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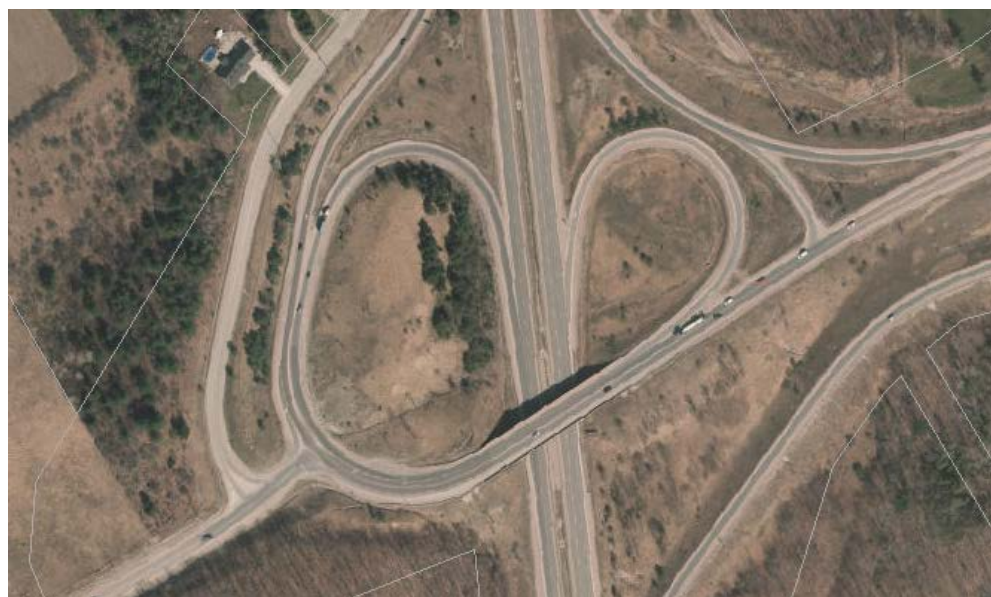
## PRELIMINARY FOUNDATION INVESTIGATION REPORT

### WIDENING OF DEEP CUTS AND HIGH FILL EMBANKMENTS, HIGHWAY 12 MEMORIAL AVENUE TO HORSESHOE VALLEY ROAD ENVIRONMENTAL ASSESSMENT CITY OF ORILLIA, ONTARIO W.O. 011-20002

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# REPORT



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### 1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by AECOM on behalf of the Ministry of Transportation, Ontario (MTO) to provide preliminary foundation engineering services for the widening/upgrades to Highway 12, from Horseshoe Valley Road to Memorial Avenue, in the City of Orillia, Ontario.

This report addresses the widening of deep cuts and high fill embankments at the following locations within the project boundaries:

- Northwest and Southwest quadrants of Highway 12 / Old Barrie Road Interchange
  - Cuts between 6 m and 14 m deep.
- Southeast quadrant of Highway 12 / Old Barrie Road Interchange
  - Embankment fills between 10 m to 14 m high.
- Southwest and southeast quadrants of Highway 12 / Coldwater Road Interchange
  - Embankment fills between 6 m and 9 m high.
- North side of Highway 12, east of Wainman Line
  - Embankment fill between 4 m and 5 m high.
- North side of Highway 12, west of Fairgrounds Road
  - Embankment fill between 4 m and 5 m high.

The terms of reference and scope of work for the foundation engineering services are outlined in Section 5.8 of MTO's Request for Proposal (RFP) for Assignment No. 2011-E-0024 dated February 2013, and in Section 5.8 of the *Technical Proposal* for this assignment.

### 2.0 SITE DESCRIPTION

The deep cuts and high fill embankments addresses in this report are located throughout the project boundaries along Highway 12, between Horseshoe Valley Road and Memorial Avenue, in the City of Orillia, Ontario. The major deep cuts and high fills are located in proximity to the Old Barrie Road / Highway 12 Interchange and the Coldwater Road / Highway 12 Interchange. Two additional fill areas are located on the stretch of Highway 12 between the Coldwater Road Interchange and Horseshoe Valley Road. Site specific descriptions are provided below for the proposed deep cuts and high fill embankments.

#### 2.1 Deep Widening Cut Highway 12 / Old Barrie Road Interchange

The top of the existing embankment at the north end of this section, near Boreholes BH15-01 and BH15-02, is about 7 m above the existing highway grade and is inclined at about 3 Horizontal to 1 Vertical (3H:1V). The slopes of the embankment are vegetated with long grasses, shrubs, and small trees. The central portion of this section, near Borehole BH15-18, is about 12 m above existing highway grade and similarly inclined at about 2H:1V. The slope is vegetated with short and tall grasses, shrubs and small trees. The southern portion of this section, near Boreholes BH15-4 and BH15-05, is about 3 m above existing highway grade and inclined at about 2.5H:1V. The





slope is vegetated with grasses and mature trees line the crest. No signs of deep seated slope instability were observed during the investigation along any of the slope sections; however, some erosion of the surficial soils at the toe of the slope were observed near the southern portion of this roadway section.

## **2.2 High Fill Embankment Widening at Highway 12 / Old Barrie Road Interchange**

The top of the existing embankment supporting the existing Highway 11 Northbound off-ramp ranges in height from 11 m at the north end of this section of ramp to level grade where it matches existing highway grade at the south end of this section. The embankment is inclined at about 2.5H:1V and is vegetated with grasses and occasional shrubs. No signs of slope instability were noted during the field investigation.

## **2.3 High Fill Embankment Widening at Highway 12 / Coldwater Road Interchange**

The existing embankments support the approach as to the bridge overpass and the on/off ramps on the south side of the interchange. The top of existing embankments are about 5 m to 6 m above the existing highway and are inclined at about 1.5H:1V. The slopes are vegetated with grass and small groves of mature trees are present at the toe of the slope. No signs of instability were observed during the investigation.

## **2.4 High Fill Embankment Widening at Highway 12 / Wainman Lane**

The top of the existing embankment is about 4 m to 5 m high and is inclined at about 1.5H:1V. The slope is densely vegetated with grasses and mature trees both at the toe of the slope and on the slope face. No signs of slope instability were noted during the investigation.

## **2.5 High Fill Embankment Widening at Highway 12 / Fairgrounds Road**

The top of the existing embankment is about 3 m to 4 m high and is inclined at about 2H:1V. The slope is vegetated with long grass and no signs of slope instability were noted during the investigation.

## **3.0 INVESTIGATION PROCEDURES**

The field work for this subsurface investigation was carried out between September 16 and October 6, 2015, during which time a total of 17 boreholes were drilled at the locations shown on Drawing 1 to 6.

