REPORT

**December 21, 2015**

# FOUNDATION INVESTIGATION REPORT

# TIFFIN STREET OVERPASS REPLACEMENT
# STRUCTURE SITE NO. 30-176/1 & 2
# BARRIE, ONTARIO
# G.W.P. 2159-11-00

**Submitted to:**
Morrison Hershfield
125 Commerce Valley Drive West, Suite 300
Markham, Ontario
L3T 7W4

**GEOCRES No. 31D-630**

**Report Number:** 1532543-1

**Distribution:**

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Golder Associates

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# 1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield Limited (MH) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services to support the detail design for the proposed replacement of the Highway 400-Tiffin Street overpasses in the City of Barrie. This report addresses the foundation investigation carried out for the proposed construction of the following structures:

- New overpass structure that will permit the Highway 400 Northbound Lanes (NBL) to cross over the widened Tiffin Street corridor.
- Replacement of the existing overpass structure for the Highway 400 Southbound Lanes (SBL) to cross over the widened Tiffin Street corridor.

The purpose of this investigation is to establish the subsurface conditions at the location of the proposed replacement structures, approach embankments and wing walls, by means of a limited borehole investigation and geotechnical laboratory testing on selected samples.

Golder has completed the foundation engineering services in accordance with Proposal No. GEOTETOB22161AA, dated March 13, 2015, originally provided to MH by Coffey Geotechnics Inc. (Coffey).

# 2.0 SITE DESCRIPTION

The existing overpass structure carrying Highway 400 over Tiffin Street is located between the Dunlop Street and Essa Road interchanges, in Barrie, Ontario, at the location shown on the Key Plan on the Borehole Location and Soil Strata drawings contained in the Contract Documents.

This portion of Highway 400, including the existing Tiffin Street overpass, was built between 1950 and 1955. The existing structure consists of a 15.5 m long, single-span, concrete rigid frame structure supported on spread footings. The overpass carries six lanes of Highway 400 traffic. The existing overpass structure is approximately 30 m wide and currently lies at a 22.5 degree skew to the Highway 400 centreline.

At the site, Tiffin Street is is two lanes wide where it passes beneath Highway 400; the highway is constructed on fill / raised embankments. The existing Highway 400 / Tiffin overpass structure surface level is at about Elevation 240.5 m; the new Highway 400 grade at the north and south abutments is proposed to be at about Elevation 243.5 m, requiring a grade raise of approximately 3 m.

# 3.0 INVESTIGATION PROCEDURES

## 3.1 Previous Investigation by Others

Coffey completed a preliminary foundation investigation for the Highway 400 / Tiffin Street overpass structures involving the advancement of a total of four boreholes (F1, F2, F3 and F4) in October 2014; the records for these boreholes are provided in Appendix A. The locations of these boreholes are shown on the Borehole Location and Soil Strata drawings contained in the Contract Documents.

Boreholes F1 and F2 were advanced as part of the SBL overpass structure investigation; Boreholes F3 and F4 were advanced as part of the new NBL overpass structure investigation.

The results of the MTO investigation are presented in Coffey's Preliminary Foundation Investigation and Design Report (GEOCRES No. 31D-587), dated February 2015.

## 3.2 Current Investigation

The field work for the subsurface investigation for the Highway 400 / Tiffin Street overpass structures was carried out between June 25 and July 13, 2015, during which time a total of six boreholes were advanced using a track-mounted drill rig, supplied and operated by specialist drilling subcontractors. The locations of the six boreholes advanced at the NBL and SBL structures are shown on the Borehole Location and Soil Strata drawings contained in the Contract Documents.

The boreholes were advanced to depths ranging from 10.1 m to 19.8 m below existing ground surface using hollow stem auger drilling methods. Soil samples were obtained in the boreholes at 0.75 m and 1.5 m intervals of depth using 50 mm outer diameter split-spoon samplers driven by an automatic hammer, in accordance with the Standard Penetration Test (SPT) procedure. Each of the boreholes was terminated at the depths provided in the Coffey proposal, in order to avoid penetrating into a trichloroethylene (TCE) plume that is present in the vicinity of the site.

The groundwater conditions were observed in the open boreholes during and immediately following the drilling operations, and monitoring wells were installed in three boreholes (Boreholes 15-2, 15-4 and HF4) to permit monitoring of the groundwater levels at these locations. The monitoring wells consist of 50 mm diameter PVC pipe, with a slotted screen sealed within a sand filter pack at a selected depth interval within the borehole. The monitoring well installation details and water level readings are indicated on the borehole records contained in Appendix A. All remaining boreholes were backfilled with bentonite upon completion, in accordance with Ontario Regulation 903 (as amended).

The field work was supervised on a full-time basis by a member of Golder's staff who observed the drilling, sampling and in situ testing operations, and logged the subsurface conditions encountered in the boreholes. The soil samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Mississauga for further examination and laboratory testing. Index and classification tests consisting of water contents, Atterberg limits and grain size distributions were carried out on selected soil samples.

The borehole locations and ground surface elevations were obtained from the digital terrain model provided by MH. The borehole locations, including MTM NAD83 and UTM NAD83 northing and easting coordinates and ground surface elevations referenced to geodetic datum, are summarized below and are shown on the Borehole Location and Soil Strata drawings contained in the Contract Documents.

| Borehole No. | NAD83 MTM Zone 10 Coordinates | | Ground Surface Elevation (m) | Borehole Depth (m) |
|---|---|---|---|---|
| | Northing (m) | Easting (m) | | |
| 15-1 | 4914534.5 | 288258.2 | 240.5 | 19.8 |
| 15-2 | 4914565.9 | 288247.2 | 239.8 | 19.8 |
| 15-3 | 4914544.2 | 288286.9 | 240.7 | 19.8 |
| 15-4 | 4914580.1 | 288286.1 | 233.6 | 14.0 |
| 15-5 | 4914575.3 | 288233.7 | 239.5 | 13.7 |
| HF4 | 4914537.7 | 288309.6 | 236.5 | 10.1 |

# 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

## 4.1 Regional Geology

This section of Highway 400 lies within the Simcoe Lowlands, as delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, Third Edition, 1984). The soil deposits are typically interlayered, non-cohesive sand and silt layers, with occasional cohesive clayey silt to silty clay layers.

## 4.2 Subsurface Conditions

The detailed soil and groundwater conditions encountered in the boreholes, and the results of in situ and geotechnical laboratory testing, are summarized on the borehole records in Appendix A. The results of the laboratory tested samples from Golder's current borehole investigation are shown on Figures B1 to B5 in Appendix B. The stratigraphic boundaries shown on the borehole records and on the interpreted stratigraphic profile and cross sections on the Borehole Location and Soil Strata drawings contained in the Contract Documents are inferred from non-continuous sampling and, therefore, represent the transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole location.

In summary, the subsoils encountered in the boreholes consist of fill overlying interlayered native strata comprised of silt, sand, and clayey silt. A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

### 4.2.1 Fill

An approximately 100 mm to 400 mm thick layer of asphalt was encountered immediately below the ground surface in Boreholes 15-1 to 15-3, 15-5, F1, F2 and F4.

Each of the boreholes encountered fill materials of variable composition and thickness. As boreholes were advanced from the Highway 400 embankment grade, as well as at the Tiffin Street level, the elevations of the surface of the fill materials are variable. The elevations of the surface and base of the fill and the thickness of the fill materials as encountered in the boreholes are summarized below.

| Borehole No. | Fill Surface Depth | Fill Surface Elevation | Fill Thickness | Base of Fill Elevation |
|---|---|---|---|---|
| 15-1 | 0.3 m | 240.2 m | 6.9 m | 233.3 m |
| 15-2 | 0.1 m | 239.7 m | 8.6 m | 231.1 m |
| 15-3 | 0.3 m | 240.4 m | 9.9 m | 230.5 m |
| 15-4 | 0.0 m | 233.6 m | 2.2 m | 231.4 m |
| 15-5 | 0.4 m | 239.1 m | 9.8 m | 229.2 m |
| HF-4 | 0.0 m | 236.5 m | 3.9 m | 232.6 m |
| F1 | 0.2 m | 240.6 m | 7.0 m | 233.4 m |
| F2 | 0.4 m | 239.1 m | 5.0 m | 234.1 m |
| F3 | 0.0 m | 234.1 m | 1.4 m | 232.7 m |
| F4 | 0.2 m | 239.7 m | 7.0 m | 232.7 m |

The fill materials vary in composition from gravelly sand containing some silt and trace clay, to silty sand containing trace to some gravel. Clayey silt to silty clay layers were observed in Boreholes 15-3 and 15-5 from the current investigation, as well as in Borehole F1. Organics were found between 5.6 m and 7.2 m depth in Boreholes 15-1 and 15-2, as well as in Borehole F3. The results of grain size distribution tests completed on two selected samples of the fill from the current investigation are shown on Figure B1.

