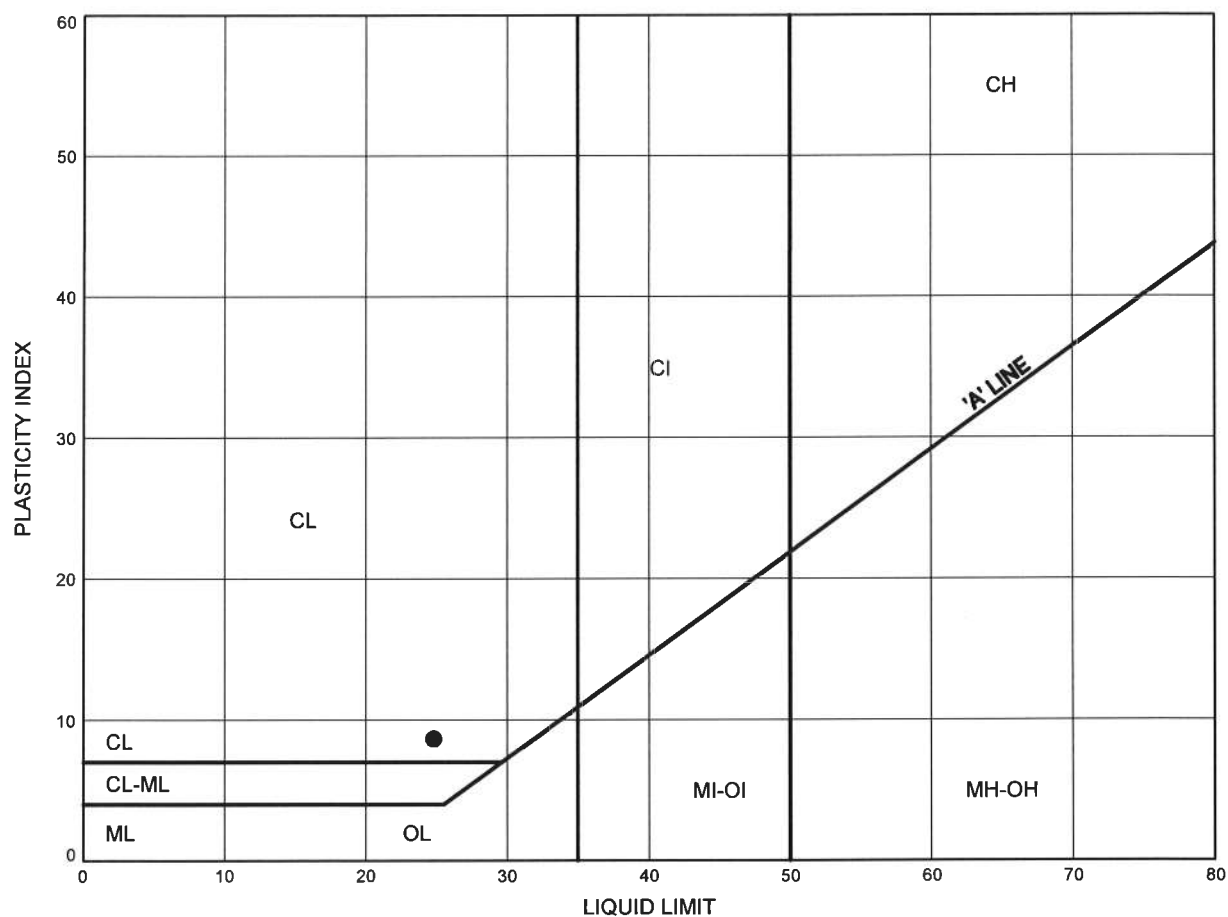


Prep'd MFA  
Chkd. LRB

# Highway 417 Ottawa: Vanier to OR 174 ATTERBERG LIMITS TEST RESULTS

FIGURE E4

Sandy Silt Till



### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 15N-01   | 1.74      | 59.36     |

Date May 2012  
W.P.# 4320-06-00



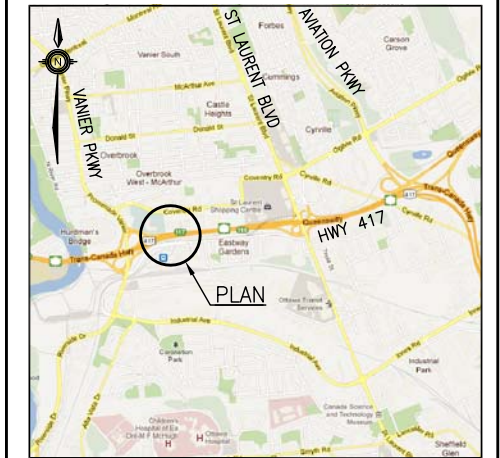
Prep'd MFA  
Chkd. LRB

METRIC

DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN






|                  |
|------------------|
| CONT No          |
| WP No 4320-06-00 |

|  |  |
|--|--|
| <p>HIGHWAY 417<br/>CANADIAN TIRE WALL<br/>VANIER TO BELFAST NORTH<br/>BOREHOLE LOCATIONS AND SOIL STRATA</p> |  |
|--|--|



## KEYPLAN

### LEGEND

- |   |                                       |
|---|---------------------------------------|
|  | Borehole                              |
|  | Borehole and Cone                     |
| N   | Blows /0.3m (Std Pen Test, 475J/blow) |
| CONE  | Blows /0.3m (60° Cone, 475J/blow)     |
| PH  | Pressure, Hydraulic                   |
|  | Water Level                           |
|  | Head Artesian Water                   |
|  | Piezometer                            |
| 90%   | Rock Quality Designation (RQD)        |
| A/R   | Auger Refusal                         |

| NO      | ELEVATION | NORTHING    | EASTING   |
|---------|-----------|-------------|-----------|
| CTW-1   | 61.0      | 5 031 386.6 | 371 185.5 |
| CTW-2   | 61.0      | 5 031 395.1 | 371 258.6 |
| 15N-01  | 61.1      | 5 031 400.9 | 371 304.1 |
| OHS-07L | 60.9      | 5 031 391.4 | 371 216.4 |

-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

**GEOCRES No. 31G5-250**



SANDY SILT TO SILTY SAND TILL  
SOME CLAY TO CLAYEY, TRACE GRAVEL  
Very Dense to Loose

## PROFILE

H 1:1000

V 1:200

[illegible]

## **Appendix F**

### **Belfast Road (North) - Wall 15N**

#### **Boreholes 15N-01 to 15N-12**



# RECORD OF BOREHOLE No 15N-01

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 400.9 E 371 304.1 ORIGINATED BY LPG  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.07.25 - 2011.07.25 CHECKED BY LRB

| SOIL PROFILE  |  |            | SAMPLES |      |              | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |                                     |                                   | UNIT<br>WEIGHT<br><br>γ<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 (%)                           |                                     |                                   |  |  |
|               |  |            |         |      |              |                            |                 |   |                                     |                                   |  |  |
| 61.1          |  |            |         |      |              |                            | 20 40 60 80 100 | PLASTIC LIMIT<br>w <sub>p</sub>             | NATURAL<br>MOISTURE<br>CONTENT<br>w | LIQUID<br>LIMIT<br>w <sub>L</sub> |  |  |
| 0.0           | ASPHALT: (200mm)   |            |         |      |              |                            |                 |   |                                     |                                   |  |  |
| 0.2           | Gravelly SAND, some silt<br>Brown<br>Moist<br>(FILL)   |            | 1       | AS   |              |                            |                 |   |                                     |                                   |  |  |
| 60.3          |  |            |         |      |              |                            |                 |   |                                     |                                   |  |  |
| 0.8           | Sandy SILT, some clay, trace gravel<br>Compact to Very Dense<br>Brown to Grey<br>Moist<br>(TILL)   |            | 2       | SS   | 45           |                            |                 |   |                                     |                                   |  |  |
|               |  |            |         |      |              |                            |                 |   |                                     |                                   |  |  |
|               |  |            | 3       | SS   | 64/<br>0.275 |                            |                 |   |                                     |                                   |  |  |
|               |  |            |         |      |              |                            |                 |   |                                     |                                   |  |  |
|               |  |            | 4       | SS   | 27           |                            |                 |   |                                     |                                   |  |  |
|               |  |            |         |      |              |                            |                 |   |                                     |                                   |  |  |
|               |  |            | 5       | SS   | 19           |                            |                 |   |                                     |                                   |  |  |
|               |  |            |         |      |              |                            |                 |   |                                     |                                   |  |  |
|               | Difficult augering from 4.0m   |            |         |      |              |                            |                 |   |                                     |                                   |  |  |
|               |  |            |         |      |              |                            |                 |   |                                     |                                   |  |  |
| 56.5          | Shale fragments  |            | 6       | SS   | 50/<br>0.00  |                            |                 |   |                                     |                                   |  |  |
| 4.6           | END OF BOREHOLE AT 4.6m ON<br>PROBABLE BEDROCK.<br>Piezometer installation consists of<br>19mm diameter Schedule 40 PVC pipe<br>with a 3.05m slotted screen.<br><br>WATER LEVEL READINGS:<br>DATE DEPTH (m) ELEV. (m)<br>Jul. 26/11 3.5 57.6<br>Aug. 18/11 3.5 57.6<br>Oct. 12/11 2.7 58.4 |            |         |      |              |                            |                 |   |                                     |                                   |  |  |

RECORD OF BOREHOLE No 15N-02

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 408.5 E 371 370.3 ORIGINATED BY LPG  
HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2011.07.25 - 2011.07.25 CHECKED BY LRB

| SOIL PROFILE  |  |            | SAMPLES |      |              | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  | PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT |                   |  | UNIT<br>WEIGHT<br><br>γ<br><br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |
|---------------|--|------------|---------|------|--------------|----------------------------|-----------------|---|--|---|-------------------|--|--|---|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES   |                            |                 | 20   40   60   80   100                     | W <sub>P</sub> W                      W <sub>L</sub> | 20   40   60  | GR   SA   SI   CL |  |  |   |
| 61.5          |  |            |         |      |              |                            |                 |   |  |   |                   |  |  |   |
| 0.0           | ASPHALT: (200mm)   |            |         |      |              |                            |                 |   |  |   |                   |  |  |   |
| 0.2           | Gravelly SAND, some silt<br>Brown<br>Moist<br>(FILL)   |            | 1       | AS   |              |                            |                 |   |  |   |                   |  |  |   |
| 60.7          |  |            |         |      |              |                            |                 |   |  |   |                   |  |  |   |
| 0.8           | Sandy SILT, trace gravel, trace clay<br>Very Dense to Dense<br>Brown<br>Moist to Wet<br>(FILL)   |            | 2       | SS   | 56           |                            |                 |   |  |   |                   |  |  | 2   25   70   3                                   |
|               |  |            |         |      |              |                            |                 |   |  |   |                   |  |  |   |
|               |  |            | 3       | SS   | 33           |                            |                 |   |  |   |                   |  |  |   |
| 59.3          |  |            |         |      |              |                            |                 |   |  |   |                   |  |  |   |
| 2.2           | Sandy, Clayey SILT, trace gravel<br>Compact to Very Dense<br>Brown to Grey<br>Moist<br>(TILL)  |            | 4       | SS   | 17           |                            |                 |   |  |   |                   |  |  |   |
|               |  |            |         |      |              |                            |                 |   |  |   |                   |  |  |   |
|               |  |            | 5       | SS   | 30           |                            |                 |   |  |   |                   |  |  | 1   29   48   22                                  |
|               |  |            |         |      |              |                            |                 |   |  |   |                   |  |  |   |
|               | Shale fragments at 4.6m  |            | 6       | SS   | 50/<br>0.075 |                            |                 |   |  |   |                   |  |  |   |
|               | Difficult augering   |            |         |      |              |                            |                 |   |  |   |                   |  |  |   |
|               |  |            |         |      |              |                            |                 |   |  |   |                   |  |  |   |
|               |  |            | 7       | SS   | 93/<br>0.250 |                            |                 |   |  |   |                   |  |  |   |
| 55.8          |  |            |         |      |              |                            |                 |   |  |   |                   |  |  |   |
| 5.7           | END OF BOREHOLE AT 5.7m ON<br>PROBABLE BEDROCK.<br>BOREHOLE BACKFILLED WITH<br>CUTTINGS AND BENTONITE<br>HOLEPLUG TO 0.2m, THEN<br>ASPHALT COLD PATCH TO<br>SURFACE. |            |         |      |              |                            |                 |   |  |   |                   |  |  |   |

## METRIC

| SOIL PROFILE  |  |            |        |      |              | SAMPLES |
|---------------|--|------------|--------|------|--------------|---------|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER | TYPE | "N" VALUES   |         |
| 61.9<br>0.0   | ASPHALT: (150mm)   | [Pattern]  |        |      |              |         |
| 0.2           | Gravelly SAND, some silt<br>Brown<br>Moist<br>(FILL)   | [Pattern]  | 1      | AS   |              |         |
| 61.1<br>0.8   | SILT, some sand to sandy, some clay, trace gravel<br>Dense to Very Dense<br>Grey<br>Moist<br>(FILL)  | [Pattern]  | 2      | SS   | 48           |         |
|               |  |            | 3      | SS   | 50/<br>0.025 |         |
| 59.6          |  |            |        |      |              |         |
| 2.3           | Sandy SILT, some clay, trace gravel<br>Dense to Very Dense<br>Dark Grey<br>Moist<br>(TILL)<br><br>Auger grinding at 3.5m, 4.0m and 4.3m  | [Pattern]  | 4      | SS   | 43           |         |
|               |  |            | 5      | SS   | 65           |         |
|               |  |            |        |      |              |         |
|               |  |            | 6      | SS   | 50/<br>0.125 |         |
|               |  |            |        |      |              |         |
| 56.4          | Shale fragments  | [Pattern]  | 7      | SS   | 50/<br>0.075 |         |
| 5.5           | END OF BOREHOLE AT 5.5m ON PROBABLE BEDROCK.<br>Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.<br><br>WATER LEVEL READINGS:<br>DATE      DEPTH (m)    ELEV. (m)<br>July 26/ 11     1.8        60.1<br>Aug. 18/ 11     1.8        60.1<br>Oct. 12/ 11     2.0        59.9 |            |        |      |              |         |

RECORD OF BOREHOLE No 15N-04

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 423.0 E 371 508.4 ORIGINATED BY LPG  
HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2011.07.23 - 2011.07.23 CHECKED BY LRB

| SOIL PROFILE  |  |            | SAMPLES |      |             | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT  |    |    | 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    × LAB VANE |    |    |   |  | WATER CONTENT (%)<br>w <sub>p</sub> w                      w <sub>L</sub> |  |  |  |  |  |  |
| 62.3          |  |            |         |      |             |                            |                 | 20   | 40 | 60 | 80  | 100  |   |  |  |  |  |  |  |
| 0.0           | ASPHALT: (200mm)   |            |         |      |             |                            |                 |  |    |    |   |  |   |  |  |  |  |  |  |
| 0.2           | Gravelly SAND, some silt   |            | 1       | AS   |             |                            | 62              |  |    |    |   |  |   |  |  |  |  |  |  |
| 61.5          | Brown Moist (FILL)   |            |         |      |             |                            |                 |  |    |    |   |  |   |  |  |  |  |  |  |
| 0.8           | Silty SAND, trace gravel<br>Compact to Dense<br>Brown Moist (FILL)   |            | 2       | SS   | 17          |                            |                 | 61   |    |    |   |  |   |  |  |  |  |  |  |
|               |  |            | 3       | SS   | 41          |                            |                 |  |    |    |   |  |   |  |  |  |  |  |  |
| 60.1          |  |            |         |      |             |                            | 60              |  |    |    |   |  |   |  |  |  |  |  |  |
| 2.2           | Silty SAND, trace gravel, trace clay,<br>trace shale fragments<br>Very Dense<br>Dark Grey<br>Moist (TILL)                                      |            | 4       | SS   | 58          |                            |                 |  |    |    |   |  |   |  |  |  |  |  |  |
|               |  |            | 5       | SS   | 50/<br>0.15 |                            | 59              |  |    |    |   |  |   |  |  |  |  |  |  |
|               | Difficult augering at 4.1m   |            |         |      |             |                            | 58              |  |    |    |   |  |   |  |  |  |  |  |  |
| 57.7          |  |            |         |      |             |                            |                 |  |    |    |   |  |   |  |  |  |  |  |  |
| 54.6          | SHALE, slightly weathered  |            | 6       | SS   | 50/         |                            |                 |  |    |    |   |  |   |  |  |  |  |  |  |
| 4.7           | END OF BOREHOLE AT 4.7m.<br>BOREHOLE BACKFILLED WITH<br>BENTONITE HOLEPLUG AND<br>CUTTINGS TO 0.15m, THEN<br>ASPHALT COLD PATCH TO<br>SURFACE. |            |         |      | 0.075       |                            |                 |  |    |    |   |  |   |  |  |  |  |  |  |

+ <sup>3</sup> . <sup>3</sup> : Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

## METRIC

| SOIL PROFILE   |           |   | SAMPLES     |        | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT |            | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT |    |    | UNIT WEIGHT | REMARKS & GRAIN SIZE DISTRIBUTION (%) |    |     |                |           |                |             |     |      |             |     |      |             |     |      |
|--|-----------|---|-------------|--------|-------------------------|-----------------|--|------------|---|----|----|-------------|---------------------------------------|----|-----|----------------|-----------|----------------|-------------|-----|------|-------------|-----|------|-------------|-----|------|
| ELEV. (m)  | DEPTH (m) | DESCRIPTION   | STRAT. PLOT | NUMBER |                         |                 | TYPE                                     | "N" VALUES | 20  | 40 | 60 |             |                                       | 80 | 100 | W <sub>P</sub> | W         | W <sub>L</sub> |             |     |      |             |     |      |             |     |      |
| 62.8   | 0.0       | ASPHALT: (200mm)  |             |        |                         |                 |  |            |   |    |    |             |                                       |    |     |                |           |                |             |     |      |             |     |      |             |     |      |
| 62.0   | 0.2       | Gravelly SAND, some silt<br>Brown<br>Moist<br>(FILL)  |             | 1      | AS                      |                 |  |            |   |    |    |             |                                       |    |     |                |           |                |             |     |      |             |     |      |             |     |      |
| 62.0   | 0.8       | Silty SAND, some gravel, trace clay,<br>occasional cobbles<br>Dense<br>Brown<br>Moist<br>(FILL) |             | 2      | SS                      | 36              |  |            |   |    |    |             |                                       |    |     |                |           |                |             |     |      |             |     |      |             |     |      |
| 60.6   | 2.2       | Silty SAND, trace gravel<br>Very Dense<br>Dark Grey<br>Moist to Wet<br>(TILL)                   |             | 3      | SS                      | 47              |  |            |   |    |    |             |                                       |    |     |                |           |                |             |     |      |             |     |      |             |     |      |
|  |           |   |             | 4      | SS                      | 64              |  |            |   |    |    |             |                                       |    |     |                |           |                |             |     |      |             |     |      |             |     |      |
|  |           |   |             | 5      | SS                      | 50/<br>0.075    |  |            |   |    |    |             |                                       |    |     |                |           |                |             |     |      |             |     |      |             |     |      |
|  |           |   |             | 6      | SS                      | 50/<br>0.025    |  |            |   |    |    |             |                                       |    |     |                |           |                |             |     |      |             |     |      |             |     |      |
| 57.4   | 5.4       | SHALE, slightly weathered   |             | 7      | SS                      | 50/<br>0.025    |  |            |   |    |    |             |                                       |    |     |                |           |                |             |     |      |             |     |      |             |     |      |
| <p>END OF BOREHOLE AT 5.4m.<br/>Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.</p> <p>WATER LEVEL READINGS:</p> <table border="1"> <thead> <tr> <th>DATE</th> <th>DEPTH (m)</th> <th>ELEV. (m)</th> </tr> </thead> <tbody> <tr> <td>July 26/ 11</td> <td>2.9</td> <td>59.9</td> </tr> <tr> <td>Aug. 18/ 11</td> <td>3.0</td> <td>59.8</td> </tr> <tr> <td>Oct. 12/ 11</td> <td>3.2</td> <td>59.6</td> </tr> </tbody> </table> |           |   |             |        |                         |                 |  |            |   |    |    |             |                                       |    |     | DATE           | DEPTH (m) | ELEV. (m)      | July 26/ 11 | 2.9 | 59.9 | Aug. 18/ 11 | 3.0 | 59.8 | Oct. 12/ 11 | 3.2 | 59.6 |
| DATE   | DEPTH (m) | ELEV. (m)   |             |        |                         |                 |  |            |   |    |    |             |                                       |    |     |                |           |                |             |     |      |             |     |      |             |     |      |
| July 26/ 11  | 2.9       | 59.9  |             |        |                         |                 |  |            |   |    |    |             |                                       |    |     |                |           |                |             |     |      |             |     |      |             |     |      |
| Aug. 18/ 11  | 3.0       | 59.8  |             |        |                         |                 |  |            |   |    |    |             |                                       |    |     |                |           |                |             |     |      |             |     |      |             |     |      |
| Oct. 12/ 11  | 3.2       | 59.6  |             |        |                         |                 |  |            |   |    |    |             |                                       |    |     |                |           |                |             |     |      |             |     |      |             |     |      |



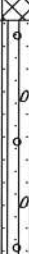

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 15N-06

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 437.9 E 371 639.5 ORIGINATED BY LPG  
HWY 417 BOREHOLE TYPE Hollow Stern Augers COMPILED BY AN  
DATUM Geodetic DATE 2011.07.23 - 2011.07.23 CHECKED BY LRB

| 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                          |  |  |  |                                    |                                     |                                   |  |  |
| 63.7          |  |  |         |      |              |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
| 0.0           | ASPHALT: (200mm)   |  |         |      |              |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
| 0.2           | Gravelly SAND, some silt   |   | 1       | AS   |              |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
| 62.9          | Brown<br>Moist<br>(FILL)   |  |         |      |              |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
| 0.8           | Sandy SILT, trace gravel   |   | 2       | SS   | 44           |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
| 62.3          | Dense<br>Brown<br>Moist<br>(FILL)  |  |         |      |              |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
| 1.4           | Sandy SILT, trace clay, trace gravel   |   | 3       | SS   | 35           |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
|               | Dense to Very Dense<br>Brown<br>Moist<br>(TILL)  |  |         |      |              |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
|               |  |  |         | 4    | SS           | 85/<br>0.250               |                 |   |  |  |  |                                    |                                     |                                   |  |  |
| 60.7          |  |  |         |      |              |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
| 3.0           | Silty SAND, trace gravel   |  | 5       | SS   | 88           |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
|               | Very Dense<br>Dark Grey<br>Moist<br>(TILL)   |  |         |      |              |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
| 59.1          |  |  |         |      |              |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
| 58.9          | SHALE, slightly weathered  |  | 6       | SS   | 60/<br>0.025 |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
| 4.6           | END OF BOREHOLE AT 4.6m.<br>BOREHOLE BACKFILLED WITH<br>CUTTINGS AND BENTONITE<br>HOLEPLUG TO 0.15m, THEN<br>ASPHALT COLD PATCH TO<br>SURFACE. |  |         |      |              |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |

+ <sup>3</sup> , X <sup>3</sup> : Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 15N-07

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 446.5 E 371 715.3 ORIGINATED BY LPG  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2011.07.22 - 2011.07.22 CHECKED BY LRB

| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |  |  | 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                          |  |  |  |   |   |
| 64.5          |  |            |         |      |            |                            |                 | 20 40 60 80 100                             |  |  |  |   |   |
| 0.0           | ASPHALT: (200mm)   |            |         |      |            |                            |                 | 20 40 60 80 100                             |  |  |  |   |   |
| 0.2           | Gravelly SAND, some silt<br>Brown<br>Moist<br>(FILL.)  |            | 1       | AS   |            |                            | 64              |   |  |  |  |   |   |
| 63.6          |  |            |         |      |            |                            |                 |   |  |  |  |   |   |
| 0.9           | Silty SAND, trace gravel, trace clay,<br>occasional shale fragments<br>Dense to Very Dense<br>Dark Grey<br>Moist<br>(TILL)           |            | 2       | SS   | 32         |                            | 63              |   |  |  |  |   |   |
|               |  |            |         |      |            |                            |                 |   |  |  |  |   |   |
|               |  |            | 3       | SS   | 52         |                            | 62              |   |  |  |  |   |   |
|               |  |            |         |      |            |                            |                 |   |  |  |  |   |   |
|               |  |            | 4       | SS   | 45         |                            | 61              |   |  |  |  |   |   |
| 61.5          |  |            |         |      |            |                            |                 |   |  |  |  |   |   |
| 3.0           | SHALE, slightly weathered to fresh,<br>laminated, very thin limestone<br>interbeds through out, grey                                 |            | 1       | RUN  |            |                            | 60              |   |  |  |  |   |   |
|               | Highly fractured   |            |         |      |            |                            | 59              |   |  |  |  |   |   |
|               |  |            |         |      |            |                            |                 |   |  |  |  |   |   |
|               |  |            | 2       | RUN  |            |                            |                 |   |  |  |  |   |   |
|               |  |            |         |      |            |                            |                 |   |  |  |  |   |   |
|               |  |            | 3       | RUN  |            |                            |                 |   |  |  |  |   |   |
| 58.1          |  |            |         |      |            |                            |                 |   |  |  |  |   |   |
| 6.4           | END OF BOREHOLE AT 6.4m.<br>Piezometer installation consists of<br>19mm diameter Schedule 40 PVC pipe<br>with a 3.0m slotted screen. |            |         |      |            |                            |                 |   |  |  |  |   |   |
|               | WATER LEVEL READINGS:<br>DATE DEPTH (m) ELEV. (m)<br>July26/ 11 3.6 60.9<br>Aug.18/ 11 3.5 61.0<br>Oct.12/ 11 4.0 60.5               |            |         |      |            |                            |                 |   |  |  |  |   |   |

+ 3, x 3 : Numbers refer to  
Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 15N-08

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 454.8 E 371 789.9 ORIGINATED BY LPG  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2011.07.19 - 2011.07.19 CHECKED BY LRB

| SOIL PROFILE  |   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT                          |  |  | UNIT<br>WEIGHT<br><br>$\gamma$<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   |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 | <div><div><div></div><div></div></div></div> <div>○ UNCONFINED</div> | <div><div><div></div><div></div></div></div> <div>+ FIELD VANE</div> | <div><div><div></div><div></div></div></div> <div>× LAB VANE</div> |   |  |  |  |  |  |  |  |  |
| 65.4          |   |            |         |      |            |                            | 20              | 40   | 60   | 80   | 100   |  |  |  |  |  |  |  |  |
| 0.0           | ASPHALT: (150mm)  |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
| 0.2           | Gravelly SAND, some silt<br>Brown<br>Moist<br>(FILL)  |            | 1       | AS   |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
| 64.6          |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
| 0.8           | Sandy SILT, shale fragments<br>Very Dense<br>Grey<br>Moist<br>(TILL)  |            | 2       | SS   | 58         |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
| 64.0          |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
| 1.4           | SHALE, slightly weathered,<br>laminated, very thin limestone<br>interbeds through out, grey<br><br>Highly fractured |            | 1       | RUN  |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |   |  |  |  |  |  |  |  |  |



RECORD OF BOREHOLE No 15N-09

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 463.0 E 371 862.8 ORIGINATED BY LPG  
HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2011.07.19 - 2011.07.19 CHECKED BY LRB

| SOIL PROFILE  |             |  | SAMPLES |      |              | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |              |                  | UNIT<br>WEIGHT<br><br>γ<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 | ● QUICK TRIAXIAL |  |  | × LAB VANE        | w <sub>p</sub> | w | w <sub>L</sub>   |  |
| 66.2          |             |  |         |      |              |                            | 20              | 40  | 60           | 80               | 100  | 20   | 40                | 60             |   |  |  |
| 0.0           |             |  |         |      |              |                            |                 |   |              |                  |  |  |                   |                |   |  |  |
| 65.9          |             | ASPHALT: (250mm)   |         |      |              |                            |                 |   |              |                  |  |  |                   |                |   |  |  |
| 0.3           |             | Gravelly SAND, some silt, trace clay<br>Brown<br>Moist<br>Moist to Wet<br>(FILL)   | 1       | AS   |              |                            |                 |   |              |                  |  |  |                   |                |   | 27 50 17 6   |  |
| 65.1          |             |  | 2       | SS   | 62/<br>0.225 |                            |                 |   |              |                  |  |  |                   |                |   |  |  |
| 1.1           |             | SHALE, fresh, laminated, very thin<br>limestone interbeds through out, grey<br><br>Moderately fractured, horizontally<br>bedded  | 1       | RUN  |              |                            |                 |   |              |                  |  |  |                   |                |   | RUN #1<br>TCR=100%<br>SCR=82%<br>RQD=50%<br>UCS=27MPa<br>(Average) |  |
|               |             |  | 2       | RUN  |              |                            |                 |   |              |                  |  |  |                   |                |   | RUN #2<br>TCR=100%<br>SCR=98%<br>RQD=93%<br>UCS=25MPa<br>(Average) |  |
| 61.9          |             |  |         |      |              |                            |                 |   |              |                  |  |  |                   |                |   |  |  |
| 4.3           |             | END OF BOREHOLE AT 4.3m.<br>Piezometer installation consists of<br>19mm diameter Schedule 40 PVC pipe<br>with a 2.1m slotted screen.<br><br>WATER LEVEL READINGS:<br>DATE      DEPTH (m)      ELEV. (m)<br>July26/ 11      2.2      64.0<br>Aug.18/ 11      2.2      64.0<br>Oct.12/ 11      2.5      63.5 |         |      |              |                            |                 |   |              |                  |  |  |                   |                |   |  |  |

