



June 28, 2016

FOUNDATION INVESTIGATION REPORT

Port Colborne Patrol Yards 2626 Highway 140 Port Colborne, Ontario

Submitted to:

Ministry of Transportation, Ontario
Geotechnical Engineering Section
5th Floor, Building D
145 Sir William Hearst Avenue
Downsview, ON
M3M 0B6

REPORT



Report Number: 13-1184-0123

Distribution:

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Table of Contents

| | |
|--|----------|
| 1.0 INTRODUCTION..... | 1 |
| 2.0 SITE AND PROJECT DESCRIPTION | 1 |
| 3.0 INVESTIGATION PROCEDURES | 1 |
| 4.0 GENERAL SITE GEOLOGY AND STRATIGRAPHY | 2 |
| 4.1 Regional Geology | 2 |
| 4.2 Site Stratigraphy | 2 |
| 4.2.1 Asphalt | 3 |
| 4.2.2 Sand and Gravel Fill..... | 3 |
| 4.2.3 Clay Fill | 3 |
| 4.2.4 Silty Clay to Clay..... | 3 |
| 4.2.5 Silt and Sand..... | 4 |
| 4.2.6 Gravelly Sand | 4 |
| 4.3 Groundwater Conditions | 5 |
| 5.0 CLOSURE..... | 5 |

DRAWINGS

Drawing 1 Borehole Location Plan

APPENDIX A

Borehole Records

APPENDIX B

Geotechnical Laboratory Test Results



1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the proposed material storage structure at the Port Colborne Patrol Yard at 2626 Highway 140 in Port Colborne, Ontario (refer to the Key Plan on Drawing 1).

The factual information contained in this report pertains to a specific project as described in the report and is not applicable to any other project or site location. If the project is modified in concept, location or elevation, or if the project is not initiated within eighteen (18) months of the date of the report, Golder should be given an opportunity to confirm that the information provided in this report is still valid.

This report addresses only the geotechnical (physical) aspects of the subsurface conditions at this site. The geo-environmental (chemical) aspects of the subsurface conditions, including the consequences of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources, are outside the terms of reference for this investigation.

The terms of reference and scope of work for the foundation engineering services are outlined in MTO's Assignment Order Form for Order #20 for Agreement No. 2013-E-0025, issued on May 26, 2016.

2.0 SITE AND PROJECT DESCRIPTION

The site is located on the west side of Highway 140, approximately 550 m south of Third Concession Road in Port Colborne. The site currently contains two approximately 30 m diameter silos in the northwest corner, and a storage building at the southwest corner. The remainder of the site is covered by asphalt pavement and is used for storage and maintenance vehicle parking. The terrain at the site is generally flat, with the ground surface varying between about Elevation 177.5 m and 178.5 m, referenced to geodetic datum.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out on June 8 and 9, 2016, at which time five boreholes (BH16-1 to 16-5) were advanced at the locations shown on the Borehole Location Plan, Drawing 1. The boreholes were advanced to depths ranging from about 11.3 m to 18.4 below existing ground surface.

The borehole investigation was carried out using a B57 track-mounted drill rig supplied and operated by Landshark Drilling, a specialist drilling contractor subcontracted to Golder. The boreholes were advanced through the overburden using 83 mm inside diameter (I.D.) continuous flight hollow-stem augers and wash boring drilling methods. Soil samples were obtained at intervals of depth of about 0.75 m and 1.5 m, using a 50 mm outside diameter split-spoon sampler driven by an automatic hammer in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586 – Standard Test Method for Standard Penetration Test). In-situ field vane testing, using MTO standard "N"-sized vanes, was carried out in the soft to stiff portions of the cohesive soils, where encountered, to measure the undrained shear strength of the deposit.

The shallow groundwater conditions were noted in open boreholes during and upon completion of drilling. All boreholes were backfilled to the ground surface upon completion of the drilling operations using bentonite pellets,



FOUNDATION INVESTIGATION REPORT PORT COLBORNE PATROL YARDS

in accordance with Ontario Regulation 903, as amended. The boreholes located within paved areas of the site were patched at the surface with cold mix asphalt.

The field work for this investigation was observed by members of our engineering staff who arranged underground service locates, observed the drilling and sampling operations, and logged the boreholes. The soil samples were identified in the field, placed in appropriate containers, labelled and transported to Golder's Mississauga geotechnical laboratory for further examination, natural water content testing and selected classification testing (i.e. sieve and hydrometer and Atterberg limits).

The borehole locations were located in the field by Golder, measured from existing site features and based on the borehole location plan titled "Port Colborne Patrol Yard (2626 Highway 140)", dated May 9, 2016, provided by MTO on May 20, 2016. The proposed borehole locations were relocated to provide broad coverage of the site, as one borehole was located at the center of one of the existing silos. The ground surface elevations and coordinates of the boreholes were obtained from a Global Positioning System (GPS) provided by Golder. The borehole locations in MTM NAD83 northing and easting coordinates and the ground surface elevations (referenced to geodetic datum) are summarized in Table 1 below. The MTM NAD83 coordinates and ground surface elevations are also presented on the borehole records.

Table 1: Borehole Northing, Easting, Elevation and Depth

| Borehole Number | Location (MTM NAD 83) | | Ground Surface Elevation (m) | Borehole Depth (m) |
|-----------------|-----------------------|-------------|------------------------------|--------------------|
| | Northing (m) | Easting (m) | | |
| 16-1 | 4753786.6 | 326896.4 | 178.4 | 11.3 |
| 16-2 | 4753788.2 | 326940.6 | 177.7 | 11.3 |
| 16-3 | 4753814.5 | 326934.3 | 177.8 | 18.4 |
| 16-4 | 4753820.1 | 326905.0 | 178.3 | 11.3 |
| 16-5 | 4753839.6 | 326923.4 | 178.0 | 11.7 |

4.0 GENERAL SITE GEOLOGY AND STRATIGRAPHY

4.1 Regional Geology

The study area from this assignment lies within the Haldimand clay plain physiographic region of Southern Ontario. Subsoils in this physiographic region generally consist of glacial lacustrine deposits of silts and clays over a thin layer of glacial till, underlain by dolomite limestone bedrock (Chapman and Putnam, 1984¹).

4.2 Site Stratigraphy

The detailed subsurface soil and groundwater conditions encountered in the boreholes, together with the results of geotechnical laboratory tests carried out on selected soil samples, are given on the borehole records included in Appendix A and on Figures B1 to B6 in Appendix B. Also contained in Appendix A are Lists of Abbreviations and Symbols to assist in the interpretation of the borehole records. The results of the in-situ field tests (i.e. Standard Penetration Test (SPT) 'N' values and undrained shear strengths from field vanes) as presented on the borehole records and in Section 4.2.4 are uncorrected. The stratigraphic boundaries shown on the borehole

¹ Chapman, L.J., and Putnam, D/FI, 1984. *The Physiography of Southern Ontario*, 3rd Edition. Ontario Geological Survey, Special Volume 2. Ontario Ministry of Natural Resources.



records are inferred from non-continuous sampling, observations of drilling progress and the results of geotechnical in-situ and laboratory tests. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Subsoil conditions will vary between and beyond the borehole locations.