The measured Standard Penetration Test (SPT) "N"-values within the non-cohesive fill materials range from 3 blows to 74 blows per 0.3 m of penetration, indicating that the fill materials are very loose to very dense, but typically compact. The measured SPT "N"-value within the clayey silt to silty clay fill layers in Boreholes 15-5 and F1 range from 8 blows to 14 blows per 0.3 m of penetration, suggestive of a stiff consistency.

### 4.2.2 Sand to Silt

A deposit of sand to silt was encountered below the fill in Boreholes 15-1 to 15-4, HF4, and F1 to F4, and below an upper clayey silt layer in Borehole 15-5. The deposit varies in composition from sand containing some silt, to silty sand, to sandy silt, to silt containing trace to some sand, with variable amounts of gravel and trace clay. The results of grain size distribution tests carried out on three selected samples of the sand to silty sand portions of the deposit from the current investigation are shown on Figure B2, and the results of grain size distribution tests carried out on seven selected samples of the silt to sandy silt portions of the deposit are shown on Figure B3 in Appendix B.

The elevations of the surface and base of the sand to silt deposit and the deposit thickness encountered at the borehole locations are summarized below.

| Borehole No. | Sand to Silt Surface Depth | Sand to Silt Surface Elevation | Sand to Silt Thickness | Sand to Silt Base Elevation |
|---|---|---|---|---|
| 15-1 | 7.2 m | 233.3 m | 11.5 m | 221.8 m |
| 15-2 | 8.7 m | 231.1 m | 7.7 m | 223.4 m |
| 15-3 | 10.2 m | 230.5 m | 8.8 m | 221.7 m |
| 15-4 | 2.2 m | 231.4 m | 9.5 m | 221.9 m |
| 15-5 | 11.7 m | 227.7 m | >2.0 m | Below 225.7 m |
| HF4 | 3.9 m | 232.6 m | >6.2 m | Below 226.4 m |
| F1 | 7.2 m | 233.4 m | >8.6 m | Below 224.8 m |
| F2 | 5.4 m | 234.1 m | >10.4 m | Below 223.7 m |
| F3 | 1.4 m | 232.7 m | >8.3 m | Below 224.4 m |
| F4 | 7.2 m | 232.7 m | >8.6 m | Below 224.1 m |

The measured SPT "N"-values in the sand to silt deposit range from 7 blows to 42 blows per 0.3 m of penetration, indicating this deposit is loose to dense material, but typically compact to dense.

### 4.2.3 Clayey Silt

An upper layer of clayey silt was encountered underlying the fill in Borehole 15-5, and a lower layer of clayey silt to silty clay was encountered below the sand to silt deposit in Boreholes 15-1 to 15-4. Boreholes 15-1 to 15-4

were terminated in the lower clayey silt deposit. The elevation of the surface and base of the deposit and the thickness of the stratum as encountered in the boreholes are summarized below.

| Borehole No. | Clayey Silt to Silty Clay Surface Depth | Clayey Silt to Silty Clay Surface Elevation | Clayey Silt to Silty Clay Thickness | Clayey Silt to Silty Clay Base Elevation |
|---|---|---|---|---|
| 15-1 | 18.7 m (Lower) | 221.8 m | >1.1 m | Below 220.7 m |
| 15-2 | 16.3 m (Lower) | 223.4 m | >3.5 m | Below 219.9 m |
| 15-3 | 19.1 m (Lower) | 221.7 m | >0.8 m | Below 220.9 m |
| 15-4 | 11.7 m (Lower) | 221.9 m | >2.4 m | Below 219.5 m |
| 15-5 | 10.2 m (Upper) | 229.2 m | 1.5 m | 227.7 m |

The measured SPT "N"-values within the clayey silt to silty clay deposit range from 9 blows to 37 blows per 0.3 meters of penetration, suggesting a stiff to hard consistency.

The results of a grain size distribution test completed on one selected samples of the clayey silt to silty clay deposit is shown on Figure B4 in Appendix B. Atterberg limits testing was carried out on one selected sample of the deposit and measured a plastic limit of 15 per cent, a liquid limit of 19 per cent and a plasticity index of 4 per cent. This result, which is plotted on the plasticity chart on Figure B5 in Appendix B, confirms that the tested sample of the deposit consists of clayey silt of low plasticity.

## 4.3 Groundwater Conditions

The observed water levels in the open boreholes following completion of drilling, and the water levels measured the three piezometers installed at this site, are summarized in the following table. The table also provides the groundwater elevations in Borehole F3, which was installed by Coffey Geotechnics Inc. as part of the preliminary investigation at this site.

| Bridge Structure | Foundation Element | Borehole No. | Ground Surface Elevation (m) | Groundwater Elevation (m) | Date of Measurement | Notes |
|---|---|---|---|---|---|---|
| SBL | South Abutment | 15-1 | 240.5 | 226.8 | June 29, 2015 | Open Borehole |
| | North Abutment | 15-2 | 239.8 | 230.7<br>230.1 | June 25, 2015<br>November 8, 2015 | Open Borehole<br>Monitoring Well |
| | North Approach | 15-5 | 239.5 | 236.0 | June 29, 2015 | Open Borehole |
| NBL | South Abutment | 15-3 | 240.7 | 232.9 | June 28, 2015 | Open Borehole |
| | | F3 | 234.1 | 229.7 | November 6, 2015 | Monitoring Well |
| | North Abutment | 15-4 | 233.6 | 227.0<br>229.6<br>229.5 | July 13, 2015<br>August 11, 2015<br>November 6, 2015 | Open Borehole<br>Monitoring Well<br>Monitoring Well |

| Bridge Structure | Foundation Element | Borehole No. | Ground Surface Elevation (m) | Groundwater Elevation (m) | Date of Measurement | Notes |
|---|---|---|---|---|---|---|
| | South Approach | HF4 | 236.5 | 228.0<br>231.7<br>231.6 | July 7, 2015<br>August 11, 2015<br>November 6, 2015 | Open Borehole<br>Monitoring Well<br>Monitoring Well |

The groundwater level at the site is expected to fluctuate seasonally in response to changes in precipitation and snow melt, and is expected to be higher during the spring and other wet periods of the year.

## 5.0 CLOSURE

This Foundation Investigation Report was prepared by Mr. Nick La Posta, P. Eng., and reviewed by Ms. Lisa Coyne, P.Eng., a Designated MTO Foundations Contact for Golder.

**GOLDER ASSOCIATES LTD.**


Nick La Posta, P. Eng.
Geotechnical Engineer


Lisa Coyne, P.Eng.
Designated MTO Foundations Contact, Principal

NL/LCC/sm

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# REFERENCES

Chapman, L.J., and Putnam, D.F., 1984. *The Physiography of Southern Ontario*, 3rd Edition. Ontario Geological Survey, Special Volume 2. Ontario Ministry of Natural Resources.

# APPENDIX A

## Borehole Records

# LIST OF SYMBOLS

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

## I. GENERAL

| | |
|---|---|
| $\pi$ | 3.1416 |
| ln x, | natural logarithm of x |
| $\log_{10}$ | x or log x, logarithm of x to base 10 |
| g | acceleration due to gravity |
| t | time |
| FoS | factor of safety |

## II. STRESS AND STRAIN

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

## III. SOIL PROPERTIES

### (a) Index Properties

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

* Density symbol is $\rho$. Unit weight symbol is $\gamma$ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

### (a) Index Properties (continued)

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

### (b) Hydraulic Properties

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

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

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

### (d) Shear Strength

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

**Notes:** 1 $\tau = c' + \sigma' \tan\phi'$

2 shear strength = (compressive strength)/2

# LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

## I. SAMPLE TYPE

| | |
|---|---|
| AS | Auger sample |
| BS | Block sample |
| CS | Chunk sample |
| DS | Denison type sample |
| FS | Foil sample |
| RC | Rock core |
| SC | Soil core |
| SS | Split-spoon |
| ST | Slotted tube |
| TO | Thin-walled, open |
| TP | Thin-walled, piston |
| WS | Wash sample |

## II. PENETRATION RESISTANCE

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

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

**Dynamic Cone Penetration Resistance; $N_d$:**

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

**PH:** Sampler advanced by hydraulic pressure
**PM:** Sampler advanced by manual pressure
**WH:** Sampler advanced by static weight of hammer
**WR:** Sampler advanced by weight of sampler and rod

**Piezo-Cone Penetration Test (CPT)**

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 $cm^2$ pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance ($Q_t$), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