The boreholes were drilled using a track-mounted drill rig, supplied and operated by Davis Drilling Ltd., of Milton, Ontario. The boreholes were advanced using 200 mm diameter hollow stem augers, with soil samples obtained at 0.75 m and 1.5 m intervals of depth using 50 mm outside diameter split-spoon samplers driven by an automatic hammer, in accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586)<sup>1</sup>.

The groundwater conditions were observed in the open boreholes during and immediately following the drilling operations and a standpipe piezometer was installed in Borehole BH15-12 (at the Coldwater Road High Fill Embankment Site) to permit monitoring of the groundwater level at this location. The piezometer consists of 50 mm diameter PVC pipe, with a slotted screen sealed within a sand filter pack at a selected depth interval within

<sup>1</sup> ASTM D1586, Standard Test Method for Standard Penetration Test.





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the borehole. The piezometer 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 AECOM. The borehole locations, including MTM NAD83 (Zone 10) northing and easting coordinates and ground surface elevations referenced to Geodetic datum and the drilled depths, are summarized below and are shown on Drawings 1 to 6.

In addition, Boreholes B15-S1, B15-S4, B15-S5 and B15-N1 drilled between September 14 and October 1, 2015, associated with the Highway 11/Old Barrie Road – Hwy 12 Interchange and the Highway 11 Coldwater Rd. – Hwy 12 Interchange are utilized herein in describing the subsurface conditions for the High Fill Embankment and Deep Cut Widening in these area.

Borehole No.	MTM NAD83 Zone 10 Coordinates		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m)	Easting (m)		
BH15-01	4939276.9	308979.1	289.4	11.1
BH15-02	4939050.1	308964.9	282.4	14.0
BH15-03	4938871.2	308899.6	276.9	14.0
BH15-04	4938561.1	309062.0	250.9	11.1
BH15-05	4938317.4	309096.5	238.0	11.1
BH15-06	4938950.1	309452.2	251.1	16.9
BH15-08	4938741.0	309182.3	247.8	20.2
BH15-09	4938634.0	309180.3	248.7	15.7
BH15-10	4941196.4	308977.4	259.8	12.6
BH15-11	4941122.0	309272.1	263.3	12.6
BH15-12	4941159.4	309141.8	257.6	8.1
BH15-13	4941127.5	309192.2	256.5	8.1
BH15-14	4941527.0	306223.6	263.4	11.1
BH15-15	4941547.2	306169.0	260.6	5.0
BH15-16	4941429.6	307559.3	282.2	5.0
BH15-17	4941416.0	307461.1	286.0	11.1
BH15-18	4938858.7	308980.4	276.8	15.4
BH15-S1	4938798.8	309031.3	268.9	20.0
BH15-S4	4938799.8	309083.1	260.7	13.5
BH15-S5	4938838.0	309128.1	266.8	23.1





Borehole No.	MTM NAD83 Zone 10 Coordinates		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m)	Easting (m)		
BH15-N1	4941197.4	309188.3	257.3	30.7

## 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

### 4.1 Regional Geology

This section of Highway 11 lies within the Simcoe Uplands, as delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984)<sup>2</sup>. The soil deposits are typically glacial tills comprised of sandy loam, deposited in broad, rolling plains which are separated by steep-sided, flat-floored valleys. In some areas within the Simcoe Uplands, localized areas of sands and silts have been surficially deposited.

### 4.2 Subsurface Conditions

As part of the subsurface investigation, 17 boreholes were advanced within the proposed deep cut and high fill embankment widening areas, supplemented with four boreholes advanced for the Highway 11/Old Barrie Road – Highway 12 Interchange structures and the Highway 11 / Coldwater Road – Highway 12 Interchange. The borehole locations and ground surface elevations at each of the cut and fill locations are shown on Drawings 2 to 6.

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are given on the borehole records contained in Appendix A of this report; the results of geotechnical laboratory testing are also presented in Appendix B. The results of the in situ field tests (i.e. SPT “N” values) as presented on the Record of Borehole Sheets and in Sections 4 are uncorrected. The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

A more detailed discussion on the subsurface conditions at the deep cut and high fill embankment widening sites is provided in the following sections:

- Section 4.3 addresses the deep cut widening to the northwest and southwest of the Highway 12 / Old Barrie Road Interchange;
- Section 4.4 addresses the high fill embankment widening at the southeast quadrant of Highway 12 / Old Barrie Road Interchange;
- Section 4.5 addresses the high fill embankment widening at the southwest and southeast quadrants of Highway 12 / Coldwater Road Interchange;

<sup>2</sup> 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.





- Section 4.6 addresses the high fill embankment widening along the north side of Highway 12, east of Wainman Line; and
- Section 4.7 addresses the high fill embankment widening along the north side of Highway 12, west of Fairgrounds Road.

### 4.3 Deep Widening Cut at Highway 12 / Old Barrie Road Interchange

The deep cut for the widenings of Highway 12 in the northwest and southwest quadrants of the Highway 12 / Old Barrie Road Interchange range between 6 m and 14 m. Boreholes BH15-01 to BH15-05, and BH15-18 were advanced in the cut areas, supplemented with Borehole BH15-S1 drilled for the interchange structure. The borehole locations for these deep cut areas are shown on Drawing 1 and the stratigraphic profile along the cut section and the cross-sections through the N – E / W and E / W - S Ramps are shown on Drawings 2 and 3, respectively.

In summary, the subsurface conditions encountered in the boreholes in this cut areas consist of a surface layer of topsoil or a pavement structure underlain by soil deposits comprised of variable fill materials, and silt to some sand and gravel glacial till, clayey silt, silty sand and silty sand to sand till. A more detailed description of the subsurface conditions is provided in the following subsections.

#### 4.3.1 Topsoil / Pavement Structure

Each of the boreholes encountered topsoil or a pavement structure surficially. The thickness of the topsoil and pavement structure encountered in the boreholes is indicated below.

Borehole No.	Topsoil Thickness (mm)	Asphalt Thickness (mm)	Granular Fill Thickness (mm)
BH15-01	-	130	370
-	-	150	450
BH15-03	200	-	-
BH15-04	300	-	-
BH15-05	100	-	-
BH15-18	-	-	-
BH15-S1	200	-	-

#### 4.3.2 Fill

Boreholes BH15-02 and BH15-18 encountered fill materials underlying the pavement structure and topsoil, respectively. 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.