In summary, the boreholes advanced at the site encountered asphalt underlain by clay fill overlying a lacustrine deposit of silty clay to clay. The silty clay to clay deposit is underlain by layers of silt and sand and gravelly sand. A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Asphalt

An approximately 75 mm to 100 mm layer of asphalt was encountered at the ground surface in all of the boreholes advanced at the site. The ground surface at the borehole locations varied from about Elevation 177.7 m to 178.4 m, based on the handheld Global Positioning System (GPS) unit survey.

4.2.2 Sand and Gravel Fill

An approximately 0.5 m to 1.4 m thick layer of sand and gravel fill was encountered below the asphalt in all of the boreholes advanced at the site. The base of the sand and gravel fill layers was encountered at depths ranging from 0.6 m to 1.5 m below ground surface (Elevation 177.6 m to 177.0 m). The sand and gravel fill contains trace to some silt.

The measured SPT 'N' values within the sand and gravel fill range from 7 blows to 22 blows per 0.3 m of penetration, indicating a loose to compact relative density.

The water content measured on three samples of the sand and gravel fill vary from 5 per cent to 30 per cent.

4.2.3 Clay Fill

A 0.8 m to 1.3 m layer of clay fill was encountered below the sand and gravel fill in all boreholes advanced at the site. The clay fill was encountered at depths ranging from 0.6 m to 1.5 m below ground surface (Elevation 177.6 m to 177.0 m). The clay fill generally contains trace sand and trace gravel.

The measured SPT 'N' values within the clay fill range from 6 blows to 15 blows per 0.3 m of penetration, suggesting a firm to stiff consistency.

Atterberg limits tests were carried out on three samples of the clay fill and measured liquid limits ranging from 57 per cent to 61 per cent, plastic limits ranging from 19 per cent to 23 per cent and plasticity indices ranging from 36 per cent to 42 per cent. The test results, which are plotted on a plasticity chart on Figure B1 in Appendix B, indicate that the material is a clay of high plasticity.

The results of grain size distribution testing completed on two samples of the clay fill are shown on Figure B2 in Appendix B.

The water contents measured on five samples of the clay fill range from 20 per cent to 29 per cent.

4.2.4 Silty Clay to Clay

A deposit of silty clay to clay was encountered below the clay fill in all boreholes advanced at the site. The surface of the silty clay to clay deposit was encountered at depths ranging from 1.5 m to 2.3 m below ground surface



(Elevation 176.8 m to 175.8 m). Where the deposit was fully penetrated in Borehole 16-3, it is 14.2 m thick. Boreholes 16-1, 16-2, 16-4 and 16-5 were terminated within the silty clay to clay at depths of 11.3 m to 11.7 m below ground surface (Elevation 167.1 m to 166.3 m) after penetrating 9.0 m to 10.2 m into the deposit. The silty clay to clay deposit typically contains trace sand and sand pockets. Organics and rootlets were noted to be present within the top 0.2 m to 0.6 m of the deposit in Boreholes 16-2 to 16-4.

The measured SPT 'N' values within the silty clay to clay deposit range from 0 blows (weight of SPT hammer) to 23 blows per 0.3 m of penetration. Field vane tests measured undrained shear strengths ranging from about 38 kPa to greater than 96 kPa and sensitivities between about 1.7 and 4.3. The SPT 'N' values together with the vane undrained shear strength results indicate that the deposit has a firm to very stiff consistency.

Atterberg limits tests were carried out on eleven samples of the silty clay to clay deposit and measured liquid limits ranging from 37 per cent to 64 per cent, plastic limits ranging from 17 per cent to 23 per cent and plasticity indices ranging from 19 per cent to 42 per cent. The test results, which are plotted on a plasticity chart on Figures B3A and B3B in Appendix B, indicate that the material is a silty clay to clay of intermediate to high plasticity.

The results of grain size distribution testing completed on ten samples of the silty clay to clay are shown on Figures B4A and B4B in Appendix B.

The natural water contents measured on twenty samples of the silty clay to clay range from 23 per cent to 49 per cent.

4.2.5 Silt and Sand

A 1.8 m thick deposit of silt and sand was encountered below the silty clay to clay deposit in Borehole 16-3, at a depth of 16.2 m below ground surface (Elevation 161.6 m). The silt and sand deposit contains trace to some clay and trace to some gravel.

One SPT 'N' value of 69 blows per 0.3 m of penetration was measured within the silt and sand deposit, indicating a very dense relative density.

The result of grain size distribution testing completed on a sample of the silt and sand is shown on Figure B5 in Appendix B.

A natural water content measured on one sample of the silt and sand was 12 per cent.

4.2.6 Gravelly Sand

A layer of gravelly sand was encountered below the silt and sand in Borehole 16-3 at a depth of 18.0 m below ground surface (Elevation 159.8 m). Borehole 16-3 was terminated within the gravelly sand at a depth of 18.4 m below ground surface (Elevation 159.4 m) after penetrating 0.4 m into the layer. The gravelly sand contains some silt and trace clay.

One SPT 'N' value of 50 blows per 0.13 m of penetration was measured within the gravelly sand, indicating a very dense relative density.

The result of grain size distribution testing completed on a sample of the gravelly sand is shown on Figure B6 in Appendix B.

A natural water content measured on a sample of the gravelly sand was 16 per cent.



4.3 Groundwater Conditions

The open boreholes were observed to be dry on completion of drilling operations (with the exception of Borehole 16-3, which was advanced using mud rotary techniques). However, this is not considered to be representative of the stabilized groundwater level at the site.

The water level was measured in an existing well, located approximately 18 m west and 7 m north of Borehole 16-2, to be at a depth of approximately 2.3 m below ground surface at that well location. The existing well extended to a depth of approximately 9.2 m.

5.0 CLOSURE

This Foundation Investigation Report was prepared by Ted Beadle, P.Eng. Lisa Coyne, P.Eng., a Designated MTO Foundation Contact for Foundations, conducted an independent quality review of the report.



FOUNDATION INVESTIGATION REPORT PORT COLBORNE PATROL YARDS

Report Signature Page

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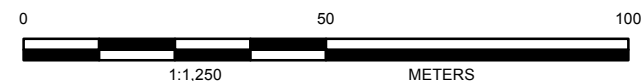
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LEGEND

BOREHOLE LOCATION



REFERENCE(S)

1. IMAGERY: SOURCES: ESRI, HERE, DELORME, TOMTOM, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, MAPMYINDIA, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

CLIENT

MINISTRY OF TRANSPORTATION ONTARIO

PROJECT

PORT COLBORNE PATROL YARDS
2626 HIGHWAY 140, PORT COLBORNE, ONTARIO

TITLE

BOREHOLE LOCATION PLAN

CONSULTANT



YYYY-MM-DD 2016-06-21

DESIGNED SO

PREPARED SO

REVIEWED TWB

APPROVED LCC

PROJECT NO.
13-1184-0123

CONTROL
0001

REV.
0.0

Drawing
1



APPENDIX A

Borehole Records



LIST OF SYMBOLS

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

I. GENERAL

| | |
|-------------|---------------------------------------|
| π | 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

| | |
|--------------------------------|--|
| γ | shear strain |
| Δ | change in, e.g. in stress: $\Delta \sigma$ |
| ε | linear strain |
| ε_v | volumetric strain |
| η | coefficient of viscosity |
| ν | Poisson's ratio |
| σ | total stress |
| σ' | effective stress ($\sigma' = \sigma - u$) |
| σ'_{vo} | initial effective overburden stress |
| $\sigma_1, \sigma_2, \sigma_3$ | principal stress (major, intermediate, minor) |
| σ_{oct} | mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$ |
| τ | 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 |
| γ' | unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$) |
| D_R | relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s) |
| e | void ratio |
| n | porosity |
| S | degree of saturation |