# RECORD OF BOREHOLE No 15N-10

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 471.3 E 371 938.1 ORIGINATED BY LPG  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2011.07.19 - 2011.07.19 CHECKED BY LRB

| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |  |  | PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT |  |  | UNIT<br>WEIGHT<br><br>γ<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                     |  |  |  |   |  |  |  |  |
|               |  |            |         |      |            |                            |                 | ○ UNCONFINED      + FIELD VANE              |  |  |  |   |  |  |  |  |
|               |  |            |         |      |            |                            |                 | ● QUICK TRIAXIAL      × LAB VANE            |  |  |  |   |  |  |  |  |
|               |  |            |         |      |            |                            |                 |   |  |  |  |   |  |  |  |  |
| 67.1          |  |            |         |      |            |                            |                 |   |  |  |  |   |  |  |  |  |
| 0.0           | ASPHALT: (300mm)   |            |         |      |            |                            | 67              |   |  |  |  |   |  |  |  |  |
| 66.8          |  |            |         |      |            |                            |                 |   |  |  |  |   |  |  |  |  |
| 0.3           | Gravelly SAND, some silt   |            | 1       | AS   |            |                            |                 |   |  |  |  |   |  |  |  |  |
| 66.3          | Grey   |            |         |      |            |                            |                 |   |  |  |  |   |  |  |  |  |
| 0.8           | Moist  |            |         |      |            |                            |                 |   |  |  |  |   |  |  |  |  |
|               | (FILL)   |            |         |      |            |                            |                 |   |  |  |  |   |  |  |  |  |
|               | SILT, some sand, trace gravel, shale   |            | 2       | SS   | 60         |                            | 66              |   |  |  |  |   |  |  |  |  |
|               | fragments  |            |         |      |            |                            |                 |   |  |  |  |   |  |  |  |  |
|               | Very Dense   |            |         |      |            |                            |                 |   |  |  |  |   |  |  |  |  |
| 65.6          | Brown  |            |         |      |            |                            |                 |   |  |  |  |   |  |  |  |  |
| 1.5           | Moist  |            | 3       | SS   | 50         |                            |                 |   |  |  |  |   |  |  |  |  |
|               | (TILL)   |            |         |      | 0.075      |                            |                 |   |  |  |  |   |  |  |  |  |
|               | SHALE, slightly weathered,   |            | 1       | RUN  |            |                            | 65              |   |  |  |  |   |  |  |  |  |
|               | laminated, very thin limestone   |            |         |      |            |                            |                 |   |  |  |  |   |  |  |  |  |
|               | interbeds through out, grey  |            |         |      |            |                            |                 |   |  |  |  |   |  |  |  |  |
|               |  |            |         |      |            |                            |                 |   |  |  |  |   |  |  |  |  |
|               | Highly fractured from 3.3m to 4.2m   |            | 2       | RUN  |            |                            | 64              |   |  |  |  |   |  |  |  |  |
|               |  |            |         |      |            |                            |                 |   |  |  |  |   |  |  |  |  |
|               |  |            |         |      |            |                            |                 |   |  |  |  |   |  |  |  |  |
|               | Highly fractured from 4.4m to 4.9m   |            | 3       | RUN  |            |                            | 63              |   |  |  |  |   |  |  |  |  |
|               |  |            |         |      |            |                            |                 |   |  |  |  |   |  |  |  |  |
| 62.2          |  |            |         |      |            |                            |                 |   |  |  |  |   |  |  |  |  |
| 4.9           | END OF BOREHOLE AT 4.9m.<br>BOREHOLE BACKFILLED WITH<br>CUTTINGS AND BENTONITE<br>HOLEPLUG TO 0.15m, THEN<br>ASPHALT COLD PATCH TO<br>SURFACE. |            |         |      |            |                            |                 |   |  |  |  |   |  |  |  |  |

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 15N-11

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 481.3 E 372 014.7 ORIGINATED BY LPG  
HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2011.07.19 - 2011.07.19 CHECKED BY LRB

| SOIL PROFILE  |   |            | SAMPLES |      |              | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT                        |    |    | PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT |    |    | UNIT<br>WEIGHT<br><br>γ<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      x LAB VANE |    |    |   |    |    |  |  |  |  |
| 67.9          |   |            |         |      |              |                            | 20              | 40   | 60 | 80 | 100   | 20 | 40 | 60   |  |  |  |
| 0.0           | ASPHALT: (150mm)  |            |         |      |              |                            |                 |  |    |    |   |    |    |  |  |  |  |
| 0.2           | SAND, some gravel, some silt<br>Brown<br>Moist<br>(FILL)  |            | 1       | AS   |              |                            |                 |  |    |    |   |    |    |  |  |  |  |
| 67.1          |   |            |         |      |              |                            |                 |  |    |    |   |    |    |  |  |  |  |
| 0.8           | Silty SAND, trace gravel, trace clay<br>Very Dense<br>Brown<br>Moist<br>(TILL)  |            | 2       | SS   | 75           |                            |                 |  |    |    |   |    |    |  |  |  |  |
|               |   |            |         |      |              |                            |                 |  |    |    |   |    |    |  |  |  |  |
|               |   |            | 3       | SS   | 50/<br>0.075 |                            |                 |  |    |    |   |    |    |  |  | 4   62   27   6  |  |
| 65.6          |   |            |         |      |              |                            |                 |  |    |    |   |    |    |  |  |  |  |
|               |   |            | 4       | SS   | 50/<br>0.00  |                            |                 |  |    |    |   |    |    |  |  |  |  |
| 2.3           | SHALE, fresh, laminated, very thin<br>limestone interbeds through out, grey   |            |         |      |              |                            |                 |  |    |    |   |    |    |  |  |  |  |
|               |   |            | 1       | RUN  |              |                            |                 |  |    |    |   |    |    |  |  | RUN #1<br>TCR=100%<br>SCR=98%<br>RQD=83%<br>UCS=14MPa<br>(Average) |  |
|               |   |            |         |      |              |                            |                 |  |    |    |   |    |    |  |  |  |  |
|               |   |            | 2       | RUN  |              |                            |                 |  |    |    |   |    |    |  |  | RUN #2<br>TCR=100%<br>SCR=78%<br>RQD=67%<br>UCS=19MPa<br>(Average) |  |
|               | Highly fractured zone from 5.0m to<br>5.3m  |            |         |      |              |                            |                 |  |    |    |   |    |    |  |  |  |  |
| 62.3          |   |            |         |      |              |                            |                 |  |    |    |   |    |    |  |  |  |  |
| 5.6           | END OF BOREHOLE AT 5.6m.<br>Piezometer installation consists of<br>19mm diameter Schedule 40 PVC pipe<br>with a 3.0m slotted screen.<br><br>WATER LEVEL READINGS:<br>DATE      DEPTH (m)      ELEV. (m)<br>July 26/ 11      4.1      63.8<br>Aug. 18/ 11      4.1      63.8<br>Oct. 12/ 11      4.2      63.7 |            |         |      |              |                            |                 |  |    |    |   |    |    |  |  |  |  |

+ 3, x 3: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 15N-12

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 493.3 E 372 089.6 ORIGINATED BY LPG  
HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2011.07.22 - 2011.07.22 CHECKED BY LRB

| 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<br>○ UNCONFINED + FIELD VANE<br>● QUICK TRIAXIAL × LAB VANE |    |    |                                    |                                     |                                   |  |  | WATER CONTENT (%) |  |
| 68.7          |  |            |         |      |              |                            |                 | 20   | 40 | 60 | 80                                 | 100                                 |                                   |  |  |                   |  |
| 0.0           | ASPHALT: (150mm)   |            |         |      |              |                            |                 |  |    |    |                                    |                                     |                                   |  |  |                   |  |
| 0.2           | SAND, some gravel, some silt<br>Grey<br>Moist<br>(FILL)  |            | 1       | AS   |              |                            |                 |  |    |    |                                    |                                     |                                   |  |  |                   |  |
| 67.9          |  |            |         |      |              |                            |                 |  |    |    |                                    |                                     |                                   |  |  |                   |  |
| 0.8           | Gravelly SAND, shale fragments<br>Dense<br>Brown<br>Moist<br>(FILL)  |            | 2       | SS   | 42           |                            |                 |  |    |    |                                    |                                     |                                   |  |  |                   |  |
| 67.2          |  |            |         |      |              |                            |                 |  |    |    |                                    |                                     |                                   |  |  |                   |  |
| 1.5           | Sandy SILT, trace gravel<br>Very Dense<br>(TILL)   |            | 3       | SS   | 50/<br>0.100 |                            |                 |  |    |    |                                    |                                     |                                   |  |  |                   |  |
|               |  |            | 1       | RUN  |              |                            |                 |  |    |    |                                    |                                     |                                   |  |  |                   |  |
| 66.0          |  |            |         |      |              |                            |                 |  |    |    |                                    |                                     |                                   |  |  |                   |  |
| 2.7           | SHALE, slightly weathered to fresh,<br>laminated, very thin limestone<br>interbeds through out, grey   |            |         |      |              |                            |                 |  |    |    |                                    |                                     |                                   |  |  |                   |  |
|               | Highly fractured zone from 3.3m to<br>3.8m   |            | 2       | RUN  |              |                            |                 |  |    |    |                                    |                                     |                                   |  |  |                   |  |
|               | 25mm thick limestone interbed at 3.9m  |            |         |      |              |                            |                 |  |    |    |                                    |                                     |                                   |  |  |                   |  |
|               | Limestone interbeds:<br>50mm at 4.3m<br>50mm at 5.1m<br>75mm at 5.5m   |            | 3       | RUN  |              |                            |                 |  |    |    |                                    |                                     |                                   |  |  |                   |  |
| 62.9          |  |            |         |      |              |                            |                 |  |    |    |                                    |                                     |                                   |  |  |                   |  |
| 5.8           | END OF BOREHOLE AT 5.8m.<br>BOREHOLE BACKFILLED WITH<br>CUTTINGS AND BENTONITE<br>HOLEPLUG TO 0.15m, THEN<br>ASPHALT COLD PATCH TO<br>SURFACE. |            |         |      |              |                            |                 |  |    |    |                                    |                                     |                                   |  |  |                   |  |

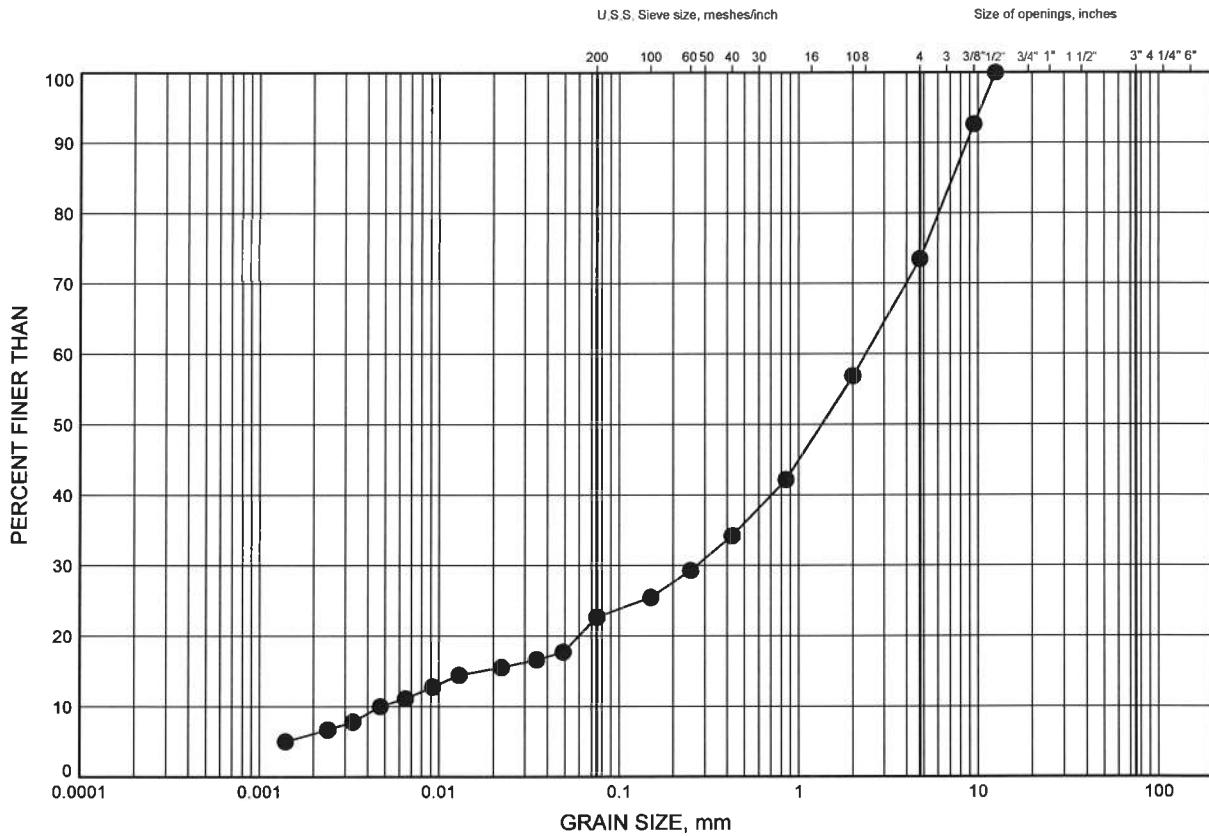
+<sup>3</sup>, X<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

# Highway 417 Ottawa: Nicholas Street to OR 174

## GRAIN SIZE DISTRIBUTION

FIGURE F1

### GRAVELLY SAND FILL



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

### LEGEND

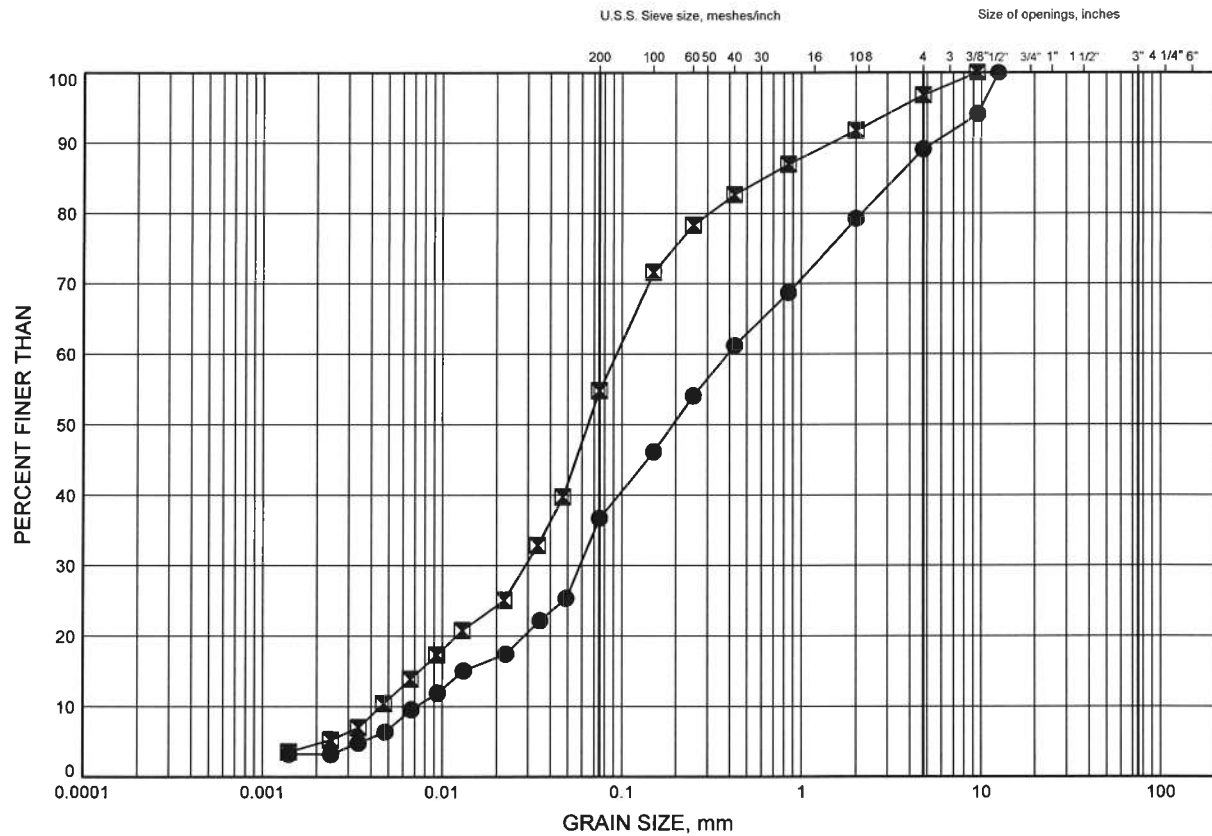
| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 15N-09   | 0.46      | 65.74     |

# Highway 417 Ottawa: Nicholas Street to OR 174

## GRAIN SIZE DISTRIBUTION

FIGURE F2

### SANDY SILT to SILTY SAND FILL



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

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 15N-05   | 1.83      | 60.94     |
| ⊠      | 15N-06   | 1.07      | 62.63     |



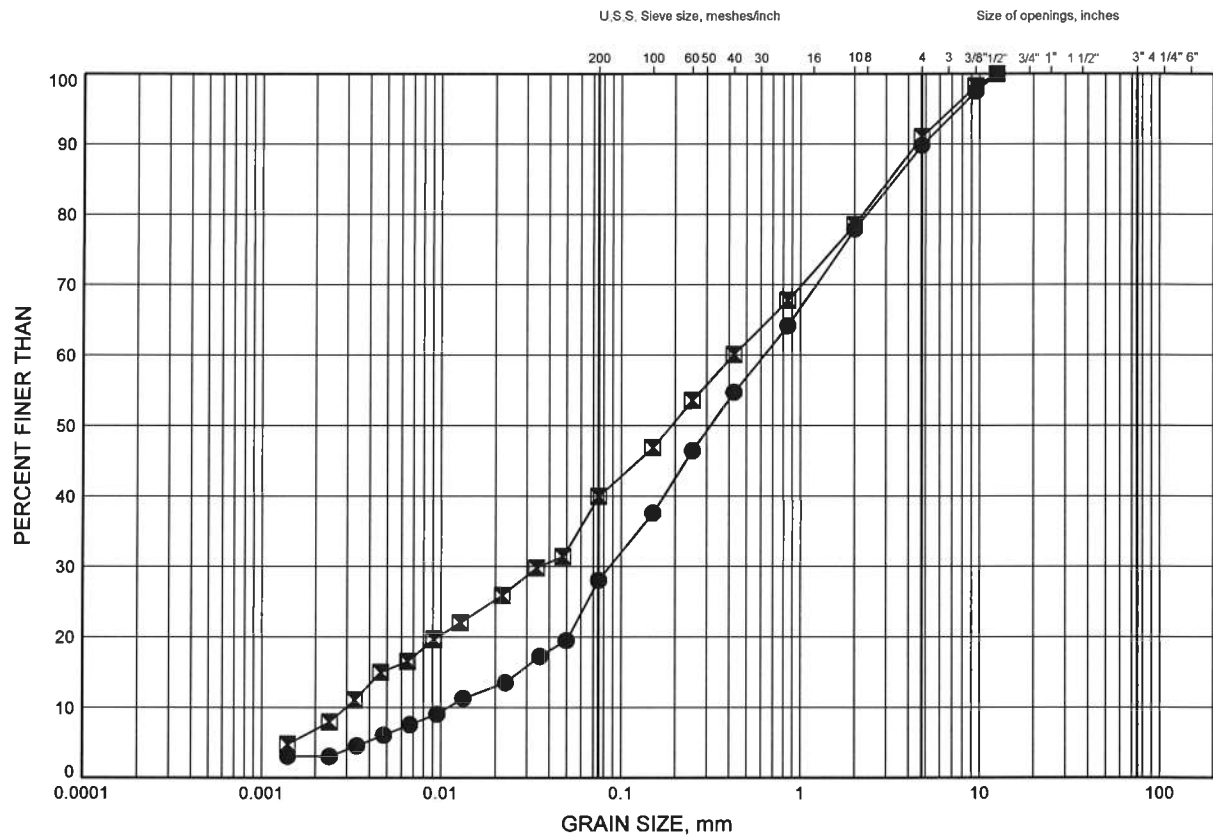
W.P.# 4320-06-00  
 Prepared By AN  
 Checked By LRB

# Highway 417 Ottawa: Nicholas Street to OR 174

## GRAIN SIZE DISTRIBUTION

FIGURE F3

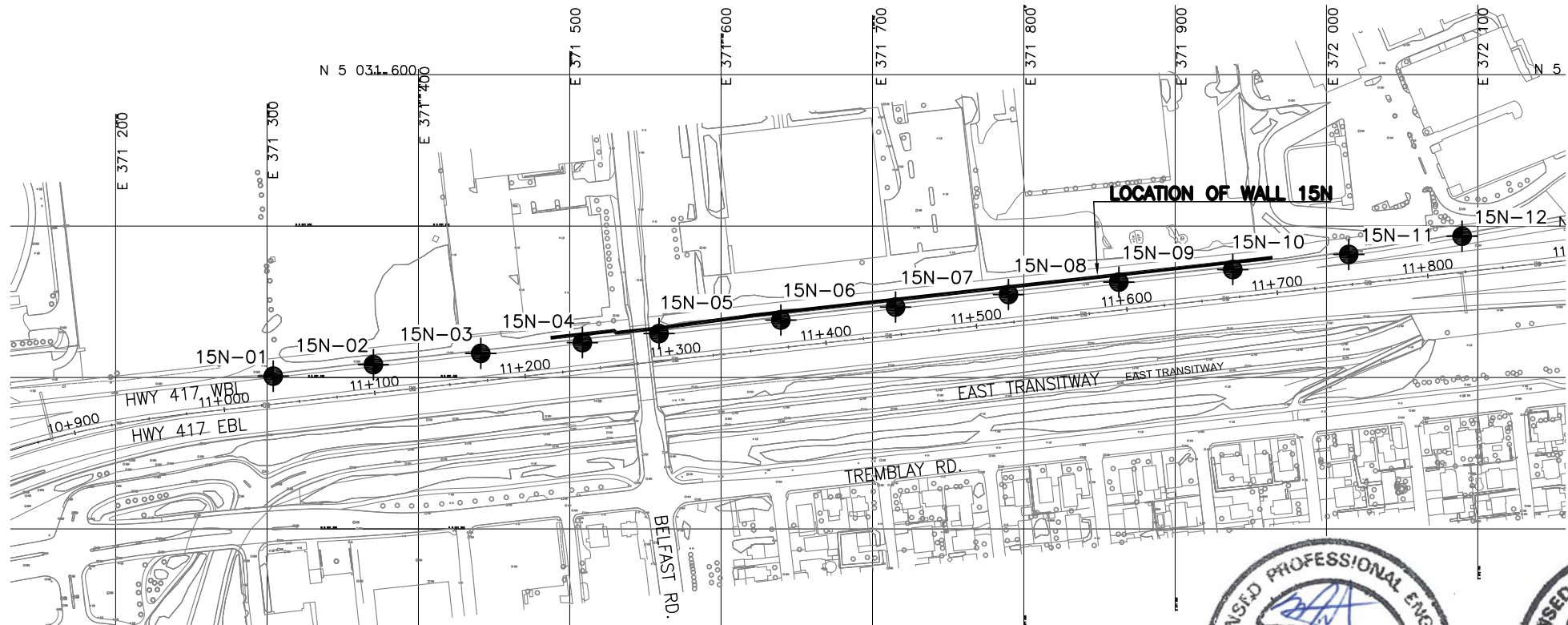
### SILTY SAND TILL



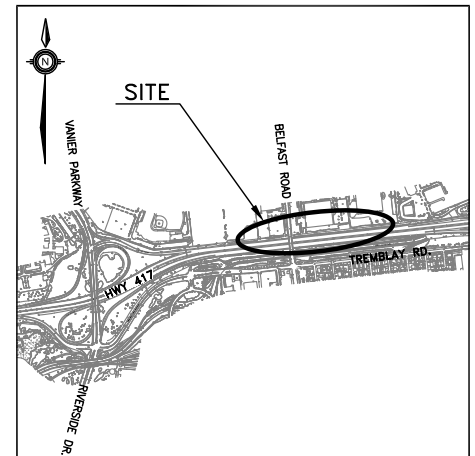
|               |      |        |        |        |        |             |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE   | COARSE | COBBLE SIZE |
| FINE GRAINED  | SAND |        |        | GRAVEL |        |             |

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 15N-04   | 2.59      | 59.68     |
| ◻      | 15N-07   | 2.59      | 61.95     |



PLAN



KEYPLAN

LEGEND

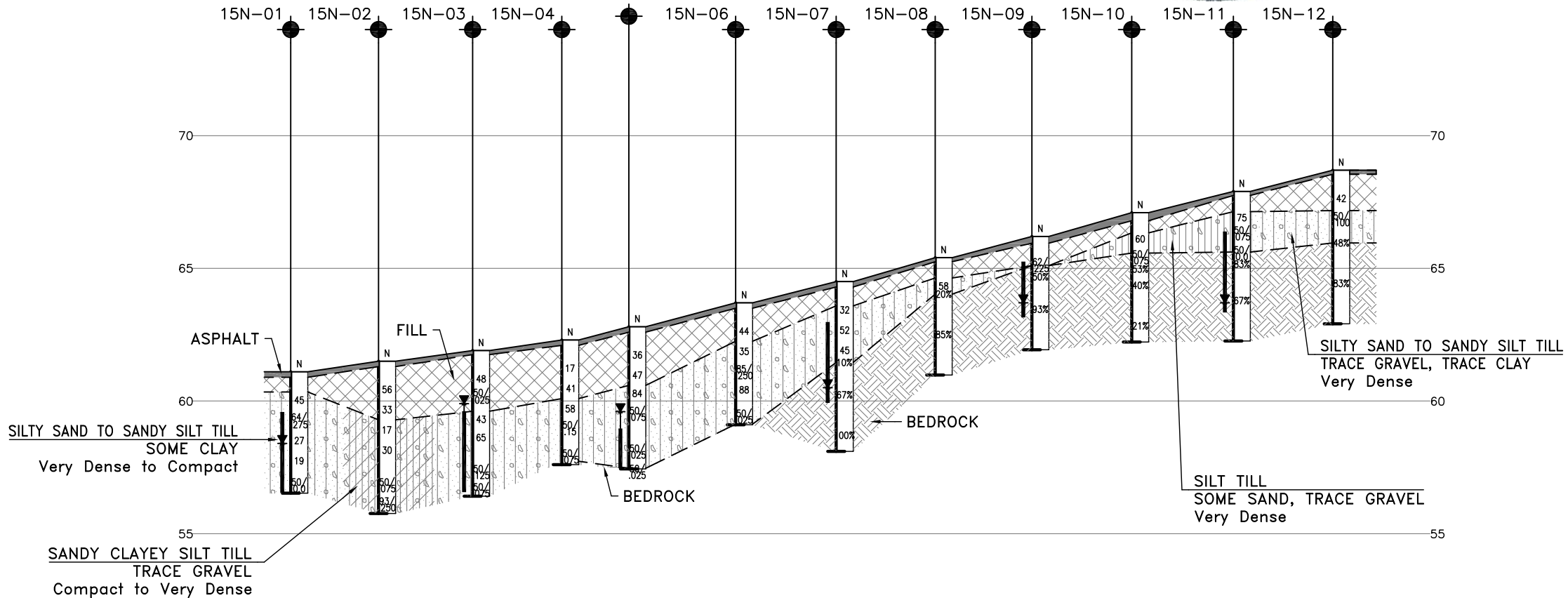
- Borehole
- Borehole and Cone
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60° Cone, 475J/blow)
- PH Pressure, Hydraulic
- Water Level
- Head Artesian Water
- Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

| NO     | ELEVATION | NORTHING    | EASTING   |
|--------|-----------|-------------|-----------|
| 15N-01 | 61.1      | 5 031 400.9 | 371 304.1 |
| 15N-02 | 61.5      | 5 031 408.5 | 371 370.3 |
| 15N-03 | 61.9      | 5 031 415.9 | 371 441.2 |
| 15N-04 | 62.3      | 5 031 423.0 | 371 508.4 |
| 15N-05 | 62.8      | 5 031 429.0 | 371 559.0 |
| 15N-06 | 63.7      | 5 031 437.9 | 371 639.5 |
| 15N-07 | 64.5      | 5 031 446.5 | 371 715.3 |
| 15N-08 | 65.4      | 5 031 454.8 | 371 789.9 |
| 15N-09 | 66.2      | 5 031 463.0 | 371 862.8 |
| 15N-10 | 67.1      | 5 031 471.3 | 371 938.1 |
| 15N-11 | 67.9      | 5 031 481.3 | 372 014.7 |
| 15N-12 | 68.7      | 5 031 493.3 | 372 089.6 |

NOTES

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 31G5-250



PROFILE

HOR. 1:4000

VER. 1:200

| REVISIONS | DATE | BY        | DESCRIPTION |
|-----------|------|-----------|-------------|
| DESIGN    | LRB  | CHK       | LRB         |
| DRAWN     | AN   | CHK       | PKC         |
| LOAD      | DATE | AUG. 2012 |             |
| STRUCT    | DWG  | 1         |             |




## **Appendix G**

### **Belfast Road (South) - Wall 23S**

#### **Boreholes 23S-01 to 23S-09**

## METRIC

| SOIL PROFILE |             |            | SAMPLES |      |            | GROUND WATER CONDITIONS | ELEVATION SCALE             | DYNAMIC CONE PENETRATION RESISTANCE PLOT  | PLASTIC LIMIT     | NATURAL MOISTURE CONTENT | LIQUID LIMIT   | UNIT WEIGHT<br>$\gamma$<br>kN/m <sup>3</sup> | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|--------------|-------------|------------|---------|------|------------|-------------------------|-----------------------------|---|-------------------|--------------------------|----------------|--|---------------------------------------|
| ELEV DEPTH   | DESCRIPTION | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                         |                             |  | w <sub>p</sub>    | w                        | w <sub>L</sub> |  |                                       |
|              |             |            |         |      |            |                         |                             | SHEAR STRENGTH kPa  | WATER CONTENT (%) |                          |                |  |                                       |
| 61.9         |             |            |         |      |            |                         | ○ UNCONFINED + FIELD VANE   |   |                   |                          |                |  |                                       |
|              |             |            |         |      |            |                         | ● QUICK TRIAXIAL × LAB VANE |   |                   |                          |                |  |                                       |
|              |             |            |         |      |            |                         | 20 40 60 80 100             | 20 40 60  |                   |                          |                | GR SA SI C                                   |                                       |

[illegible]

ONTMT4S 1201B.GPJ 5/14/12

+ 3, x 3 Numbers refer to Sensitivity

# RECORD OF BOREHOLE No 23S-02

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 390.0 E 371 540.9 ORIGINATED BY LPG  
HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2011.07.22 - 2011.07.22 CHECKED BY LRB

| SOIL PROFILE  |             |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT                                    |    |    | UNIT<br>WEIGHT<br>$\gamma$<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| ELEV<br>DEPTH | DESCRIPTION | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa<br>○ UNCONFINED + FIELD VANE<br>● QUICK TRIAXIAL x LAB VANE |    |    |   |   | WATER CONTENT (%)<br>w <sub>p</sub> w w <sub>L</sub> |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 62.5          |             |            |         |      |            |                            |                 | 20   | 40 | 60 | 80  | 100   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

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Sensitivity 20  
15 10 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 23S-03