## III. SOIL DESCRIPTION

**(a) Non-Cohesive (Cohesionless) Soils**

| Density Index / Relative Density | N Blows/300 mm or Blows/ft |
|---|---|
| Very loose | 0 to 4 |
| Loose | 4 to 10 |
| Compact | 10 to 30 |
| Dense | 30 to 50 |
| Very dense | over 50 |

**(b) Cohesive Soils**

**Consistency**

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

## IV. SOIL TESTS

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

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

## V. MINOR SOIL CONSTITUENTS

| Per cent by Weight | Modifier | Example |
|---|---|---|
| 0 to 5 | Trace | Trace sand |
| 5 to 12 | Trace to Some (or Little) | Trace to some sand |
| 12 to 20 | Some | Some sand |
| 20 to 30 | (ey) or (y) | Sandy |
| over 30 | And (non-cohesive (cohesionless)) or With (cohesive) | Sand and Gravel / Silty Clay with sand / Clayey Silt with sand |

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# RECORD OF BOREHOLE No 15-1

1 OF 2 **METRIC**

PROJECT 1532543 | G.W.P. 2159-11-00 | LOCATION N 4914534.5; E 288258.2 | ORIGINATED BY D.M

DIST Central | HWY 400 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | COMPILED BY NLP

DATUM GEODETIC | DATE June 29, 2015 | CHECKED BY LCC

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (10 20 30) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 240.5 | GROUND SURFACE | | | | | | | | | | |
| 0.0 / 240.2 | ASPHALT | | | | | | 240 | | | | |
| 0.5 | Gravelly sand, trace silt, crushed (FILL) Grey Moist | | | | | | | | | | |
| | Sand, trace to some gravel, some silt, containing organics and rootlets (FILL) Compact to very loose Brown | | 1A 1B | SS | 12 | | 239 | | | | |
| 238.6 / 1.9 | Moist | | | | | | | | | | |
| | Silty sand to sand, trace to some silt, trace clay, trace to some gravel (FILL) Loose to compact Light brown to brown Moist | | 2 | SS | 3 | | 238 | | ○ | | 8 79 10 3 |
| | | | 3 | SS | 3 | | 237 | | | | |
| | | | 4 | SS | 8 | | | | ○ | | 0 60 35 5 |
| | - 12.7 mm clayey silt pocket observed at 4.3 m - Refusal inferred to be on cobble at 4.4 m - Trace rounded to angular gravel, below 4.6 m | | 5 | SS | 20 | | 236 | | | | |
| 234.8 | | | | | | | 235 | | | | |
| 5.6 | Gravelly silty sand, containing organics (FILL) Loose Dark brown Moist | | 6 | SS | 6 | | 234 | | | | |
| 233.3 | | | | | | | | | | | |
| 7.2 | SAND, some silt Compact Brown Moist | | 7 | SS | 27 | | 233 | | ○ | | 0 85 13 2 |
| 231.8 | | | | | | | 232 | | | | |
| 8.7 | Sandy SILT to SILT, trace sand, trace clay Compact to dense Brown Wet | | 8 | SS | 30 | | 231 | | | | |
| | | | 9 | SS | 17 | | 230 | | | | |
| 228.7 | | | | | | | 229 | | | | |
| 11.7 | CLAYEY SILT, trace sand, trace gravel (TILL) Very stiff | | | | | | | | | | |
| 228.1 / 12.4 | Brown Moist | | 10A 10B | SS | 30 | | 228 | | | | |
| | SILT, trace clay, some sand Compact to dense Grey Wet | | | | | ▽ | 227 | | | | |
| | | | 11 | SS | 15 | | | | | | |
| | | | | | | | 226 | | | | |

SUD-MTO 001 1532543.GPJ GAL-MISS.GDT 07/10/15 DATA INPUT:

Continued Next Page

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

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# RECORD OF BOREHOLE No 15-1

2 OF 2 **METRIC**

PROJECT 1532543 | G.W.P. 2159-11-00 | LOCATION N 4914534.5; E 288258.2 | ORIGINATED BY D.M

DIST Central | HWY 400 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | COMPILED BY NLP

DATUM GEODETIC | DATE June 29, 2015 | CHECKED BY LCC

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (10 20 30) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | |
| | SILT, trace clay, some sand<br>Compact to dense<br>Grey<br>Wet | | 12 | SS | 11 | | 225 | | ○ | | 0 15 83 2 |
| | | | | | | | 224 | | | | |
| | | | 13 | SS | 21 | | | | | | |
| | - 51 mm thick silty clay pocket observed at 17.3 m | | | | | | 223 | | | | |
| 221.8 | | | 14A | SS | 10 | | 222 | | | | |
| 18.7 | CLAYEY SILT, trace fine sand<br>Stiff<br>Grey | | 14B | | | | | | | | |
| | - Containing pockets of wet sandy silt below 19.2 m | | 15 | SS | 12 | | 221 | | | | |
| 220.7 | | | | | | | | | | | |
| 19.8 | END OF BOREHOLE | | | | | | | | | | |
| | NOTES:<br>1. Groundwater measured at a depth of 13.7 m (Elev. 226.8 m) during drilling.<br>2. Borehole sloughed to 11.9 m (Elev. 228.6 m) after removal of augers. | | | | | | | | | | |

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

Golder Associates

# RECORD OF BOREHOLE No 15-2

1 OF 2 **METRIC**

PROJECT 1532543 | G.W.P. 2159-11-00 | LOCATION N 4914565.9; E 288247.2 | ORIGINATED BY AK

DIST Central | HWY 400 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | COMPILED BY NLP

DATUM GEODETIC | DATE June 25, 2015 | CHECKED BY LCC

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (10 20 30) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 239.8 | GROUND SURFACE | | | | | | | | | | |
| 0.0 | ASPHALT | | | | | | | | | | |
| 0.1 | Gravelly sand, trace silt (FILL) | | | | | | | | | | |
| 239.2 | Brown | | 1 | AS | - | | | | | | |
| 0.6 | Moist | | | | | | | | | | |
| | Silty sand, some gravel (FILL) | | 2 | AS | - | | 239 | | | | |
| | Brown | | | | | | | | | | |
| | Moist | | | | | | | | | | |
| 238.2 | | | | | | | | | | | |
| 1.5 | Silty sand to sand, trace to some gravel, trace to some silt, trace to some clay (FILL) | | 3 | SS | 12 | | 238 | | ○ | | |
| | Compact to dense | | | | | | | | | | |
| | Light brown to brown | | 4 | SS | 27 | | | | | | |
| | Moist | | | | | | 237 | | | | |
| | | | 5 | SS | 34 | | | | | | |
| | | | | | | | 236 | | | | |
| | | | 6 | SS | 10 | | | | ○ | | 10 58 25 7 |
| | | | 7 | SS | 25 | | 235 | | | | |
| | | | | | | | | | | | |
| | | | | | | | 234 | | | | |
| | | | 8 | SS | 35 | | | | | | |
| | - Organic layer at a depth of 6.7 m | | | | | | 233 | | | | |
| | | | | | | | | | | | |
| | | | 9 | SS | 33 | | 232 | | | | |
| 231.1 | | | | | | | | | | | |
| 8.7 | SILT, trace to some clay | | | | | | 231 | | | | |
| | Compact to dense | | | | | ▽ | | | | | |
| | Grey | | | | | | | | | | |
| | Wet | | 10 | SS | 41 | | | | | | |
| | | | | | | | 230 | | | | |
| | | | 11 | SS | 24 | | 229 | | ○ | | 0 0 89 11 |
| 228.0 | | | | | | | | | | | |
| 11.7 | SILTY SAND, trace clay | | | | | | 228 | | | | |
| | Compact | | | | | | | | | | |
| | Grey | | | | | | | | | | |
| | Moist to wet | | 12 | SS | 16 | | | | | | |
| | | | | | | | 227 | | | | |
| | | | | | | | | | | | |
| | | | 13 | SS | 10 | | 226 | | | | |
| | | | | | | | | | | | |
| | | | | | | | 225 | | | | |

Continued Next Page

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

SUD-MTO 001 1532543.GPJ GAL-MISS.GDT 07/10/15 DATA INPUT:

Golder Associates

PROJECT 1532543

# RECORD OF BOREHOLE No 15-2

2 OF 2 **METRIC**

G.W.P. 2159-11-00 LOCATION N 4914565.9; E 288247.2 ORIGINATED BY AK

DIST Central HWY 400 BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers COMPILED BY NLP

DATUM GEODETIC DATE June 25, 2015 CHECKED BY LCC

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (10 20 30) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | |
| | SILTY SAND, trace clay<br>Compact<br>Grey<br>Moist to wet | | 14 | SS | 19 | | 224 | | | | |
| 223.4 | | | | | | | | | | | |
| 16.3 | CLAYEY SILT, trace sand<br>Stiff to very stiff<br>Grey | | 15 | SS | 16 | | 223 | | ○ | | |
| | | | | | | | 222 | | | | |
| | | | 16 | SS | 13 | | 221 | | | | |
| | | | 17 | SS | 9 | | | | | | |
| 219.9 | | | | | | | 220 | | | | |
| 19.8 | END OF BOREHOLE | | | | | | | | | | |