(a) Index Properties (continued)

| | |
|-------------|--|
| w | water content |
| w_l 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_α | 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 |
| σ'_p | pre-consolidation stress |
| OCR | over-consolidation ratio = σ'_p / σ'_{vo} |

(d) Shear Strength

| | |
|------------------|--|
| τ_p, τ_r | peak and residual shear strength |
| ϕ' | effective angle of internal friction |
| δ | angle of interface friction |
| μ | 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 |

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

Notes: 1
2

$$\tau = c' + \sigma' \tan \phi'$$
$$\text{shear strength} = (\text{compressive strength})/2$$



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, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² 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 | N |
|------------------|--------------------------|
| Relative Density | Blows/300 mm or Blows/ft |
| Very loose | 0 to 4 |
| Loose | 4 to 10 |
| Compact | 10 to 30 |
| Dense | 30 to 50 |
| Very dense | over 50 |

(b) Cohesive Soils Consistency

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

IV. SOIL TESTS

| | |
|-----------------|---|
| w | water content |
| w _p | plastic limit |
| w _l | liquid limit |
| C | consolidation (oedometer) test |
| CHEM | chemical analysis (refer to text) |
| CID | consolidated isotropically drained triaxial test 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) |
| γ | 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 |

| | | | | | | | |
|----------------------|--|---|--|------------------|--|---------------|--|
| PROJECT 13-1184-0123 | | RECORD OF BOREHOLE No BH16-1 | | SHEET 1 OF 1 | | METRIC | |
| W.P. 2013-E-0025 | | LOCATION N 4753786.6 ; E 326896.4 | | ORIGINATED BY JL | | | |
| DIST Central HWY 140 | | BOREHOLE TYPE B57 Track Mount, 83 mm I.D. Hollow Stem Auger | | COMPILED BY SD | | | |
| DATUM Geodetic | | DATE June 9, 2016 | | CHECKED BY TWB | | | |

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|--|---|------------|---------|------|------------|-------------------------|-----------------|--|-----------------------------|---|--|--|---------------------------------------|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | W _p W W _L | | | |
| | | | | | | | | ○ UNCONFINED ● QUICK TRIAXIAL | + FIELD VANE × REMOULDED | WATER CONTENT (%) | | | |
| 178.4 | Silt | | | | | | | | | | | | |
| 177.0 | ASPHALT Sand and gravel, trace fines (FILL) Compact Brown Moist | | 1 | SS | 11 | | | | | | | | |
| 177.0 | | | 2 | SS | 11 | | | | | | | | |
| 176.1 | Clay, trace sand (FILL) Stiff Brown | | 3 | SS | 10 | | | | | | | | |
| 176.1 | | | 4 | SS | 9 | | | | | | | | |
| 175.0 | SILTY CLAY to CLAY, trace sand, containing sand pockets Firm to very stiff Brown | | 5 | SS | 23 | | | | | | | | |
| 174.0 | | | 6 | SS | 14 | | | | | | | | |
| 173.0 | | | 7 | SS | 13 | | | | | | | | |
| 172.0 | | | 8 | SS | 5 | | | | | | | | |
| 171.0 | | | 9 | SS | 8 | | | | | | | | |
| 170.0 | | | | | | | | | | | | | |
| 169.0 | | | 10 | SS | 7 | | | | | | | | |
| 168.0 | | | | | | | | | | | | | |
| 167.1 | | | 11 | SS | 5 | | | | | | | | |
| 167.1 | END OF BOREHOLE | | | | | | | | | | | | |
| NOTES: 1. Borehole dry on completion of drilling. | | | | | | | | | | | | | |



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




| | | | | | | | |
|----------------------|--|---|--|------------------|--|---------------|--|
| PROJECT 1311840123 | | RECORD OF BOREHOLE No BH16-3 | | SHEET 1 OF 2 | | METRIC | |
| W.P. 2013-E-0025 | | LOCATION N 4753814.5 ; E 326934.3 | | ORIGINATED BY JL | | | |
| DIST Central HWY 140 | | BOREHOLE TYPE B57 Track Mount, Mud Rotary | | COMPILED BY SD | | | |
| DATUM Geodetic | | DATE June 8, 2016 | | CHECKED BY TWB | | | |

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | PLASTIC NATURAL LIQUID LIMIT | | | UNIT WEIGHT γ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|--------------|---|------------|----------|------|------------|-------------------------|-----------------|--|-----------------|---------------------------------|---------------------------------|---------------------------------|----------------------|---------------------------------------|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | 20 40 60 80 100 | 20 40 60 80 100 | W _p W W _L | W _p W W _L | W _p W W _L | | |
| 177.8 | GROUND SURFACE | | | | | | | | | | | | | |
| 0.1 | ASPHALT | | | | | | | | | | | | | |
| 177.1 | Sand and gravel, trace silt (FILL) Compact Brown Moist | | 1 | SS | 12 | | | | | | | | | |
| 0.7 | Clay, trace sand (FILL) Firm Brown | | 2 | SS | 7 | | | | | | | | | |
| 175.8 | | | 3 | SS | 7 | | | | | | | | | |
| 2.0 | SILTY CLAY to CLAY, trace sand, containing sand pockets Very stiff to firm Brown - Containing organics to a depth of 2.6 m | | 4A 4B | SS | 23 | | | | | | | | | |
| | | | 5 | SS | 21 | | | | | | | | | |
| | - Reddish brown below a depth of 3.7 m | | 6 | SS | 6 | | | | | | | | | |
| | | | 7 | SS | 7 | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | 8 | SS | 5 | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | 9 | SS | 11 | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | 10 | SS | 11 | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | 11 | SS | 4 | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | 12 | SS | WH | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | 13 | SS | 1 | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | - Trace gravel at a depth below 14.8 m | | | | | | | | | | | | | |