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 398.2 E 371 615.1 ORIGINATED BY LPG  
HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2011.07.18 - 2011.07.18 CHECKED BY LRB

| SOIL PROFILE  |  |            | SAMPLES |      |              | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |    | 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                          |    |    |    |   |   |  |  |  |  |  |  |  |
| 63.2          |  |            |         |      |              |                            |                 | 20  | 40 | 60 | 80 | 100   |   |  |  |  |  |  |  |  |
| 0.0           | ASPHALT: (300mm)   |            |         |      |              |                            | 63              |   |    |    |    |   |   |  |  |  |  |  |  |  |
| 62.9          |  |            |         |      |              |                            |                 |   |    |    |    |   |   |  |  |  |  |  |  |  |
| 0.3           | SAND, some gravel, some silt<br>Brown<br>Moist<br>(FILL)   |            | 1       | AS   |              |                            |                 |   |    |    |    |   |   |  |  |  |  |  |  |  |
| 62.4          |  |            |         |      |              |                            |                 |   |    |    |    |   |   |  |  |  |  |  |  |  |
| 0.8           | Silty SAND, some clay, trace gravel<br>Dense to Very Dense<br>Dark Grey<br>Moist<br>(TILL)   |            | 2       | SS   | 34           |                            | 62              |   |    |    |    |   |   |  |  |  |  |  |  |  |
|               |  |            |         |      |              |                            |                 |   |    |    |    |   |   |  |  |  |  |  |  |  |
|               |  |            | 3       | SS   | 50           |                            |                 |   |    |    |    |   |   |  |  |  |  |  |  |  |
|               |  |            | 4       | SS   | 50/<br>0.075 |                            | 61              |   |    |    |    |   |   |  |  |  |  |  |  |  |
|               |  |            |         |      |              |                            |                 |   |    |    |    |   |   |  |  |  |  |  |  |  |
|               |  |            | 5       | SS   | 61           |                            | 60              |   |    |    |    |   |   |  |  |  |  |  |  |  |
|               |  |            |         |      |              |                            |                 |   |    |    |    |   |   |  |  |  |  |  |  |  |
|               |  |            |         |      |              |                            | 59              |   |    |    |    |   |   |  |  |  |  |  |  |  |
|               |  |            |         |      |              |                            |                 |   |    |    |    |   |   |  |  |  |  |  |  |  |
|               | Shale fragments from 5.0m to 5.8m  |            | 6       | SS   | 70/<br>0.275 |                            |                 |   |    |    |    |   |   |  |  |  |  |  |  |  |
|               | Highly fractured<br>Alternating layers of shale and till   |            | 1       | RUN  |              |                            | 58              |   |    |    |    |   |   |  |  |  |  |  |  |  |
| 57.4          |  |            |         |      |              |                            |                 |   |    |    |    |   |   |  |  |  |  |  |  |  |
| 5.8           | SHALE, slightly weathered,<br>laminated, grey, frequent limestone<br>interbeds, sub-horizontal bedding   |            | 2       | RUN  |              |                            | 57              |   |    |    |    |   |   |  |  |  |  |  |  |  |
|               |  |            |         |      |              |                            |                 |   |    |    |    |   |   |  |  |  |  |  |  |  |
|               | Highly fractured   |            |         |      |              |                            |                 |   |    |    |    |   |   |  |  |  |  |  |  |  |
|               |  |            |         |      |              |                            | 56              |   |    |    |    |   |   |  |  |  |  |  |  |  |
|               |  |            | 3       | RUN  |              |                            |                 |   |    |    |    |   |   |  |  |  |  |  |  |  |
|               |  |            |         |      |              |                            |                 |   |    |    |    |   |   |  |  |  |  |  |  |  |
|               |  |            |         |      |              |                            | 55              |   |    |    |    |   |   |  |  |  |  |  |  |  |
|               |  |            |         |      |              |                            |                 |   |    |    |    |   |   |  |  |  |  |  |  |  |
| 54.4          |  |            |         |      |              |                            |                 |   |    |    |    |   |   |  |  |  |  |  |  |  |
| 8.8           | END OF BOREHOLE AT 8.8m.<br>BOREHOLE BACKFILLED WITH<br>BENTONITE HOLEPLUG AND<br>CUTTINGS TO 0.15m, THEN<br>ASPHALT COLD PATCH TO<br>SURFACE. |            |         |      |              |                            |                 |   |    |    |    |   |   |  |  |  |  |  |  |  |

ONTMT4S 1201B GPJ 4/23/12

+ 3 x 3; Numbers refer to  
Sensitivity 20 15 10 5 10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 23S-04

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 405.8 E 371 683.8 ORIGINATED BY LPG  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2011.07.18 - 2011.07.18 CHECKED BY LRB

| SOIL PROFILE  |   | SAMPLES    |        |      | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |                    | PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT |                   |  | UNIT<br>WEIGHT<br><br>γ<br><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 (%) |  |  |  |
|               |   |            |        |      |                            |                 | 20 40 60 80 100                             | 20 40 60           |   |                   |  |  |  |
|               |   |            |        |      |                            |                 | ○ UNCONFINED   + FIELD VANE                 |                    |   |                   |  |  |  |
|               |   |            |        |      |                            |                 | ● QUICK TRIAXIAL   × LAB VANE               |                    |   |                   |  |  |  |
| 64.0          |   |            |        |      |                            |                 | 20 40 60 80 100                             | 20 40 60           |   |                   |  |  |  |
| 0.0           | ASPHALT: (300mm)  |            |        |      |                            |                 |   |                    |   |                   |  |  |  |
| 63.7          |   |            |        |      |                            |                 |   |                    |   |                   |  |  |  |
| 0.3           | Silty SAND, some gravel<br>Brown<br>Moist<br>(FILL)   |            | 1      | AS   |                            |                 |   |                    |   |                   |  |  |  |
| 63.2          |   |            |        |      |                            |                 |   |                    |   |                   |  |  |  |
| 0.8           | Silty SAND, some clay, some gravel/<br>Very Dense<br>Dark Grey<br>Moist<br>(TILL)   |            | 2      | SS   | 50/<br>0.125               |                 |   |                    |   |                   |  |  |  |
|               |   |            |        |      |                            |                 |   |                    |   |                   |  |  |  |
|               |   |            | 3      | SS   | 92/<br>0.275               |                 |   |                    |   |                   |  |  | 12 47 31 10  |
|               | No recovery   |            | 4      | SS   | 58                         |                 |   |                    |   |                   |  |  |  |
|               |   |            |        |      |                            |                 |   |                    |   |                   |  |  |  |
|               | Shale fragments   |            | 5      | SS   | 94/<br>0.175               |                 |   |                    |   |                   |  |  |  |
|               |   |            |        |      |                            |                 |   |                    |   |                   |  |  |  |
|               |   |            |        |      |                            |                 |   |                    |   |                   |  |  |  |
| 59.4          |   |            |        |      |                            |                 |   |                    |   |                   |  | FI   |  |
| 4.6           | SHALE, slightly weathered to fresh,<br>laminated, grey,<br>Highly fractured   |            | 1      | RUN  |                            |                 |   |                    |   |                   |  | >10<br>>10<br>>10<br>>10                         | RUN #1<br>TCR=100%<br>SCR=21%<br>RQD=8%<br>UCS=12MPa<br>(Average)  |
|               |   |            |        |      |                            |                 |   |                    |   |                   |  |  |  |
|               | Very thin limestone interbeds through<br>out  |            | 2      | RUN  |                            |                 |   |                    |   |                   |  | 0<br>1<br>3<br>2                                 | RUN #2<br>TCR=100%<br>SCR=88%<br>RQD=78%<br>UCS=11MPa<br>(Average) |
|               |   |            |        |      |                            |                 |   |                    |   |                   |  |  |  |
|               | Vertical fractures from 7.1m to 7.6m  |            | 3      | RUN  |                            |                 |   |                    |   |                   |  | >10<br>2<br>4                                    | RUN #3<br>TCR=100%<br>SCR=92%<br>RQD=38%<br>UCS=8MPa<br>(Average)  |
| 56.0          |   |            |        |      |                            |                 |   |                    |   |                   |  |  |  |
| 8.0           | END OF BOREHOLE AT 8.0m.<br>Piezometer installation consists of<br>19mm diameter Schedule 40 PVC pipe<br>with a 1.52m slotted screen.<br><br>WATER LEVEL READINGS:<br>DATE      DEPTH (m)      ELEV. (m)<br>Jul. 21/ 11      2.6      61.4<br>Jul. 26/ 11      2.5      61.5<br>Aug. 18/ 11      2.5      61.5<br>Oct.12/ 11      2.5      61.5<br>* Piezo likely plugged at 2.5m |            |        |      |                            |                 |   |                    |   |                   |  |  |  |

ONTMT4S 1201B GPJ 4/23/12

+<sup>3</sup> ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 23S-05

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 414.1 E 371 756.2 ORIGINATED BY LPG  
HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2011.07.20 - 2011.07.20 CHECKED BY LRB

| SOIL PROFILE  |  |            | SAMPLES |      |              | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |    | 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                          |    |    |    |   |   |  |
| 64.9          |  |            |         |      |              |                            |                 | 20  | 40 | 60 | 80 | 100   |   |  |
| 0.0           | ASPHALT: (250mm)   |            |         |      |              |                            |                 |   |    |    |    |   |   |  |
| 64.6          |  |            |         |      |              |                            |                 |   |    |    |    |   |   |  |
| 0.3           | Gravelly SAND, some silt<br>Brown<br>Moist<br>(FILL)   |            | 1       | AS   |              |                            |                 |   |    |    |    |   |   |  |
| 64.0          |  |            |         |      |              |                            |                 |   |    |    |    |   |   |  |
| 0.9           | Silty SAND, some clay, trace gravel<br>Dense to Very Dense<br>Dark Grey<br>Moist<br>(TILL)<br>Hydrocarbon smell  |            | 2       | SS   | 35           |                            | 64              |   |    |    |    |   |   |  |
|               |  |            |         |      |              |                            |                 |   |    |    |    |   |   |  |
|               |  |            | 3       | SS   | 77           |                            | 63              |   |    |    |    |   |   | 9 45 31 16   |
|               |  |            |         |      |              |                            |                 |   |    |    |    |   |   |  |
|               |  |            | 4       | SS   | 89/<br>0.180 |                            |                 |   |    |    |    |   |   |  |
| 62.2          |  |            |         |      |              |                            |                 |   |    |    |    |   |   |  |
| 2.7           | SHALE, slightly weathered,<br>sub-horizontally laminated, very thin<br>limestone interbeds through out, grey<br><br>Limestone interbeds:<br>75mm at 3.0m<br>25mm at 3.1m<br>25mm at 3.4m<br><br>Highly fractured |            | 1       | RUN  |              |                            | 62              |   |    |    |    |   |   | RUN #1<br>TCR=100%<br>SCR=82%<br>RQD=48%<br>UCS=14MPa<br>(Average) |
|               |  |            |         |      |              |                            | 61              |   |    |    |    |   |   | RUN #2<br>TCR=100%<br>SCR=77%<br>RQD=28%<br>UCS=19MPa<br>(Average) |
|               |  |            | 2       | RUN  |              |                            | 60              |   |    |    |    |   |   |  |
| 59.1          |  |            |         |      |              |                            |                 |   |    |    |    |   |   |  |
| 5.8           | END OF BOREHOLE AT 5.8m.<br>BOREHOLE BACKFILLED WITH<br>CUTTINGS AND BENTONITE<br>HOLEPLUG TO 0.15m, THEN<br>ASPHALT COLD PATCH TO<br>SURFACE.   |            |         |      |              |                            |                 |   |    |    |    |   |   |  |

## METRIC





[illegible]

RECORD OF BOREHOLE No 23S-07

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 430.4 E 371 905.6 ORIGINATED BY LPG  
HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2011.07.20 - 2011.07.20 CHECKED BY LRB

| SOIL PROFILE  |  |  | SAMPLES |      |              | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT                  |    |    | PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT |    |    | UNIT<br>WEIGHT<br><br>γ<br><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 (%)                                       |    |    |  |   |  |
|               |  |  |         |      |              |                            |                 | ○ UNCONFINED   + FIELD VANE<br>● QUICK TRIAXIAL   × LAB VANE |    |    |   |    |    |  |   |  |
| 66.6          |  |  |         |      |              |                            | 20              | 40   | 60 | 80 | 100   | 20 | 40 | 60   |   |  |
| 0.0           | ASPHALT: (150mm)   |   |         |      |              |                            |                 |  |    |    |   |    |    |  |   |  |
| 0.2           | Gravelly SAND, some silt<br>Brown<br>Moist<br>(FILL)   |   | 1       | AS   |              |                            |                 |  |    |    |   |    |    |  |   |  |
| 65.8          |  |  |         |      |              |                            |                 |  |    |    |   |    |    |  |   |  |
| 0.8           | Silty SAND, trace gravel, shale<br>fragments<br>Very Dense<br>Grey<br>Moist<br>(TILL)  |   | 1       | SS   | 63/<br>0.175 |                            |                 |  |    |    |   |    |    |  |   |  |
| 65.4          |  |  |         |      |              |                            |                 |  |    |    |   |    |    |  |   |  |
| 1.2           | SHALE, slightly weathered to fresh,<br>very thin limestone interbeds through<br>out, grey<br>Calcite infilled vertical fracture from<br>1.2m to 4.3m<br>25mm limestone interbeds at 2.2m |  | 1       | RUN  |              |                            |                 |  |    |    |   |    |    |  |   |  |
|               |  |  |         |      |              |                            |                 |  |    |    |   |    |    |  |   |  |
|               |  |  | 2       | RUN  |              |                            |                 |  |    |    |   |    |    |  |   |  |
|               |  |  |         |      |              |                            |                 |  |    |    |   |    |    |  |   |  |
| 62.3          |  |  |         |      |              |                            |                 |  |    |    |   |    |    |  |   |  |
| 4.3           | END OF BOREHOLE AT 4.3m.<br>BOREHOLE BACKFILLED WITH<br>CUTTINGS AND BENTONITE<br>HOLEPLUG TO 0.15m, THEN<br>ASPHALT COLD PATCH TO<br>SURFACE.   |  |         |      |              |                            |                 |  |    |    |   |    |    |  |   |  |

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No 23S-08

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 437.5 E 371 979.4 ORIGINATED BY LPG  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2011.07.20 - 2011.07.20 CHECKED BY LRB

| SOIL PROFILE  |   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    | PLASTIC<br>LIMIT | NATURAL<br>MOISTURE<br>CONTENT | LIQUID<br>LIMIT | UNIT<br>WEIGHT<br><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 (%) |
| 67.4          |   |            |         |      |            |                            |                 | 20  | 40 | 60 | 80               | 100                            |                 |   |   |                   |
| 0.0           | ASPHALT: (150mm)  |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
| 0.2           | Gravelly SAND, some silt<br>Brown<br>Moist<br>(FILL)                                |            | 1       | AS   |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
| 66.6          |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
| 0.8           | Silty SAND, trace gravel, shale<br>fragments<br>Compact<br>Grey<br>Moist<br>(TILL)  |            | 2       | SS   | 26         |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
| 66.2          |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
| 1.2           | SHALE, slightly weathered,<br>laminated, grey<br>Highly fractured from 1.2m to 1.9m |            | 1       | RUN  |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |
|               |   |            |         |      |            |                            |                 |   |    |    |                  |                                |                 |   |   |                   |

+<sup>3</sup> ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 23S-09

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 443.4 E 372 055.2 ORIGINATED BY LPG  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2011.07.21 - 2011.07.21 CHECKED BY LRB

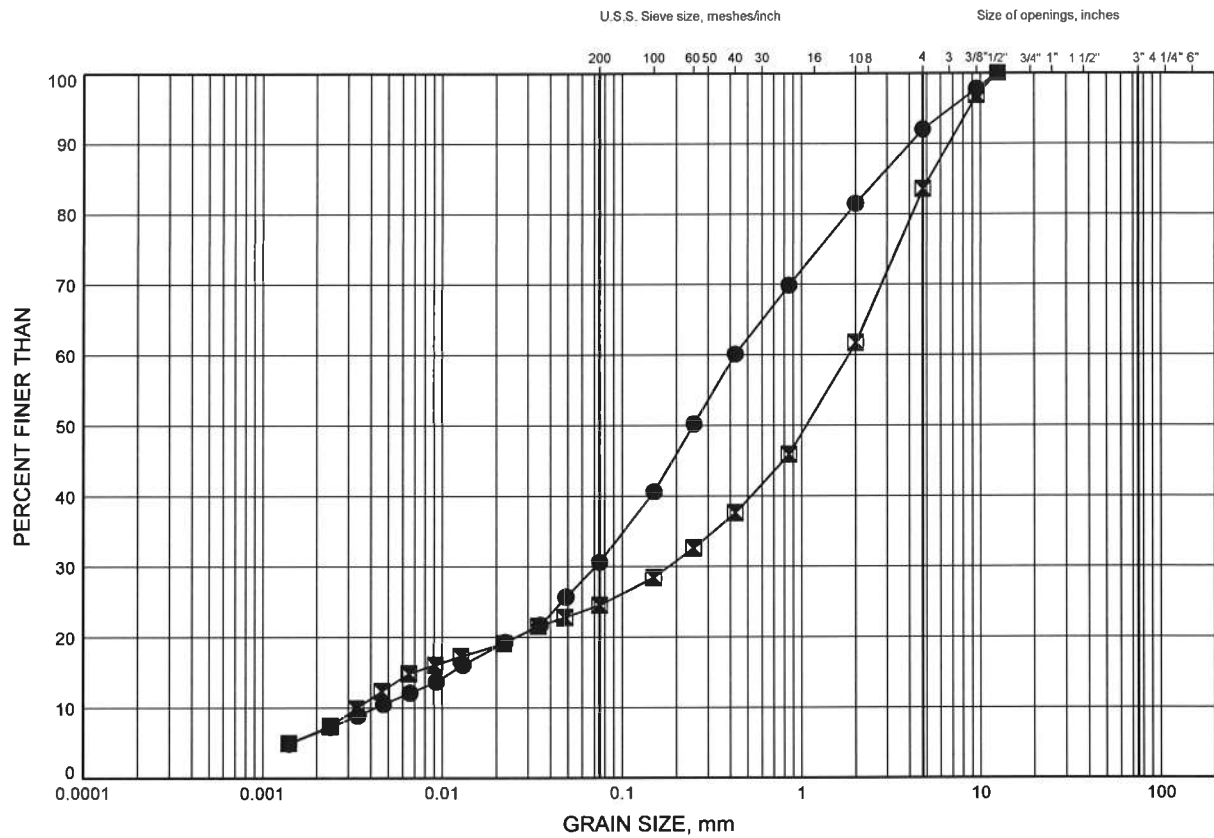
| SOIL PROFILE  |  |            | SAMPLES |      |              | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |  | UNIT<br>WEIGHT<br>$\gamma$<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |  |
|---------------|--|------------|---------|------|--------------|----------------------------|-----------------|---|--|--|---|---|--|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES   |                            |                 | SHEAR STRENGTH kPa                          |  |  |   |   |  |
| 68.2          |  |            |         |      |              |                            |                 | 20 40 60 80 100                             |  |  |   |   |  |
| 0.0           | ASPHALT: (200mm)   |            |         |      |              |                            | 68              |   |  |  |   |   |  |
| 0.2           | Gravelly SAND, some silt   |            | 1       | AS   |              |                            |                 |   |  |  |   |   |  |
| 67.4          | Brown Moist (FILL)   |            |         |      |              |                            |                 |   |  |  |   |   |  |
| 0.8           | Silty SAND, some gravel, trace clay  |            | 2       | SS   | 44           |                            | 67              |   |  |  |   |   | 19 59 16 5   |
|               | Very Dense Brown Moist (TILL)  |            |         |      |              |                            |                 |   |  |  |   |   |  |
| 66.2          |  |            | 3       | SS   | 56/<br>0.280 |                            |                 |   |  |  |   |   |  |
| 2.0           | SHALE, highly weathered  |            |         |      |              |                            | 66              |   |  |  |   |   |  |
|               | Started coring at 2.7m<br>Slightly weathered to fresh, laminated,<br>very thin limestone interbeds through<br>out                              |            |         |      |              |                            |                 |   |  |  |   |   |  |
|               |  |            | 1       | RUN  |              |                            | 65              |   |  |  |   |   | RUN #1<br>TCR=100%<br>SCR=82%<br>RQD=13%<br>UCS=7MPa<br>(Average)  |
|               |  |            |         |      |              |                            |                 |   |  |  |   |   |  |
|               | Vertical fractures from 4.2m to 5.1m   |            |         |      |              |                            | 64              |   |  |  |   |   |  |
|               |  |            |         |      |              |                            |                 |   |  |  |   |   |  |
|               | Limestone interbeds:<br>25mm at 5.4m<br>50mm at 5.5m<br>25mm at 5.6m   |            | 2       | RUN  |              |                            | 63              |   |  |  |   |   | RUN #2<br>TCR=100%<br>SCR=97%<br>RQD=43%<br>UCS=18MPa<br>(Average) |
| 62.4          |  |            |         |      |              |                            |                 |   |  |  |   |   |  |
| 5.8           | END OF BOREHOLE AT 5.8m.<br>BOREHOLE BACKFILLED WITH<br>BENTONITE HOLEPLUG AND<br>CUTTINGS TO 0.15m, THEN<br>ASPHALT COLD PATCH TO<br>SURFACE. |            |         |      |              |                            |                 |   |  |  |   |   |  |

+<sup>3</sup>, x<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

# Highway 417 Ottawa: Vanier to OR 174 GRAIN SIZE DISTRIBUTION

FIGURE G1

## SILTY SAND to SAND FILL



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

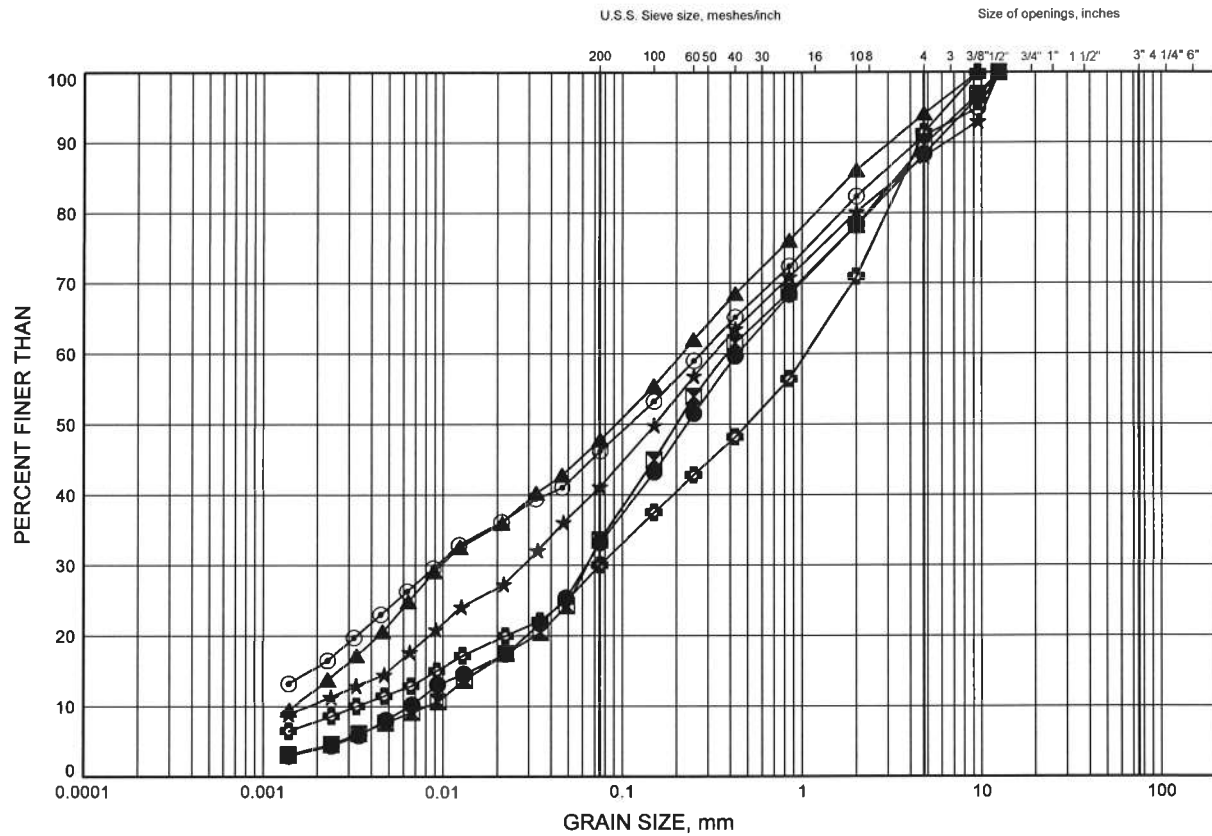
### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 23S-01   | 1.83      | 60.07     |
| ⊠      | 23S-06   | 0.46      | 65.34     |

# Highway 417 Ottawa: Vanier to OR 174 GRAIN SIZE DISTRIBUTION

FIGURE G2

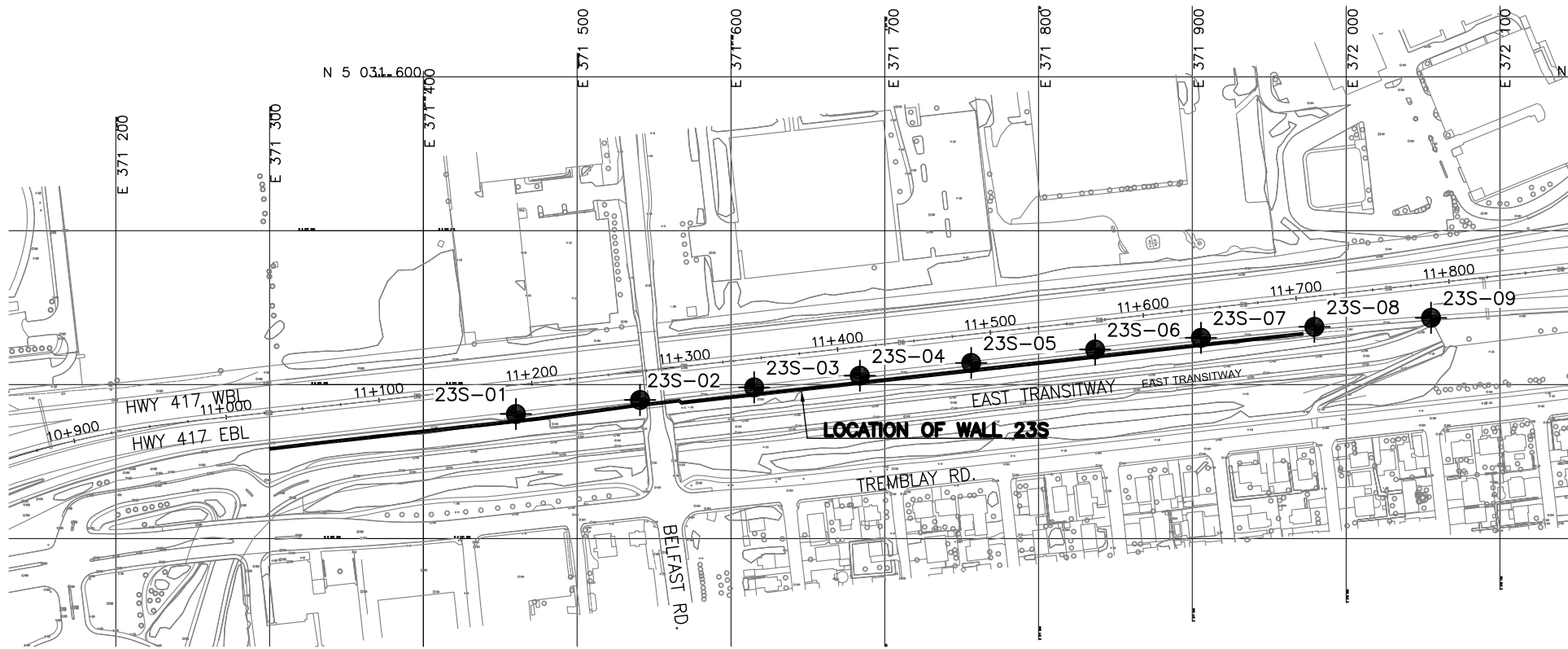
## SILTY SAND TILL



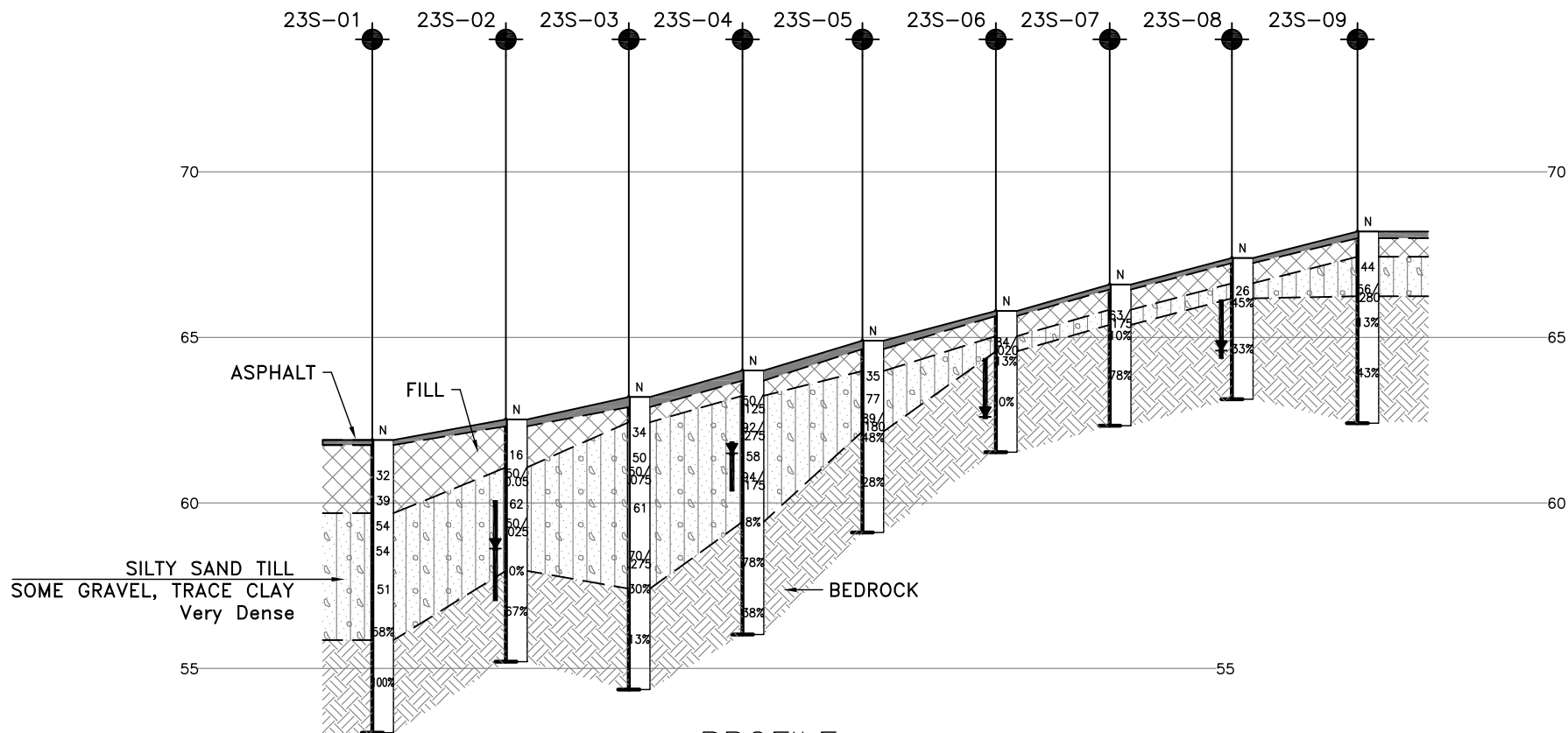
|               |      |        |        |        |        |             |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE   | COARSE | COBBLE SIZE |
| FINE GRAINED  | SAND |        |        | GRAVEL |        |             |

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 23S-01   | 3.35      | 58.55     |
| ⊠      | 23S-02   | 2.55      | 59.96     |
| ▲      | 23S-03   | 1.83      | 61.37     |
| ★      | 23S-04   | 1.71      | 62.29     |
| ⊙      | 23S-05   | 1.75      | 63.15     |
| ⊕      | 23S-07   | 0.95      | 65.65     |