NOTE:

1. Groundwater measured at a depth of 9.1 m (Elev. 230.7 m) during drilling operations.

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

Golder Associates

# RECORD OF BOREHOLE No 15-3

1 OF 2 **METRIC**

PROJECT 1532543 | G.W.P. 2159-11-00 | LOCATION N 4914544.2; E 288286.9 | ORIGINATED BY D.M

DIST Central | HWY 400 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | COMPILED BY NLP

DATUM GEODETIC | DATE June 28, 2015 | CHECKED BY LCC

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT w / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (10 20 30) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 240.7 | GROUND SURFACE | | | | | | | | | | |
| 0.0 / 240.4 | ASPHALT | | | | | | | | | | |
| 240.1 / 0.6 | Gravelly sand, trace silt (FILL) Brown Moist | | | | | | | | | | |
| | Sand, trace to some silt, trace gravel to silty sand (FILL) Loose to compact Light brown to brown Moist | | 1 | SS | 9 | | 240 | | | | |
| | | | | | | | 239 | | | | |
| | - Wet below a depth of 2.3 m | | 2 | SS | 3 | | 238 | | | | |
| | | | 3A 3B | SS | 5 | | 237 | | | | |
| | - 51 mm thick silty clay layer observed at a depth of 4.0 m | | 4 | SS | 15 | | | | ○ | | 0 69 28 3 |
| | | | 5 | SS | 18 | | 236 | | | | |
| | | | 6 | SS | 19 | | 235 | | | | |
| | | | 7 | SS | 18 | ▽ | 234 | | | | |
| | | | 8 | SS | 61 | | 233 | | | | |
| 230.5 | | | | | | | 232 | | | | |
| 10.2 | SILT, trace to some sand, trace clay Dense Brown Moist | | 9 | SS | 39 | | 231 | | ○ | | 0 19 76 5 |
| 228.9 | | | | | | | 230 | | | | |
| 11.8 | SILTY SAND, trace clay Compact Brown becoming grey below a depth of 13.7 m Wet | | 10 | SS | 21 | | 229 | | | | |
| | | | 11 | SS | 17 | | 228 | | | | |
| | | | | | | | 227 | | | | |
| | | | | | | | 226 | | | | |

Continued Next Page

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

SUD-MTO 001 1532543.GPJ GAL-MISS.GDT 07/10/15 DATA INPUT:

Golder Associates

# RECORD OF BOREHOLE No 15-3

2 OF 2 **METRIC**

PROJECT 1532543 | G.W.P. 2159-11-00 | LOCATION N 4914544.2; E 288286.9 | ORIGINATED BY D.M

DIST Central | HWY 400 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | COMPILED BY NLP

DATUM GEODETIC | DATE June 28, 2015 | CHECKED BY LCC

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ / WATER CONTENT (%) (10 20 30) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | |
| | SILTY SAND, trace clay<br>Compact<br>Brown becoming grey below a depth of 13.7 m<br>Wet | | 12 | SS | 15 | | 225 | | | | |
| | | | 13 | SS | 18 | | 224 | | | | |
| | | | 14 | SS | 16 | | 223 | | | | |
| 221.7 | | | | | | | 222 | | | | |
| 19.1 | CLAYEY SILT, trace fine sand<br>Stiff<br>Grey | | 15 | SS | 10 | | | | | | 0 1 86 13 |
| 220.9 | | | | | | | 221 | | | | |
| 19.8 | END OF BOREHOLE | | | | | | | | | | |

NOTES:

1. Groundwater encountered at 10.7 m (Elev. 230.0 m) during drilling.
2. Groundwater measured in augers at 7.8 m (Elev. 232.9 m) upon completion.
3. Borehole sloughed to 11.6 m (Elev. 229.1 m) upon removal of augers.

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

Golder Associates

# RECORD OF BOREHOLE No 15-4

1 OF 2 **METRIC**

PROJECT 1532543 | G.W.P. 2159-11-00 | LOCATION N 4914580.1; E 288286.1 | ORIGINATED BY AK

DIST Central | HWY 400 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | COMPILED BY NLP

DATUM GEODETIC | DATE July 13, 2015 | CHECKED BY LCC

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT w / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (10 20 30) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 233.6 | GROUND SURFACE | | | | | | | | | | |
| 0.0 | Sand to silty sand, trace gravel (FILL)<br>Loose to very dense<br>Brown<br>Moist | | 1 | SS | 8 | | 233 | | | | |
| | | | 2 | SS | 74 | | | | | | |
| | | | 3 | SS | 11 | | 232 | | | | |
| 231.4 | | | | | | | | | | | |
| 2.2 | SILT, trace to some sand, trace clay<br>Compact<br>Light brown<br>Moist to wet | | 4 | SS | 23 | | 231 | | | | |
| | | | 5 | SS | 29 | | | | | | |
| | | | 6 | SS | 15 | | 230 | | H ○ | | 0 10 89 10 |
| | | | 7 | SS | 26 | | 229 | | | | |
| 227.9 | | | | | | | | | | | |
| 5.6 | SILTY SAND<br>Compact<br>Grey<br>Moist to wet | | 8A<br>8B | SS | 25 | | 228 | | ○ | | |
| 227.0 | | | | | | | 227 | | | | |
| 6.6 | SILT, trace to some sand to sandy, trace clay<br>Compact to dense<br>Grey<br>Wet | | 9 | SS | 16 | | 226 | | | | |
| | | | 10 | SS | 29 | | 225 | | | | |
| | | | 11A<br>11B | SS | 43 | | 224 | | ○ | | 0 8 91 1 |
| 221.9 | | | | | | | 223 | | | | |
| 11.7 | SILTY CLAY, trace sand<br>Very stiff to hard<br>Grey | | 12 | SS | 17 | | 222 | | | | |
| | | | 13 | SS | 37 | | 221 | | ○ | | |
| 219.5 | | | | | | | 220 | | | | |
| 14.0 | | | | | | | | | | | |

Continued Next Page

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

SUD-MTO 001 1532543.GPJ GAL-MISS.GDT 07/10/15 DATA INPUT:

Golder Associates

# RECORD OF BOREHOLE No 15-4

2 OF 2 **METRIC**

PROJECT 1532543 | G.W.P. 2159-11-00 | LOCATION N 4914580.1; E 288286.1 | ORIGINATED BY AK

DIST Central | HWY 400 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | COMPILED BY NLP

DATUM GEODETIC | DATE July 13, 2015 | CHECKED BY LCC

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED) (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (10 20 30) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | | | | GR SA SI CL |
| | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | |
| | END OF BOREHOLE<br><br>NOTE:<br><br>1. Groundwater measured at a depth of 6.6 m (Elev. 227.0 m) during drilling. | | | | | | | | | | |

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

Golder Associates

# RECORD OF BOREHOLE No 15-5

1 OF 1 **METRIC**

PROJECT 1532543 | G.W.P. 2159-11-00 | LOCATION N 4914575.3; E 288233.7 | ORIGINATED BY D.M

DIST Central HWY 400 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | COMPILED BY NLP

DATUM GEODETIC | DATE June 29, 2015 | CHECKED BY LCC

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT w / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (10 20 30) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 239.5 | GROUND SURFACE | | | | | | | | | | |
| 0.0 / 239.1 | ASPHALT | | | | | | | | | | |
| 238.8 / 0.6 | Gravelly sand, trace silt (FILL) Brown Moist | | | | | | 239 | | | | |
| | Sand, some gravel, trace silt (FILL) Brown Moist | | | | | | | | | | |
| 237.9 / 1.5 | Clayey silt, trace to some sand, trace gravel (FILL) Stiff Brown Moist | | 1 | SS | 14 | | 238 | | ○ | | |
| 237.2 / 2.2 | Silty sand, trace clay, trace gravel (FILL) Compact to dense Brown to greyish brown Moist | | 2 | SS | 33 | | 237 | | | | |
| | | | 3 | SS | 19 | ▽ | 236 | | ○ | | 3 71 21 5 |
| | - 25 mm sand seam at 4.2 m Compact to loose Moist | | 4 | SS | 14 | | 235 | | | | |
| 234.4 | - Asphalt pieces at 4.9 m | | 5A 5B | SS | 10 | | | | | | |
| 5.1 | Sand and silt, trace to some clay (FILL) Compact Brown, oxidation staining Moist | | | | | | 234 | | | | |
| 233.1 | | | 6A 6B | SS | 22 | | 233 | | ○ | | 0 51 39 10 |
| 6.4 | Silty sand, trace clay, containing silty clay pockets (FILL) Compact to dense Brown Moist | | | | | | 232 | | | | |
| | - Wet below 7.6 m | | 7 | SS | 42 | | | | | | |
| 229.2 | | | 8 | SS | 33 | | 230 | | | | |
| 10.2 | CLAYEY SILT, trace sand Very stiff Grey Moist | | 9 | SS | 20 | | 229 | | | | |
| 227.7 | | | | | | | 228 | | | | |
| 11.7 | SILTY SAND, trace clay Loose to compact Grey Wet | | 10 | SS | 8 | | 227 | | | | |
| 225.7 | | | 11 | SS | 29 | | 226 | | | | |
| 13.7 | END OF BOREHOLE NOTE: 1. Groundwater measured at 3.5 m (Elev. 236.0 m) during drilling. | | | | | | | | | | |