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Borehole No.	Fill Surface Elevation (m)	Fill Thickness (m)	Base of Fill Elevation (m)
BH15-02	281.8	1.5	280.3
BH15-18	276.6	6.9	269.7
BH15-S1	268.7	8.4	260.3

The fill materials are comprised of silt and sand containing trace to some clay and gravel. The fill in Boreholes BH15-02 and BH15-18 contains trace organic material to a depth of about 2.0 m. Auger grinding was noted in Borehole BH15-18 at a depth of about 4.9 m

The water content measured on samples of the fill deposits ranged between 6 per cent and 9 per cent.

The measured Standard Penetration Test (SPT) "N"-values within the silt and sand fill deposit range from 4 blows to 20 blows per 0.3 m of penetration, indicating the fill is loose to compact in relative density.

The results of grain size distribution tests completed on three selected samples of the fill are shown on Figure B1. Atterberg limits testing was carried out on the three samples of the fill and measured plastic limits ranging between 11 per cent and 13 per cent, liquid limits ranging between 14 per cent and 16 per cent and plasticity indices ranging between 2 per cent and 4 per cent. The results, which are plotted on the plasticity chart on Figure B2 in Appendix B, confirms that the tested samples of the fill consists of silt and sand of slight plasticity.

### 4.3.3 Silt and Sand Till

A till deposit was encountered in Boreholes BH15-01, BH15-02, and BH15-18 underlying the fill and in Borehole BH15-03 underlying a sand layer and interlayered within the silty sand to clayey silt deposits in Borehole 15-51. The till deposit is comprised silt and sand in Boreholes BH15-01 to BH15-03 and BH15-18 and consists of separate layers of silty sand and gravelly clayey silt with sand in Borehole BH15-S1. The till deposits in Ontario typically contain cobbles and boulders and these materials should be anticipated to be present throughout the till deposit encountered at the site as inferred by auger grinding in three of the boreholes.

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

Borehole No.	Till Surface Elevation (m)	Till Thickness (m)	Base of Till Elevation (m)
BH15-01	288.9	> 10.6	Below 278.3
BH15-02	280.3	> 11.9	Below 268.4
BH15-03	275.5	> 12.6	Below 262.9
BH15-18	269.7	> 8.3	Below 261.4
BH15-S1	255.7	1.5	254.2
	254.2	1.5	252.7





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The measured SPT “N” value within the till deposit(s) range from 11 blows to greater than 100 blows per 0.3 m of penetration, indicating the till is compact to very dense, and generally very dense, in relative density.

The water content measured on samples of the till deposits ranged between 5 per cent and 8 per cent.

The result of grain size distribution tests completed on six samples of the till deposit are shown on Figures B3 and B4 in Appendix B. Atterberg limits testing was carried out on four selected samples of the till deposit and measured plastic limit ranging between 10 per cent and 11 per cent, liquid limits ranging between 12 per cent and 14 per cent and plasticity indices ranging between 2 per cent and 5 per cent. These results, which are plotted on the plasticity chart on Figure B5 in Appendix B, confirms that the tested samples of the deposit consist of silt of slight plasticity.

### 4.3.4 Silt to Sand and Gravel

Interlayered non-cohesive deposits of variable composition were encountered in Boreholes BH15-03, BH15-04, and BH15-05. The materials encountered range from silt, to silt and sand, to sand, to sand and gravel. The elevations of the surface and base of the non-cohesive deposits and the deposit thickness encountered at the borehole locations are summarized below.

Borehole No.	Surface Elevation (m)	Thickness (m)	Base Elevation (m)
BH15-03	276.3	0.8	275.5
BH15-04	250.6	5.3	245.3
BH15-05	237.9	10.9	227.0
BH15-S1	260.3	4.6	255.7
	249.8	>0.9	Below 247.9

The measured SPT “N”-values in the non-cohesive deposits range from 15 blows to 68 blows per 0.3 m of penetration, and one value of 100 blows for 0.13 m penetration, indicating this deposit is compact to very dense in relative density.

The water content measured on samples of the sand and gravel to silt deposits ranged between 4 per cent and 23 per cent.

The results of grain size distribution tests carried out on two selected samples of the silt and sand to silty sand, three selected samples of the silt, and one selected sample of the sand and gravel portions of the deposits are shown on Figures B6, B7, and B8, respectively.

### 4.3.5 Silty Clay to Clayey Silt

Layers of clayey silt were encountered in Boreholes BH15-03, BH15-04, and BH15-05. The elevation of the surface and base of these layers and their thickness as encountered in the boreholes are summarized below.





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Borehole No.	Silty Clay to Clayey Silt Surface Elevation (m)	Silty Clay to Clayey Silt Thickness (m)	Silty Clay to Clayey Silt Base Elevation (m)
BH15-03	276.7	0.4	276.3
BH15-04	245.3	> 5.5 m	Below 239.8
BH15-05	227.0	> 0.1	Below 226.9
BH15-S1	252.7	2.9	249.8

The measured SPT “N”-values within the clayey silt layers range from 10 blows to 37 blows per 0.3 meters of penetration, with two values of 100 blows for 0.18 m and for 0.15 m of penetration, suggesting a stiff to hard consistency.

The water content measured on samples of the clayey silt layer range between 16 per cent and 20 per cent.

The result of a grain size distribution test completed on one selected sample of the clayey silt stratum is shown on Figure B9 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 25 per cent and a plasticity index of 10 per cent. This result, which is plotted on the plasticity chart on Figure B10 in Appendix B, confirms that the tested sample of the deposit consists of clayey silt of low plasticity.

### 4.4 High Fill Embankment Widening at Highway 12 / Old Barrie Road Interchange

The height of the embankment in the high fill area in the southeast quadrant of the Highway 12 / Old Barrie Road Interchange, at the location of the existing off-ramp from Highway 11 northbound will be up to about 14 m. Boreholes BH15-06, BH15-08, and BH15-09 were advanced within the fill area approximately at the locations shown on Drawing 1. A stratigraphic profile along the Highway 11/12 S – E / W Ramp and a cross section through the ramp are shown in Drawing 3.

In summary, the subsurface conditions encountered in the boreholes in this area consist of surficial fill or a pavement structure underlain by variable deposits of sand and gravel, glacial till, clayey silt, silty sand, and silty sand to sand till. A more detailed description of the subsurface conditions is provided in the following subsections.

#### 4.4.1 Pavement Structure / Fill

Boreholes BH15-06, BH15-S4 and BH15-S5, advanced through the pavement structure of the off-ramp, penetrated a layer of asphalt 270 mm to 300 mm thick and the underlying granular fill layer about 430 mm to 1.4 m thick.