PLAN  
SCALE 1:4000



PROFILE  
HOR. 1:4000  
VER. 1:200

**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

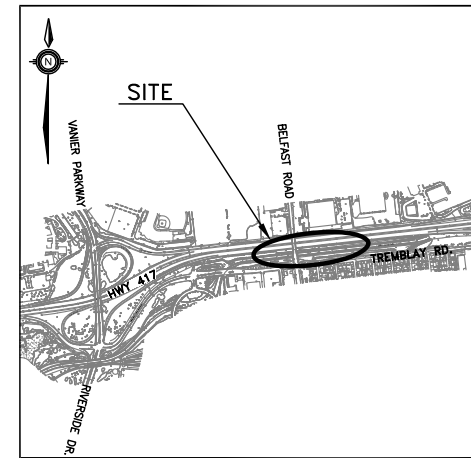


CONT No  
WP No 4320-06-00

HIGHWAY 417  
BELFAST ROAD (SOUTH)  
RETAINING WALL 23S  
BOREHOLE LOCATIONS AND SOIL STRATA



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

- Borehole
- Borehole and Cone
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60° Cone, 475J/blow)
- PH Pressure, Hydraulic
- Water Level
- Head Artesian Water
- Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

| NO     | ELEVATION | NORTHING    | EASTING   |
|--------|-----------|-------------|-----------|
| 23S-01 | 61.9      | 5 031 380.9 | 371 460.2 |
| 23S-02 | 62.5      | 5 031 390.0 | 371 540.9 |
| 23S-03 | 63.2      | 5 031 398.2 | 371 615.1 |
| 23S-04 | 64.0      | 5 031 405.8 | 371 683.8 |
| 23S-05 | 64.9      | 5 031 414.1 | 371 756.2 |
| 23S-06 | 65.8      | 5 031 422.8 | 371 836.8 |
| 23S-07 | 66.6      | 5 031 430.4 | 371 905.6 |
| 23S-08 | 67.4      | 5 031 437.5 | 371 979.4 |
| 23S-09 | 68.2      | 5 031 443.4 | 372 055.2 |

**-NOTES-**

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

**GEOCRETS No. 31G5-250**

| REVISIONS | DATE | BY        | DESCRIPTION |
|-----------|------|-----------|-------------|
| DESIGN    | LRB  | CHK       | LRB         |
| DRAWN     | AN   | CHK       | PKC         |
| LOAD      | DATE | AUG. 2012 |             |
| STRUCT    | DWG  | 1         |             |

## **Appendix H**

### **St. Laurent Boulevard N-W Ramp - Wall 16N**

#### **Boreholes 16N-1 to 16N-3**

## METRIC

[illegible]

(%) STRAIN AT FAILURE

ONTMT4S 1201B.GPJ 4/23/12

RECORD OF BOREHOLE No 16N-1

2 OF 2

METRIC

W.P. 4320-06-00 LOCATION N 5 031 515.2 E 372 266.7 ORIGINATED BY LPG  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2011.08.18 - 2011.08.18 CHECKED BY LRB

| SOIL PROFILE  |                              |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |    |     | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT |   |                | 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 |                            |                 | 20  | 40 | 60 | 80 | 100 | W <sub>p</sub>                                      | W | W <sub>L</sub> |   |  |
|               | Continued From Previous Page |            |         |      |            |                            |                 |   |    |    |    |     |   |   |                |   |  |
|               | Sep. 20/11 5.2 64.7          |            |         |      |            |                            |                 |   |    |    |    |     |   |   |                |   |  |
|               | Oct. 12/11 5.8 64.1          |            |         |      |            |                            |                 |   |    |    |    |     |   |   |                |   |  |

ONTMT4S 1201B.GPJ 4/23/12



# RECORD OF BOREHOLE No 16N-2

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 524.5 E 372 330.2 ORIGINATED BY LPG  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2011.08.17 - 2011.08.17 CHECKED BY LRB

| SOIL PROFILE  |   |            | SAMPLES |      |              | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |                                 | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT |  |  | UNIT<br>WEIGHT<br><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 (%)                                   |  |  |   |   |
|               |   |            |         |      |              |                            |                 | 20 40 60 80 100                             | w <sub>p</sub> w w <sub>L</sub> |   |  |  |   |   |
| 69.3          |   |            |         |      |              |                            |                 |   |                                 |   |  |  |   |   |
| 0.0           |   |            |         |      |              |                            |                 |   |                                 |   |  |  |   |   |
| 0.1           | ASPHALT: (100mm)  |            |         |      |              |                            |                 |   |                                 |   |  |  |   |   |
|               | Gravelly SAND, some silt<br>Dense to Very Dense<br>Brown<br>Moist<br>(FILL)   |            | 1       | AS   |              |                            |                 |   |                                 |   |  |  |   |   |
|               |   |            | 2       | SS   | 50/<br>0.125 |                            |                 |   |                                 |   |  |  |   |   |
|               |   |            | 3       | SS   | 30           |                            |                 |   |                                 |   |  |  |   |   |
| 67.0          |   |            |         |      |              |                            |                 |   |                                 |   |  |  |   |   |
| 2.3           | SAND, some silt, some gravel<br>Compact<br>Brown<br>Moist<br>(FILL)   |            | 4       | SS   | 21           |                            |                 |   |                                 |   |  |  |   |   |
| 66.3          |   |            |         |      |              |                            |                 |   |                                 |   |  |  |   |   |
| 3.0           | Silty SAND, trace gravel, trace clay<br>Compact<br>Brown<br>Wet   |            | 5       | SS   | 11           |                            |                 |   |                                 |   |  |  |   |   |
|               |   |            |         |      |              |                            |                 |   |                                 |   |  |  |   |   |
| 64.7          |   |            |         |      |              |                            |                 |   |                                 |   |  |  |   |   |
| 4.6           | Sandy SILT, some clay, trace gravel<br>Dense<br>Brown<br>Moist to Wet<br>(TILL)   |            | 6       | SS   | 45           |                            |                 |   |                                 |   |  |  |   |   |
|               |   |            |         |      |              |                            |                 |   |                                 |   |  |  |   |   |
| 63.5          |   |            |         |      |              |                            |                 |   |                                 |   |  |  |   |   |
| 5.8           | SHALE, fresh, laminated, grey, very<br>thin limestone interbeds through out   |            | 1       | RUN  |              |                            |                 |   |                                 |   |  |  |   |   |
|               |   |            |         |      |              |                            |                 |   |                                 |   |  |  |   |   |
|               |   |            | 2       | RUN  |              |                            |                 |   |                                 |   |  |  |   |   |
|               |   |            |         |      |              |                            |                 |   |                                 |   |  |  |   |   |
| 60.5          |   |            |         |      |              |                            |                 |   |                                 |   |  |  |   |   |
| 8.8           | END OF BOREHOLE AT 8.8m.<br>BOREHOLE BACKFILLED WITH<br>BENTONITE HOLEPLUG AND<br>CUTTINGS TO 0.1m, THEN<br>ASPHALT COLD PATCH TO<br>SURFACE. |            |         |      |              |                            |                 |   |                                 |   |  |  |   |   |

ONTMT4S 1201B GPJ 4/23/12

+<sup>3</sup>, x<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 16N-3

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 533.0 E 372 394.4 ORIGINATED BY LPG  
HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2011.08.17 - 2011.08.17 CHECKED BY LRB

| 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><br>γ<br><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 (%)                                      |  |  |  |  |
| 68.5          |   |            |         |      |              |                            |                 | 20 40 60 80 100                             |  |  |  |  |  |  |
| 0.0           | ASPHALT: (150mm)  |            |         |      |              |                            |                 | 20 40 60 80 100                             |  |  |  |  |  |  |
| 0.2           | Gravelly SAND, some silt<br>Dense<br>Brown<br>Moist<br>(FILL)   |            | 1       | AS   |              |                            | 68              |   |  |  |  |  |  |  |
|               |   |            | 2       | SS   | 39           |                            |                 |   |  |  |  |  |  |  |
| 67.0          |   |            |         |      |              |                            | 67              |   |  |  |  |  |  |  |
| 1.5           | Silty SAND, trace gravel<br>Dense<br>Brown<br>Moist   |            | 3       | SS   | 39           |                            |                 |   |  |  |  |  |  |  |
| 66.2          |   |            |         |      |              |                            | 66              |   |  |  |  |  |  |  |
| 2.3           | Clayey SILT and SAND<br>Stiff<br>Grey<br>(TILL)   |            | 4       | SS   | 14           |                            |                 |   |  |  |  |  |  | 0 26 53 21   |
| 65.5          |   |            |         |      |              |                            | 65              |   |  |  |  |  |  |  |
| 3.0           | Silty SAND, trace clay, trace gravel<br>Compact to Very Dense<br>Dark Grey<br>Moist<br>(TILL)   |            | 5       | SS   | 24           |                            |                 |   |  |  |  |  |  | 3 54 38 5  |
|               |   |            | 6       | SS   | 50/<br>0.100 |                            | 64              |   |  |  |  |  | FI   |  |
| 63.6          |   |            |         |      |              |                            |                 |   |  |  |  |  |  |  |
| 4.9           | SHALE, slightly weathered to fresh,<br>laminated, grey, with clay infilled<br>fractures, very thin limestone interbeds<br>through out<br><br>Limestone interbed (75mm) at 5.2m  |            | 1       | RUN  |              |                            | 63              |   |  |  |  |  | >10<br>2   | RUN #1<br>TCR=77%<br>SCR=46%<br>RQD=25%<br>UCS=18MPa<br>(Average)    |
|               |   |            | 2       | RUN  |              |                            | 62              |   |  |  |  |  | >5<br>3<br>0<br>5                                | RUN #2<br>TCR=100%<br>SCR=83%<br>RQD=52%<br>UCS=34MPa<br>(Average)   |
|               |   |            | 3       | RUN  |              |                            | 61              |   |  |  |  |  | 3<br>1<br>1                                      | RUN #3<br>TCR=100%<br>SCR=100%<br>RQD=100%<br>UCS=15MPa<br>(Average) |
| 60.2          | END OF BOREHOLE AT 8.3m.<br>Piezometer installation consists of<br>19mm diameter Schedule 40 PVC pipe<br>with a 1.52m slotted screen.<br><br>WATER LEVEL READINGS:<br>DATE DEPTH (m) ELEV. (m)<br>Aug. 18/11 4.7 63.8<br>Sep. 20/11 3.7 64.8<br>Oct. 12/11 3.7 64.8 |            |         |      |              |                            |                 |   |  |  |  |  |  |  |
| 8.3           |   |            |         |      |              |                            |                 |   |  |  |  |  |  |  |

ONTWT4S 1201B GPJ 5/14/12

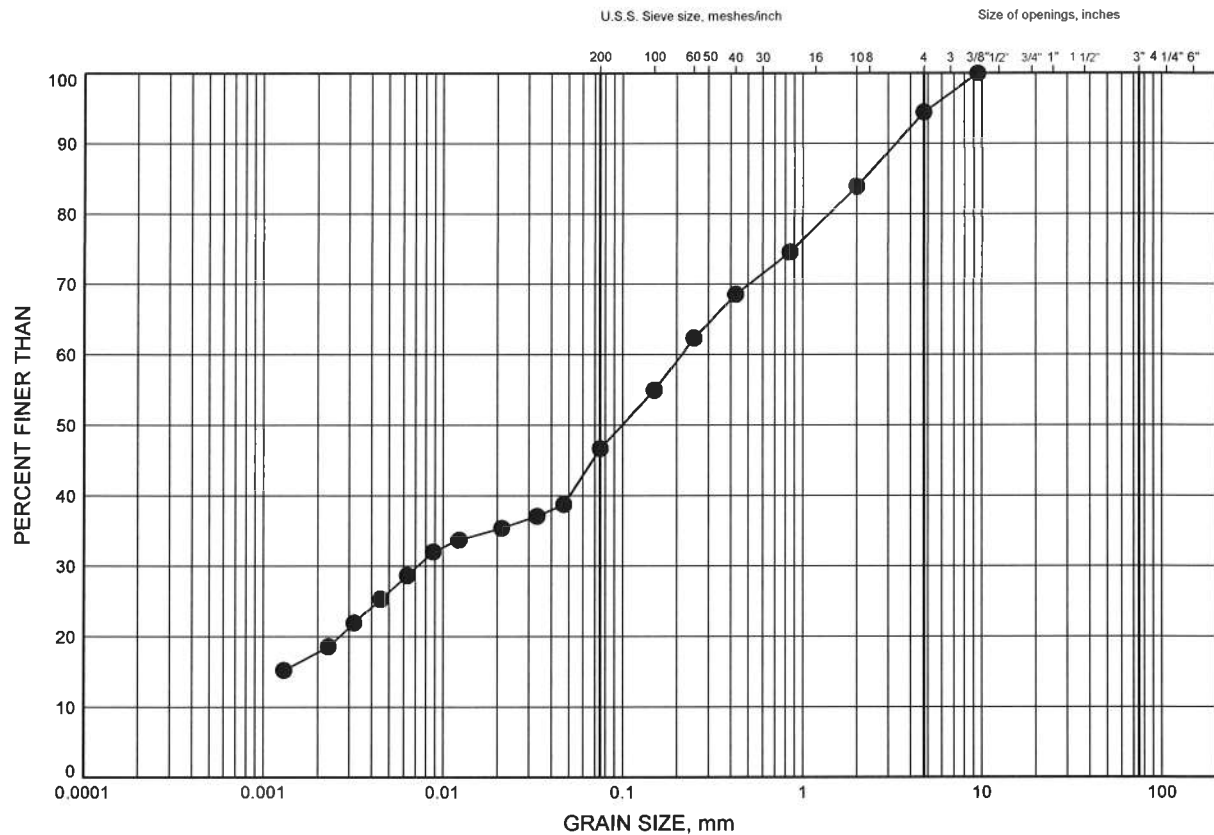
+<sup>3</sup> ×<sup>3</sup>: Numbers refer to  
Sensitivity 20  
15 10 5 0  
(%) STRAIN AT FAILURE

# Highway 417 Ottawa: Nicholas Street to OR 174

## GRAIN SIZE DISTRIBUTION

FIGURE H1

### SILTY SAND FILL



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

### LEGEND

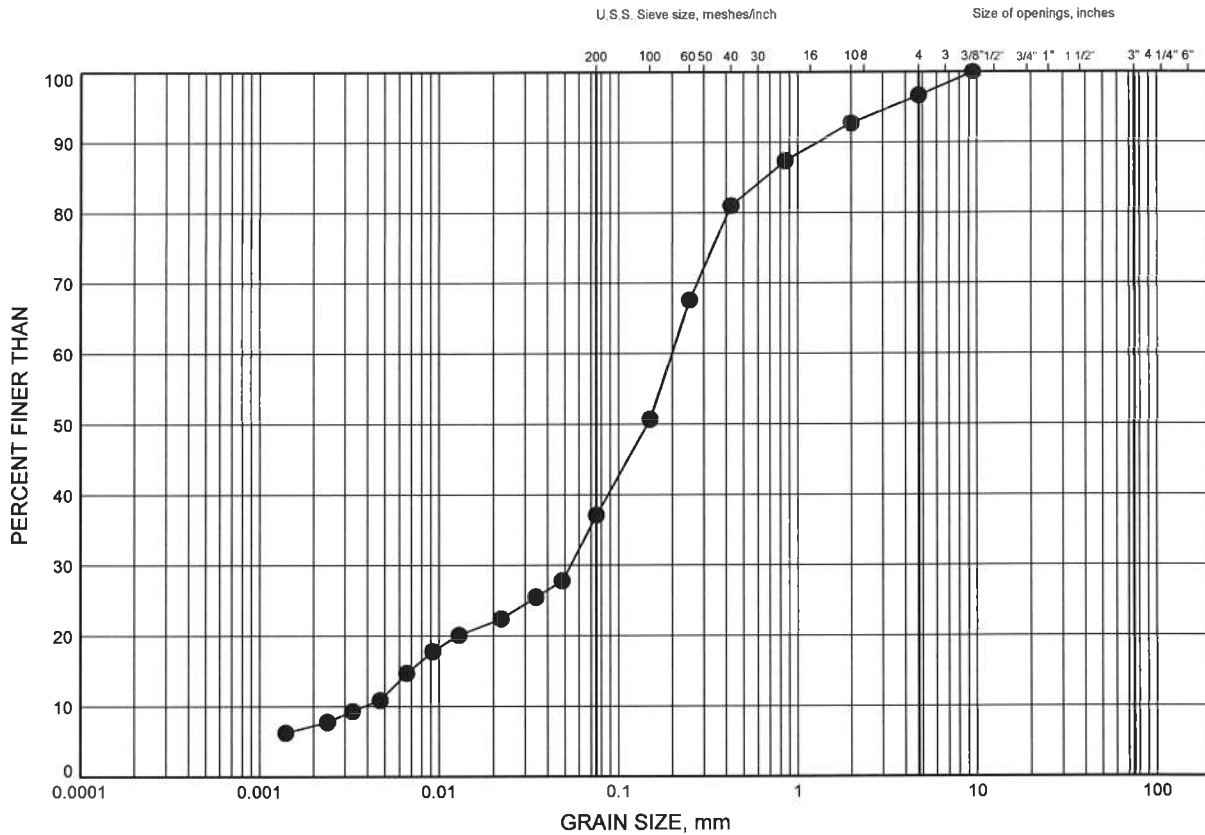
| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 16N-1    | 1.07      | 68.83     |

# Highway 417 Ottawa: Nicholas Street to OR 174

## GRAIN SIZE DISTRIBUTION

FIGURE H2

### SILTY SAND



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

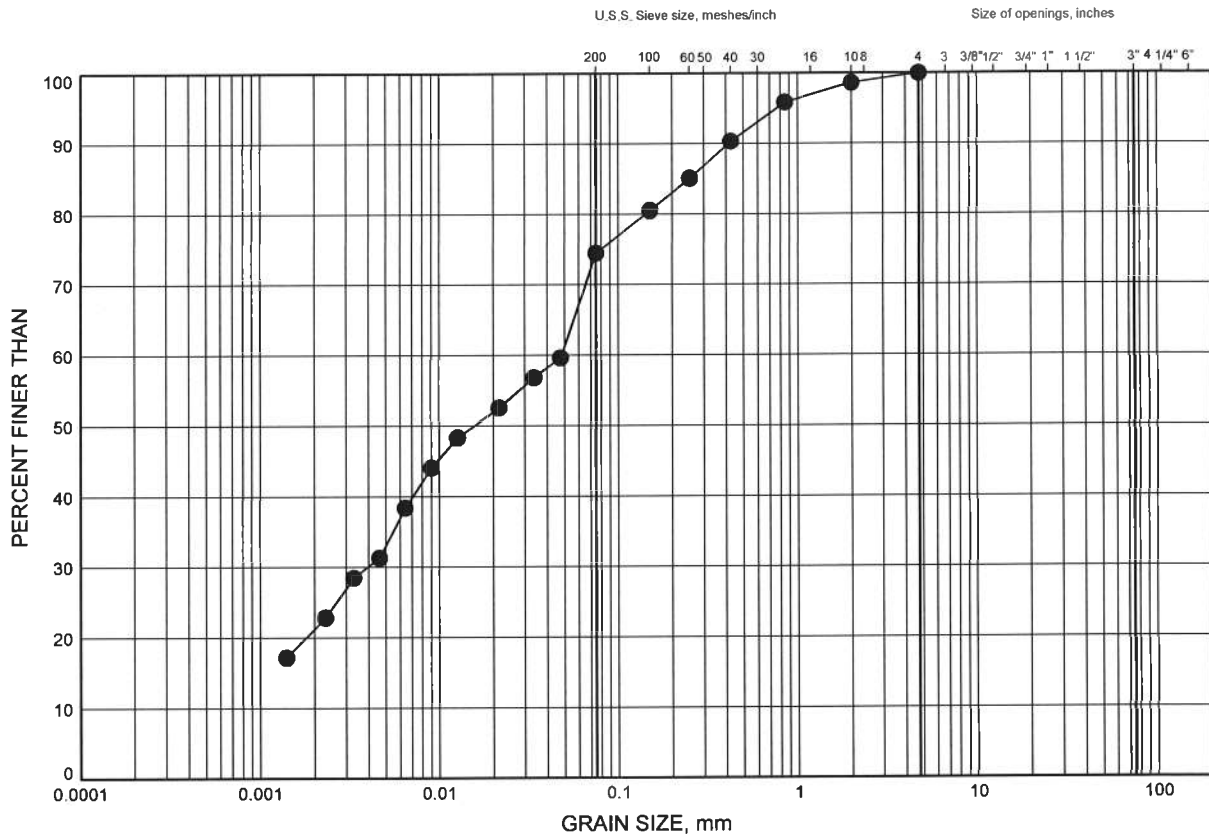
### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 16N-2    | 3.35      | 65.95     |

Highway 417 Ottawa: Nicholas Street to OR 174  
GRAIN SIZE DISTRIBUTION

FIGURE H3

CLAYEY SILT & SAND TILL



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

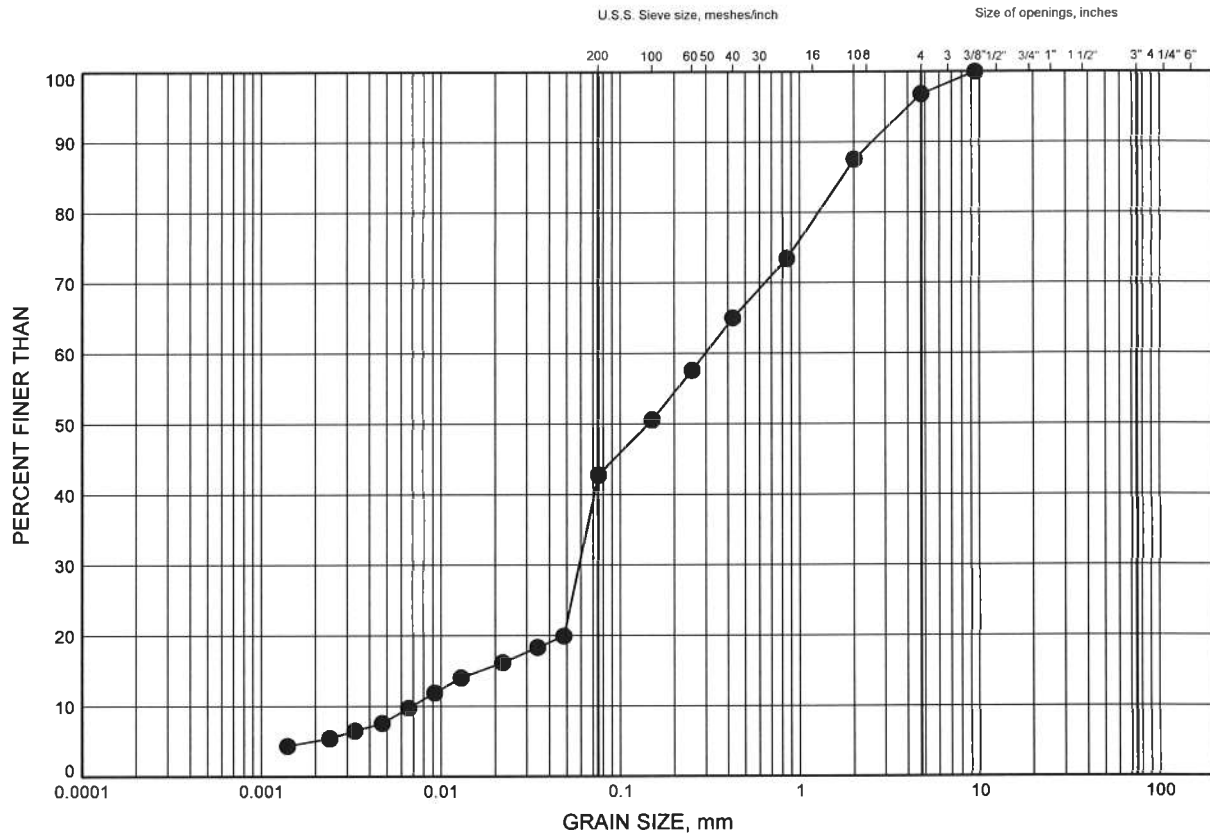
LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 16N-3    | 2.59      | 65.93     |

# Highway 417 Ottawa: Vanier to OR 174 GRAIN SIZE DISTRIBUTION

FIGURE H4

## SILTY SAND TILL



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

### LEGEND

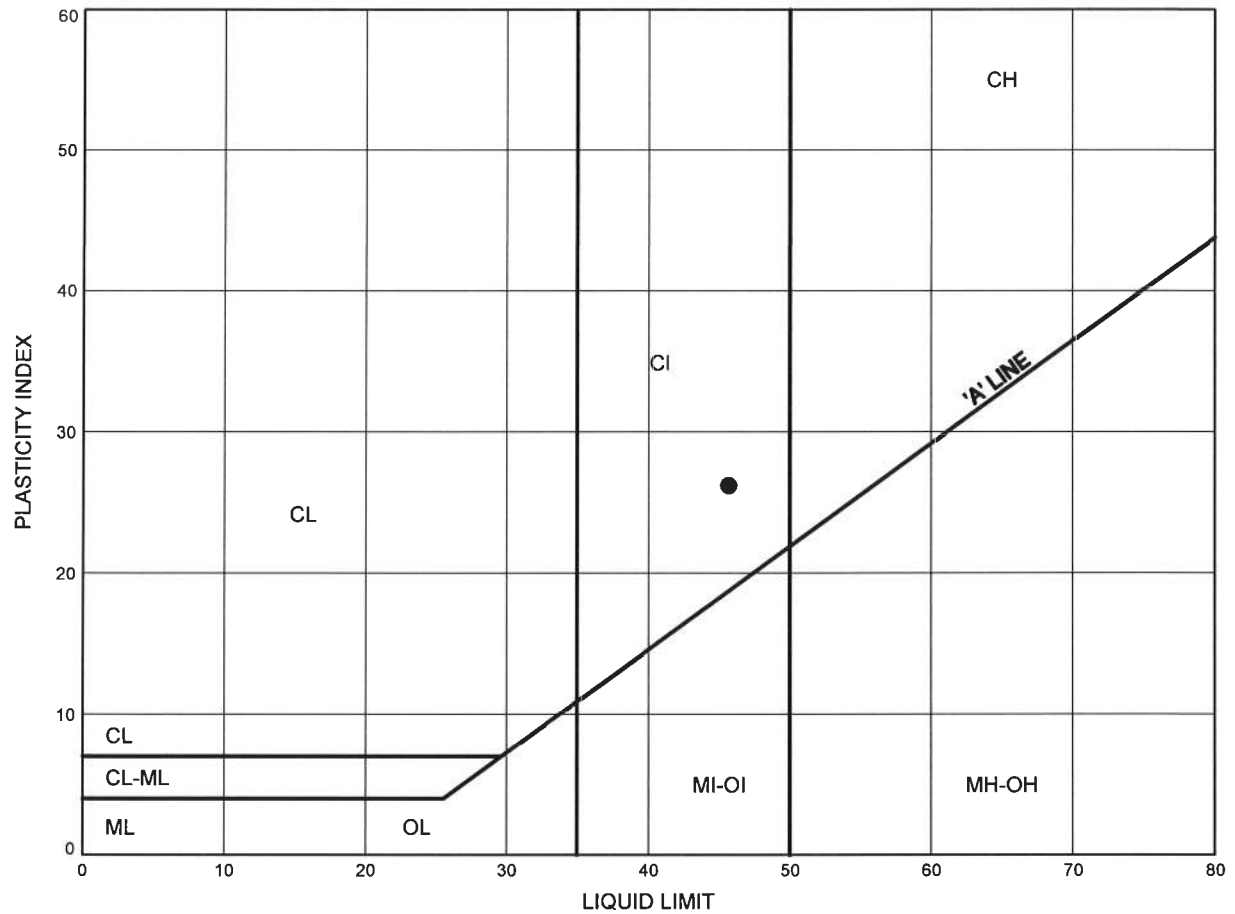
| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 16N-3    | 3.35      | 65.17     |

Highway 417 Ottawa: Vanier to OR 174

# ATTERBERG LIMITS TEST RESULTS

FIGURE H5

## CLAYEY SILT AND SAND TILL



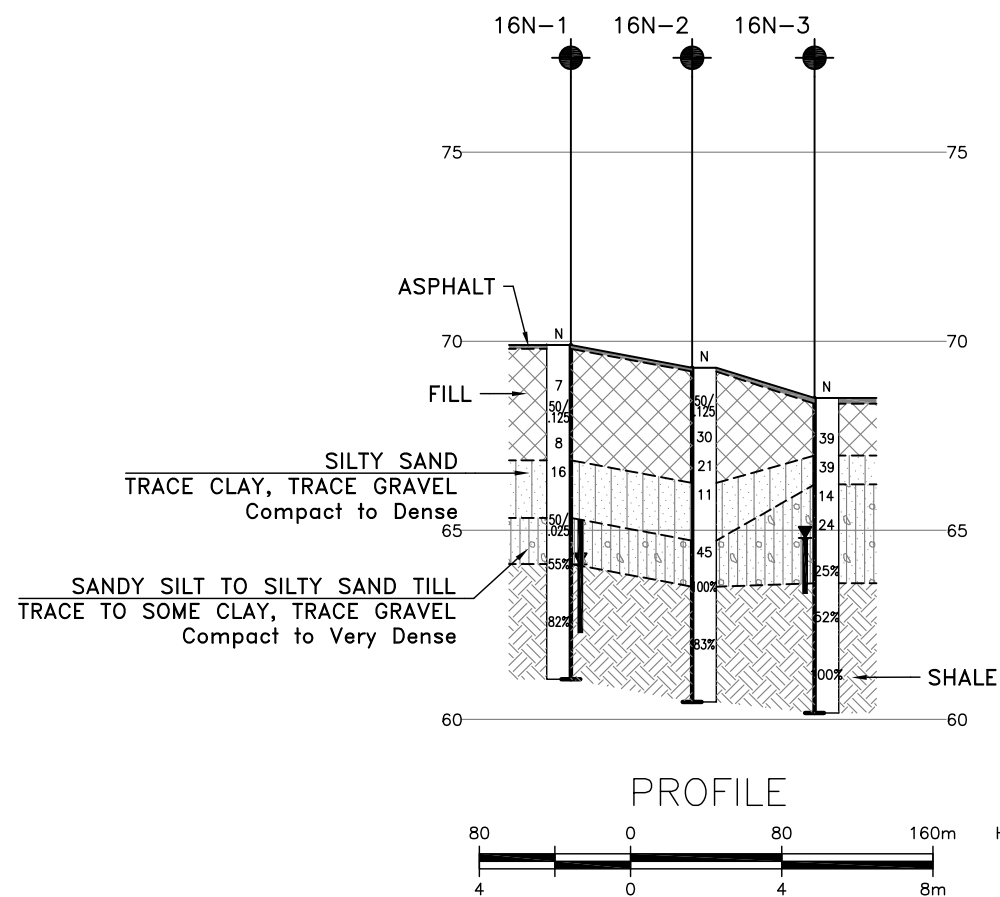
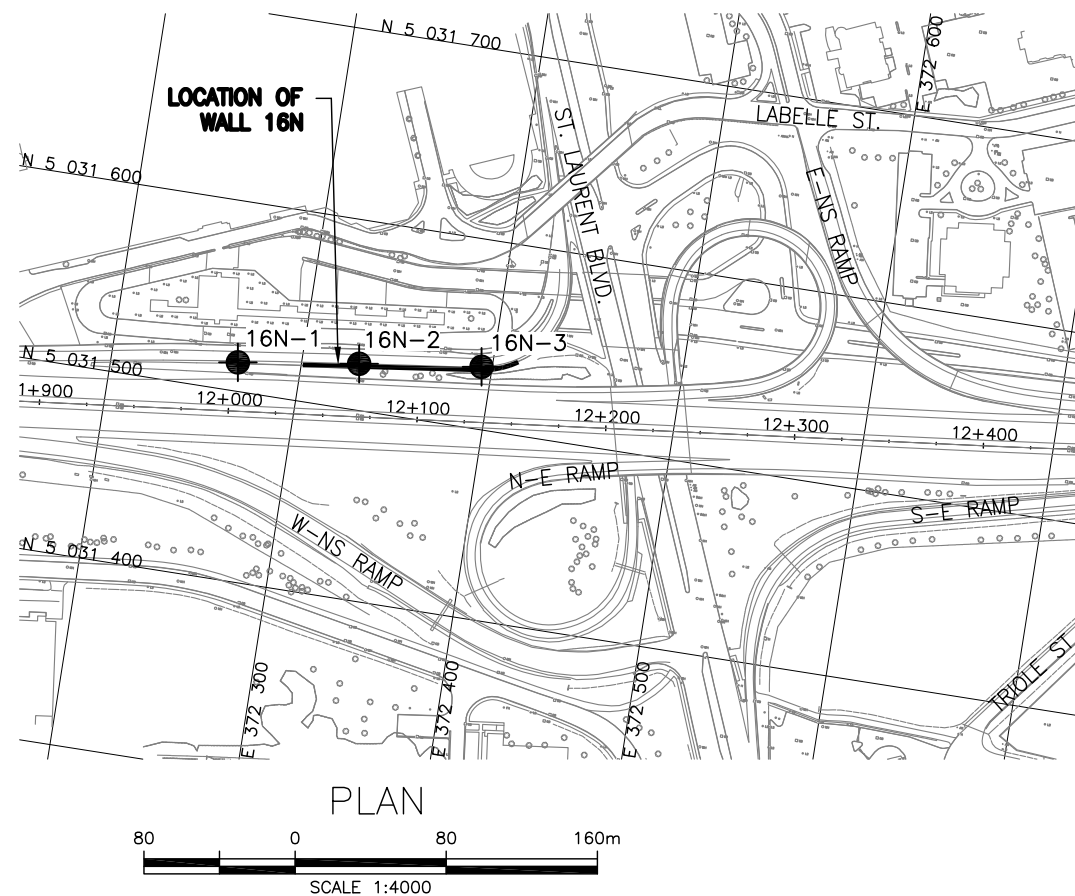
### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 16N-3    | 2.59      | 65.93     |