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

SUD-MTO 001 1532543.GPJ GAL-MISS.GDT 07/10/15 DATA INPUT:

Golder Associates

# RECORD OF BOREHOLE No HF4

1 OF 1 **METRIC**

PROJECT 1532543
G.W.P. 2159-11-00
LOCATION N 4914537.7; E 288309.6
ORIGINATED BY AK
DIST Central HWY 400
BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers
COMPILED BY NLP
DATUM GEODETIC
DATE July 7, 2015
CHECKED BY LCC

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | UNIT WEIGHT $\gamma$ kN/m$^3$ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|
| 236.5 | GROUND SURFACE | | | | | | | | |
| 0.0 | Sand, trace gravel, trace silt (FILL)<br>Compact<br>Dark brown to brown<br>Moist | | 1 | SS | 22 | | 236 | | |
| | | | 2 | SS | 21 | | | | |
| 235.1 | | | | | | | 235 | | |
| 1.4 | Silty sand to sandy silt, trace gravel (FILL)<br>Compact to dense<br>Light brown to brown<br>Moist | | 3 | SS | 23 | | | | |
| | | | 4 | SS | 28 | | 234 | | |
| | | | 5 | SS | 35 | | 233 | | |
| 232.6 | | | | | | | | | |
| 3.9 | SILT, trace sand, trace clay<br>Compact<br>Grey<br>Moist to wet | | 6 | SS | 25 | | 232 | | |
| | | | 7 | SS | 12 | ▽ | | | 0 0 95 5 |
| 230.9 | | | | | | | 231 | | |
| 5.6 | SANDY SILT to SILTY SAND<br>Compact<br>Grey<br>Moist | | 8 | SS | 16 | | 230 | | |
| | | | 9 | SS | 19 | | 229 | | 0 30 70 0 |
| | | | 10 | SS | 18 | | 228 | | |
| | | | 11 | SS | 16 | | 227 | | |
| 226.4 | | | | | | | | | |
| 10.1 | END OF BOREHOLE | | | | | | | | |

NOTES:

1. Groundwater encountered at 8.5 m (Elev. 228.0 m) during drilling.

2. Groundwater measured at 4.8 m (Elev. 231.7 m) on August 11, 2015.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100

PLASTIC LIMIT $w_P$ — NATURAL MOISTURE CONTENT $w$ — LIQUID LIMIT $w_L$

WATER CONTENT (%): 10 20 30

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

SUD-MTO 001 1532543.GPJ GAL-MISS.GDT 07/10/15 DATA INPUT:

# RECORD OF BOREHOLE No BH F1 1 OF 2 METRIC

GWP 2074-11-00 LOCATION 29+721, 2.6 m Lt C/L (N 4914538.5, E286270.5) ORIGINATED BY LG

DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP

DATUM Geodetic DATE 15/10/2014 CHECKED BY SH

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) o UNCONFINED + FIELD VANE • POCKET PENETR. × LAB VANE (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ WATER CONTENT (%) (10 20 30) | UNIT WEIGHT $\gamma$ kN/m$^3$ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 240.8 | GROUND SURFACE | | | | | | | | | | |
| 240.6 | 220 mm ASPHALT | | | | | | | | | | |
| 0.2 | **PAVEMENT GRANULAR FILL:** 0.2 m Sand and Gravel 0.4 m Sand, some gravel | | 1 | SS | 24 | | 240 | | | | |
| 239.8 | | | | | | | | | | | |
| 0.9 | **FILL:** Silty Sand trace to some gravel trace silty clay lenses grey to brown, compact to loose moist | | 2 | SS | 22 | | | | | | |
| | | | 3 | SS | 8 | | 239 | | | | |
| | very loose | | 4 | SS | 3 | | 238 | | | | |
| | | | 5 | SS | 5 | | | | | | |
| | silty clay lenses | | 6 | SS | 8 | | 237 | | | | |
| | | | 7 | SS | 13 | | 236 | | | | |
| | | | 8 | SS | 20 | | 235 | | | | |
| | silty clay lenses | | 9 | SS | 10 | | 234 | | | | |
| 233.4 | | | | | | | | | | | |
| 7.2 | **SILTY SAND** brown, compact, moist | | 10 | SS | 14 | | 233 | | | | 0 66 (34) |
| | | | 11 | SS | 29 | | 232 | | | | |
| 230.4 | | | | | | | 231 | | | | |
| 10.2 | **SILT** trace sand, trace clay brown, compact, moist | | 12 | SS | 19 | ▼ | 230 | | | | 0 1 91 8 |
| 228.9 | | | | | | | | | | | |
| 11.7 | **SANDY SILT** grey, compact, wet | | 13 | SS | 18 | | 229 | | | | wet spoon |
| | | | 14 | SS | 15 | | 228 | | | | |
| | | | | | | | 227 | | | | |
| 225.6 | | | | | | | 226 | | | | |

Continued Next Page

+ $^3$, × $^3$: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No BH F1 2 OF 2 METRIC

GWP 2074-11-00 LOCATION 29+721, 2.6 m Lt C/L (N 4914538.5, E288270.5) ORIGINATED BY LG

DIST _____ HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP

DATUM Geodetic DATE 15/10/2014 CHECKED BY SH

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) o UNCONFINED + FIELD VANE • POCKET PENETR. × LAB VANE (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ WATER CONTENT (%) (10 20 30) | UNIT WEIGHT $\gamma$ kN/m$^3$ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | | | | GR SA SI CL |
| 225.8 | | | | | | | | | | | |
| 15.0 | SANDY SILT<br>grey, compact, wet | | 15 | SS | 10 | | 225 | | o | | 0 27 69 4 |
| 224.8 | | | | | | | | | | | |
| 15.9 | End of Borehole<br>wet cave- in @10.7 m | | | | | | | | | | |

$+^3, \times^3$: Numbers refer to Sensitivity

$15 \oplus^{20}_{10}$ (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No BH F2 1 OF 2 METRIC

GWP 2074-11-00 LOCATION 10+030, 10.8 m Lt C/L (N 4914569.2, E 288234.3) ORIGINATED BY JD

DIST — HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP

DATUM Geodetic DATE 23/10/2014 CHECKED BY SH

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (10 20 30) | UNIT WEIGHT $\gamma$ kN/m$^3$ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 239.5 | GROUND SURFACE | | | | | | | | | | |
| 0.0 / 239.1 | 400 mm ASPHALT | | | | | | | | | | |
| 0.4 / 238.6 | PAVEMENT GRANULAR FILL: 0.3 m Sand and Gravel | | 1 | SS | 48 | | | | | | |
| 0.9 | 0.2 m Sand, some gravel | | 2 | SS | 24 | | | | | | |
| | FILL: Silty Sand brown to grey, dense to compact, moist | | 3 | SS | 27 | | | | | | |
| | trace clay | | 4 | SS | 24 | | | | | | |
| | | | 5 | SS | 29 | | | | | | 6 71 15 6 |
| | | | 6 | SS | 11 | | | | | | |
| | | | 7 | SS | 24 | | | | | | |
| 234.1 | | | | | | | | | | | |
| 5.4 | SILTY SAND trace gravel, trace clay brown to grey, compact, moist to wet | | 8 | SS | 27 | | | | | | |
| | | | 9 | SS | 24 | | | | | | |
| | | | 10 | SS | 11 | | | | | | wet spoon 1 70 24 5 |
| | | | 11 | SS | 39 | ▼ | | | | | |
| 229.3 | | | | | | | | | | | |
| 10.2 | SILT some sand, trace clay, dilatant grey, compact, wet | | 12 | SS | 13 | | | | | | |
| | sand and silt | | 13 | SS | 16 | | | | | | |
| | | | 14 | SS | 23 | | | | | | |
| 224.5 | | | | | | | | | | | |