#### 4.4.2 Fill

All of the boreholes in this area encountered fill, either from ground surface or beneath the pavement structure. The elevations of the surface and base of the fill and the thickness of the fill layer as encountered in the boreholes are summarized below.





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Borehole No.	Fill Surface Elevation (m)	Fill Thickness (m)	Base of Fill Elevation (m)
BH15-06	250.2	6.2	244.0
BH15-08	247.8	0.6	247.2
BH15-09	248.7	4.0	244.7
BH15-S4	260.0	6.4	253.6
BH15-S5	265.4	14.8	250.6

The fill materials are primarily non-cohesive, and are comprised of silt and sand to sand, whereas in Borehole BH15-08 the fill is comprised of sandy organic silt containing trace fibrous organics; organics were also noted in the fill in Borehole BH15-09. The non-cohesive fill in Borehole BH15-S4 is underlain by a fill layer of sandy clayey silt.

The water content measured on samples of the fill deposits ranged between 3 per cent and 15 per cent.

The measured SPT “N”-values in the non-cohesive fill layers range from 4 blows to 101 blows per 0.3 m of penetration, indicating the fill deposit is compact to very dense in relative density; the SPT-“N”-value measured in the sandy clayey silt fill layer is 16 blows per 0.3 m of penetration, suggesting a very stiff consistency.

The results of grain size distribution tests completed on two selected samples of the non-cohesive fill are shown on Figure B11.

### 4.4.3 Clayey Silt

A clayey silt stratum was encountered in Boreholes BH15-08, BH15-09 and BH15-S4. 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.	Silty Clay to Clayey Silt Surface Elevation (m)	Silty Clay to Clayey Silt Thickness (m)	Silty Clay to Clayey Silt Base Elevation (m)
15-08	236.1	3.0	233.1
15-09	244.7	7.7	237.0
15-S4	250.8	2.7	248.1

The measured SPT “N”-values within the clayey silt deposit range from 11 blows to 48 blows per 0.3 m of penetration, with three values of 100 blows for less than 0.3 m of penetration, suggesting a stiff to hard consistency.

The water content measured on samples of the clayey silt deposits ranged between 8 per cent and 25 per cent.

The results of grain size distribution tests completed on three selected samples of the clayey silt deposit are shown on Figure B12 in Appendix B. Atterberg limits testing was carried out on two selected samples of the deposit and measured plastic limits of 12 percent and 16 per cent, liquid limit of 23 per cent and 22 per cent and plasticity





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indices 8 per cent and 10 per cent. These results, which are plotted on the plasticity chart on Figure B13 in Appendix B, confirms that the tested samples of the deposit consist of clayey silt of low plasticity.

### 4.4.4 Sandy Gravel to Silt

Non-cohesive deposits were encountered in Boreholes BH15-06, BH15-08 and BH15-09. The materials encountered range from silt to silty sand, to sand, to sandy gravel. The elevations of the surface and base of the non-cohesive deposits and the deposit thickness encountered at the borehole locations are summarized below.

Borehole No.	Surface Elevation (m)	Thickness (m)	Base Elevation (m)
BH15-06	241.0	1.7	239.3
BH15-08	247.2 and 233.1	11.1 and > 5.5	236.1 and Below 227.6
BH15-09	237.0	> 4.0	Below 233.0
BH15-S4	25.6 and 241.1	2.8 and 0.9	250.8 and Below 249.2
BH15-S5	245.3	1.6	Below 243.7

The measured SPT “N”-values in the non-cohesive deposits range from 12 blows to 70 blows per 0.3 m of penetration with five “N”-values greater than 100 blows per less than 0.3 m of penetration, indicating this deposit is compact to very dense in relative density.

The water content measured on samples of the silt to sandy gravel deposits ranged between 7 per cent and 24 per cent.

The results of grain size distribution tests carried out on three samples of the silty sand to sand and the silt portions of the deposit are shown on Figures B14 and B15.

### 4.4.5 Silty Sand to Sand to Sand and Gravel Till

A glacial till deposit was encountered in Borehole BH15-06 underlying the fill and sandy gravel layer and in Borehole BH15-S5 underlying the fill. The till deposit is comprised of silty sand to sand or sand and gravel.

The elevations of the surface and base of the till deposit and the deposit thickness encountered in Borehole BH15-06 are summarized below.

Borehole No.	Till Surface Elevation (m)	Till Thickness (m)	Base of Till Elevation (m)
BH15-06	244.0 and 239.3	3.0 and > 5.1	241.0 and Below 234.2
BH15-S5	250.6	5.3	245.3

The measured SPT “N” value within the till deposit range from 11 blows to 100 blows per 0.3 m of penetration, with four “N”-values of 100 blows for less than 0.23 m of penetration, indicating the till is very dense in relative density.





The water content measured on samples of the till deposits ranged between 5 per cent and 10 per cent.

The results of grain size distribution tests completed on three selected sample of the till deposit are shown on Figure B16 in Appendix B. An Atterberg limits test carried out on the fines portion of the sand and gravel till measured a plastic limit of 16 per cent, a liquid limit of 24 per cent and a plasticity index of 8 per cent, as shown on Figure 17, indicating that the fines consist of clayey silt of low plasticity.

### 4.5 High Fill Embankment Widening at Highway 12 / Coldwater Road Interchange

The height of the embankment in the high fill areas in the southwest and southeast quadrants of the Highway 12 / Coldwater Road Interchange range between 6 m and 9 m. Boreholes BH15-10, BH15-11, BH15-12, and BH15-13 were advanced within of the fill footprint and along the toe of the widening. The borehole locations for these high fill areas as well as the profile along the fill area and cross-section through the embankment are shown on Drawing 4.

In summary, the subsurface conditions encountered in the boreholes in this area consist of surficial topsoil or fill and/or a pavement structure, underlain by non-cohesive deposits ranging from sand to silt. A more detailed description of the subsurface conditions is provided in the following subsections.

#### 4.5.1 Pavement Structure / Fill

Boreholes 15-10 and 15-11 were advanced through pavement structures at the site; Boreholes BH15-12 and BH15-13 were advanced from the landscaped/grassed areas and encountered topsoil at ground surface. The thickness of the topsoil and pavement structure encountered in the boreholes is indicated below.