Date May 2012  
W.P.# 4320-06-00



Prep'd MFA  
Chkd. LRB



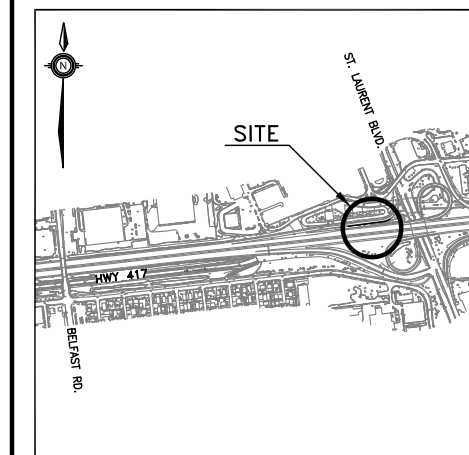
**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No  
WP No 4320-06-00

HIGHWAY 417  
ST. LAURENT (NORTH)  
RETAINING WALL 16N  
BOREHOLE LOCATIONS AND SOIL STRATA








**THURBER** ENGINEERING LTD.



## KEYPLAN

## LEGEND

|   |                                       |
|---|---------------------------------------|
|  | Borehole                              |
|  | Borehole and Cone                     |
| N   | Blows /0.3m (Std Pen Test, 475J/blow) |
| CONE  | Blows /0.3m (60° Cone, 475J/blow)     |
| PH  | Pressure, Hydraulic                   |
|  | Water Level                           |
|  | Head Artesian Water                   |
|  | Piezometer                            |
| 90%   | Rock Quality Designation (RQD)        |
| A/R   | Auger Refusal                         |

[illegible]

-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

**GEOCRES No. 31G5-250**

[illegible]



## **Appendix I**

**Retaining Walls 17N, 18N, 19N, 21S, 22S, 1M**

**Boreholes 17N-02, 18N-1 to 3, 19N-1 & 2, 21S-01 to 03, 22S-01 & 02, 1M-01 & 02**

# RECORD OF BOREHOLE No 17N-02

1 OF 2

METRIC

W.P. 4320-06-00 LOCATION N 5 031 557.5 E 372 555.7 ORIGINATED BY LPG  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2011.09.13 - 2011.09.13 CHECKED BY LRB

| SOIL PROFILE  |  |            | SAMPLES |      |              | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT  |  |          | 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<br>○ UNCONFINED    + FIELD VANE<br>● QUICK TRIAXIAL    x LAB VANE |  |          |   |  |
| 72.2          |  |            |         |      |              |                            |                 | 20 40 60 80 100  |  | 20 40 60 |   |  |
| 0.0           | ASPHALT: (150mm)   |            |         |      |              |                            | 72              |  |  |          |   |  |
| 0.2           | SAND, some gravel, some silt<br>Grey<br>Moist<br>(FILL)                                      |            | 1       | AS   |              |                            |                 |  |  |          |   |  |
| 71.4          |  |            |         |      |              |                            |                 |  |  |          |   |  |
| 0.8           | Gravelly SAND, some silt and clay<br>Very Dense to Dense<br>Grey to Brown<br>Moist<br>(FILL) |            | 2       | SS   | 50/<br>0.100 |                            | 71              |  |  |          |   |  |
|               |  |            |         |      |              |                            |                 |  |  |          |   |  |
|               |  |            | 3       | SS   | 34           |                            |                 |  |  |          |   |  |
| 69.9          |  |            |         |      |              |                            | 70              |  |  |          |   |  |
| 2.3           | SAND and GRAVEL, some silt and<br>clay<br>Dense to Very Dense<br>Brown<br>Moist<br>(FILL)    |            | 4       | SS   | 50/<br>0.125 |                            |                 |  |  |          |   |  |
|               |  |            |         |      |              |                            |                 |  |  |          |   |  |
|               |  |            | 5       | SS   | 37           |                            | 69              |  |  |          |   |  |
|               |  |            |         |      |              |                            |                 |  |  |          |   |  |
|               |  |            |         |      |              |                            | 68              |  |  |          |   |  |
|               |  |            | 6       | SS   | 50/<br>0.075 |                            |                 |  |  |          |   |  |
|               |  |            |         |      |              |                            | 67              |  |  |          |   |  |
| 66.1          |  |            |         |      |              |                            |                 |  |  |          |   |  |
| 6.1           | SAND, some gravel<br>Compact<br>Brown<br>Moist<br>(FILL)                                     |            | 7       | SS   | 21           |                            | 66              |  |  |          |   |  |
| 65.3          |  |            |         |      |              |                            |                 |  |  |          |   |  |
| 6.9           | CONCRETE   |            | 1       | RUN  |              |                            | 65              |  |  |          |   |  |
|               |  |            |         |      |              |                            |                 |  |  |          |   |  |
| 64.1          |  |            | 2       | RUN  |              |                            | 64              |  |  |          |   |  |
| 8.1           | SHALE, fresh, laminated, grey, very<br>thin limestone interbeds throughout                   |            |         |      |              |                            |                 |  |  |          |   |  |
|               |  |            |         |      |              |                            |                 |  |  |          |   |  |
|               | Clay infill at 8.8m  |            |         |      |              |                            | 63              |  |  |          |   |  |
|               |  |            | 3       | RUN  |              |                            |                 |  |  |          |   |  |

Continued Next Page

+ <sup>3</sup> , × <sup>3</sup> : Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17N-02

2 OF 2

METRIC

W.P. 4320-06-00 LOCATION N 5 031 557.5 E 372 555.7 ORIGINATED BY LPG  
HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2011.09.13 - 2011.09.13 CHECKED BY LRB

| SOIL PROFILE  |  | SAMPLES    |        |      | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |                                | PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT |                   |  | UNIT<br>WEIGHT<br><br>γ<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 (%) |  |  |  |
|               | Continued From Previous Page   |            |        |      |                            |                 | 20   40   60   80   100                     | ○ UNCONFINED      + FIELD VANE | 20   40   60  |                   |  |  |  |
|               |  |            |        |      |                            |                 | ● QUICK TRIAXIAL      x LAB VANE            |                                |   |                   |  |  |  |
| 61.0          |  |            | 4      | RUN  |                            | 62              |   |                                |   |                   |  | 0  | RUN #4<br>TCR=100%<br>SCR=100%<br>RQD=100%<br>UCS=18MPa<br>(Average)       |
|               |  |            |        |      |                            |                 |   |                                |   |                   |  | 3  |  |
|               |  |            |        |      |                            |                 |   |                                |   |                   |  | 1  |  |
|               |  |            |        |      |                            |                 |   |                                |   |                   |  | 0  |  |
| 11.2          | END OF BOREHOLE AT 11.2m.<br>BOREHOLE BACKFILLED WITH<br>BENTONITE HOLEPLUG AND<br>CUTTINGS TO 0.1m, THEN<br>ASPHALT COLD PATCH TO<br>SURFACE. |            |        |      |                            | 61              |   |                                |   |                   |  |  |  |

# RECORD OF BOREHOLE No 18N-1

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 575.3 E 372 757.8 ORIGINATED BY LPG  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.09.13 - 2011.09.13 CHECKED BY LRB

| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    | PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT |     |  | UNIT<br>WEIGHT<br><br>γ<br><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 (%)   |     |  |  |   |
| 71.7          |  |            |         |      |            |                            |                 | 20  | 40 | 60 | 80  | 100 |  |  |   |
| 0.0           | ASPHALT: (150mm)   |            |         |      |            |                            |                 |   |    |    |   |     |  |  |   |
| 0.2           | Gravelly SAND, some silt<br>Brown<br>Moist<br>(FILL)   |            | 1       | AS   |            |                            |                 |   |    |    |   |     |  |  |   |
| 70.9          |  |            |         |      |            |                            |                 |   |    |    |   |     |  |  |   |
| 0.8           | Clayey SILT, some sand<br>Stiff<br>Brown<br>Moist<br>(FILL)  |            | 2       | SS   | 8          |                            |                 |   |    |    |   |     |  |  |   |
| 70.2          |  |            |         |      |            |                            |                 |   |    |    |   |     |  |  |   |
| 1.5           | Silty CLAY, some sand<br>Stiff<br>Brown<br>Moist   |            | 3       | SS   | 15         |                            |                 |   |    |    |   |     |  |  |   |
| 69.4          |  |            |         |      |            |                            |                 |   |    |    |   |     |  |  |   |
| 2.3           | SILT, some sand, some clay<br>Compact<br>Brown<br>Moist  |            | 4       | SS   | 21         |                            |                 |   |    |    |   |     |  |  |   |
| 68.6          |  |            |         |      |            |                            |                 |   |    |    |   |     |  |  |   |
| 3.1           | Shale fragments  |            | 5       | SS   | 50         |                            |                 |   |    |    |   |     |  |  |   |
|               | END OF BOREHOLE AT 3.1m ON<br>PROBABLE BEDROCK.<br>BOREHOLE BACKFILLED WITH<br>BENTONITE HOLEPLUG AND<br>CUTTINGS TO 0.1m, THEN<br>ASPHALT COLD PATCH TO<br>SURFACE. |            |         |      | 0.075      |                            |                 |   |    |    |   |     |  |  |   |

# RECORD OF BOREHOLE No 18N-2

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 580.4 E 372 801.9 ORIGINATED BY GA  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.08.14 - 2011.08.14 CHECKED BY LRB

| SOIL PROFILE  |   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  | PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT |  |  | UNIT<br>WEIGHT<br><br>γ<br><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 (%)   |  |  |  |   |
| 70.8          |   |            |         |      |            |                            |                 | 20 40 60 80 100                             |  | 20 40 60  |  |  |  |   |
| 69.8          | ASPHALT: (25mm)   |            |         |      |            |                            |                 |   |  |   |  |  |  |   |
|               | Silty SAND, some clay, trace gravel   |            | 1       | SS   | 18         |                            |                 |   |  |   |  |  |  |   |
|               | Compact   |            |         |      |            |                            |                 |   |  |   |  |  |  |   |
|               | Grey  |            |         |      |            |                            |                 |   |  |   |  |  |  |   |
|               | Damp  |            |         |      |            |                            |                 |   |  |   |  |  |  |   |
|               | (FILL)  |            | 2       | SS   | 17         |                            |                 |   |  |   |  |  | 2 51 35 12                                       |   |
| 69.4          |   |            |         |      |            |                            |                 |   |  |   |  |  |  |   |
| 1.4           | Silty SAND, some clay, trace gravel   |            |         |      |            |                            |                 |   |  |   |  |  |  |   |
|               | Very Dense  |            |         |      |            |                            |                 |   |  |   |  |  |  |   |
|               | Brown   |            | 3       | SS   | 125        |                            |                 |   |  |   |  |  |  |   |
| 68.8          | Damp  |            |         |      |            |                            |                 |   |  |   |  |  |  |   |
| 2.0           | (TILL)  |            |         |      |            |                            |                 |   |  |   |  |  |  |   |
| 68.4          | SHALE   |            | 4       | SS   | 50/        |                            |                 |   |  |   |  |  |  |   |
| 2.4           | END OF BOREHOLE AT 2.4m.<br>BOREHOLE OPEN TO 2.4m AND<br>DRY UPON COMPLETION.<br>BOREHOLE BACKFILLED WITH<br>CUTTINGS TO SURFACE. |            |         |      | 0.00       |                            |                 |   |  |   |  |  |  |   |

+ 3, X 3 Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 18N-3

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 589.1 E 372 835.8 ORIGINATED BY GA  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.08.14 - 2011.08.14 CHECKED BY LRB

| SOIL PROFILE  |   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    | PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT |     |                | UNIT<br>WEIGHT<br><br>γ<br><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 (%)                                       |     |                |  |   |            |
| 71.4          |   |            |         |      |            |                            | 20              | 40  | 60 | 80  | 100 | W <sub>P</sub> | W  | W <sub>L</sub>                                    |            |
| 71.4          | ASPHALT: (25mm)   |            |         |      |            |                            |                 |   |    |   |     |                |  |   |            |
| 70.7          | Gravelly SAND, some silt, some clay<br>Compact<br>Brown/Grey  |            | 1       | SS   | 19         |                            |                 |   |    |   |     |                |  |   |            |
| 70.7          | Damp<br>(FILL)  |            |         |      |            |                            |                 |   |    |   |     |                |  |   |            |
| 69.9          | Silty SAND, some clay, trace gravel<br>Compact<br>Dark Grey   |            | 2       | SS   | 20         |                            |                 |   |    |   |     |                |  |   | 1 56 32 10 |
| 69.9          | Damp<br>(FILL)  |            |         |      |            |                            |                 |   |    |   |     |                |  |   |            |
| 69.3          | Silty SAND, some clay, trace gravel<br>Dense<br>Brown   |            | 3       | SS   | 42         |                            |                 |   |    |   |     |                |  |   |            |
| 69.3          | Dry<br>(TILL)   |            | 4       | SS   | 100/       |                            |                 |   |    |   |     |                |  |   |            |
| 68.8          | SHALE, thinly bedded, grey  |            |         |      | 0.075      |                            |                 |   |    |   |     |                |  |   |            |
| 2.6           | END OF BOREHOLE AT 2.6m UPON<br>AUGER REFUSAL.<br>BOREHOLE OPEN TO 2.6m AND<br>DRY UPON COMPLETION.<br>BOREHOLE BACKFILLED WITH<br>CUTTINGS TO SURFACE. |            |         |      |            |                            |                 |   |    |   |     |                |  |   |            |

# RECORD OF BOREHOLE No 19N-1

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 663.0 E 373 082.0 ORIGINATED BY GA  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.08.14 - 2011.08.14 CHECKED BY LRB

| SOIL PROFILE  |   |            | SAMPLES |      |              | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |                 |                 |                 |                 | 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   |                            |                 | 20 40 60 80 100                             | 20 40 60 80 100 | 20 40 60 80 100 | 20 40 60 80 100 | 20 40 60 80 100 |   |  |
| 69.8          | <b>TOPSOIL: (25mm)</b>  |            | 1       | SS   | 14           |                            |                 |   |                 |                 |                 |                 |   |  |
| 69.1          | Silty <b>SAND</b> , some clay, trace gravel,<br>occasional rootlets<br>Compact<br>Grey<br>Damp  |            | 2       | SS   | 50/<br>0.150 |                            | 69              |   |                 |                 |                 |                 |   | 5 44 39 11   |
| 0.7           | Silty <b>SAND</b> , some clay, trace gravel<br>Very Dense<br>Grey<br>Dry<br>(TILL)  |            | 3       | SS   | 70           |                            | 68              |   |                 |                 |                 |                 |   |  |
| 67.7          |   |            |         |      |              |                            |                 |   |                 |                 |                 |                 |   |  |
| 2.1           | <b>SHALE</b>  |            |         |      |              |                            |                 |   |                 |                 |                 |                 |   |  |
| 67.4          |   |            |         |      |              |                            |                 |   |                 |                 |                 |                 |   |  |
| 2.4           | END OF BOREHOLE AT 2.4m UPON<br>AUGER REFUSAL.<br>BOREHOLE OPEN TO 2.4m AND<br>DRY UPON COMPLETION.<br>BOREHOLE BACKFILLED WITH<br>CUTTINGS TO SURFACE. |            |         |      |              |                            |                 |   |                 |                 |                 |                 |   |  |

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15 5  
10  
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 19N-2

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 673.0 E 373 106.8 ORIGINATED BY GA  
HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2011.08.13 - 2011.08.13 CHECKED BY LRB

| SOIL PROFILE  |   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |    |     | 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 |                            |                 | 20  | 40 | 60 | 80 | 100 |   |   |
| 69.4          |   |            |         |      |            |                            |                 |   |    |    |    |     |   |   |
| 0.0           | TOPSOIL: (50mm)   |            |         |      |            |                            |                 |   |    |    |    |     |   |   |
|               | Silty SAND, some clay, trace gravel,<br>occasional rootlets<br>Compact to Very Dense<br>Brown to Grey<br>Damp<br>(TILL)           |            | 1       | SS   | 24         |                            | 69              |   |    |    |    |     |   |   |
| 68.1          |   |            | 2       | SS   | 64         |                            |                 |   |    |    |    |     |   | 1 49 38 12  |
| 1.3<br>67.8   | SHALE, fresh, thinly bedded, grey   |            | 3       | SS   | 100/       |                            | 68              |   |    |    |    |     |   |   |
| 1.6           | END OF BOREHOLE AT 1.6m.<br>BOREHOLE OPEN TO 1.6m AND<br>DRY UPON COMPLETION.<br>BOREHOLE BACKFILLED WITH<br>CUTTINGS TO SURFACE. |            |         |      | 0.075      |                            |                 |   |    |    |    |     |   |   |

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No 21S-01

1 OF 1

METRIC

W.P. 4091-07-00 LOCATION N 5 031 116.4 E 369 877.9 ORIGINATED BY GA  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.08.16 - 2011.08.16 CHECKED BY LRB

| SOIL PROFILE  |   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |  |  |  | UNIT<br>WEIGHT<br><br>γ<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                          |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 | 20 40 60 80 100                             |  |  |  |  |  |  |  |  |
| 60.2          |   |            |         |      |            |                            |                 |   |  |  |  |  |  |  |  |  |
| 0.0           | <b>SAND</b> , some silt, trace gravel<br>Dense to Compact<br>Brown<br>Dry<br>(FILL)   |            | 1       | SS   | 32         |                            | 60              |   |  |  |  |  |  |  |  |  |
|               |   |            |         |      |            |                            |                 |   |  |  |  |  |  |  |  |  |
|               |   |            | 2       | SS   | 43         |                            | 59              |   |  |  |  |  |  |  |  |  |
|               |   |            | 3       | SS   | 14         |                            | 58              |   |  |  |  |  |  |  |  |  |
|               |   |            | 4       | SS   | 15         |                            | 57              |   |  |  |  |  |  |  |  |  |
| 55.9          | <b>SAND</b> , some silt, trace gravel<br>Compact<br>Dark Grey<br>Dry  |            | 5       | SS   | 9          |                            | 56              |   |  |  |  |  |  |  |  |  |
| 4.3           |   |            | 6       | SS   | 22         |                            | 55              |   |  |  |  |  |  |  |  |  |
| 55.0          | END OF BOREHOLE AT 5.2m.<br>BOREHOLE OPEN TO 5.2m AND<br>DRY UPON COMPLETION.<br>Piezometer installation consists of<br>19mm diameter Schedule 40 PVC pipe<br>with a 1.52m slotted screen.<br><br>WATER LEVEL READINGS:<br>DATE DEPTH (m) ELEV. (m)<br>Sep.20/11 Dry<br>Oct.12/11 Dry |            |         |      |            |                            |                 |   |  |  |  |  |  |  |  |  |
| 5.2           |   |            |         |      |            |                            |                 |   |  |  |  |  |  |  |  |  |

# RECORD OF BOREHOLE No 21S-02

1 OF 1

METRIC

W.P. 4091-07-00 LOCATION N 5 031 107.9 E 369 936.3 ORIGINATED BY GA  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.08.17 - 2011.08.17 CHECKED BY LRB

| SOIL PROFILE  |   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |    |     | UNIT<br>WEIGHT<br>γ<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |
|---------------|---|------------|---------|------|------------|----------------------------|-----------------|---|----|----|----|-----|--|---|
| ELEV<br>DEPTH | DESCRIPTION   | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | 20  | 40 | 60 | 80 | 100 |  |   |
| 60.4<br>0.0   | SAND, some gravel to gravelly, some silt and clay, occasional rootlets<br>Loose to Dense<br>Brown<br>Dry<br>(FILL)  |            | 1       | SS   | 4          |                            | 60              |   |    |    |    |     |  | 23 63 14<br>(SI+CL)                               |
|               |   |            | 2       | SS   | 42         |                            | 59              |   |    |    |    |     |  |   |
|               |   |            | 3       | SS   | 7          |                            | 58              |   |    |    |    |     |  |   |
|               |   |            | 4       | SS   | 4          |                            | 57              |   |    |    |    |     |  |   |
| 57.4<br>3.0   | SAND, trace silt, occasional gravel<br>Compact<br>Brown<br>Dry  |            | 5       | SS   | 12         |                            | 56              |   |    |    |    |     |  | 4 60 32 4   |
| 55.8<br>4.6   | Silty SAND, trace gravel, trace clay<br>Dense<br>Brown<br>Damp<br>(TILL)  |            | 6       | SS   | 30         |                            |                 |   |    |    |    |     |  |   |
| 55.2<br>5.2   | END OF BOREHOLE AT 5.2m.<br>BOREHOLE OPEN TO 5.2m AND<br>DRY UPON COMPLETION.<br>BOREHOLE BACKFILLED WITH<br>BENTONITE HOLEPLUG AND<br>CUTTINGS TO SURFACE. |            |         |      |            |                            |                 |   |    |    |    |     |  |   |

RECORD OF BOREHOLE No 21S-03

1 OF 1

METRIC

W.P. 4091-07-00 LOCATION N 5 031 098.7 E 369 993.9 ORIGINATED BY GA  
HWY 417 BOREHOLE TYPE Hollow Stem Augers - CME-55 COMPILED BY AN  
DATUM Geodetic DATE 2011.08.17 - 2011.08.17 CHECKED BY LRB

| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT                        |    |    |     |  | PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT |  |  | UNIT<br>WEIGHT<br><br>γ<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      × LAB VANE |    |    |     |  |   |  |  |  |  |
| 60.4          |  |            |         |      |            |                            | 20              | 40   | 60 | 80 | 100 |  |   |  |  |  |  |
| 0.0           | SAND, trace to some silt, trace gravel, occasional rootlets<br>Compact<br>Brown<br>Dry<br>(FILL)   |            | 1       | SS   | 11         |                            |                 |  |    |    |     |  |   |  |  |  |  |
|               |  |            | 2       | SS   | 28         |                            |                 |  |    |    |     |  |   |  |  |  |  |
| 58.9          |  |            |         |      |            |                            |                 |  |    |    |     |  |   |  |  |  |  |
| 1.5           | Silty SAND, trace gravel, trace clay<br>Compact<br>Brown<br>Damp to Dry<br>(TILL)  |            | 3       | SS   | 16         |                            |                 |  |    |    |     |  |   |  |  |  |  |
|               |  |            | 4       | SS   | 11         |                            |                 |  |    |    |     |  |   |  |  |  |  |
| 57.4          |  |            |         |      |            |                            |                 |  |    |    |     |  |   |  |  |  |  |
| 3.0           | SAND, some silt, trace gravel<br>Compact<br>Grey<br>Damp to Wet  |            | 5       | SS   | 11         |                            |                 |  |    |    |     |  |   |  |  |  |  |
|               |  |            |         |      |            |                            |                 |  |    |    |     |  |   |  |  |  |  |
| 55.2          |  |            | 6       | SS   | 24         |                            |                 |  |    |    |     |  |   |  |  |  |  |
| 5.2           | END OF BOREHOLE AT 5.2m.<br>BOREHOLE OPEN TO 5.2m AND DRY UPON COMPLETION.<br>Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.<br><br>WATER LEVEL READINGS:<br>DATE      DEPTH (m)      ELEV. (m)<br>Oct.12/11      Destroyed |            |         |      |            |                            |                 |  |    |    |     |  |   |  |  |  |  |

RECORD OF BOREHOLE No 22S-01

1 OF 1

METRIC

W.P. 4091-07-00 LOCATION N 5 031 091.9 E 370 029.5 ORIGINATED BY GA  
HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2011.08.17 - 2011.08.17 CHECKED BY LRB

| SOIL PROFILE  |   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |    |     | UNIT<br>WEIGHT<br>γ<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |
|---------------|---|------------|---------|------|------------|----------------------------|-----------------|---|----|----|----|-----|--|---|
| ELEV<br>DEPTH | DESCRIPTION   | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | 20  | 40 | 60 | 80 | 100 |  |   |
| 60.7<br>0.0   | SAND, some silt to silty, trace gravel<br>Compact to Very Loose<br>Brown<br>Dry<br>(FILL)   |            | 1       | SS   | 14         |                            |                 |   |    |    |    |     |  |   |
|               |   |            | 2       | SS   | 3          |                            |                 |   |    |    |    |     |  |   |
|               |   |            | 3       | SS   | 13         |                            |                 |   |    |    |    |     |  |   |
| 58.4<br>2.3   | Silty SAND, trace gravel, trace clay<br>Loose to Compact<br>Brown to Grey<br>Dry to Damp<br>(TILL)  |            | 4       | SS   | 8          |                            |                 |   |    |    |    |     |  |   |
|               |   |            | 5       | SS   | 27         |                            |                 |   |    |    |    |     |  |   |
|               |   |            | 6       | SS   | 25         |                            |                 |   |    |    |    |     |  |   |
| 55.5<br>5.2   | END OF BOREHOLE AT 5.2m.<br>BOREHOLE OPEN AND DRY UPON<br>COMPLETION.<br>BOREHOLE BACKFILLED WITH<br>BENTONITE HOLEPLUG AND<br>CUTTINGS TO SURFACE. |            |         |      |            |                            |                 |   |    |    |    |     |  |   |

# RECORD OF BOREHOLE No 22S-02

1 OF 1

METRIC

W.P. 4091-07-00 LOCATION N 5 031 081.4 E 370 082.5 ORIGINATED BY GA  
HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2011.08.18 - 2011.08.18 CHECKED BY LRB

| SOIL PROFILE  |   |            | SAMPLES |      |              | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT  |    |    | PLASTIC LIMIT      NATURAL<br>LIMIT      MOISTURE<br>CONTENT      LIQUID<br>LIMIT |    |    | UNIT<br>WEIGHT<br><br>γ<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<br>○ UNCONFINED      + FIELD VANE<br>● QUICK TRIAXIAL      × LAB VANE |    |    | WATER CONTENT (%)<br>w <sub>p</sub> w      w <sub>L</sub>                         |    |    |  |  |           |  |
| 60.5          |   |            |         |      |              |                            | 20              | 40   | 60 | 80 | 100   | 20 | 40 | 60   |  |           |  |
| 0.0           | TOPSOIL: (75mm)   |            | 1       | SS   | 50/<br>0.150 |                            |                 |  |    |    |   | ○  |    |  |  |           |  |
| 0.1           | SAND, trace silt, trace gravel<br>Very Dense<br>Brown<br>Dry<br>(FILL)  |            |         |      |              |                            |                 |  |    |    |   |    |    |  |  |           |  |
| 59.7          |   |            |         |      |              |                            |                 |  |    |    |   |    |    |  |  |           |  |
| 0.8           | Silly SAND, trace gravel<br>Dense to Very Dense<br>Brown<br>Dry<br>(FILL)   |            | 2       | SS   | 32           |                            |                 |  |    |    |   | ○  |    |  |  |           |  |
|               |   |            |         |      |              |                            |                 |  |    |    |   |    |    |  |  |           |  |
|               |   |            | 3       | SS   | 53           |                            |                 |  |    |    |   | ○  |    |  |  | 3 55 34 8 |  |
| 58.4          |   |            |         |      |              |                            |                 |  |    |    |   |    |    |  |  |           |  |
| 2.1           | Silly SAND, trace gravel, trace clay<br>Very Dense to Very Loose<br>Brown to Grey<br>Dry to Wet<br>(TILL)   |            | 4       | SS   | 50/<br>0.150 |                            |                 |  |    |    |   | ○  |    |  |  |           |  |
|               |   |            |         |      |              |                            |                 |  |    |    |   |    |    |  |  |           |  |
|               |   |            | 5       | SS   | 4            |                            |                 |  |    |    |   | ○  |    |  |  | 7 58 30 5 |  |
|               |   |            |         |      |              |                            |                 |  |    |    |   |    |    |  |  |           |  |
|               |   |            |         |      |              |                            |                 |  |    |    |   |    |    |  |  |           |  |
|               |   |            |         |      |              |                            |                 |  |    |    |   |    |    |  |  |           |  |
|               |   |            | 6       | SS   | 32           |                            |                 |  |    |    |   | ○  |    |  |  |           |  |
| 55.3          |   |            |         |      |              |                            |                 |  |    |    |   |    |    |  |  |           |  |
| 5.2           | END OF BOREHOLE AT 5.2m.<br>BOREHOLE OPEN TO 5.2m AND<br>DRY UPON COMPLETION.<br>Piezometer installation consists of<br>19mm diameter Schedule 40 PVC pipe<br>with a 1.52m slotted screen.<br><br>WATER LEVEL READINGS:<br>DATE      DEPTH (m)      ELEV. (m)<br>Sep.20/11      3.1      57.4<br>Oct.12/11      3.8      56.7 |            |         |      |              |                            |                 |  |    |    |   |    |    |  |  |           |  |