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

# RECORD OF BOREHOLE No BH F2 2 OF 2 METRIC

GWP 2074-11-00 LOCATION 10+030, 10.8 m Lt C/L (N 4914589.2, E 288234.3) ORIGINATED BY JD

DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP

DATUM Geodetic DATE 23/10/2014 CHECKED BY SH

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) o UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ WATER CONTENT (%) (10 20 30) | UNIT WEIGHT $\gamma$ kN/m$^3$ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | | | | GR SA SI CL |
| 224.5 | | | | | | | | | | | |
| 15.0 / 223.7 | SILT<br>some sand, trace clay, dilatant<br>grey, compact, wet | | 15 | SS | 20 | | 224 | | o | | |
| 15.9 | End of Borehole<br>cave-in @ 9.1 m<br>Water level @ 9.1 m (not stabilized)* upon completion. | | | | | | | | | | |

+ $^3$, × $^3$: Numbers refer to Sensitivity

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

# RECORD OF BOREHOLE No BH F3 1 OF 1 METRIC

GWP 2074-11-00 LOCATION 29+712, 31.6 m Rt C/L (N 4914553.7, E288302.4) ORIGINATED BY LG

DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP

DATUM Geodetic DATE 02/10/2014 CHECKED BY SH

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES 'N' VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE 20 40 60 80 100 | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ WATER CONTENT (%) 10 20 30 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 234.1 | GROUND SURFACE | | | | | | | | | | |
| 0.0 | 0.1 m TOPSOIL<br>FILL: Silty Sand to Sand and Silt<br>trace to some gravel<br>trace rootlets<br>trace organics<br>brown, loose, moist | | 1 | SS | 7 | | 234 | | | | |
| 232.7 | | | 2 | SS | 4 | | 233 | | | | |
| 1.4 | SILTY SAND<br>trace gravel, trace clay<br>brown, loose to dense, moist to wet | | 3 | SS | 23 | | 232 | | | | |
| | sand<br>some silt | | 4 | SS | 29 | | | | | | 0 77 20 3 |
| | | | 5 | SS | 17 | | 231 | | | | |
| | | | 6 | SS | 34 | | 230 | | | | wet spoon |
| | silt<br>trace sand<br>loose | | 7 | SS | 8 | | 229 | | | | |
| | | | 8 | SS | 16 | | 228 | | | | |
| | | | 9 | SS | 17 | | 227 | | | | |
| | | | 10 | SS | 11 | | 226 | | | | |
| 224.4 | loose | | 11 | SS | 7 | | 225 | | | | |
| 9.8 | End of Borehole<br>Water level upon completion @ 4.2 m<br>Piezometer installed to 9.1 m.<br>Piezometer water level records :<br>Oct. 31, 2014 4.1 m (El. 230 m) | | | | | | | | | | |

+³, ×³: Numbers refer to Sensitivity

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

# RECORD OF BOREHOLE No BH F4 1 OF 2 METRIC

GWP 2074-11-00 LOCATION 10+012, 11.9 m Rt C/L (N 4914570.4, E 288262.9) ORIGINATED BY LG

DIST _____ HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP

DATUM Geodetic DATE 02/10/2014 CHECKED BY SH

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ WATER CONTENT (%) (10 20 30) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 239.9 | GROUND SURFACE | | | | | | | | | | |
| 239.9 | 230 mm ASPHALT | | | | | | | | | | |
| 0.2 | PAVEMENT GRANULAR FILL: 0.4 m Sand and Gravel 0.3 m Sand, some gravel | | 1 | SS | 40 | | | | | | |
| 239.0 | | | | | | | 239 | | | | |
| 0.9 | FILL: Silty Sand trace to some gravel brown to grey, very loose to dense, moist | | 2 | SS | 13 | | | | | | |
| | | | 3 | SS | 7 | | 238 | | | | |
| | sand loose | | 4 | SS | 8 | | | | | | 4 84 9 3 |
| | | | 5 | SS | 10 | | 237 | | | | |
| | | | 6 | SS | 14 | | 236 | | | | |
| | | | 7 | SS | 3 | | 235 | | | | |
| | very loose to loose | | 8 | SS | 6 | | | | | | |
| | | | 9 | SS | 11 | | 234 | | | | |
| 232.7 | | | | | | | 233 | | | | |
| 7.2 | SILTY SAND trace gravel, trace clay brown to grey, compact, moist to wet | | 10 | SS | 19 | | 232 | | | | |
| | | | 11 | SS | 32 | ▼ | 231 | | | | wet spoon 0 9 85 6 |
| | silt | | | | | | 230 | | | | |
| | | | 12 | SS | 26 | | 229 | | | | |
| | some clay | | | | | | 228 | | | | |
| | | | 13 | SS | 22 | | 227 | | | | |
| | | | | | | | 226 | | | | |
| | | | 14 | SS | 16 | | | | | | |
| 224.9 | | | | | | | 225 | | | | |

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No BH F4 2 OF 2 METRIC

GWP 2074-11-00 LOCATION 10+012, 11.9 m Rt C/L (N 4914570.4, E 288282.9) ORIGINATED BY LG

DIST _____ HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP

DATUM Geodetic DATE 02/10/2014 CHECKED BY SH

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE 20 40 60 80 100 | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ WATER CONTENT (%) 10 20 30 | UNIT WEIGHT $\gamma$ kN/m$^3$ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | | | | GR SA SI CL |
| 224.9 / 15.0 | **SILTY SAND** trace gravel brown to grey, compact, moist to wet | | 15 | SS | 20 | | | | ○ | | |
| 224.1 / 15.9 | End of Borehole cave-in @ 11.6 m Water level upon completion @ 9.8 m | | | | | | | | | | |

+ $^3$, × $^3$: Numbers refer to Sensitivity

15-20/10-5 (%) STRAIN AT FAILURE

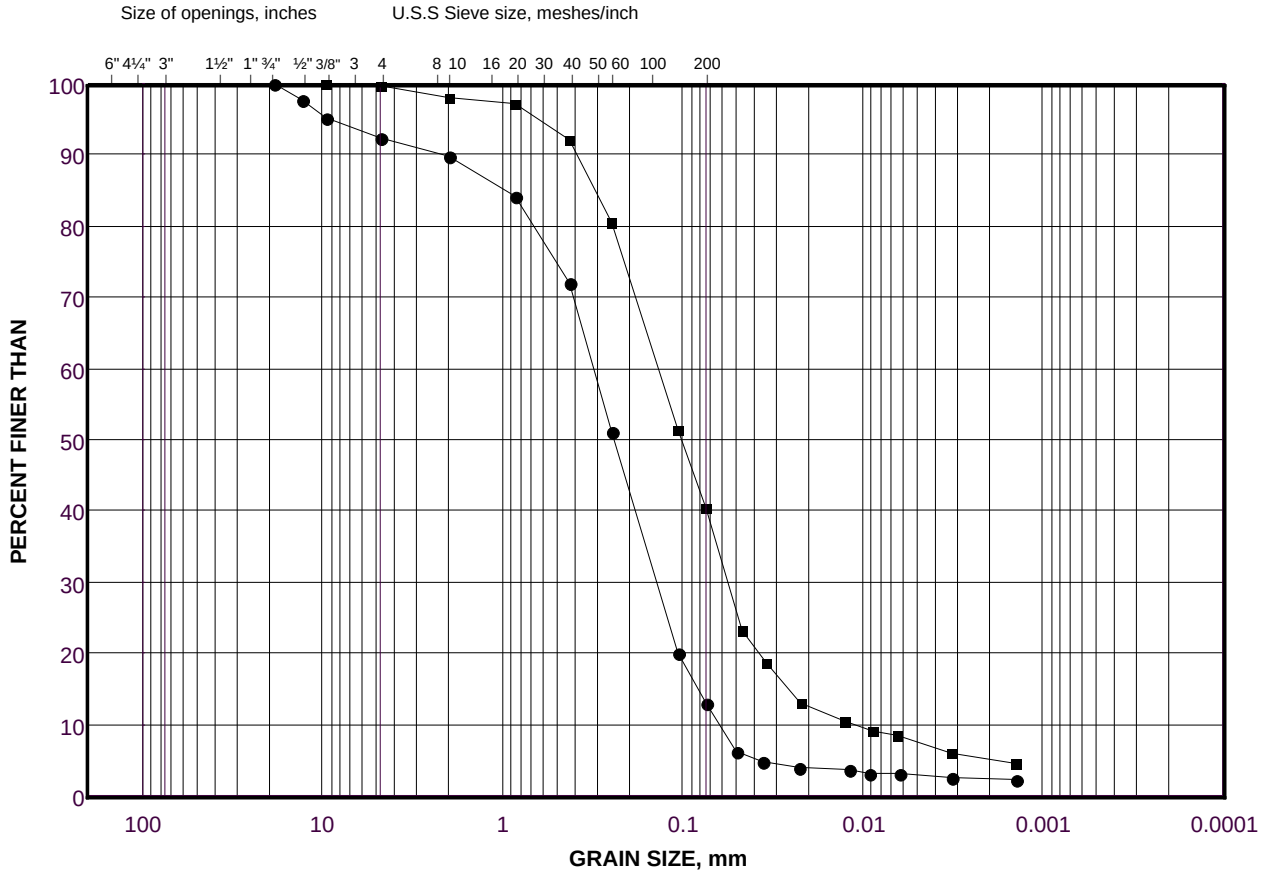
# APPENDIX B

## Geotechnical Laboratory Test Results

# GRAIN SIZE DISTRIBUTION

Silty Sand to Sand Fill

FIGURE B1




**LEGEND**

| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|---|---|---|---|
| ● | 15-1 | 2 | 238.0 |
| ■ | 15-1 | 4 | 236.5 |