Borehole No.	Topsoil Thickness (mm)	Asphalt Thickness (mm)	Granular Fill Thickness (mm)
BH15-10	-	150	450
BH15-11	-	160	540
BH15-12	100	-	-
BH15-13	300	-	-
BH15-N1	200	-	-

#### 4.5.2 Fill

Boreholes BH15-10, BH15-11 and BH15-12 encountered fill materials underlying the pavement structure and topsoil. 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 Elevation (m)	Fill Thickness (m)	Base of Fill Elevation (m)
BH15-10	259.2	3.4	255.8
BH15-11	262.6	6.4	256.2





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Borehole No.	Fill Surface Elevation (m)	Fill Thickness (m)	Base of Fill Elevation (m)
BH15-12	257.5	2.0	255.5
BH15-N1	257.1	2.1	255.0

The fill materials are comprised of silt and sand to silty sand to sand to gravelly sand. Organics were also noted in the fill in Boreholes BH15-10, BH15-12, and BH15-13; auger grinding was noted in Borehole BH15-11.

The water content measured on samples of the fill deposits ranged between 3 per cent and 10 per cent.

The measured SPT “N”-values in the non-cohesive deposits range from 6 blows to 43 blows per 0.3 penetration, with one “N”-value of 100 blows per 0.2 m of penetration, indicating the fill is loose to very dense in relative density.

The results of grain size distribution tests completed on three selected samples of the fill are shown on Figure B18. Atterberg limits testing was carried out on one selected sample of fill and measured a plastic limit of 12 per cent, a liquid limit of 15 per cent and a plasticity index of 3 per cent. This result, which is plotted on the plasticity chart on Figure B19 in Appendix B, indicates that the tested sample of the fill consists of silt and sand of slight plasticity.

### 4.5.3 Silt to Sand

Non-cohesive deposits of variable composition, ranging from silt to silt and sand to silty and to sand were encountered in Boreholes BH15-10, BH15-11, BH15-12 and BH15-13. The elevations of the surface and base of the non-cohesive deposits and the deposit thickness encountered at the borehole locations are summarized below.

Borehole No.	Surface Elevation (m)	Thickness (m)	Base Elevation (m)
BH15-10	255.8	> 8.6	Below 247.2
BH15-11	256.2	> 5.5	Below 250.7
BH15-12	255.5	> 6.0	Below 249.5
BH15-13	256.2	> 7.8	Below 248.4
BH15-N1	255.0	10.8	244.2
	242.7	10.6	232.1

The SPT “N”-values measured in the non-cohesive deposits range from 3 blows to 46 blows per 0.3 m of penetration, indicating this deposit is very loose to very dense in relative density.

The water content measured on samples of the sand to silt deposits ranged between 7 per cent and 28 per cent.

The results of grain size distribution tests carried out on six selected samples of the silt to sand deposit are shown on Figures B20 and B21 in Appendix B.





## **4.6 High Fill Embankment Widening at Highway 12 / Wainman Line**

The height of the embankment in the high fill area along the north side of Highway 12, east of Wainman Line ranges between 4 m and 5 m. Boreholes BH15-14 and BH15-15 were advanced within and immediately adjacent to the fill footprint as shown on Drawings 5. A stratigraphic cross-section across the embankment is also shown on drawings.

In summary, the subsurface conditions encountered in the boreholes in this area consist of surficial topsoil/pavement structure and fill underlying the pavement structure underlain by a deposit of silt and sand and interlayered deposits of silty sand, silty clay, sand to sand and gravel fill and gravelly sand deposits. A more detailed description of the subsurface conditions is provided in the following subsections.

### **4.6.1 Topsoil / Pavement Structure**

Borehole BH15-14 was advanced through the pavement structure on Highway 12 and Borehole BH15-15 was advanced through topsoil at the toe of the existing embankment. The thickness of the pavement structure and the topsoil encountered in the boreholes is indicated below.

<b>Borehole No.</b>	<b>Topsoil Thickness (mm)</b>	<b>Asphalt Thickness (mm)</b>	<b>Granular Fill Thickness (mm)</b>
BH15-14	-	220	680
BH15-15	200	-	-

### **4.6.2 Fill**

Borehole BH15-14 encountered a deposit of silt and sand fill underlying the pavement structure. The elevations of the surface and base of the fill and the thickness of the fill deposit as encountered in the boreholes are summarized below.

<b>Borehole No.</b>	<b>Fill Surface Elevation (m)</b>	<b>Fill Thickness (m)</b>	<b>Base of Fill Elevation (m)</b>
BH15-14	262.5	3.1	259.4

The SPT “N”-values measured in the fill deposit range from 4 blows to 19 blows per 0.3 m of penetration, indicating this deposit is loose to compact in relative density.

The water content measured on samples of the fill is 5 per cent and 8 per cent.

The result of a grain size distribution test completed on one sample of the fill is shown on Figure B22. An Atterberg limits test was carried out on the same sample of the fill material and measured a plastic limit of 11 per cent, a liquid limit of 13 per cent and a plasticity index of 2 per cent. This result, which is plotted on the plasticity chart on Figure B23 in Appendix B, confirms that the tested sample of the fill consists of silt and sand of slight plasticity.

### **4.6.3 Silt to Sand**

A primary deposit of silt and sand and interlayered deposits of non-cohesive material were encountered in Boreholes BH15-14 and BH15-15. The interlayered deposits encountered ranged from silty sand and gravelly





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sand. The elevations of the surface and base of the non-cohesive deposits and the deposit thickness encountered at the borehole locations are summarized below.

Borehole No.	Surface Elevation (m)	Thickness (m)	Base Elevation (m)
BH15-14	259.4	> 7.1	Below 252.3
BH15-15	260.4	1.2	259.2
	256.6	> 1.0	Below 255.6

The measured SPT “N”-values in the non-cohesive deposits range from 4 blows to 32 blows per 0.3 m of penetration with one “N”-value of 100 blows for less than 0.3 m of penetration, indicating this deposit is loose to very dense in relative density.

The water content measured on samples of the silt to sand deposits ranged between 3 per cent and 16 per cent.

The results of grain size distribution tests carried out on two selected samples of the silt and sand portion of the deposit are shown on Figure B24 in Appendix B.

### 4.6.4 Silty Clay

A layer of silty clay was encountered in Borehole BH15-15 underlying the silty sand deposit. The elevation of the surface and base of this layer and the thickness of the stratum as encountered in the borehole are summarized below.

Borehole No.	Silty Clay Surface Elevation (m)	Silty Clay Thickness (m)	Silty Clay Base Elevation (m)
BH15-15	259.2	0.7	258.5

The measured SPT “N”-value within the silty clay deposit was 5 blows per 0.3 meters of penetration, suggesting a firm consistency.

### 4.6.5 Sand to Sand and Gravel Till

A sand to sand and gravel till deposit was encountered in Borehole BH15-15 underlying the silty clay deposit. The elevations of the surface and base of the till deposit and the deposit thickness encountered in Borehole BH15-15 are summarized below.