Continued Next Page

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

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| PROJECT | | 1311840123 | | RECORD OF BOREHOLE No BH16-3 | | SHEET 2 OF 2 | | METRIC | | | | | | | | |
|---|---|---|---------|------------------------------|------------|-----------------------------|-----------------|--|----|----|----|---------------------------------|-------------------------------|--------------------------------|---------------------------------------|---------------------------------------|
| W.P. | | 2013-E-0025 | | LOCATION | | N 4753814.5 ; E 326934.3 | | ORIGINATED BY | | | | | | | | |
| DIST | | Central HWY 140 | | BOREHOLE TYPE | | B57 Track Mount, Mud Rotary | | COMPILED BY | | | | | | | | |
| DATUM | | Geodetic | | DATE | | June 8, 2016 | | CHECKED BY | | | | | | | | |
| | | | | | | | | TWB | | | | | | | | |
| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | PLASTIC LIMIT W _p | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W _L | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | | | |
| | --- CONTINUED FROM PREVIOUS PAGE --- | | | | | | | 20 | 40 | 60 | 80 | 100 | | | | |
| 161.6 | SILTY CLAY to CLAY, trace sand, containing sand pockets Very stiff to firm Brown |  | 14 | SS | 3 | | | | | | | | | | | |
| 16.2 | SILT and SAND, trace to some clay, trace to some gravel Very dense Reddish brown Moist |  | 15 | SS | 69 | | | | | | | | | | | 7 40 45 8 |
| 159.8 | Gravelly SAND, some silt, trace to some clay Very dense Reddish Brown Wet |  | 16 | SS | 50/0.13 | | | | | | | | | | | 33 45 14 8 |
| 18.4 | END OF BOREHOLE | | | | | | | | | | | | | | | |
| NOTES: 1. Water level not measured on completion of drilling due to use of mud rotary drilling method. | | | | | | | | | | | | | | | | |

| | | | | | |
|---------|--------------|------------------------------|-------------------------|---------------|---|
| PROJECT | 13-1184-0123 | RECORD OF BOREHOLE No BH16-4 | | SHEET 1 OF 1 | METRIC |
| W.P. | 2013-E-0025 | LOCATION | N 4753820.1 ;E 326905.0 | ORIGINATED BY | JL |
| DIST | Central | HWY | 140 | BOREHOLE TYPE | B57 Track Mount, 83 mm I.D. Hollow Stem Auger |
| DATUM | Geodetic | DATE | June 9, 2016 | COMPILED BY | SD |
| | | | | CHECKED BY | TWB |

[illegible]

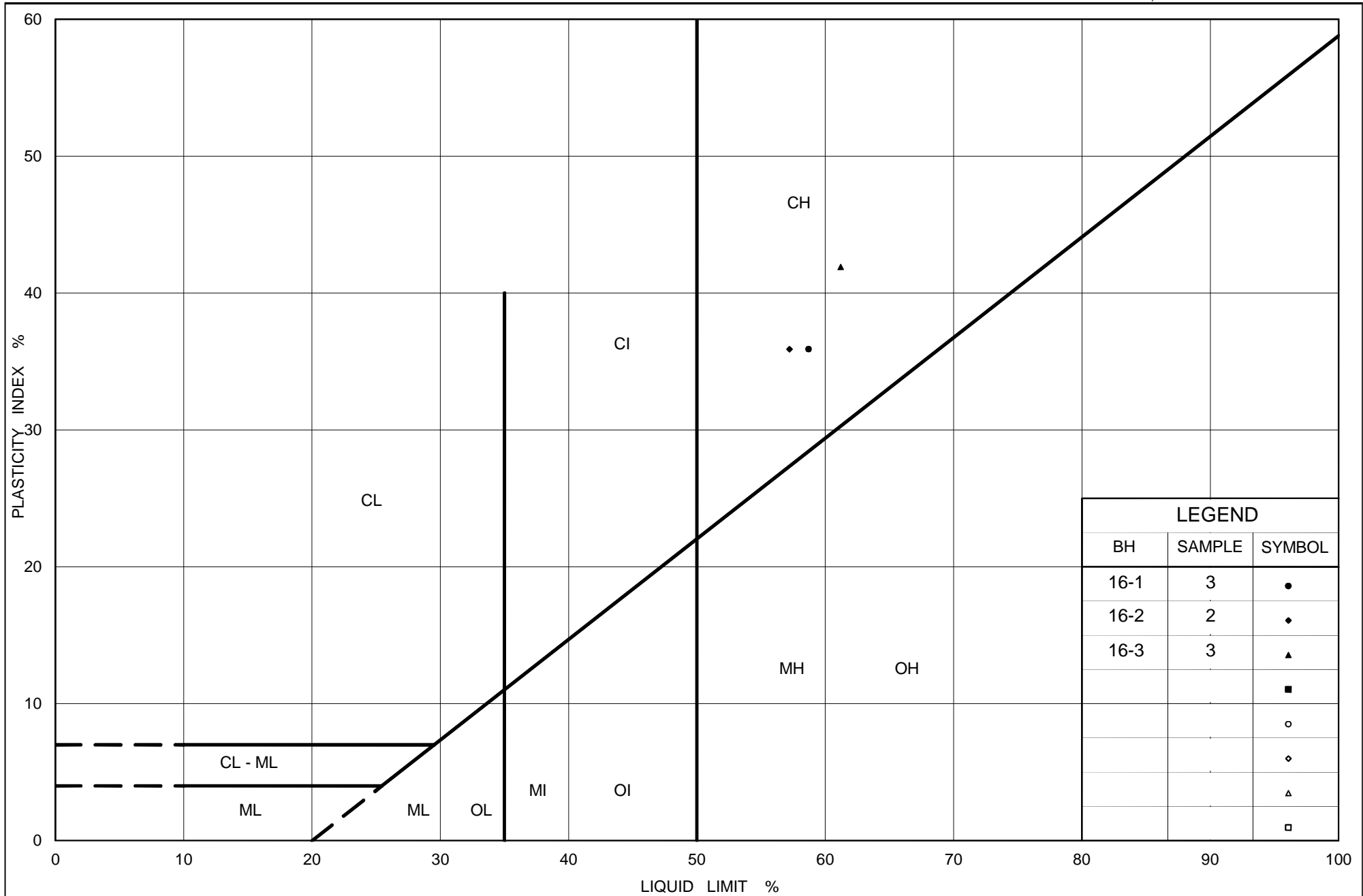
| PROJECT | | 13-1184-0123 | | RECORD OF BOREHOLE No BH16-5 | | SHEET 1 OF 1 | | METRIC | | | | | | |
|---------------|--|-----------------|---------|------------------------------|------------|---|-----------------|--|-----------------|---------------------------------|-------------------------------|--------------------------------|------------------|---------------------------------------|
| W.P. | | 2013-E-0025 | | LOCATION | | N 4753839.6 ; E 326923.4 | | ORIGINATED BY | | | | | | |
| DIST | | Central HWY 140 | | BOREHOLE TYPE | | B57 Track Mount, 83 mm I.D. Hollow Stem Auger | | COMPILED BY | | | | | | |
| DATUM | | Geodetic | | DATE | | June 8, 2016 | | CHECKED BY | | | | | | |
| | | | | | | | | TWB | | | | | | |
| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | PLASTIC LIMIT W _p | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W _L | UNIT WEIGHT γ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | |
| 178.0 | GROUND SURFACE | | | | | | | 20 40 60 80 100 | 20 40 60 80 100 | 10 20 30 | | | | |
| 0.9 | ASPHALT | | 1A | SS | 22 | | | | | | | | | |
| 177.4 | Sand and gravel, trace silt (FILL) Compact Brown to grey Moist | | 1B | | | | | | | | | | | |
| 0.6 | Clay, trace sand, trace gravel (FILL) Stiff Brown | | 2 | SS | 9 | | | | | | | | | |
| 176.6 | CLAY, trace to some sand, containing sand pockets Firm to very stiff Brown - Containing organics and rootlets to a depth of 1.8 m | | 3 | SS | 7 | | | | | | | | 52 | |
| 1.5 | | | 4 | SS | 17 | | | | | | | | | 0 5 43 52 |
| | | | 5 | SS | 18 | | | | | | | | | |
| | | | 6 | SS | 10 | | | | | | | | | |
| | | | 7 | SS | 8 | | | | | | | | | |
| | | | 8 | SS | 6 | | | | | | | | | |
| | | | 9 | SS | 6 | | | | | | | | | |
| | | | 10 | SS | 4 | | | | | | | | | |
| | | | 11 | SS | WH | | | | | | | | | |
| 166.3 | END OF BOREHOLE | | | | | | | | | | | | | |
| 11.7 | NOTE: 1. Borehole dry on completion of drilling. | | | | | | | | | | | | | |