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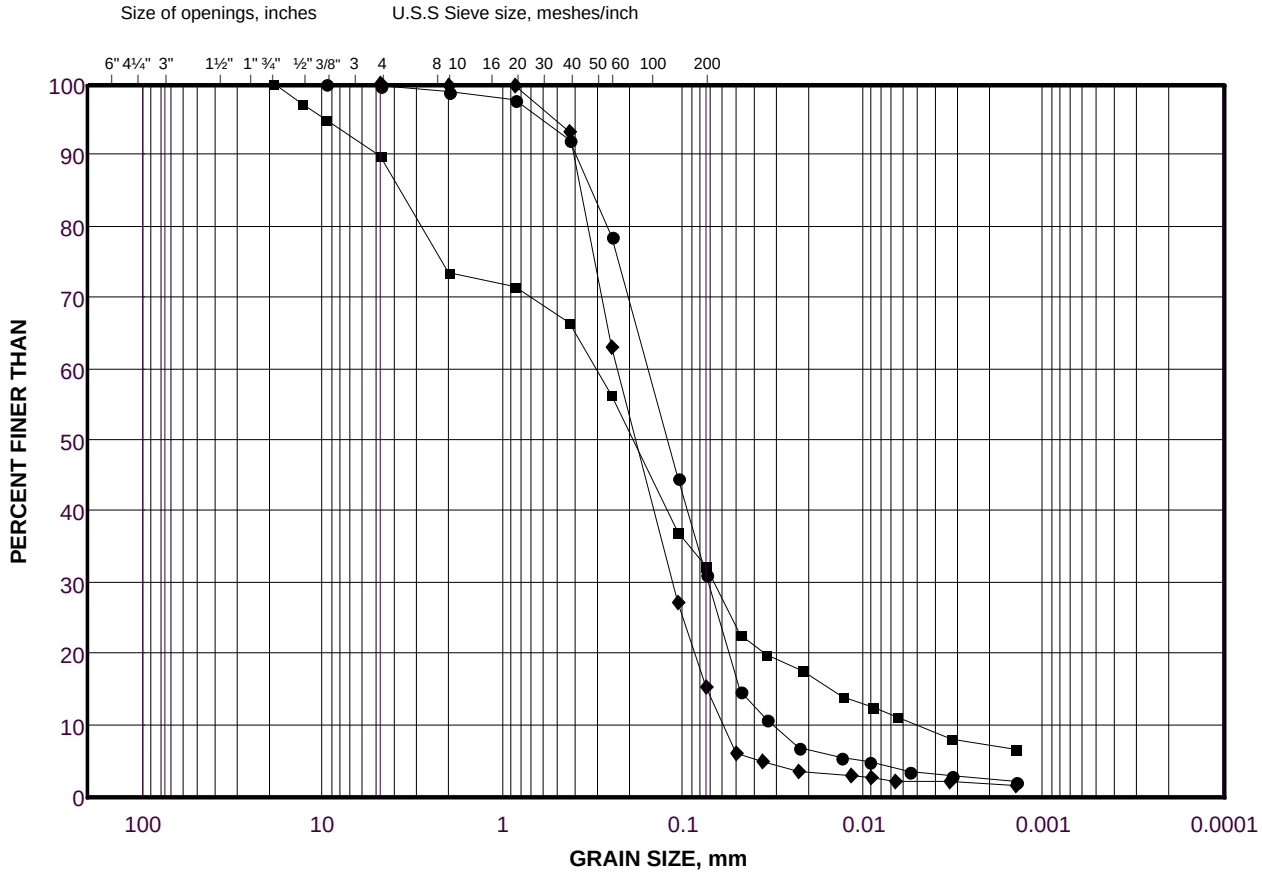
Date: 04-Sep-15

# GRAIN SIZE DISTRIBUTION

Silty Sand to Sand

FIGURE B2




**LEGEND**

| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|---|---|---|---|
| ● | 15-3 | 4 | 236.6 |
| ■ | 15-2 | 6 | 235.6 |
| ◆ | 15-1 | 7 | 232.6 |

Project Number: 1532543

Checked By: _____

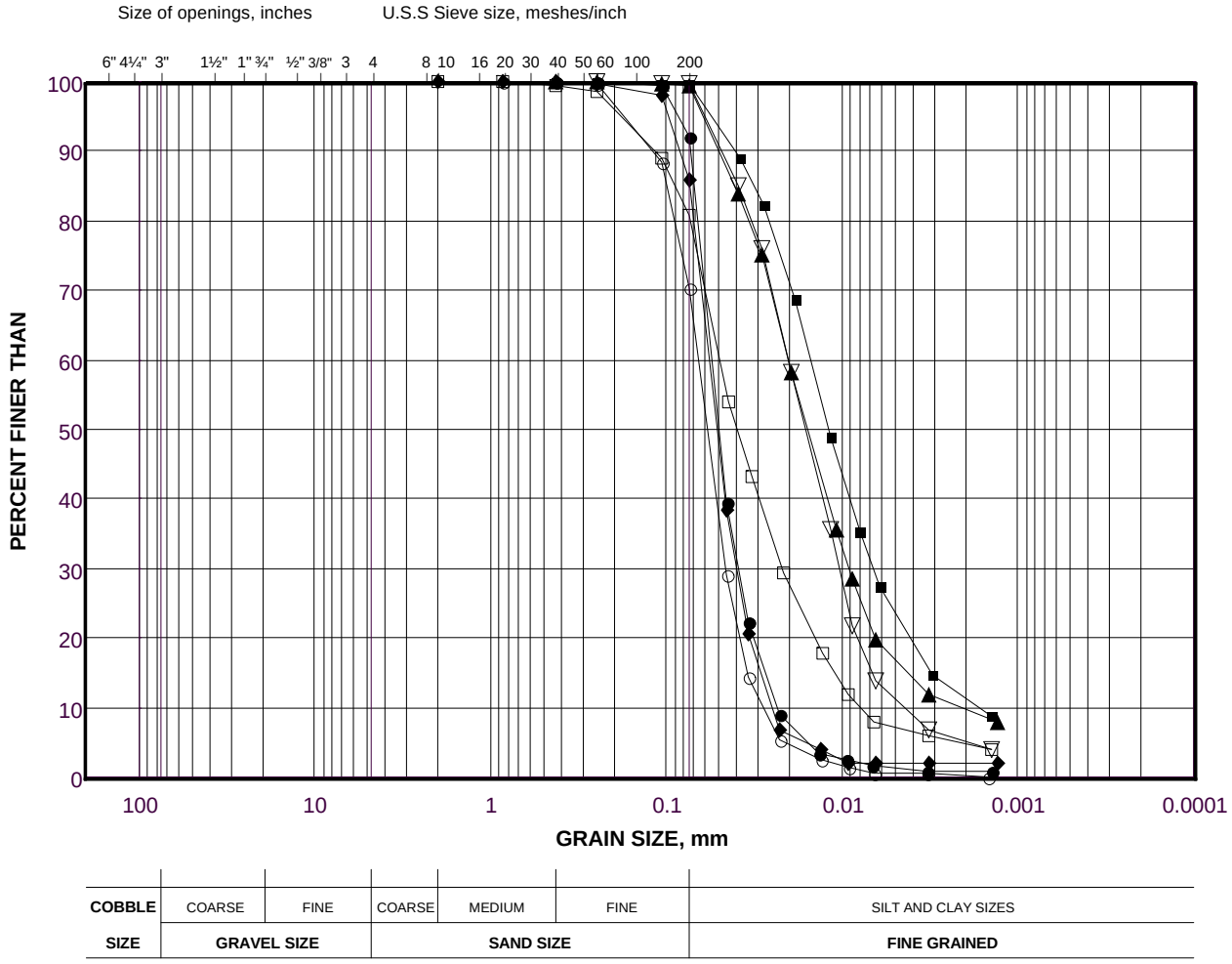
**Golder Associates**

Date: 04-Sep-15

# GRAIN SIZE DISTRIBUTION

Silt to Sandy Silt

FIGURE B3




**LEGEND**

| SYMBOL | BOREHOLE | SAMPLE | DEPTH(m) |
|---|---|---|---|
| ● | 15-4 | 10 | 224.2 |
| ■ | 15-2 | 11 | 228.8 |
| ◆ | 15-1 | 12 | 225.0 |
| ▲ | 15-4 | 6 | 229.5 |
| ▽ | HF4 | 7 | 231.7 |
| ❍ | HF4 | 9 | 228.6 |
| □ | 15-3 | 9 | 229.8 |