Borehole No.	Till Surface Elevation (m)	Till Thickness (m)	Base of Till Elevation (m)
BH15-15	258.5	1.9	256.6

The SPT “N”-values measured in the sand to sand and gravel till deposit are 23 blows and 24 blows per 0.3 m of penetration, indicating this deposit is compact in relative density.





The water content measured on a sample of the till deposit is 11 per cent.

The result of a grain size distribution test completed on one selected sample of the till deposit is shown on Figure B25 in Appendix B.

### 4.7 High Fill Embankment Widening at Highway 12 Fairgrounds Road

The height of the embankment in the high fill area along on the north side of Highway 12, west of Fairgrounds Road ranges between 4 m and 5 m. Boreholes BH15-16 and BH15-17 were advanced within and immediately adjacent to the fill footprint. The borehole locations for this high fill area are shown on Drawing 6. A stratigraphic cross-section across the embankment is also shown on Drawing 6.

In summary, the subsurface conditions encountered in the boreholes in this area consist of surficial topsoil and granular fill deposits underlain by silty sand to sand in places, underlain by a silt and sand till. A more detailed description of the subsurface conditions is provided in the following subsections.

#### 4.7.1 Topsoil / Fill

Borehole BH15-16 was advanced through a layer of topsoil beyond the roadway shoulder, whereas Borehole BH15-17 was advanced through the gravel shoulder and embankment fill of Highway 12. The thickness of the topsoil and the fill layers encountered in the boreholes is indicated below.

Borehole No.	Topsoil Thickness (mm)	Fill Thickness (mm)
BH15-16	200	-
BH15-17	-	2.1

The fill deposit is comprised of an upper layer of gravelly sand and a lower layer of sandy silt. Laboratory testing indicates that the sample of the lower layer of fill tested has an organic content of approximately 2.2 per cent.

The water content measured on a sample of the fill is 15 per cent.

The SPT “N”-values measured in the fill range from 6 blows to 7 blows per 0.3 m of penetration, indicating this deposit is loose in relative density.

#### 4.7.2 Silty Sand to Sand

A silty sand to sand deposit was encountered in Borehole BH15-16 underlying the topsoil. The elevations of the surface and base of the silty sand to sand deposit and the deposit thickness encountered at the borehole location are summarized below.

Borehole No.	Surface Elevation (m)	Thickness (m)	Base Elevation (m)
BH15-16	282.0	1.9	280.1





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The SPT “N”-values measured in the non-cohesive deposits range from 6 blows to 14 blows per 0.3 m of penetration, indicating this deposit is loose to compact in relative density.

The water content measured on a sample of the silty sand to sand deposit is 5 per cent.

The result of a grain size distribution test completed on one selected sample of the silty sand to sand is shown on Figure B26.

### 4.7.3 Silt and Sand Till

A glacial till deposit comprised of silt and sand was encountered underlying the silty sand to sand deposit in Borehole BH15-16 and underlying the fill in Borehole BH15-17. The elevations of the surface and base of the till deposit and the deposit thickness encountered at the borehole locations are summarized below.

Borehole No.	Till Surface Elevation (m)	Till Thickness (m)	Base of Till Elevation (m)
BH15-16	280.1	> 2.9	Below 277.2
BH15-17	283.9	> 9.0	Below 274.9

The SPT “N”-values measured within the till deposit range from 17 blows to 77 blows per 0.3 m of penetration, with one “N”-value of 100 blows for less than 0.3 m of penetration, indicating the till is compact to very dense in relative density.

The water content measured on samples of the till deposits range between 7 per cent and 8 per cent.

The results of grain size distribution tests completed on three selected samples of the till deposit are shown on Figure B27 in Appendix B. Atterberg limits testing was carried out on two selected samples of the till deposit and measured plastic limits of 10 per cent and 11 per cent and corresponding liquid limits of 15 per cent and 14 per cent and plasticity indices of 5 per cent and 3 per cent. These results, which are plotted on the plasticity chart on Figure B28 in Appendix B, confirms that the tested samples of the deposit consist of silt and sand of slight plasticity.

## 4.8 Groundwater Conditions

The observed water levels in the open boreholes following completion of drilling, and the water levels measured in the piezometers installed in Borehole BH15-12 and BH15-S1 are summarized below.

Borehole No.	Ground Surface Elevation (m)	Depths Groundwater Depth (m)	Groundwater Elevation (m)	Date of Measurement
BH15-01	289.4	Dry	-	Upon Completion of drilling – Sept. 29, 2015
BH15-02	282.4	13.5	268.9	Upon Completion of drilling – Sept. 29, 2015
BH15-03	276.9	13.2	263.7	Upon Completion of drilling – Sept. 30, 2015
BH15-04	250.9	9.9	241.0	Upon Completion of drilling – Sept. 24, 2015
BH15-05	238.0	6.7	231.3	Upon Completion of drilling – Sept. 24, 2015
BH15-06	251.1	10.8	240.3	Upon Completion of drilling – Sept. 17, 2015





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Borehole No.	Ground Surface Elevation (m)	Depths Groundwater Depth (m)	Groundwater Elevation (m)	Date of Measurement
BH15-08	247.8	Not Measured*	-	Used Drilling Mud
BH15-09	248.7	8.5	240.2	Upon Completion of drilling – Sept. 28, 2015
BH15-10	259.8	11.8	248.0	Upon Completion of drilling – Sept. 20, 2015
BH15-11	263.3	Dry	-	Upon Completion of drilling – Sept. 20, 2015
BH15-12	257.6	7.1 7.1	250.5 250.5	Upon Completion of drilling – Sept. 21, 2015 Standpipe Piezometer – September 30, 2015
BH15-13	256.5	6.8	249.72	Upon Completion of drilling – Sept. 30, 2015
BH15-14	263.4	Dry	-	Upon Completion of drilling – Sept. 23, 2015
BH15-15	260.6	Dry	-	Upon Completion of drilling – Sept. 30, 2015
BH15-16	282.2	Dry	-	Upon Completion of drilling – Sept. 30, 2015
BH15-17	286.0	Dry	-	Upon Completion of drilling – Oct. 6, 2015
BH15-18	276.8	Dry	-	Upon Completion of drilling – Oct. 6, 2015
BH15-S1	268.9	Dry Dry	- -	Upon Completion of drilling – Oct. 22, 2015 Standpipe Piezometer – September 30, 2015
BH15-S4	260.7	Dry	-	Upon Completion of drilling – Oct. 22, 2015
BH15-S5	266.8	Dry	-	Upon Completion of drilling – Oct. 30, 2015
BH15-N1	257.3	8.9	248.4	Upon Completion of drilling – December 10, 2014





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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 revisions made by Ms. Nikol Kochmanová, P.Eng. Mr. Jorge M.A. Costa, P.Eng., a Designated MTO Foundations Contact and Senior Consultant for Golder carried out a quality control review of the final report.