# RECORD OF BOREHOLE No 1M-01

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 226.9 E 370 866.6 ORIGINATED BY RK/GA  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.08.26 - 2011.08.26 CHECKED BY LRB

| SOIL PROFILE  |  |            | SAMPLES |      |               | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |                 |                 |                 |                 | 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    |                            |                 | 20 40 60 80 100                             | 20 40 60 80 100 | 20 40 60 80 100 | 20 40 60 80 100 | 20 40 60 80 100 |   |   |
| 60.5          |  |            |         |      |               |                            |                 |   |                 |                 |                 |                 |   |   |
| 0.0           | ASPHALT: (100mm)   |            |         |      |               |                            |                 |   |                 |                 |                 |                 |   |   |
| 0.1           |  |            |         |      |               |                            |                 |   |                 |                 |                 |                 |   |   |
| 60.2          | CONCRETE: (250mm)  |            |         |      |               |                            |                 |   |                 |                 |                 |                 |   |   |
| 0.4           | SAND, trace to some gravel<br>Compact<br>Brown<br>Damp<br>(FILL)   |            | 1       | SS   | 28            |                            |                 |   |                 |                 |                 |                 |   |   |
|               |  |            | 2       | SS   | 100/<br>0.050 |                            |                 |   |                 |                 |                 |                 |   |   |
| 58.2          |  |            |         |      |               |                            |                 |   |                 |                 |                 |                 |   |   |
| 2.3           | Sandy SILT, some gravel, with shale<br>fragments<br>Very Dense<br>Dark Brown<br>Dry<br>(TILL)  |            | 3       | SS   | 63            |                            |                 |   |                 |                 |                 |                 |   |   |
| 57.5          |  |            |         |      |               |                            |                 |   |                 |                 |                 |                 |   |   |
| 3.0           | SHALE, thinly bedded, grey   |            | 4       | SS   | 86            |                            |                 |   |                 |                 |                 |                 |   |   |
| 56.5          |  |            |         |      |               |                            |                 |   |                 |                 |                 |                 |   |   |
| 4.0           | END OF BOREHOLE AT 4.0m UPON<br>AUGER REFUSAL.<br>BOREHOLE OPEN TO 4.0m AND<br>DRY UPON COMPLETION.<br>BOREHOLE BACKFILLED WITH<br>BENTONITE HOLEPLUG AND<br>CUTTINGS FROM 4.0m TO 0.3m,<br>CONCRETE FROM 0.3m TO 0.15m<br>THEN ASPHALT PATCH TO<br>SURFACE. |            |         |      |               |                            |                 |   |                 |                 |                 |                 |   |   |

+ 3, X 3 Numbers refer to 20  
Sensitivity 15-10 5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 1M-02

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION N 5 031 244.1 E 370 901.7 ORIGINATED BY GA  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.11.14 - 2011.11.14 CHECKED BY LRB

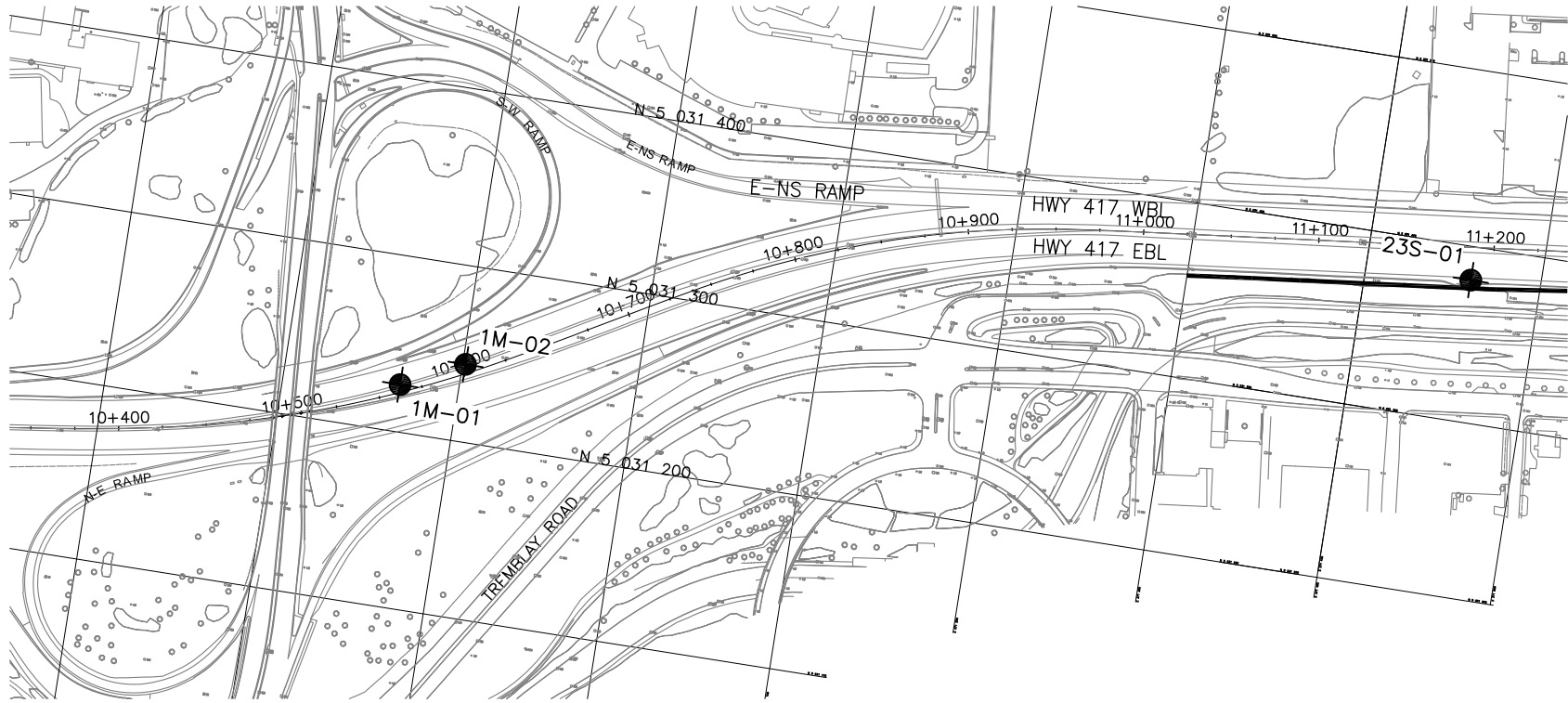
| SOIL PROFILE  |   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  | PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT |  |  | UNIT<br>WEIGHT<br><br>γ<br><br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |
|---------------|---|------------|---------|------|------------|----------------------------|-----------------|---|--|---|--|--|--|---|
| ELEV<br>DEPTH | DESCRIPTION   | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa                          |  | WATER CONTENT (%)                                       |  |  |  |   |
| 60.8          |   |            |         |      |            |                            |                 | 20 40 60 80 100                             |  |   |  |  |  |   |
| 0.0           | ASPHALT: (100mm)  |            |         |      |            |                            |                 |   |  |   |  |  |  |   |
| 0.1           | CONCRETE: (200mm)   |            |         |      |            |                            |                 |   |  |   |  |  |  |   |
| 0.3           |   |            |         |      |            |                            |                 |   |  |   |  |  |  |   |
| 60.1          | SAND and GRAVEL<br>Compact  |            | 1       | SS   | 26         |                            | 60              |   |  |   |  |  |  |   |
| 0.7           | Brown<br>Dry<br>(FILL)  |            | 2       | SS   | 28         |                            |                 |   |  |   |  |  |  | 0 92 8<br>(SI+CL)                                 |
| 59.3          | SAND, trace silt and clay<br>Compact  |            |         |      |            |                            |                 |   |  |   |  |  |  |   |
| 1.4           | Brown<br>Dry<br>(FILL)  |            | 3       | SS   | 20         |                            | 59              |   |  |   |  |  |  |   |
|               | Silty SAND, some gravel, some clay<br>Compact to Dense<br>Dark Brown to Grey<br>Dry<br>(TILL)   |            |         |      |            |                            |                 |   |  |   |  |  |  |   |
|               |   |            | 4       | SS   | 44         |                            | 58              |   |  |   |  |  |  | 15 46 26 13                                       |
| 57.8          |   |            |         |      |            |                            |                 |   |  |   |  |  |  |   |
| 2.9           | SHALE, thinly bedded, grey  |            | 5       | SS   | 50/        |                            |                 |   |  |   |  |  |  |   |
| 57.6          |   |            |         |      |            |                            |                 |   |  |   |  |  |  |   |
| 3.1           | END OF BOREHOLE AT 3.1m.<br>BOREHOLE OPEN TO 3.1m AND<br>DRY UPON COMPLETION.<br>Piezometer installation consists of<br>19mm diameter Schedule 40 PVC pipe<br>with a 1.52m slotted screen.<br><br>WATER LEVEL READINGS:<br>DATE      DEPTH (m)      ELEV. (m) |            |         |      | 0.100      |                            |                 |   |  |   |  |  |  |   |

+<sup>3</sup>, X<sup>3</sup>: Numbers refer to  
Sensitivity

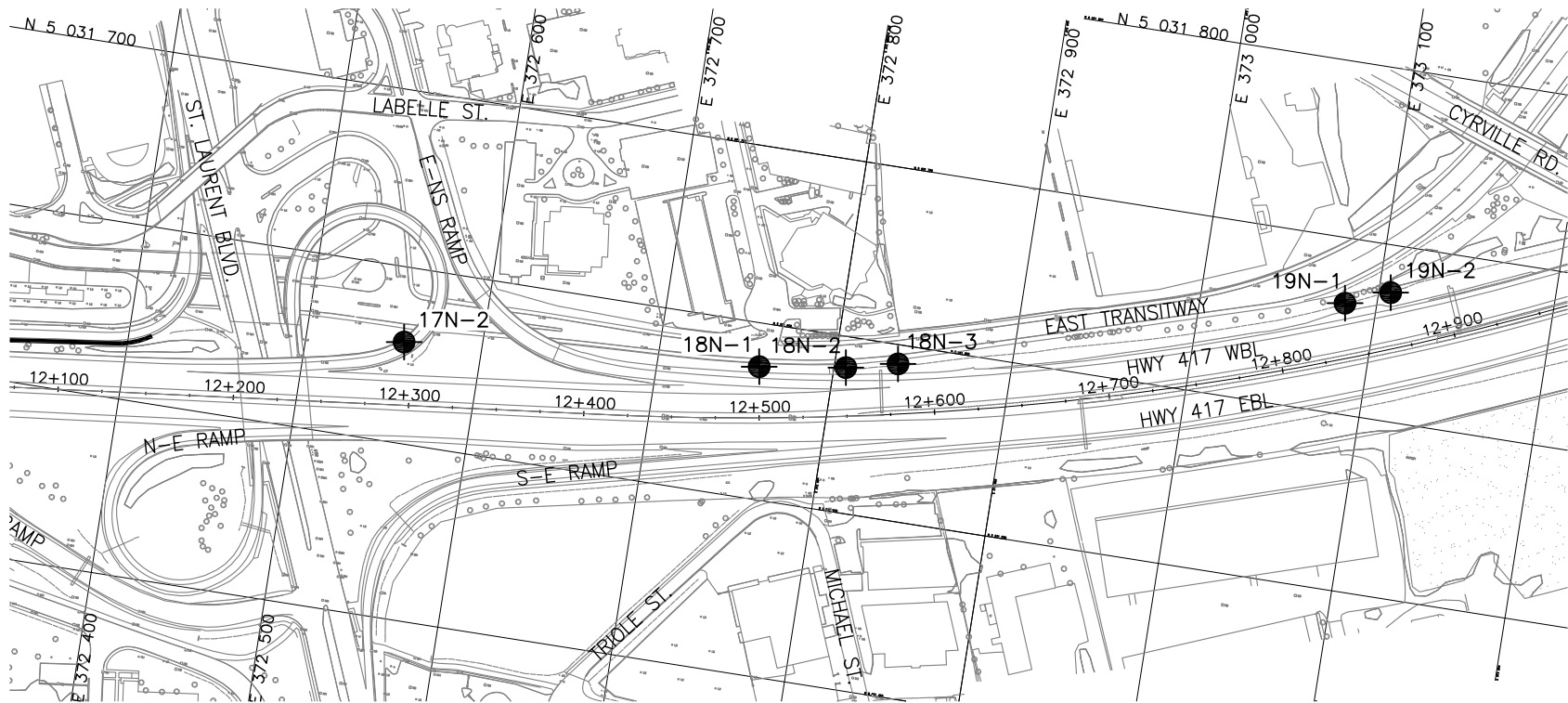
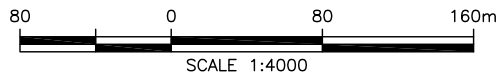
20  
15- $\phi$  5  
10

(%) STRAIN AT FAILURE





PLAN



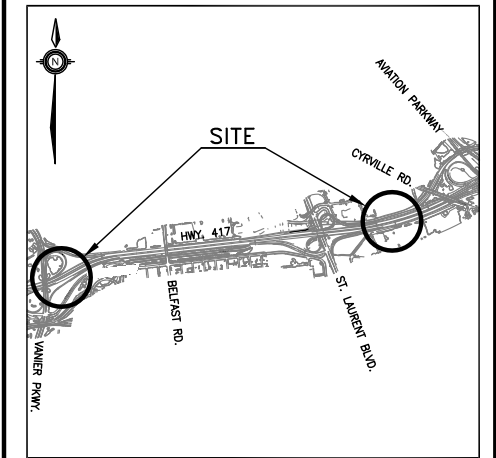
PLAN



**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No  
WP No 4320-06-00

HIGHWAY 417  
VANIER PARKWAY  
TO CYRVILLE ROAD  
BOREHOLE LOCATION PLAN



KEYPLAN

LEGEND

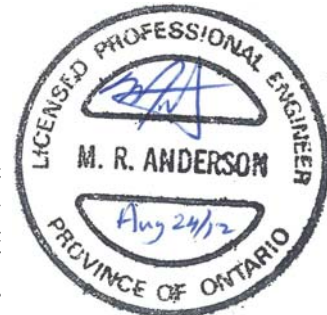
|      |                                       |
|------|---------------------------------------|
| ●    | Borehole                              |
| ⊕    | Borehole and Cone                     |
| N    | Blows /0.3m (Std Pen Test, 475J/blow) |
| CONE | Blows /0.3m (60° Cone, 475J/blow)     |
| PH   | Pressure, Hydraulic                   |
| ▽    | Water Level                           |
| ⊕    | Head Artesian Water                   |
| ⊕    | Piezometer                            |
| 90%  | Rock Quality Designation (RQD)        |
| A/R  | Auger Refusal                         |

| NO    | ELEVATION | NORTHING    | EASTING   |
|-------|-----------|-------------|-----------|
| 1M-01 | 60.5      | 5 031 226.9 | 370 866.6 |
| 1M-02 | 60.8      | 5 031 244.1 | 370 901.7 |
| 17N-2 | 72.2      | 5 031 557.5 | 372 555.7 |
| 18N-1 | 71.7      | 5 031 575.3 | 372 757.8 |
| 18N-2 | 70.8      | 5 031 580.4 | 372 801.9 |
| 18N-3 | 71.4      | 5 031 589.1 | 372 835.8 |
| 19N-1 | 69.8      | 5 031 663.0 | 373 082.0 |
| 19N-2 | 69.4      | 5 031 673.0 | 373 106.8 |

**-NOTES-**

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

**GEOCRES No. 31G5-250**



| REVISIONS | DATE | BY  | DESCRIPTION |
|-----------|------|-----|-------------|
| DESIGN    | LRB  | CHK | LRB         |
| DRAWN     | AN   | CHK | PKC         |
| LOAD      |      |     |             |
| SITE      |      |     |             |
| STRUCT    |      |     |             |
| DWG       |      |     |             |

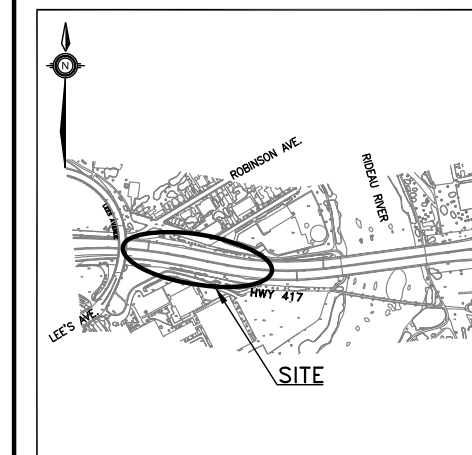


CONT No  
WP No 4320-06-00








SHEET

HIGHWAY 417  
LEES AVENUE TO  
RIDEAU RIVER  
BOREHOLE LOCATIONS PLAN



KEYPLAN  
LEGEND

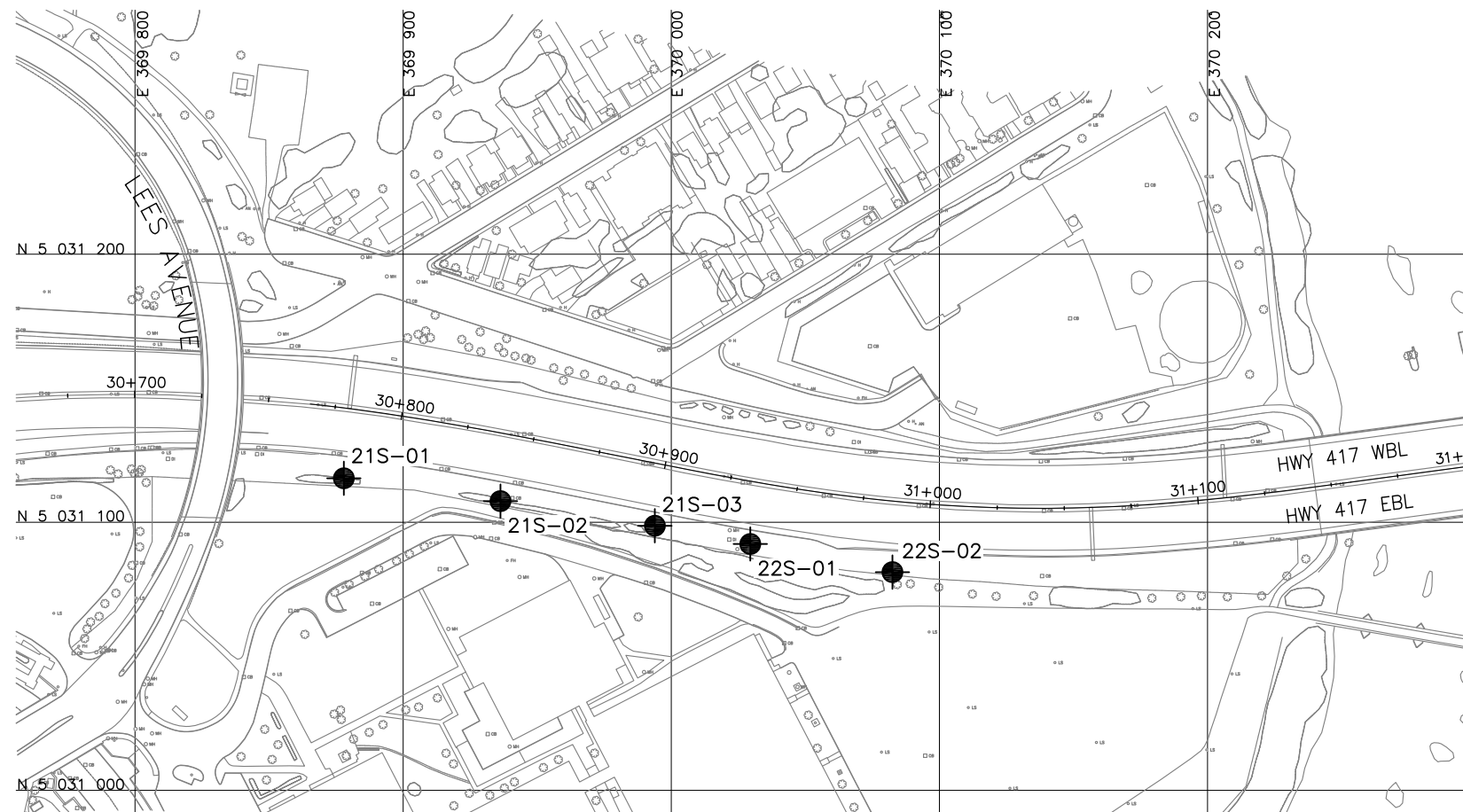
|   |                                       |
|---|---------------------------------------|
|  | Borehole                              |
|  | Borehole and Cone                     |
| N   | Blows /0.3m (Std Pen Test, 475J/blow) |
| CONE  | Blows /0.3m (60° Cone, 475J/blow)     |
| PH  | Pressure, Hydraulic                   |
|  | Water Level                           |
|  | Head Artesian Water                   |
|  | Piezometer                            |
| 90%   | Rock Quality Designation (RQD)        |
| A/R   | Auger Refusal                         |

[illegible]

-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

**GEOCRES No. 31G5-250**



## PLAN



|           |      |     |             |      |        |     |      |           |  |  |  |
|-----------|------|-----|-------------|------|--------|-----|------|-----------|--|--|--|
| REVISIONS |      |     |             |      |        |     |      |           |  |  |  |
|           |      |     |             |      |        |     |      |           |  |  |  |
|           |      |     |             |      |        |     |      |           |  |  |  |
|           |      |     |             |      |        |     |      |           |  |  |  |
|           |      |     |             |      |        |     |      |           |  |  |  |
|           | DATE | BY  | DESCRIPTION |      |        |     |      |           |  |  |  |
| DESIGN    | LRB  | CHK | LRB         | CODE | LOAD   |     | DATE | AUG. 2012 |  |  |  |
| DRAWN     | AN   | CHK | PKC         | SITE | STRUCT | DWG | 1    |           |  |  |  |

## **Appendix J**

### **Tables J1 to J5 Comparison of Wall Types**

**Table J1 - Comparison of Wall Types**  
**Nicholas Street Underpass (South) – Station 130+329 to 130+366**

| <b>Concrete Toe Wall</b>   | <b>Cantilever Wall (cast-in-place) on Native Soil</b>   | <b>Cantilever Wall (cast-in-place) on Engineered Fill</b>   | <b>Soldier Pile and Lagging Wall</b>  | <b>RSS Wall</b>   |
|--|---|---|---|---|
| <b>Advantages:</b><br>i. Typically most cost efficient for low walls.<br>ii. Suitable for low headroom site. | <b>Advantages:</b><br>i. Typically more cost efficient than piles.<br>ii. Suitable for low headroom site.   | <b>Advantages:</b><br>i. Typically more cost efficient than piles.<br>ii. Higher geotechnical resistance than for footings on native soil.  | <b>Advantages:</b><br>i. Excavation requirements are minimized.   | <b>Advantages:</b><br>i. Flexible structure with more tolerance for differential settlement.  |
| <b>Disadvantages:</b><br>i. Retained height is limited.  | <b>Disadvantages:</b><br>i. Relatively low geotechnical resistance on native soil.<br>ii. Potential for settlement of underlying silty clay layer.<br>iii. Roadway protection will be required for foundation excavation.<br>iv. Temporary support of the embankment slope is required. | <b>Disadvantages:</b><br>i. Excavation and placement of engineered fill below the groundwater level would require preconstruction dewatering.<br>ii. Expanded roadway protection would be required. | <b>Disadvantages:</b><br>i. Lateral resistance to soldier piles in native soils is relatively low.<br>ii. Liners will be required to support auger hole sidewalls in cohesionless soils below groundwater level.<br>iii. Limited headroom available below the existing underpass structure.<br>iv. Typically more costly than a concrete toe wall/cantilever wall | <b>Disadvantages:</b><br>i. May not be cost effective for a low wall<br>ii. Limited space between wall and existing abutment for installation of soil reinforcement |
| <b>RECOMMENDED</b>   | <b>FEASIBLE</b>   | <b>NOT RECOMMENDED</b>  | <b>FEASIBLE</b>   | <b>NOT RECOMMENDED</b>  |

**Table J2 - Comparison of Wall Types**  
**Lees Avenue (North) at Robinson Avenue – Station 230+718 to 230+751**

| <b>Cantilever Wall (cast-in-place) on Native Soil</b>   | <b>Cantilever Wall (cast-in-place) on Engineered Fill</b>   | <b>Soldier Pile and Lagging Wall</b>  | <b>Post and Panel Wall</b>   | <b>RSS Wall</b>  |
|---|---|---|--|--|
| <b>Advantages:</b> <ul style="list-style-type: none"> <li>i. Competent native soils were encountered below the fill at approximately 2.2 m below existing road grade on Robinson Avenue.</li> <li>ii. Typically least costly to construct.</li> </ul> | <b>Advantages:</b> <ul style="list-style-type: none"> <li>i. Generally, higher geotechnical resistance than for footings on native soil.</li> </ul>       | <b>Advantages:</b> <ul style="list-style-type: none"> <li>i. Soldier piles will develop lateral resistance in the native soils.</li> <li>ii. Excavation requirements are minimized.</li> </ul>  | <b>Advantages:</b> <ul style="list-style-type: none"> <li>i. Excavation requirements are minimized.</li> </ul>   | <b>Advantages:</b> <ul style="list-style-type: none"> <li>i. Flexible structure with more tolerance for differential settlement.</li> </ul>  |
| <b>Disadvantages:</b> <ul style="list-style-type: none"> <li>i. Roadway protection will be required for foundation excavation.</li> </ul>   | <b>Disadvantages:</b> <ul style="list-style-type: none"> <li>i. Additional cost of engineered fill construction is not warranted at this site.</li> </ul> | <b>Disadvantages:</b> <ul style="list-style-type: none"> <li>i. Cobbles and boulders in the fill and native soils may interfere with pile installation.</li> <li>ii. Liners will be required to support augerhole sidewalls in cohesionless soils below groundwater.</li> <li>iii. Limited headroom available below the existing underpass structure.</li> <li>iv. Typically more costly than a concrete cantilever wall</li> </ul> | <b>Disadvantages:</b> <ul style="list-style-type: none"> <li>i. Cobbles and boulders in the fill and native soils may interfere with post installation</li> <li>ii. Liners will be required to support augerhole sidewalls in cohesionless soils below groundwater.</li> </ul> | <b>Disadvantages:</b> <ul style="list-style-type: none"> <li>i. May not be cost effective for a low wall</li> <li>ii. Limited space between wall and existing abutment for installation of soil reinforcement</li> </ul> |
| <b>RECOMMENDED</b>  | <b>NOT RECOMMENDED</b>  | <b>FEASIBLE</b>   | <b>FEASIBLE</b>  | <b>NOT RECOMMENDED</b>   |

**Table J3 - Comparison of Wall Types**  
**Canadian Tire Parking Lot – Station 210+902 to 211+000**

| <b>Concrete Toe Wall</b>   | <b>Cantilever Wall (cast-in-place) on Native Soil</b>   | <b>Cantilever Wall (cast-in-place) on Engineered Fill</b>   | <b>Soldier Pile and Lagging Wall</b>   | <b>Post and Panel Wall</b>   | <b>RSS Wall</b>   |
|--|---|---|--|--|---|
| <b>Advantages:</b><br>i. Typically most cost efficient for low walls.  | <b>Advantages:</b><br>ii. Competent native soils are present immediately below the pavement structure.<br>iii. Typically least costly to construct. | <b>Advantages:</b><br>i. A higher geotechnical resistance can be achieved than on native soil.  | <b>Advantages:</b><br>i. Soldier piles will develop lateral resistance in the native soils and underlying bedrock.<br>ii. Excavation requirements are minimized.<br>iii. Need for roadway protection is reduced or eliminated. | <b>Advantages:</b><br>i. Excavation requirements are minimized.                              | <b>Advantages:</b><br>i. Flexible structure with more tolerance for differential settlement.  |
| <b>Disadvantages:</b><br>i. Retained height is limited.<br>ii. Foundation improvement (granular pad) is recommended. | <b>Disadvantages:</b><br>iii. Roadway protection will be required for foundation excavation.  | <b>Disadvantages:</b><br>i. Excavation and roadway protection requirements will be increased for construction of engineered fill.<br>ii. Additional cost of engineered fill may not be warranted. | <b>Disadvantages:</b><br>i. Typically more costly than a concrete cantilever wall  | <b>Disadvantages:</b><br>i. Generally applicable only to retaining wall heights up to 2.5 m. | <b>Disadvantages:</b><br>i. May not be cost effective for a low wall.<br>ii. Will likely require roadway protection and lane closures to install. |
| <b>RECOMMENDED</b>   | <b>FEASIBLE</b>   | <b>NOT RECOMMENDED</b>  | <b>FEASIBLE</b>  | <b>FEASIBLE</b>  | <b>NOT RECOMMENDED</b>  |

**Table J4 - Comparison of Wall Types**  
**Belfast Road (North) Wall 15N – Station 211+220 to 211+700**

| <b>Cantilever Wall (cast-in-place) on Native Soil or Shale</b>  | <b>Cantilever Wall (cast-in-place) on Engineered Fill</b>   | <b>Soldier Pile and Lagging Wall</b>   | <b>Post and Panel Wall</b>  | <b>RSS Wall</b>  |
|---|---|--|---|--|
| <b>Advantages:</b> <ul style="list-style-type: none"> <li>i. Competent native soil and bedrock are present at relatively shallow depths.</li> <li>ii. Typically least costly to construct.</li> </ul> | <b>Advantages:</b> <ul style="list-style-type: none"> <li>i. Generally, higher geotechnical resistance than for footings on native soil.</li> </ul>           | <b>Advantages:</b> <ul style="list-style-type: none"> <li>i. Soldier piles will develop lateral resistance in the native soils and bedrock.</li> <li>ii. Excavation requirements are minimized.</li> <li>iii. Need for roadway protection is reduced or eliminated.</li> </ul> | <b>Advantages:</b> <ul style="list-style-type: none"> <li>i. Excavation requirements are minimized.</li> </ul>                              | <b>Advantages:</b> <ul style="list-style-type: none"> <li>i. Flexible structure with more tolerance for differential settlement.</li> </ul>  |
| <b>Disadvantages:</b> <ul style="list-style-type: none"> <li>i. Roadway protection will be required for foundation excavation.</li> </ul>   | <b>Disadvantages:</b> <ul style="list-style-type: none"> <li>i. The additional cost of engineered fill construction is not warranted at this site.</li> </ul> | <b>Disadvantages:</b> <ul style="list-style-type: none"> <li>i. Typically more costly than a concrete cantilever wall</li> </ul>   | <b>Disadvantages:</b> <ul style="list-style-type: none"> <li>i. Generally applicable only to retaining wall heights up to 2.5 m.</li> </ul> | <b>Disadvantages:</b> <ul style="list-style-type: none"> <li>i. May not be cost effective for a low wall.</li> <li>ii. Will likely require roadway protection and lane closures to install.</li> </ul> |
| <b>RECOMMENDED</b>  | <b>NOT RECOMMENDED</b>  | <b>FEASIBLE</b>  | <b>FEASIBLE</b>   | <b>NOT RECOMMENDED</b>   |

**Table J5 - Comparison of Wall Types**  
**St. Laurent Boulevard N-W Ramp – Station 212+000 to 212+200**

| <b>Cantilever Wall (cast-in-place) on Native Soil</b>   | <b>Cantilever Wall (cast-in-place) on Engineered Fill</b>   | <b>Soldier Pile and Lagging Wall</b>  | <b>Post and Panel Wall</b>  | <b>RSS Wall</b>   |
|---|---|---|---|---|
| <p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. Typically least costly to construct.</li> <li>ii. To achieve higher geotechnical resistances, foundations could be extended down to very dense till or shale encountered at depths of 4.6 to 4.9 m</li> </ul>   | <p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. A higher geotechnical resistance can be achieved than on native silty sand.</li> </ul>  | <p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. Soldier piles can be extended through the fill and native soils, and socketed into the underlying bedrock.</li> <li>ii. Excavation requirements are minimized.</li> <li>iii. Need for roadway protection is reduced or eliminated.</li> </ul> | <p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>ii. Excavation requirements are minimized.</li> </ul>                              | <p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. Flexible structure with more tolerance for differential settlement.</li> </ul>  |
| <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. The wall base (spread footing) must be extended to native soil encountered at 1.5 to 3.0 m depth.</li> <li>ii. A relatively low geotechnical resistance is available in native silty sand.</li> <li>iii. Roadway protection will be required for foundation excavation.</li> </ul> | <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Excavation and roadway protection requirements will be increased for construction of engineered fill. Sufficient space may not be available in the confined area.</li> <li>ii. Additional cost of engineered fill construction.</li> </ul> | <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Typically more costly than a concrete cantilever wall</li> </ul>   | <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>ii. Generally applicable only to retaining wall heights up to 2.5 m.</li> </ul> | <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Typically cost effective.</li> <li>ii. Will likely require roadway protection and closure of Highway 417 lanes to install. Sufficient space may not be available.</li> </ul> |
| <b>RECOMMENDED</b>  | <b>NOT RECOMMENDED</b>  | <b>FEASIBLE</b>   | <b>FEASIBLE</b>   | <b>NOT RECOMMENDED</b>  |

## **Appendix K**

### **Tables 8.1 to 8.11**

### **Geotechnical Design Parameters**



**Table 8.1 - Parameters for Lateral Pile Resistance**  
**Nicholas Street Underpass (South) – Station 130+329 to 130+366**

| Borehole | Elevation (m) | Soil Strata             | $c_u$ (kPa) | $\phi'$ (degs) | $n_h$ (kN/m <sup>3</sup> ) | $K_p$ | $\gamma'$ (kN/m <sup>3</sup> ) |
|----------|---------------|-------------------------|-------------|----------------|----------------------------|-------|--------------------------------|
| NSW-1    | 58.7 to 56.8  | Dense Sand Fill**       | -           | 32             | 4,000                      | 3.3   | 21                             |
|          | 56.8 to 56.1  | Compact Sand            | -           | 32             | 4,000                      | 3.3   | 21                             |
|          | 56.1 to 55.1  | Loose Sand              | -           | 30             | 3,000                      | 3.0   | 10*                            |
|          | 55.1 to 53.0  | Soft Silty Clay         | 40          | -              | -                          | 2.5   | 7*                             |
|          | 53.0 to 50.0  | Compact Silt            | -           | 30             | 3,000                      | 3.0   | 10*                            |
|          | 50.0 to 45.2  | Compact Silty Sand Till | -           | 32             | 6,000                      | 3.3   | 11*                            |
| NSW-2    | 59.0 to 56.8  | Dense Sand Fill**       | -           | 32             | 4,000                      | 3.3   | 21                             |
|          | 56.8 to 56.1  | Compact Sand            | -           | 32             | 4,000                      | 3.3   | 21                             |
|          | 56.1 to 54.5  | Firm Silty Clay         | 40          | -              | -                          | 2.5   | 17                             |
|          | 54.5 to 51.8  | Compact to Loose Silt   | -           | 30             | 3,000                      | 3.0   | 10*                            |
|          | 51.8 to 45.2  | Compact Silty Sand Till | -           | 32             | 4,000                      | 3.3   | 11*                            |

\* Buoyant unit weight below the water table.