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APPENDIX B

Geotechnical Laboratory Test Results



Ministry of Transportation

Ontario

PLASTICITY CHART Clay Fill

Figure No. B1

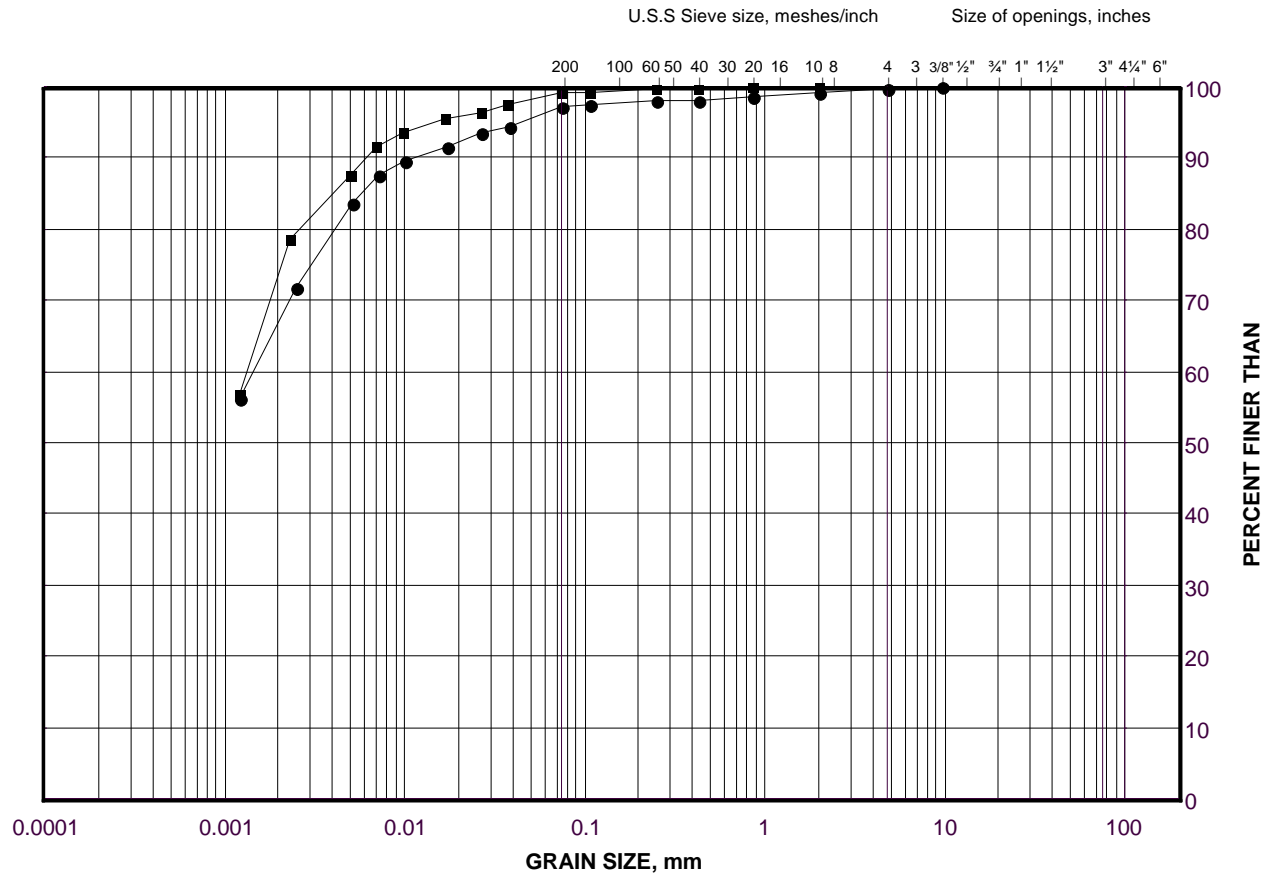
Project No. 13-1184-0123

Checked By: TWB

GRAIN SIZE DISTRIBUTION

Clay Fill

FIGURE B2



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

LEGEND

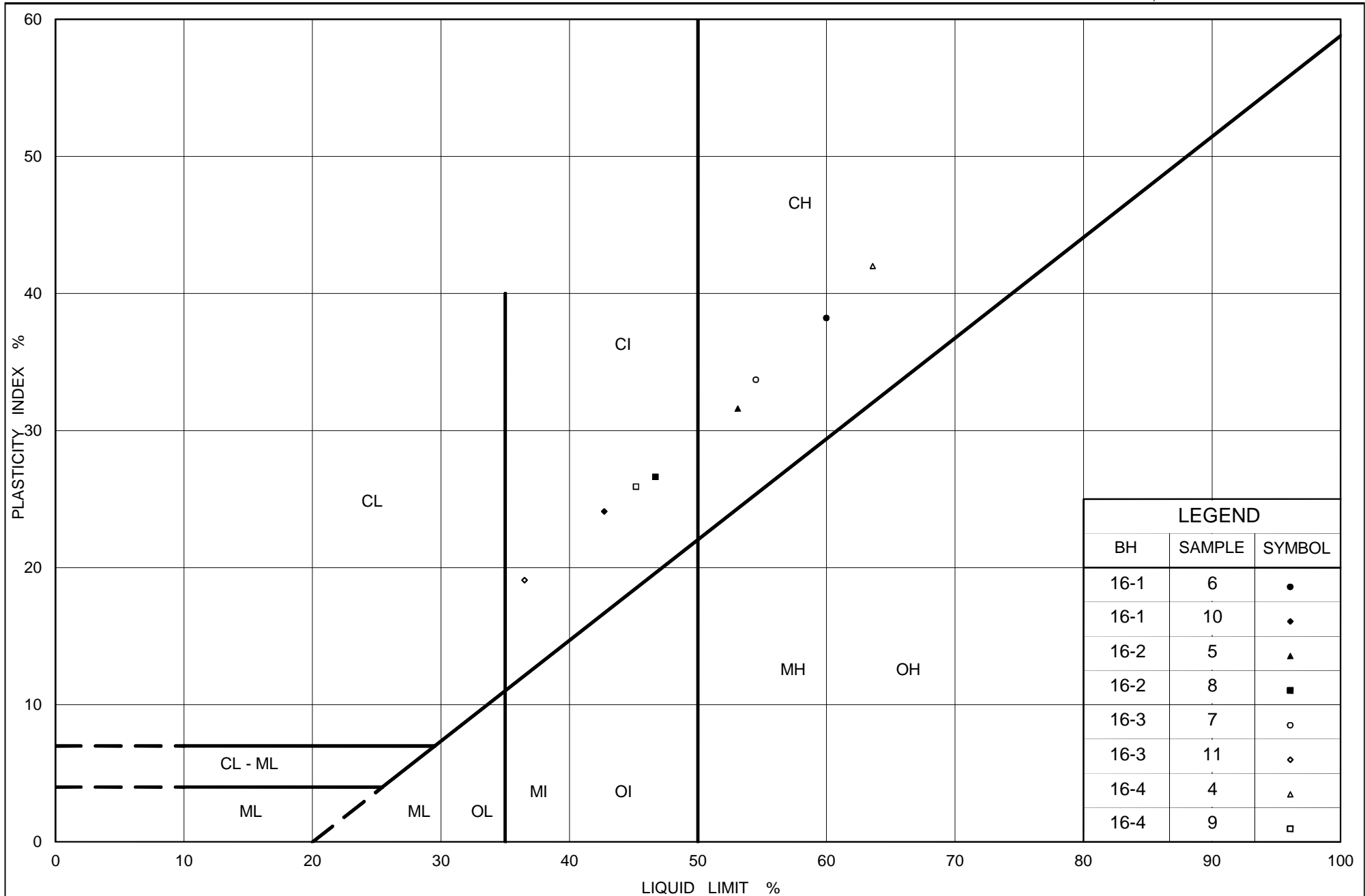
| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|--------|----------|--------|--------------|
| ● | 16-2 | 2 | 176.7 |
| ■ | 16-1 | 3 | 176.6 |