#### GOLDER ASSOCIATES LTD.



Nikol Kochmanová, Ph.D., P. Eng., PMP  
Geotechnical Engineer

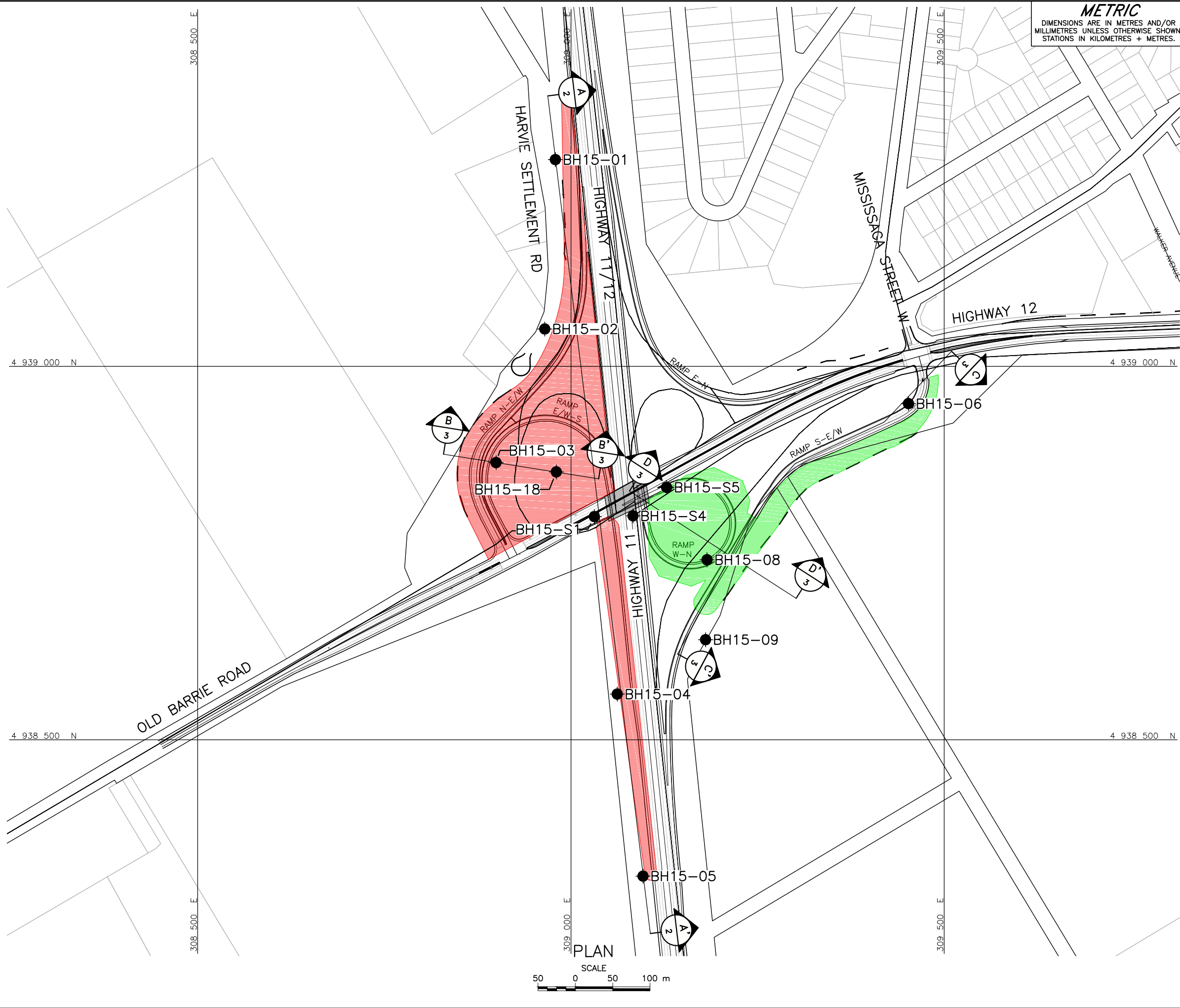


Jorge M. A. Costa, P.Eng.  
Designated MTO Foundations Contact, Senior Consultant

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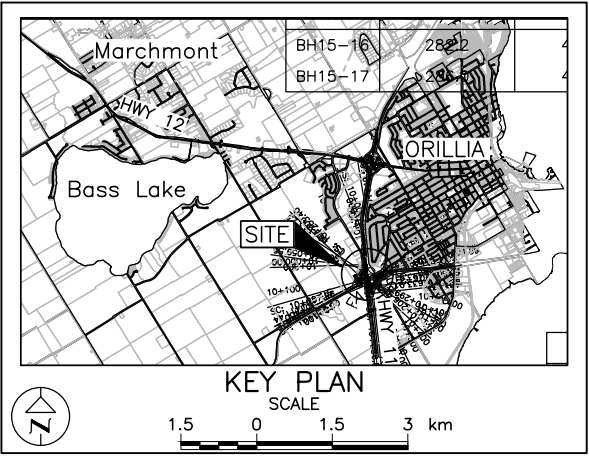
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STATIONS IN KILOMETRES + METRES.

CONT No.  
WO No.11-20002

HIGHWAY 11/12 (OLD BARRIE ROAD)  
INTERCHANGE DEEP CUT/HIGH FILL

BOREHOLE LOCATIONS

SHEET



LEGEND

Borehole Location

Cut Area

Fill Area

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
BH15-01	289.4	4939276.9	308979.1
BH15-02	282.4	4939050.1	308964.9
BH15-03	276.9	4938871.2	308899.6
BH15-04	250.9	4938561.1	309062.0
BH15-05	238.0	4938317.4	309096.5
BH15-06	251.1	4938950.1	309452.2
BH15-08	247.8	4938741.0	309182.3
BH15-09	248.7	4938634.0	309180.3
BH15-18	276.8	4938858.7	308980.4
BH15-S1	268.9	4938798.8	309031.3
BH15-S4	260.7	4938799.8	309083.1
BH15-S5	266.8	4938838.0	309128.1

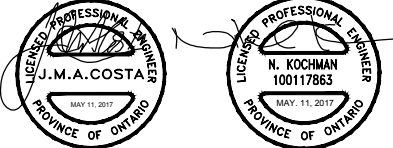
**NOTES**

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

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

**REFERENCE**

Base plans provided in digital format by AECON, drawing file no, Old Barrie Rd IC\_Corridors.dwg received FEB 25, 2016.