$c_u$  = undrained shear strength =  $q_u/2$

\*\* Neglect lateral resistance in frost depth.

**Table 8.2 - Lateral Earth Pressure Parameters**  
**Lees Avenue S-E Ramp – Station 10+290 to 10+375**

| <b>Borehole</b> | <b>Elevation (m)</b> | <b>Soil Strata</b>         | <b><math>\phi'</math> (degs)</b> | <b><math>K_a</math></b> | <b><math>K_o</math></b> | <b><math>K_p</math></b> | <b><math>\gamma'</math> (kN/m<sup>3</sup>)</b> |
|-----------------|----------------------|----------------------------|----------------------------------|-------------------------|-------------------------|-------------------------|--|
| LSER-01         | 58.7 to 55.6         | Very dense sand fill       | 35                               | 0.27                    | 0.43                    | 3.7                     | 21   |
|                 | 55.6 to 51.4         | Soft silty clay            | 25                               | 0.40                    | 0.58                    | 2.5                     | 7*   |
|                 | 51.4 to 50.3         | Loose silt                 | 30                               | 0.33                    | 0.50                    | 3.0                     | 10*  |
|                 | 50.3 to 47.6         | Compact silt and sand till | 32                               | 0.31                    | 0.47                    | 3.3                     | 11*  |
| LSER-02         | 59.0 to 55.9         | Very dense sand fill       | 35                               | 0.27                    | 0.43                    | 3.7                     | 21   |
|                 | 55.9 to 51.6         | Soft to firm silty clay    | 25                               | 0.40                    | 0.58                    | 2.5                     | 7*   |
|                 | 51.6 to 50.0         | Compact silt               | 30                               | 0.33                    | 0.50                    | 3.0                     | 10*  |
|                 | 50.0 to 48.1         | Compact sandy silt till    | 32                               | 0.31                    | 0.47                    | 3.0                     | 11*  |
| LSER-03         | 59.4 to 56.7         | Very dense sand fill       | 35                               | 0.27                    | 0.43                    | 3.7                     | 21   |
|                 | 56.7 to 55.6         | Compact sand fill          | 32                               | 0.31                    | 0.47                    | 3.0                     | 21   |
|                 | 55.6 to 53.3         | Soft silty clay            | 25                               | 0.40                    | 0.58                    | 2.5                     | 7*   |
|                 | 53.3 to 50.3         | Loose silt                 | 30                               | 0.33                    | 0.50                    | 3.0                     | 10*  |
|                 | 50.3 to 48.4         | Compact sandy silt till    | 32                               | 0.31                    | 0.47                    | 3.0                     | 11*  |
| LSER-04         | 59.6 to 56.9         | Very dense sand fill       | 35                               | 0.27                    | 0.43                    | 3.7                     | 21   |
|                 | 56.9 to 55.7         | Compact sand fill          | 32                               | 0.31                    | 0.47                    | 3.0                     | 21   |
|                 | 55.7 to 53.8         | Soft to firm silty clay    | 25                               | 0.40                    | 0.58                    | 2.5                     | 7*   |
|                 | 53.8 to 50.8         | Compact silt               | 30                               | 0.33                    | 0.50                    | 3.0                     | 10*  |
|                 | 50.8 to 48.1         | Compact sandy silt till    | 32                               | 0.31                    | 0.47                    | 3.0                     | 11*  |

\* Buoyant unit weight below the water table.

**Table 8.3 - Parameters for Lateral Pile Resistance**

**Lees Avenue (North) at Robinson Avenue – Station 230+718 to 230+751**

| Borehole | Depth (m)  | Soil Strata                                 | $n_h$ (kN/m <sup>3</sup> ) | $K_p$ | $\gamma'$ (kN/m <sup>3</sup> ) |
|----------|------------|---|----------------------------|-------|--------------------------------|
| LE-08    | 2.2 to 8.8 | Very dense sand to gravelly sand            | 6,000                      | 3.5   | 11*                            |
|          | 8.8 to 9.6 | Very dense silty sand till                  | 6,000                      | 3.5   | 11*                            |
| LE-09    | 2.2 to 8.5 | Very dense gravelly sand to sand and gravel | 6,000                      | 3.5   | 11*                            |
|          | 8.5 to 9.7 | Very dense sandy silt                       | 6,000                      | 3.5   | 11*                            |

\* Buoyant unit weight below the water table.

**Table 8.4 - Post Foundation Design Parameters**

**Lees Avenue (North) at Robinson Avenue – Station 230+718 to 230+751**

| Borehole No. | Approx. Station | Soil Strata                      | Soil Strata Level Below Existing Grade |             | Geotechnical Design Parameters |               |                               |                                |         |                          |           |
|--------------|-----------------|----------------------------------|--|-------------|--------------------------------|---------------|-------------------------------|--------------------------------|---------|--------------------------|-----------|
|              |                 |                                  |  |             | $c_u$ (kPa)                    | $\phi'$ (deg) | $\gamma$ (kN/m <sup>3</sup> ) | $\gamma'$ (kN/m <sup>3</sup> ) | $K_p$ * | Design Groundwater Level |           |
|              |                 |                                  | Depth (m)                              | Elev. (m)   |                                |               |                               |                                |         | Depth (m)                | Elev. (m) |
| LE-08        | 230+720         | Sand to gravelly sand            | 2.2 – 8.8                              | 58.5 – 51.9 | -                              | 34            | 21                            | 11                             | 3.5     | [1.1]                    | 59.6      |
| LE-09        | 230+745         | Gravelly sand to sand and gravel | 2.2 – 8.5                              | 58.3 – 52.0 | -                              | 34            | 21                            | 11                             | 3.5     | [1.0]                    | 59.5      |

[ ] Piezometer reading

\* Assuming a horizontal surface on the passive earth pressure side of the wall

**Table 8.5 – Noise Barrier Wall Foundation Design Parameters**  
**Lees Avenue (North) Noise Barrier – Station 230+680 to 231+ 080**

| Borehole No. | Approx. Station | Soil Strata             | Soil Strata Level Below Existing Grade |                          | Geotechnical Design Parameters |                  |                                  |                                   |            |                          |           |
|--------------|-----------------|-------------------------|--|--------------------------|--------------------------------|------------------|----------------------------------|-----------------------------------|------------|--------------------------|-----------|
|              |                 |                         |  |                          | $c_u$<br>(kPa)                 | $\phi'$<br>(deg) | $\gamma$<br>(kN/m <sup>3</sup> ) | $\gamma'$<br>(kN/m <sup>3</sup> ) | $K_p^{**}$ | Design Groundwater Level |           |
|              |                 |                         | Depth (m)                              | Elev. (m)                |                                |                  |                                  |                                   |            | Depth (m)                | Elev. (m) |
| 12N-1        | 230+680         | Fill (Sand & Gravel)    | 0.2 – 2.0                              | 60.8 – 59.0              | -                              | 32               | 21                               | 11                                | 3.3        | 5.8*                     | 55.2*     |
|              |                 | Sand                    | 2.0 – 6.7                              | 59.0 – 54.3              |                                | 35               | 21                               | 11                                | 3.7        |                          |           |
| 12N-2        | 230+785         | Fill (Sand)             | 0.2 - 2.3                              | 60.7 – 58.6              | -                              | 32               | 21                               | 11                                | 3.3        | 3.7*                     | 57.2*     |
|              |                 | Sand & Gravel           | 2.3- 4.6 <sup>#</sup>                  | 58.6 – 56.3 <sup>#</sup> |                                | 35               | 21                               | 11                                | 3.7        |                          |           |
| NB8-1        | 230+835         | Fill (Sand)             | 0.1 - 3.0                              | 61.0 – 58.1              | -                              | 30               | 21                               | 11                                | 3.0        | 3.8                      | 57.3      |
|              |                 | Till (Silty Sand)       | 3.0 - 6.2                              | 58.1 – 54.9              |                                | 32               | 21                               | 11                                | 3.3        |                          |           |
| 13N-1        | 230+895         | Fill (Sand)             | 0.2 - 1.5                              | 60.2 – 58.9              | -                              | 32               | 21                               | 11                                | 3.3        | 3.3                      | 57.1      |
|              |                 | Till (Silty Sand)       | 1.5 - 6.5                              | 58.9 – 53.9              |                                | 30               | 21                               | 11                                | 3.0        |                          |           |
| 14N-1        | 231+015         | Fill (Sand, Silty Sand) | 0.1 - 1.5                              | 60.3 – 58.9              | -                              | 30               | 21                               | 11                                | 3.0        | 2.9                      | 57.5      |
|              |                 | Till (Silty Sand)       | 1.5 - 6.7                              | 58.9 – 53.7              |                                | 30               | 21                               | 11                                | 3.0        |                          |           |
| 14N-2        | 231+025         | Fill (Sand, Silty Sand) | 0.2 - 2.1                              | 59.9 – 58.0              | -                              | 32               | 21                               | 11                                | 3.3        | [2.5]                    | [57.6]    |
|              |                 | Sand & Gravel           | 2.1 - 3.0                              | 58.0 – 57.1              |                                | 34               | 21                               | 11                                | 3.5        |                          |           |
|              |                 | Till (Silty Sand)       | 3.0 - 6.7                              | 57.1 – 53.4              |                                | 32               | 21                               | 11                                | 3.3        |                          |           |

[ ] Piezometer reading

\*Groundwater measurement in open borehole during drilling

\*\* Assuming a horizontal surface on the passive earth pressure side of the wall

<sup>#</sup> Refusal at Elev. 56.3

**Table 8.6 - Parameters for Lateral Pile Resistance**  
**Canadian Tire Parking Lot – Riverside Drive to Belfast (North) Station 210+902 to 211+000**

| <b>Borehole</b> | <b>Elevation (m)</b> | <b>Soil Strata</b>                    | <b><math>n_h</math> (kN/m<sup>3</sup>)</b> | <b><math>K_p</math></b> | <b><math>\gamma'</math> (kN/m<sup>3</sup>)</b> |
|-----------------|----------------------|---------------------------------------|--|-------------------------|--|
| CTW-1           | 60.3 to 58.7         | Compact silty sand fill               | 3,000                                      | 3.0                     | 11   |
|                 | 58.7 to 54.9         | Compact silty sand till               | 4,000                                      | 3.3                     | 11*  |
| OHS-07L         | 59.4 to 58.7         | Dense sandy silt fill                 | 3,000                                      | 3.0                     | 21   |
|                 | 58.7 to 58.0         | Compact sandy silt fill               | 2,000                                      | 3.0                     | 11*  |
|                 | 58.0 to 54.8         | Compact sandy silt till               | 4,000                                      | 3.3                     | 11*  |
| CTW-2           | 60.4 to 58.7         | Compact sandy silt till               | 5,000                                      | 3.3                     | 21   |
|                 | 58.7 to 56.9         | Compact to loose sandy silt till      | 4,000                                      | 3.3                     | 11*  |
| 15N-01          | 60.3 to 58.4         | Compact to very dense sandy silt till | 8,000                                      | 3.3                     | 21   |
|                 | 58.4 to 56.5         | Compact sandy silt till               | 4,000                                      | 3.3                     | 11*  |

\* Buoyant unit weight below the water table.

**Table 8.7 - Post Foundation Design Parameters**

**Canadian Tire Parking Lot – Riverside Drive to Belfast (North) Station 210+902 to 211+000**

| Borehole No. | Approx. Station | Soil Strata       | Soil Strata Level Below Existing Grade |             | Geotechnical Design Parameters |                  |                                  |                                   |         |                          |           |
|--------------|-----------------|-------------------|--|-------------|--------------------------------|------------------|----------------------------------|-----------------------------------|---------|--------------------------|-----------|
|              |                 |                   |  |             | $c_u$<br>(kPa)                 | $\phi'$<br>(deg) | $\gamma$<br>(kN/m <sup>3</sup> ) | $\gamma'$<br>(kN/m <sup>3</sup> ) | $K_p^*$ | Design Groundwater Level |           |
|              |                 |                   | Depth (m)                              | Elev. (m)   |                                |                  |                                  |                                   |         | Depth (m)                | Elev. (m) |
| CTW-1        | 210+915         | Fill (Silty Sand) | 0.7 – 2.3                              | 60.3 – 58.7 | -                              | 30               | 21                               | 11                                | 3.0     | 2.3                      | 58.7      |
|              |                 | Till (Silty Sand) | 2.3 – 6.1                              | 58.7 – 54.9 | -                              | 32               | 21                               | 11                                | 3.3     |                          |           |
|              |                 | Shale             | Below 6.1                              | Below 54.9  | 400                            | -                | -                                | -                                 | -       |                          |           |
| OHS-07L      | 210+950         | Fill (Sandy Silt) | 1.5 – 2.9                              | 59.4 – 58.0 | -                              | 30               | 21                               | 11                                | 3.0     | [2.2]                    | [58.7]    |
|              |                 | Till (Sandy Silt) | 2.9 - 6.1                              | 58.0 - 54.8 | -                              | 32               | 21                               | 11                                | 3.3     |                          |           |
| CTW-2        | 210+990         | Till (Sandy Silt) | 0.6 – 4.1                              | 60.4 – 56.9 | -                              | 32               | 21                               | 11                                | 3.3     | 2.3                      | 58.7      |
|              |                 | Shale             | Below 4.1                              | Below 56.9  | 400                            | -                | -                                | -                                 | -       |                          |           |
| 15N-01       | 211+035         | Till (Sandy Silt) | 0.8 – 4.6                              | 60.3 – 56.5 | -                              | 32               | 21                               | 11                                | 3.3     | [2.7]                    | [58.4]    |
|              |                 | Probable Shale    | Below 4.6                              | Below 56.5  | 400                            | -                | -                                | -                                 | -       |                          |           |

[ ] Piezometer reading

\* Assuming a horizontal surface on the passive earth pressure side of the wall

**Table 8.8: Parameters for Lateral Pile Resistance**  
**Belfast Road (North), Wall 15N – Station 211+220 to 211+700**

| <b>Borehole</b> | <b>Elevation</b> | <b>Soil Strata</b>         | <b><math>n_h</math> (kN/m<sup>3</sup>)</b> | <b><math>K_p</math></b> | <b><math>\gamma'</math> (kN/m<sup>3</sup>)</b> |
|-----------------|------------------|----------------------------|--|-------------------------|--|
| 15N-04          | 60.1 to 57.7     | Very dense silty sand till | 6,000                                      | 3.7                     | 11*  |
|                 | below 57.7       | Shale (see text)           | -  | -                       | -  |
| 15N-05          | 60.6 to 60.0     | Very dense silty sand till | 10,000                                     | 3.7                     | 21   |
|                 | 60.0 to 57.4     | Very dense silty sand till | 6,000                                      | 3.7                     | 11*  |
|                 | below 57.4       | Shale (see text)           | -  | -                       | -  |
| 15N-06          | 61.9 to 60.5     | Very dense sandy silt till | 10,000                                     | 3.7                     | 21   |
|                 | 60.5 to 59.1     | Very dense sandy silt till | 6,000                                      | 3.7                     | 11*  |
|                 | below 59.1       | Shale (see text)           | -  | -                       | -  |
| 15N-07          | 62.7 to 61.5     | Dense silty sand till      | 6,000                                      | 3.7                     | 21   |
|                 | below 61.5       | Shale (see text)           | -  | -                       | -  |
| 15N-08          | below 64.0       | Shale (see text)           | -  | -                       | -  |
| 15N-09          | below 65.1       | Shale (see text)           | -  | -                       | -  |
| 15N-10          | below 65.6       | Shale (see text)           | -  | -                       | -  |

\* Buoyant unit weight below the water table.

**Table 8.9 - Post Foundation Design Parameters**  
**Belfast Road (North), Wall 15N – Station 211+220 to 211+700**

| Borehole No. | Approx. Station | Soil Strata                   | Soil Strata Level Below Existing Grade |             | Geotechnical Design Parameters |                  |                                  |                                   |         |                          |           |
|--------------|-----------------|-------------------------------|--|-------------|--------------------------------|------------------|----------------------------------|-----------------------------------|---------|--------------------------|-----------|
|              |                 |                               |  |             | $c_u$<br>(kPa)                 | $\phi'$<br>(deg) | $\gamma$<br>(kN/m <sup>3</sup> ) | $\gamma'$<br>(kN/m <sup>3</sup> ) | $K_p^*$ | Design Groundwater Level |           |
|              |                 |                               | Depth (m)                              | Elev. (m)   |                                |                  |                                  |                                   |         | Depth (m)                | Elev. (m) |
| 15N-04       | 211+240         | Fill (Silty Sand)             | 0.8 - 2.2                              | 61.5 – 60.1 | -                              | 32               | 21                               | 11                                | 3.3     | 2.3                      | 60.0      |
|              |                 | Till (Silty Sand)             | 2.2 - 4.6                              | 60.1 – 57.7 | -                              | 35               | 21                               | 11                                | 3.7     |                          |           |
|              |                 | Shale                         | below 4.6                              | 57.7        | 400                            | -                | -                                | -                                 | -       |                          |           |
| 15N-05       | 211+290         | Fill (Silty Sand)             | 0.8 - 2.2                              | 62.0 – 60.6 | -                              | 32               | 21                               | 11                                | 3.3     | [2.9]                    | [59.9]    |
|              |                 | Till (Silty Sand)             | 2.2 - 5.3                              | 60.6 – 57.4 | -                              | 35               | 21                               | 11                                | 3.7     |                          |           |
|              |                 | Shale                         | below 5.3                              | 57.4        | 400                            | -                | -                                | -                                 | -       |                          |           |
| 15N-06       | 211+375         | Fill (Sandy Silt)             | 0.8- 1.4                               | 62.9 – 62.2 | -                              | 32               | 21                               | 11                                | 3.3     | 3.2                      | 60.5      |
|              |                 | Till (Sandy Silt, Silty Sand) | 1.4 - 4.6                              | 62.2 -59.1  | -                              | 35               | 21                               | 11                                | 3.7     |                          |           |
|              |                 | Shale                         | below 4.6                              | 59.1        | 400                            | -                | -                                | -                                 | -       |                          |           |
| 15N-07       | 211+450         | Till (Silty Sand)             | 0.9 - 3.0                              | 63.6 – 61.5 | -                              | 35               | 21                               | 11                                | 3.7     | [3.5]                    | [61.0]    |
|              |                 | Shale                         | below 3.0                              | 61.5        | 400                            | -                | -                                | -                                 | -       |                          |           |
| 15N-08       | 211+525         | Till (Sandy Silt)             | 0.8 - 1.4                              | 64.7 – 64.0 | -                              | 35               | 21                               | 11                                | 3.7     | 2.9                      | 62.5      |
|              |                 | Shale                         | below 1.4                              | 64.0        | 400                            | -                | -                                | -                                 | -       |                          |           |
| 15N-09       | 211+600         | Shale                         | below 1.1                              | 65.1        | 400                            | -                | -                                | -                                 | -       | [2.2]                    | [64.0]    |
| 15N-10       | 211+675         | Till (Silt)                   | 0.8 - 1.5                              | 66.3 - 65.6 | -                              | 35               | 21                               | 11                                | 3.7     | -                        | -         |
|              |                 | Shale                         | below 1.5                              | 65.6        | 400                            | -                | -                                | -                                 | -       |                          |           |

[ ] Piezometer reading

\* Assuming a horizontal surface on the passive earth pressure side of the wall



**Table 8.10 - Post Foundation Design Parameters**  
**Belfast Road (South), Wall 23S – Station 111+090 to 111+705**

| Borehole No. | Approx. Station | Soil Strata                | Soil Strata Level Below Existing Grade |             | Geotechnical Design Parameters |                  |                                  |                                   |         |                          |           |
|--------------|-----------------|----------------------------|--|-------------|--------------------------------|------------------|----------------------------------|-----------------------------------|---------|--------------------------|-----------|
|              |                 |                            |  |             | $c_u$<br>(kPa)                 | $\phi'$<br>(deg) | $\gamma$<br>(kN/m <sup>3</sup> ) | $\gamma'$<br>(kN/m <sup>3</sup> ) | $K_p^*$ | Design Groundwater Level |           |
|              |                 |                            | Depth (m)                              | Elev. (m)   |                                |                  |                                  |                                   |         | Depth (m)                | Elev. (m) |
| 23S-1        | 111+180         | Fill (Gravelly/Silty Sand) | 0.2 - 2.2                              | 61.7 – 59.7 | -                              | 32               | 21                               | 11                                | 3.3     | 2.9                      | 59.0      |
|              |                 | Till (Silty Sand)          | 2.2 - 6.0                              | 59.7 – 55.9 | -                              | 35               | 21                               | 11                                | 3.7     |                          |           |
|              |                 | Shale                      | 6.0                                    | 55.9        | 400                            | -                | -                                | -                                 | -       |                          |           |
| 23S-2        | 111+265         | Fill (Sand, Silty Sand)    | 0.2 - 1.4                              | 62.3 – 61.1 | -                              | 32               | 21                               | 11                                | 3.3     | [2.8 ]                   | [59.7]    |
|              |                 | Till (Silty Sand)          | 1.4 - 4.6                              | 61.1 – 57.9 | -                              | 35               | 21                               | 11                                | 3.7     |                          |           |
|              |                 | Shale                      | 4.6                                    | 57.9        | 400                            | -                | -                                | -                                 | -       |                          |           |
| 23S-3        | 111+345         | Fill (Sand)                | 0.3 - 0.8                              | 62.9 – 62.4 | -                              | 32               | 21                               | 11                                | 3.3     | 2.7                      | 60.5      |
|              |                 | Till (Silty Sand)          | 0.8 - 5.8                              | 62.4 – 57.4 | -                              | 35               | 21                               | 11                                | 3.7     |                          |           |
|              |                 | Shale                      | 5.8                                    | 57.4        | 400                            | -                | -                                | -                                 | -       |                          |           |
| 23S-4        | 111+410         | Fill (Silty Sand)          | 0.3 - 0.8                              | 63.7 – 63.3 | -                              | 32               | 21                               | 11                                | 3.3     | 2.8                      | 61.2      |
|              |                 | Till (Silty Sand)          | 0.8 - 4.6                              | 63.3 - 59.4 | -                              | 35               | 21                               | 11                                | 3.7     |                          |           |
|              |                 | Shale                      | 4.6                                    | 59.4        | 400                            | -                | -                                | -                                 | -       |                          |           |
| 23S-5        | 111+485         | Fill (Gravelly Sand)       | 0.3 - 0.9                              | 64.6 – 64.0 | -                              | 32               | 21                               | 11                                | 3.3     | 2.9                      | 62.0      |
|              |                 | Till (Silty Sand)          | 0.9 - 2.7                              | 64.0 – 62.1 | -                              | 35               | 21                               | 11                                | 3.7     |                          |           |
|              |                 | Shale                      | 2.7                                    | 62.1        | 400                            | -                | -                                | -                                 | -       |                          |           |

Retaining Walls and Noise Barrier Walls  
Highway 417 Widening, Nicholas Street to O.R.174 - Ottawa, Ontario

| Borehole No. | Approx. Station | Soil Strata          | Soil Strata Level Below Existing Grade |             | Geotechnical Design Parameters |                  |                                  |                                   |         |                          |           |
|--------------|-----------------|----------------------|--|-------------|--------------------------------|------------------|----------------------------------|-----------------------------------|---------|--------------------------|-----------|
|              |                 |                      |  |             | $c_u$<br>(kPa)                 | $\phi'$<br>(deg) | $\gamma$<br>(kN/m <sup>3</sup> ) | $\gamma'$<br>(kN/m <sup>3</sup> ) | $K_p^*$ | Design Groundwater Level |           |
|              |                 |                      | Depth (m)                              | Elev. (m)   |                                |                  |                                  |                                   |         | Depth (m)                | Elev. (m) |
| 23S-6        | 111+575         | Fill (Sand)          | 0.2- 0.8                               | 65.6 – 65.0 | -                              | 32               | 21                               | 11                                | 3.3     |                          |           |
|              |                 | Till (Silty Sand)    | 0.8 - 1.2                              | 65.0 – 64.6 | -                              | 35               | 21                               | 11                                | 3.7     | [3.0]                    | [62.8]    |
|              |                 | Shale                | 1.2                                    | 64.6        | 400                            | -                | -                                | -                                 | -       |                          |           |
| 23S-7        | 111+640         | Fill (Gravelly Sand) | 0.2 - 0.8                              | 66.4 – 65.8 | -                              | 32               | 21                               | 11                                | 3.3     |                          |           |
|              |                 | Till (Silty Sand)    | 0.8 - 1.2                              | 65.8 – 65.3 | -                              | 35               | 21                               | 11                                | 3.7     | 2.9                      | 63.7      |
|              |                 | Shale                | 1.2                                    | 65.3        | 400                            | -                | -                                | -                                 | -       |                          |           |
| 23S-8        | 111+715         | Fill (Gravelly Sand) | 0.2 - 0.8                              | 67.2 – 66.6 | -                              | 32               | 21                               | 11                                | 3.3     |                          |           |
|              |                 | Till (Silty Sand)    | 0.8 - 1.2                              | 66.6 – 66.2 | -                              | 35               | 21                               | 11                                | 3.7     | [2.8]                    | [64.6]    |
|              |                 | Shale                | 1.2                                    | 66.2        | 400                            | -                | -                                | -                                 | -       |                          |           |

[ ] Piezometer reading

\* Assuming a horizontal surface on the passive earth pressure side of the wall

**Table 8.11 - Parameters for Lateral Pile Resistance**  
**St. Laurent Boulevard N-W Ramp, Wall 16N – Station 212+000 to 212+200**

| Borehole | Elevation    | Soil Strata                | $n_h$ (kN/m <sup>3</sup> ) | $K_p$ | $\gamma'$ (kN/m <sup>3</sup> ) |
|----------|--------------|----------------------------|----------------------------|-------|--------------------------------|
| 16N-1    | 68.1 to 66.9 | Fill                       | 2,000                      | 3.0   | 20                             |
|          | 66.9 to 65.3 | Compact silty sand         | 4,000                      | 3.3   | 20                             |
|          | 65.3 to 64.7 | Very dense sandy silt till | 10,000                     | 3.7   | 21                             |
|          | 64.7 to 64.1 | Very dense sandy silt till | 6,000                      | 3.7   | 11*                            |
| 16N-2    | 67.5 to 66.3 | Fill                       | 3,000                      | 3.0   | 20                             |
|          | 66.3 to 64.7 | Compact silty sand         | 4,000                      | 3.3   | 20                             |
|          | 64.7 to 63.5 | Very dense sandy silt till | 6,000                      | 3.7   | 11*                            |
| 16N-3    | 66.7 to 66.2 | Dense silty sand           | 6,000                      | 3.3   | 20                             |
|          | 66.2 to 64.8 | Compact sandy silt till    | 4,000                      | 3.7   | 21                             |
|          | 64.8 to 63.6 | Very dense sandy silt till | 6,000                      | 3.7   | 11*                            |

\* Buoyant unit weight below the water table.