Project Number: 13-1184-0123

Checked By: TWB

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Date: 22-Jun-16



Ministry of Transportation

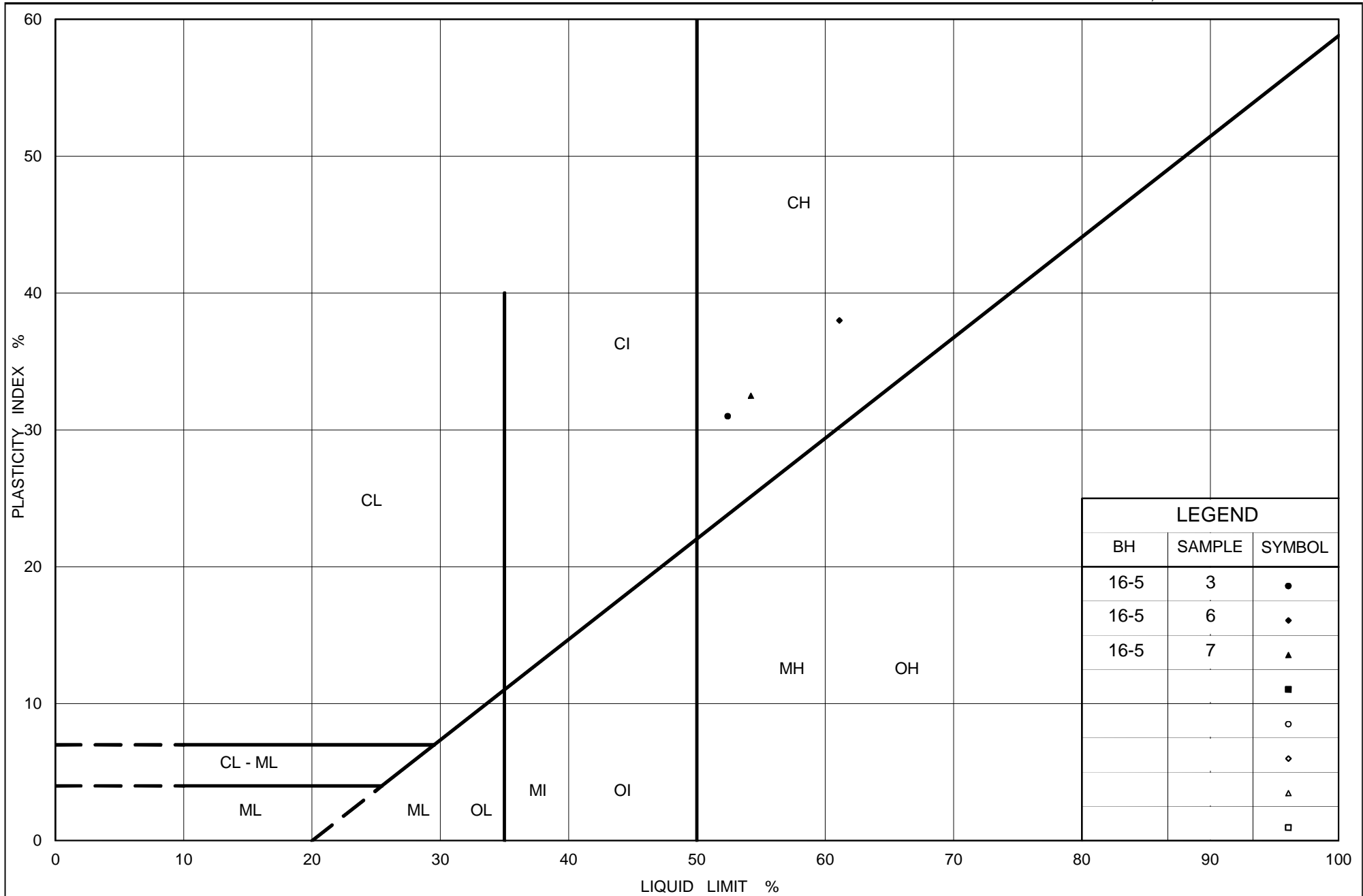
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PLASTICITY CHART Silty Clay to Clay

Figure No. B3A

Project No. 13-1184-0123

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PLASTICITY CHART Silty Clay to Clay