Project Number: 1532543

Checked By: _____

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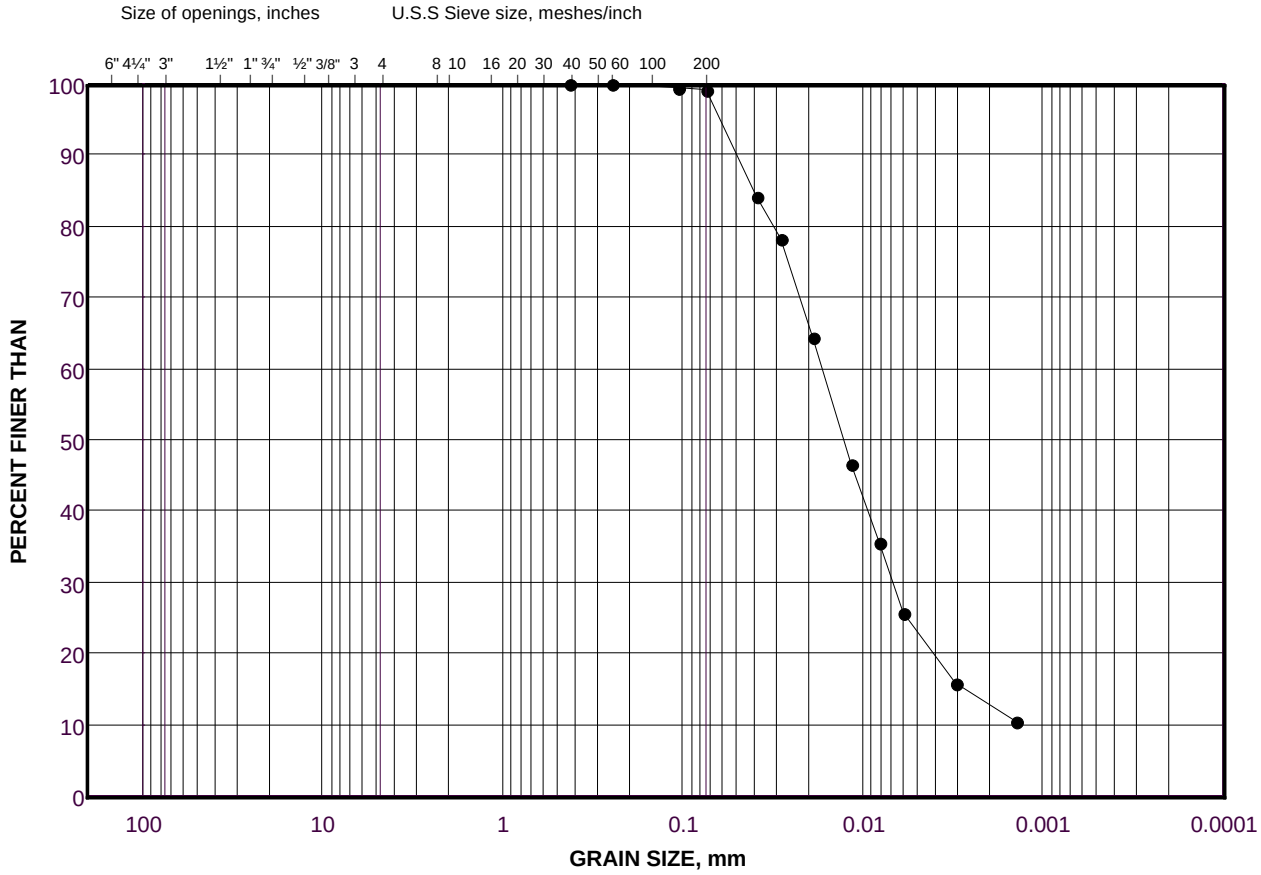
Date: 07-Oct-15

# GRAIN SIZE DISTRIBUTION

Clayey Silt

FIGURE B4




**LEGEND**

| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|---|---|---|---|
| ● | 15-3 | 15 | 221.2 |

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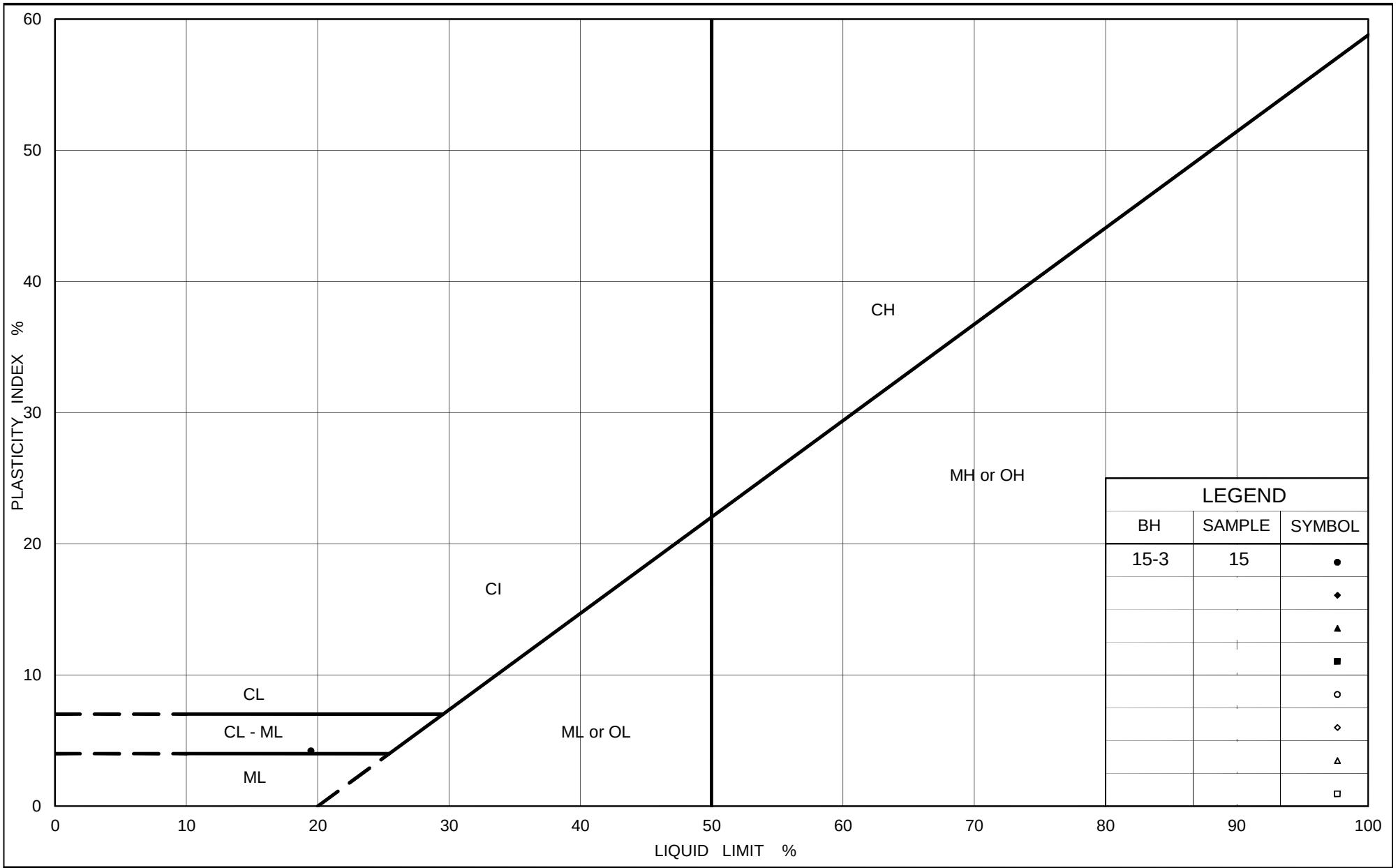
Date: 07-Oct-15

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# PLASTICITY CHART
## Clayey Silt

Figure No. B5

Project No. 1532543

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solutions@golder.com
www.golder.com

**Golder Associates Ltd.**
**6925 Century Avenue, Suite #100**
**Mississauga, Ontario, L5N 7K2**
**Canada**
**T: +1 (905) 567 4444**


Golder Associates