**Table 8.12 - Post Foundation Design Parameters**  
**St. Laurent Boulevard N-W Ramp, Wall 16N – Station 212+000 to 212+200**

| Borehole No. | Approx. Station | Soil Strata                | Soil Strata Level Below Existing Grade |             | Geotechnical Design Parameters |                  |                                  |                                   |         |                          |           |
|--------------|-----------------|----------------------------|--|-------------|--------------------------------|------------------|----------------------------------|-----------------------------------|---------|--------------------------|-----------|
|              |                 |                            |  |             | $c_u$<br>(kPa)                 | $\phi'$<br>(deg) | $\gamma$<br>(kN/m <sup>3</sup> ) | $\gamma'$<br>(kN/m <sup>3</sup> ) | $K_p^*$ | Design Groundwater Level |           |
|              |                 |                            | Depth (m)                              | Elev. (m)   |                                |                  |                                  |                                   |         | Depth (m)                | Elev. (m) |
| 16N-1        | 212+005         | Fill (Gravelly/Silty Sand) | 0.1 – 3.0                              | 68.7 – 66.9 | -                              | 30               | 20                               | 10                                | 3.0     | [5.2]                    | [64.7]    |
|              |                 | Silty Sand                 | 3.0 – 4.6                              | 66.9 – 65.3 | -                              | 32               | 20                               | 10                                | 3.3     |                          |           |
|              |                 | Till (Sandy Silt)          | 4.6 – 5.8                              | 65.3 – 64.1 | -                              | 35               | 21                               | 11                                | 3.7     |                          |           |
|              |                 | Shale                      | 5.8                                    | 64.1        | 400                            | -                | -                                | -                                 | -       |                          |           |
| 16N-2        | 212+070         | Fill (Gravelly Sand)       | 0.1 – 3.0                              | 69.2 – 66.3 | -                              | 30               | 20                               | 10                                | 3.0     | 4.6                      | 64.7      |
|              |                 | Silty Sand                 | 3.0 – 4.6                              | 66.3 – 64.7 | -                              | 32               | 20                               | 10                                | 3.3     |                          |           |
|              |                 | Till (Sandy Silt)          | 4.6 – 5.8                              | 64.7 – 63.5 | -                              | 35               | 21                               | 11                                | 3.7     |                          |           |
|              |                 | Shale                      | 5.8                                    | 63.5        | 400                            | -                | -                                | -                                 | -       |                          |           |
| 16N-3        | 212+135         | Fill (Gravelly/Silty Sand) | 0.2 – 2.3                              | 68.3 – 66.2 | -                              | 32               | 20                               | 10                                | 3.3     | [3.7]                    | [64.8]    |
|              |                 | Till (Clayey/Silty Sand)   | 2.3 – 4.9                              | 66.2 – 63.6 | -                              | 35               | 21                               | 11                                | 3.7     |                          |           |
|              |                 | Shale                      | 4.9                                    | 63.6        | 400                            | -                | -                                | -                                 | -       |                          |           |

[ ] Piezometer reading

\* Assuming a horizontal surface on the passive earth pressure side of the wall

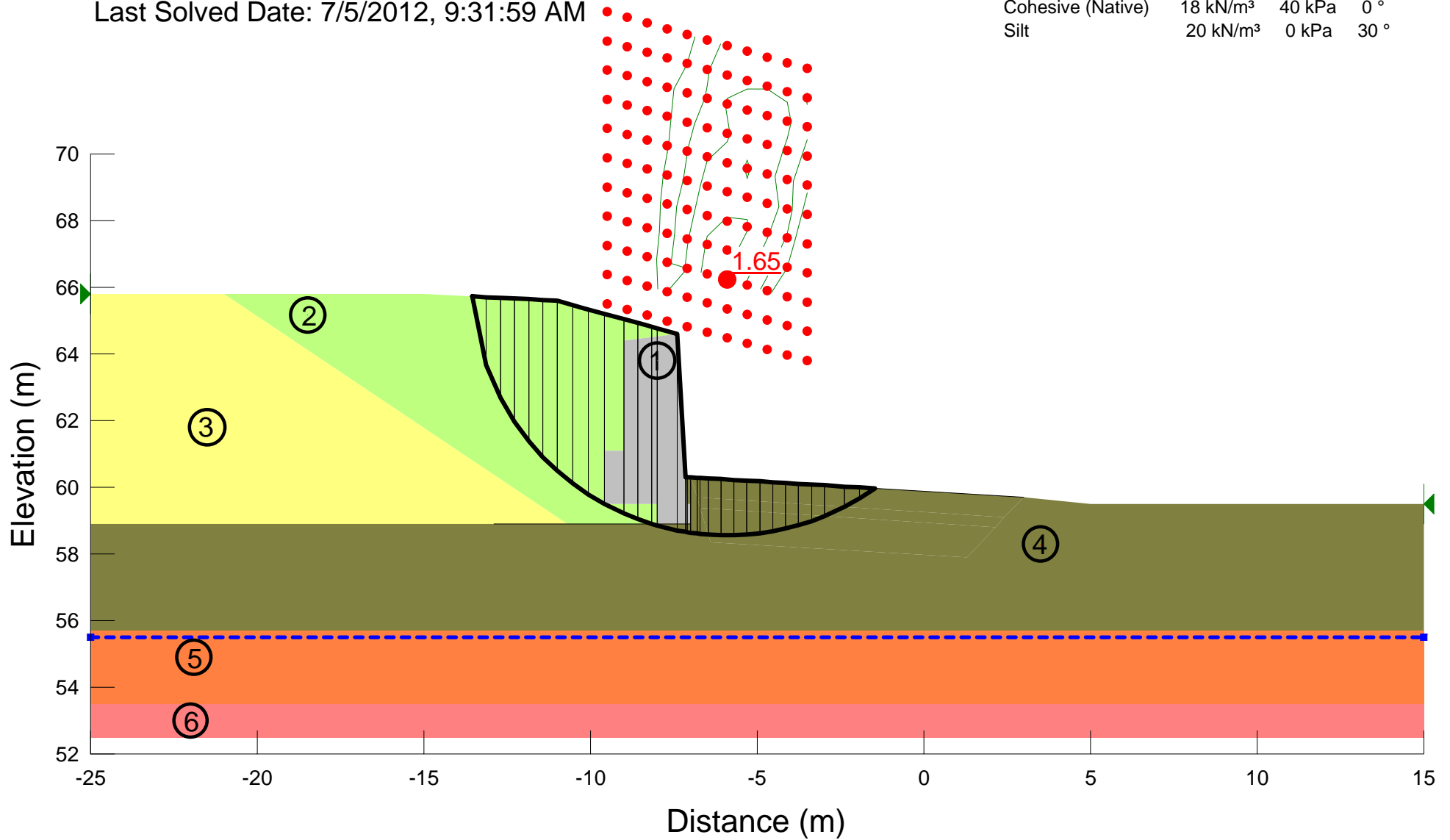
## **Appendix L**

### **Slope Stability Analyses**

#### **Lees Avenue S-E Ramp**

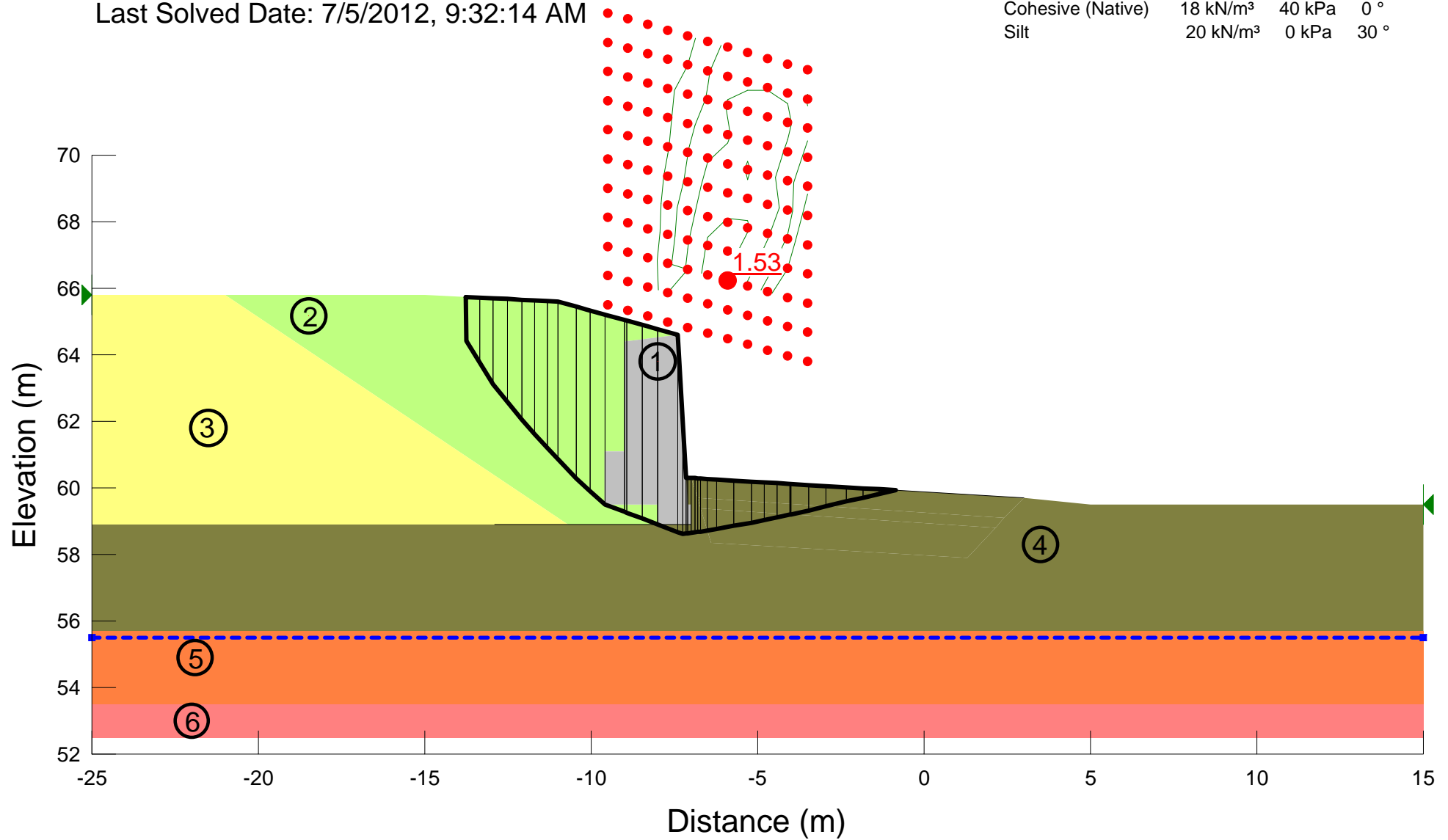
Title: Lees Avenue - Crib Wall (Sta. 10+360)  
 Name: Existing Condition (Circular)  
 Last Solved Date: 7/5/2012, 9:31:59 AM

|                   |                      |          |      |
|-------------------|----------------------|----------|------|
| Crib Wall         | 20 kN/m <sup>3</sup> | 2000 kPa | 45 ° |
| Granular Backfill | 21 kN/m <sup>3</sup> | 0 kPa    | 32 ° |
| Earth Fill        | 20 kN/m <sup>3</sup> | 0 kPa    | 30 ° |
| Road/Sand Fill    | 21 kN/m <sup>3</sup> | 0 kPa    | 34 ° |
| Cohesive (Native) | 18 kN/m <sup>3</sup> | 40 kPa   | 0 °  |
| Silt              | 20 kN/m <sup>3</sup> | 0 kPa    | 30 ° |



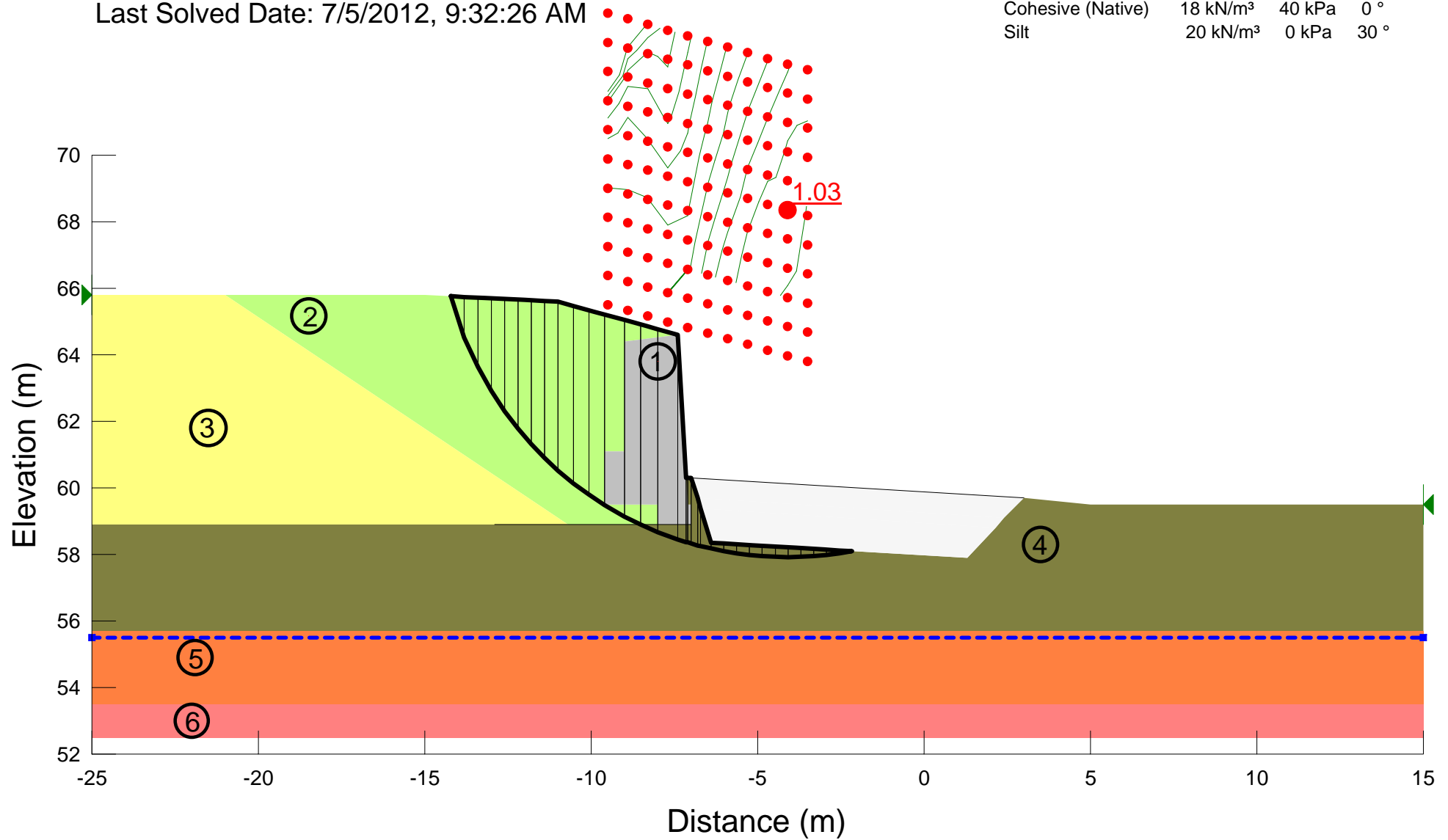
Title: Lees Avenue - Crib Wall (Sta. 10+360)  
 Name: Existing Condition (Non-Circular)  
 Last Solved Date: 7/5/2012, 9:32:14 AM

|                   |                      |          |      |
|-------------------|----------------------|----------|------|
| Crib Wall         | 20 kN/m <sup>3</sup> | 2000 kPa | 45 ° |
| Granular Backfill | 21 kN/m <sup>3</sup> | 0 kPa    | 32 ° |
| Earth Fill        | 20 kN/m <sup>3</sup> | 0 kPa    | 30 ° |
| Road/Sand Fill    | 21 kN/m <sup>3</sup> | 0 kPa    | 34 ° |
| Cohesive (Native) | 18 kN/m <sup>3</sup> | 40 kPa   | 0 °  |
| Silt              | 20 kN/m <sup>3</sup> | 0 kPa    | 30 ° |



Title: Lees Avenue - Crib Wall (Sta. 10+360)  
 Name: Proposed Cut, 1.9m (Circular)  
 Last Solved Date: 7/5/2012, 9:32:26 AM

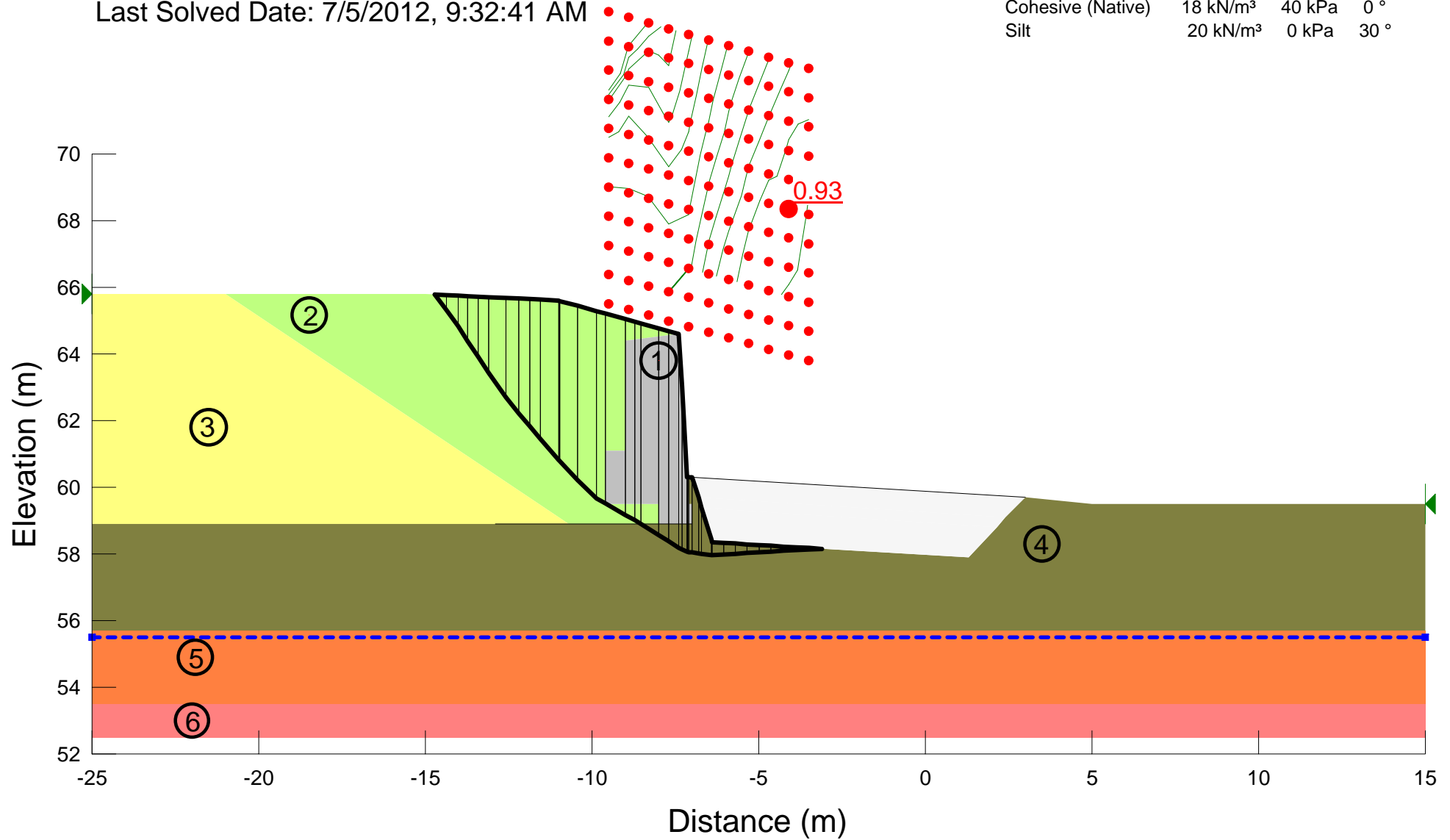
|                   |                      |          |      |
|-------------------|----------------------|----------|------|
| Crib Wall         | 20 kN/m <sup>3</sup> | 2000 kPa | 45 ° |
| Granular Backfill | 21 kN/m <sup>3</sup> | 0 kPa    | 32 ° |
| Earth Fill        | 20 kN/m <sup>3</sup> | 0 kPa    | 30 ° |
| Road/Sand Fill    | 21 kN/m <sup>3</sup> | 0 kPa    | 34 ° |
| Cohesive (Native) | 18 kN/m <sup>3</sup> | 40 kPa   | 0 °  |
| Silt              | 20 kN/m <sup>3</sup> | 0 kPa    | 30 ° |





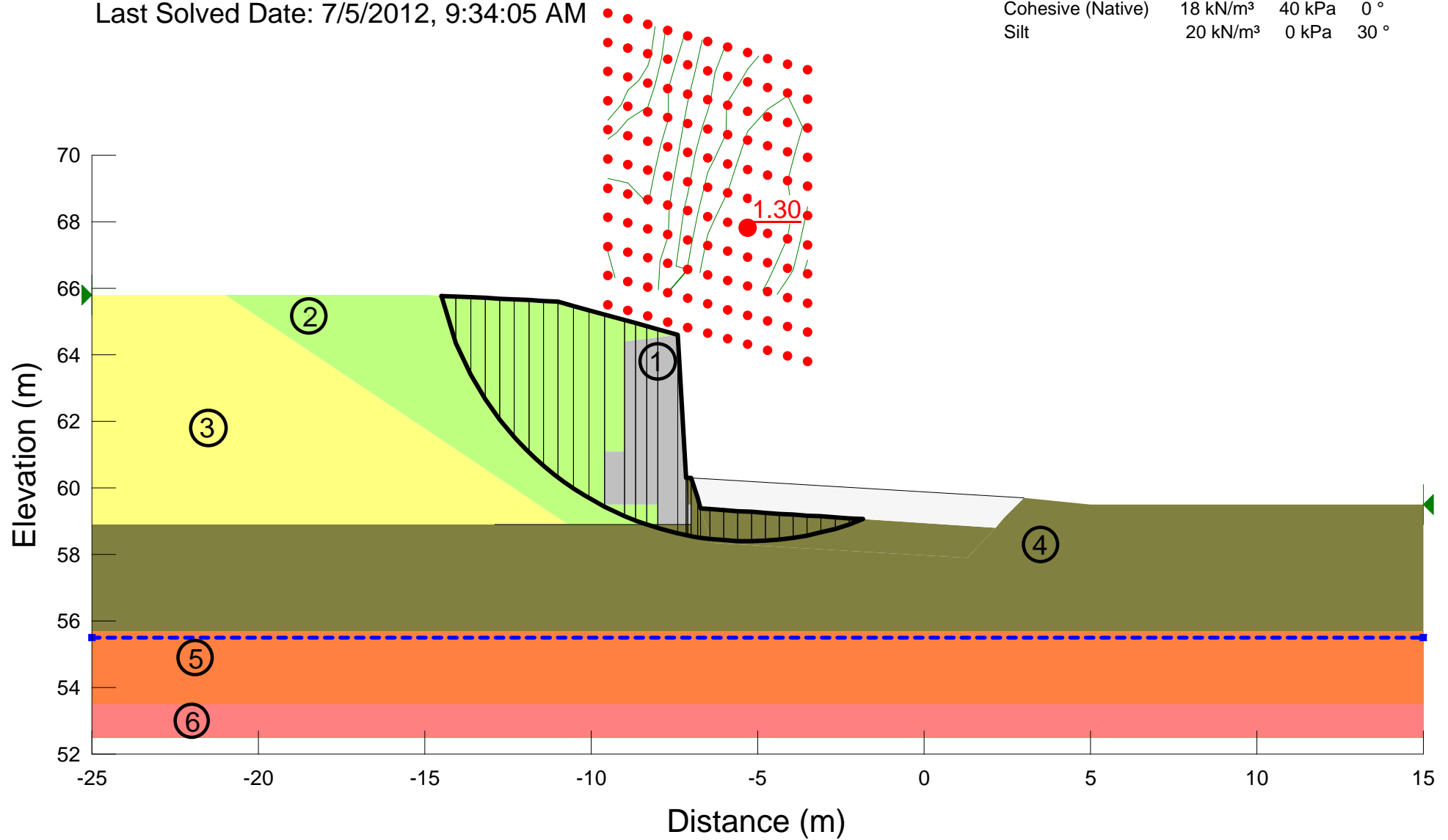
Title: Lees Avenue - Crib Wall (Sta. 10+360)  
 Name: Proposed Cut, 1.9m (Non-Circular)  
 Last Solved Date: 7/5/2012, 9:32:41 AM

|                   |                      |          |      |
|-------------------|----------------------|----------|------|
| Crib Wall         | 20 kN/m <sup>3</sup> | 2000 kPa | 45 ° |
| Granular Backfill | 21 kN/m <sup>3</sup> | 0 kPa    | 32 ° |
| Earth Fill        | 20 kN/m <sup>3</sup> | 0 kPa    | 30 ° |
| Road/Sand Fill    | 21 kN/m <sup>3</sup> | 0 kPa    | 34 ° |
| Cohesive (Native) | 18 kN/m <sup>3</sup> | 40 kPa   | 0 °  |
| Silt              | 20 kN/m <sup>3</sup> | 0 kPa    | 30 ° |



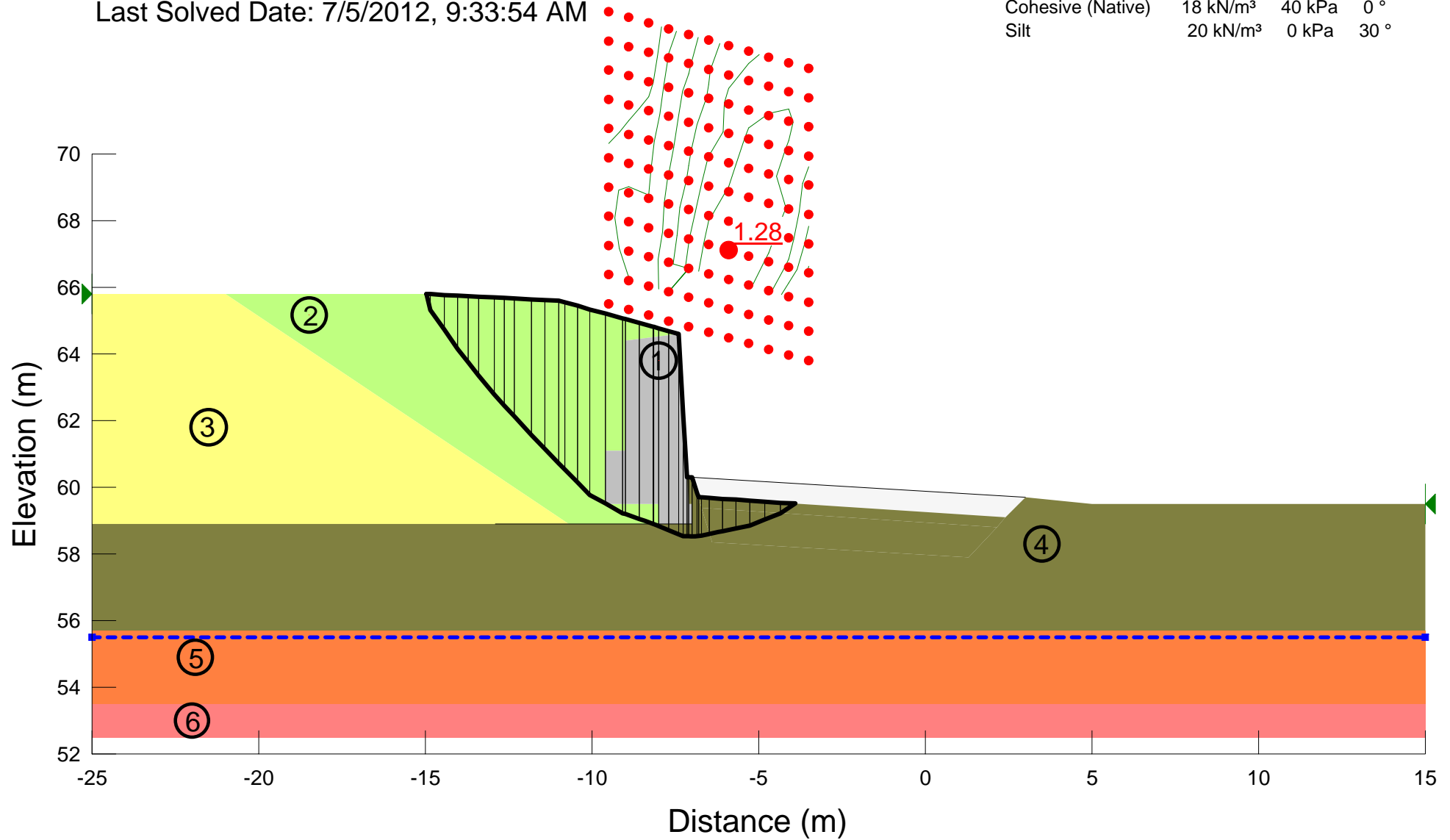
Title: Lees Avenue - Crib Wall (Sta. 10+360)  
 Name: Temporary Cut, 0.9m (Circular)  
 Last Solved Date: 7/5/2012, 9:34:05 AM

|                   |                      |          |      |
|-------------------|----------------------|----------|------|
| Crib Wall         | 20 kN/m <sup>3</sup> | 2000 kPa | 45 ° |
| Granular Backfill | 21 kN/m <sup>3</sup> | 0 kPa    | 32 ° |
| Earth Fill        | 20 kN/m <sup>3</sup> | 0 kPa    | 30 ° |
| Road/Sand Fill    | 21 kN/m <sup>3</sup> | 0 kPa    | 34 ° |
| Cohesive (Native) | 18 kN/m <sup>3</sup> | 40 kPa   | 0 °  |
| Silt              | 20 kN/m <sup>3</sup> | 0 kPa    | 30 ° |



Title: Lees Avenue - Crib Wall (Sta. 10+360)  
 Name: Temporary Cut, 0.6m (Non-Circular)  
 Last Solved Date: 7/5/2012, 9:33:54 AM

|                   |                      |          |      |
|-------------------|----------------------|----------|------|
| Crib Wall         | 20 kN/m <sup>3</sup> | 2000 kPa | 45 ° |
| Granular Backfill | 21 kN/m <sup>3</sup> | 0 kPa    | 32 ° |
| Earth Fill        | 20 kN/m <sup>3</sup> | 0 kPa    | 30 ° |
| Road/Sand Fill    | 21 kN/m <sup>3</sup> | 0 kPa    | 34 ° |
| Cohesive (Native) | 18 kN/m <sup>3</sup> | 40 kPa   | 0 °  |
| Silt              | 20 kN/m <sup>3</sup> | 0 kPa    | 30 ° |



## **Appendix M**

### **List of Selected SPs and OPSS, and Suggested Text for NSSP**

**1. List of Special Provisions and OPSS Documents Referenced in this Report**

- OPSS 501
- OPSS 539
- OPSS 902
- OPSS 903
- OPSS 942
- OPSD 3120.100
- OPSD 3121.150
- OPSD 3190.100
- SP 110S13
- SP 799F01

**2. Suggested Text for NSSP on:**

**“Augered Soldier Pile and Caisson Construction for Retaining Wall and Noise Barrier Foundations”**

The Contractor is advised that variable subsurface conditions and bedrock at potentially variable depths/elevations may be encountered at the locations of the retaining wall and noise barrier foundations. The soils typically consist of cohesionless silty to gravelly sand fill and silty sand to sandy silt till which may contain cobbles, boulders and shale slabs. Further, the underlying shale bedrock contains hard limestone layers. For additional information regarding subsurface conditions, the Contractor is referred to the Foundation Investigation Report.

These materials will potentially have an impact on the installation of augered soldier pile or caissons, such as:

- impeding the advance of the soldier piles/ caissons resulting in lower production and faster wear of drilling bits.
- requiring alternate equipment or procedures in cases where obstructions in the fill/till or thick layers of hard limestone in the bedrock are encountered.
- affecting the alignment of the soldier piles/ caissons during advancement.

The Contractor is further advised that non-cohesive soils and high groundwater levels are present on site. Non-cohesive soil is susceptible to disturbance under conditions of unbalanced hydrostatic head. Cohesive soils are also present and are susceptible to squeezing under unsupported conditions.

The Contractor is responsible for constructing the soldier pile/ caisson excavation without disturbing the sides or base of the excavation, preventing squeeze, and for cleaning of the socket base. The construction method is the responsibility of the Contractor.