Figure No. B3B

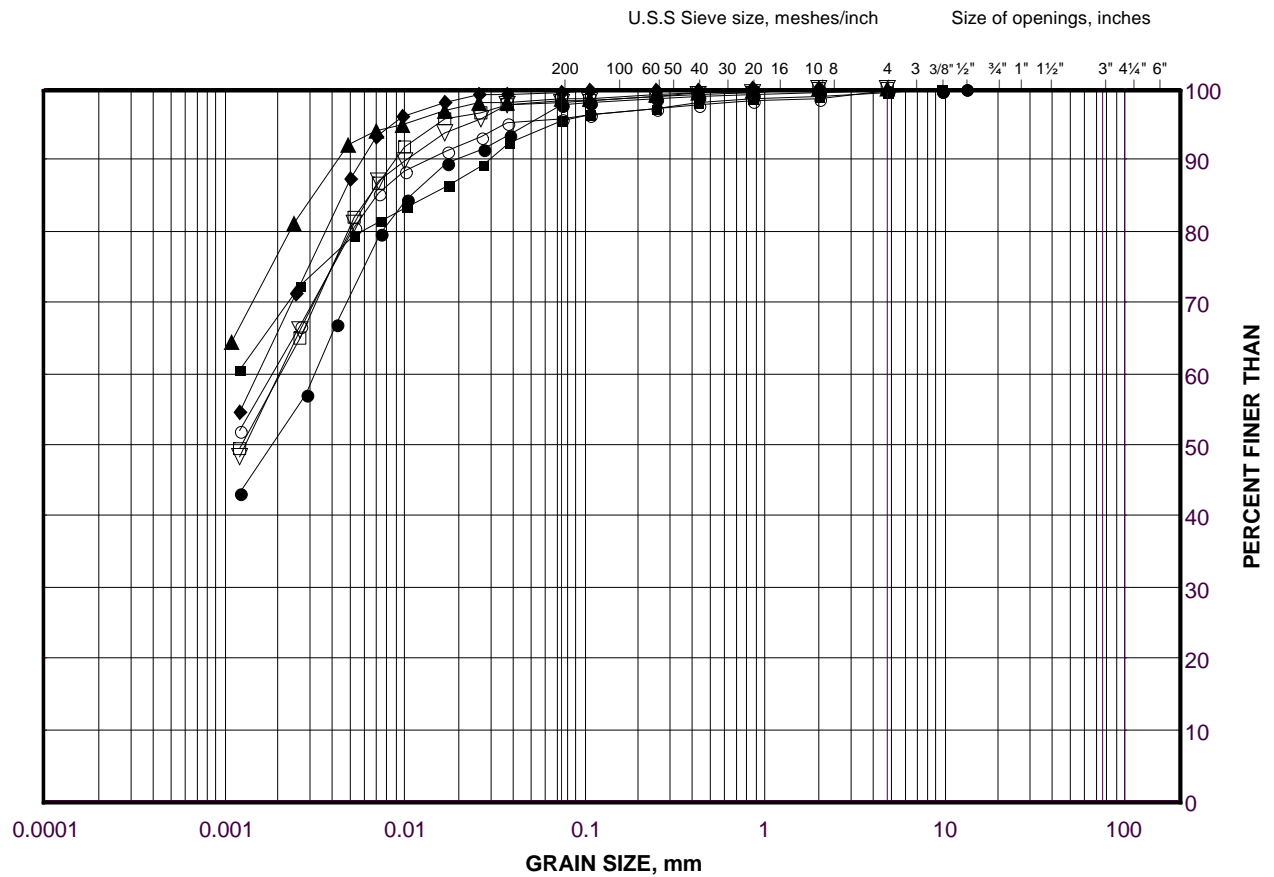
Project No. 13-1184-0123

Checked By: TWB

GRAIN SIZE DISTRIBUTION

Silty Clay to Clay

FIGURE B4A



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

LEGEND

| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|--------|----------|--------|--------------|
| ● | 16-1 | 10 | 168.9 |
| ■ | 16-4 | 4 | 175.7 |
| ◆ | 16-2 | 5 | 174.4 |
| ▲ | 16-1 | 6 | 174.2 |
| ▽ | 16-3 | 7 | 172.9 |
| ○ | 16-2 | 8 | 171.3 |
| □ | 16-4 | 9 | 170.3 |

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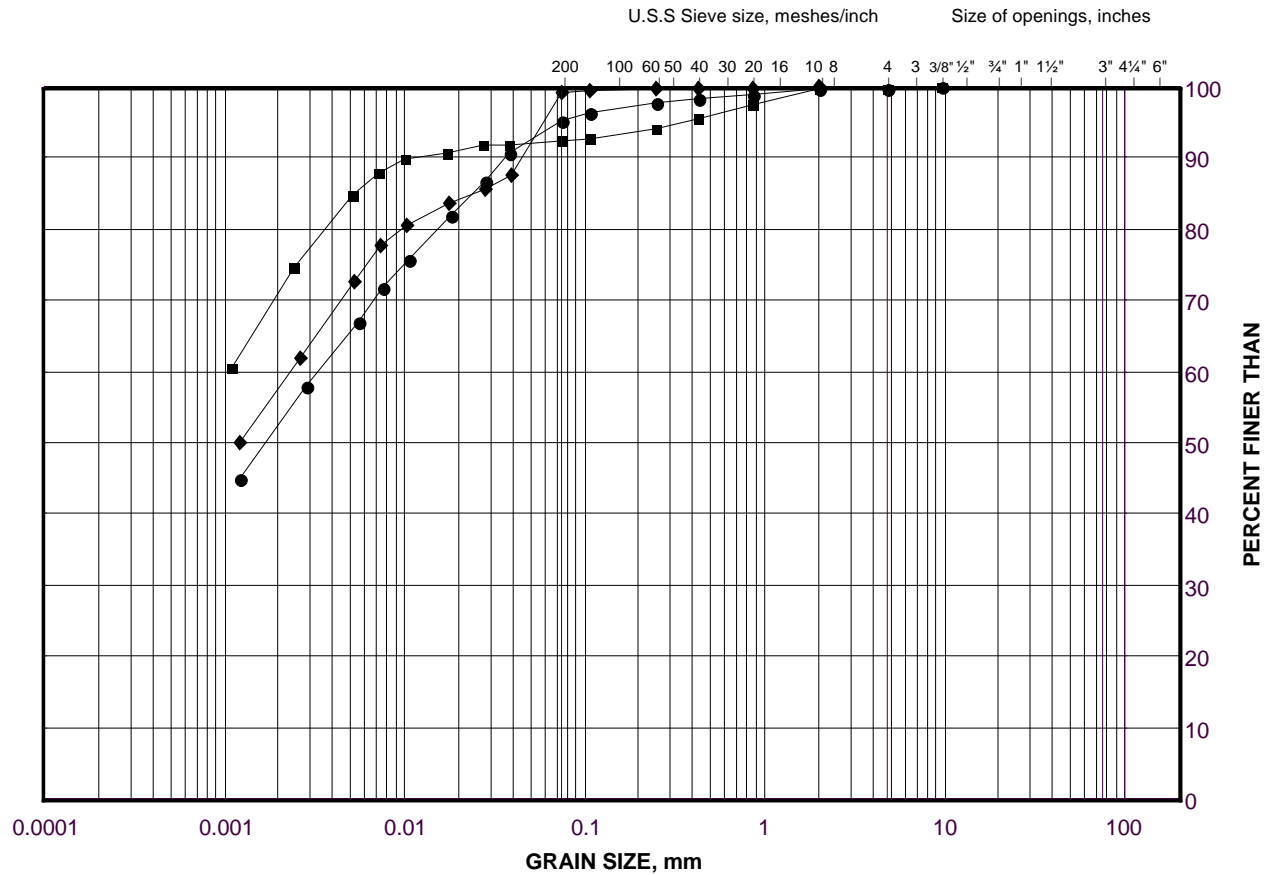
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GRAIN SIZE DISTRIBUTION

Silty Clay to Clay

FIGURE B4B



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

LEGEND

| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|--------|----------|--------|--------------|
| ● | 16-5 | 3 | 176.2 |
| ■ | 16-5 | 6 | 173.9 |
| ◆ | 16-5 | 7 | 172.8 |

Project Number: 13-1184-0123

Checked By: TWB

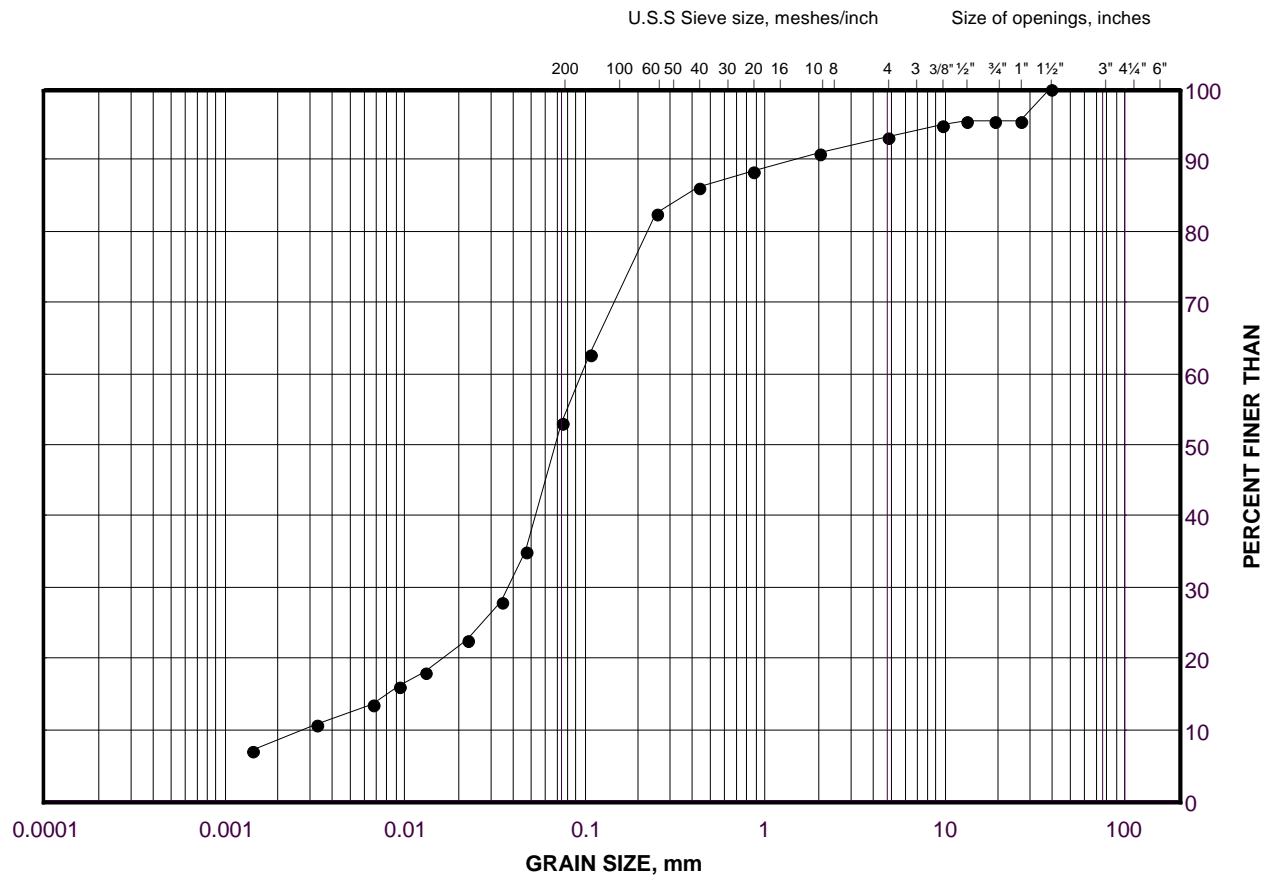
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GRAIN SIZE DISTRIBUTION

Silt and Sand

FIGURE B5



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

LEGEND

| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|--------|----------|--------|--------------|
| • | 16-3 | 15 | 160.7 |

Project Number: 13-1184-0123

Checked By: TWB

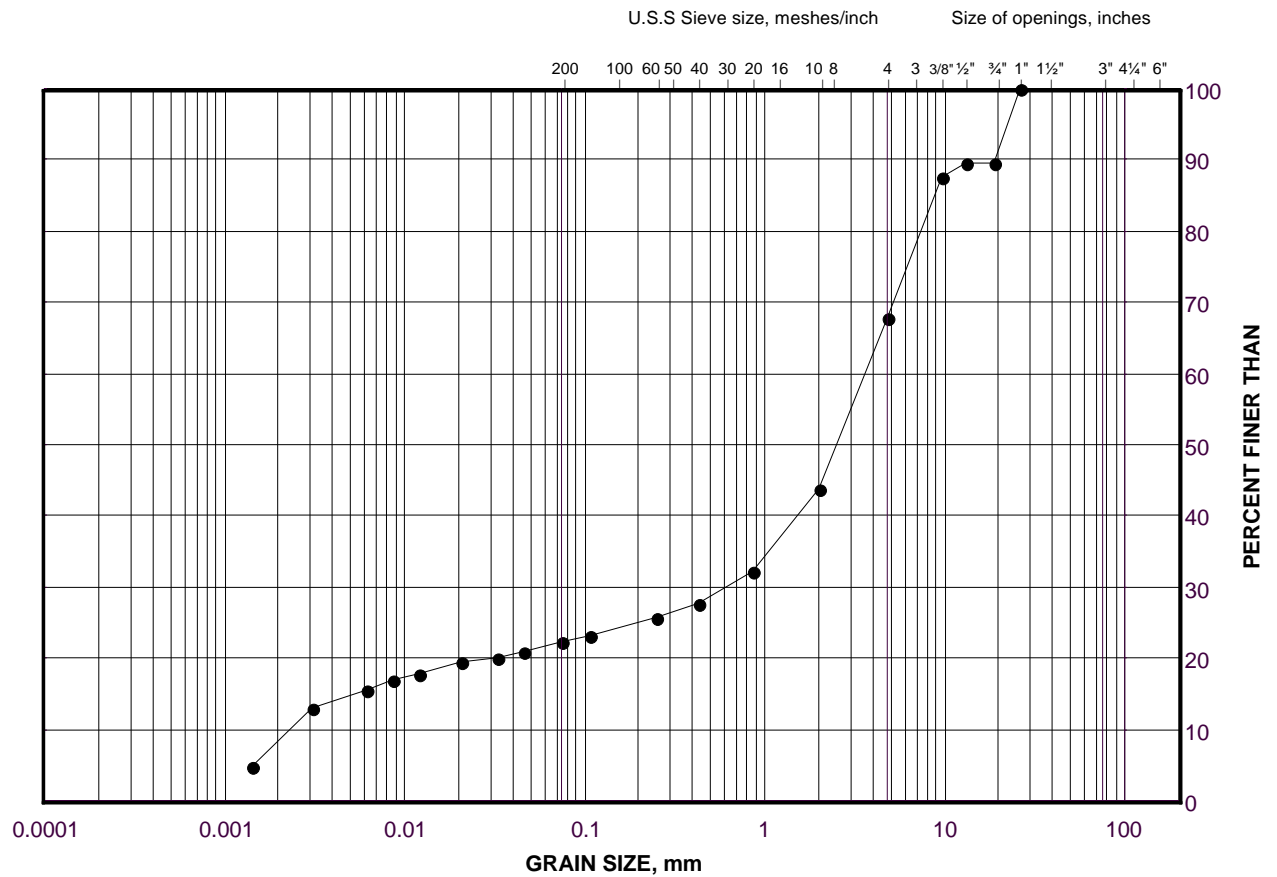
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GRAIN SIZE DISTRIBUTION

Gravelly Sand

FIGURE B6



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

LEGEND

| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|--------|----------|--------|--------------|
| • | 16-3 | 16 | 159.5 |

Project Number: 13-1184-0123

Checked By: TWB

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Date: 22-Jun-16

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