NO.	DATE	BY	REVISION
Geocres No. 31D-647			
HWY. 12	PROJECT NO. 13-1111-0026		DIST. .
SUBM'D.	CHKD. NK	DATE: 5/11/2017	SITE: .
DRAWN: TB	CHKD. NLP	APPD. JMAC	DWG. 1



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

CONT No.  
**WO No.11-20002**

**HIGHWAY 11/12 (OLD BARRIE ROAD)**  
INTERCHANGE DEEP CUT/HIGH FILL

**SOIL STRATA**

**SHEET**



**LEGEND**

- Borehole Location
- Standard Penetration Test Value
- Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL upon completion of drilling

**BOREHOLE CO-ORDINATES**

No.	ELEVATION	NORTHING	EASTING
BH15-01	289.4	4939276.9	308979.1
BH15-02	282.4	4939050.1	308964.9
BH15-04	250.9	4938561.1	309062.0
BH15-05	238.0	4938317.4	309096.5
BH15-18	276.8	4938858.7	308980.4
BH15-S1	268.9	4938798.8	309031.3

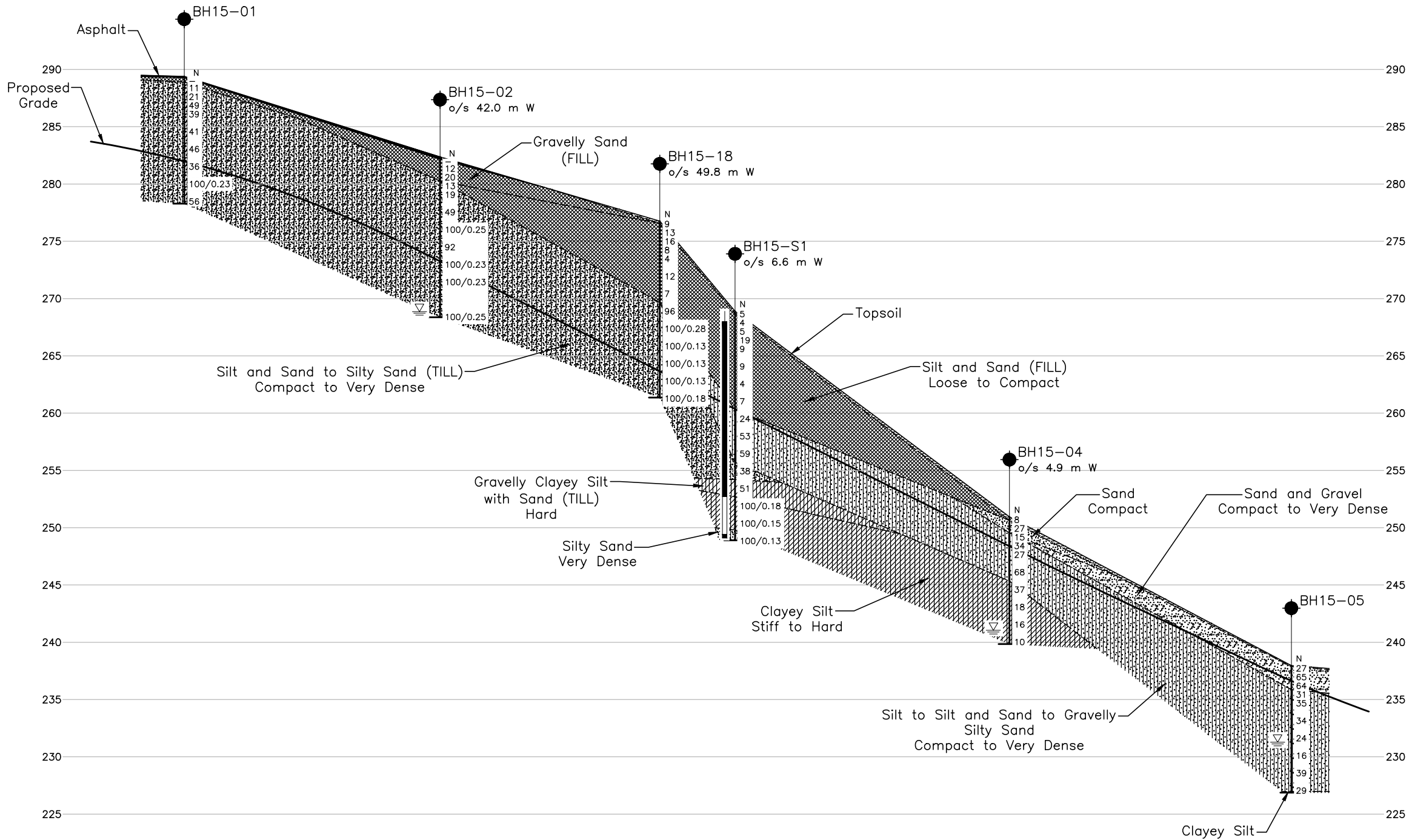
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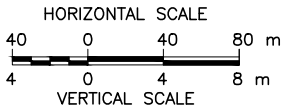
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Base plans provided in digital format by Aecom, drawing file no. Old Barrie Rd IC\_Corridors.dwg, received FEB 25, 2016.



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**PROFILE HIGHWAY 11/12**



NO.	DATE	BY	REVISION
Geocres No. 31D-647			
HWY. 12	PROJECT NO. 13-1111-0026	DIST. .	
SUBM'D.	CHKD. NK	DATE: 5/11/2017	SITE: .
DRAWN: TB	CHKD. NLP	APPD. JMAC	DWG. 2





CONT No.  
WO No.11-20002

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HIGHWAY 11/12 (OLD BARRIE ROAD)  
INTERCHANGE DEEP CUT/HIGH FILL

SOIL STRATA



- |   |  |
|---|--|
|  | Borehole Location  |
| N   | Standard Penetration Test Value                                    |
| 16  | Blows/0.3m unless otherwise stated<br>(Std. Pen. Test, 475 j/blow) |
|  | WL upon completion of drilling                                     |

BOREHOLE CO—ORDINATES			
No.	ELEVATION	NORTHING	EASTING
BH15—03	276.9	4938871.2	308899.6
BH15—06	251.1	4938950.1	309452.2
BH15—08	247.8	4938741.0	309182.3
BH15—09	248.7	4938634.0	309180.3
BH15—18	276.8	4938858.7	308980.4
BH15—S4	260.7	4938799.8	309083.1

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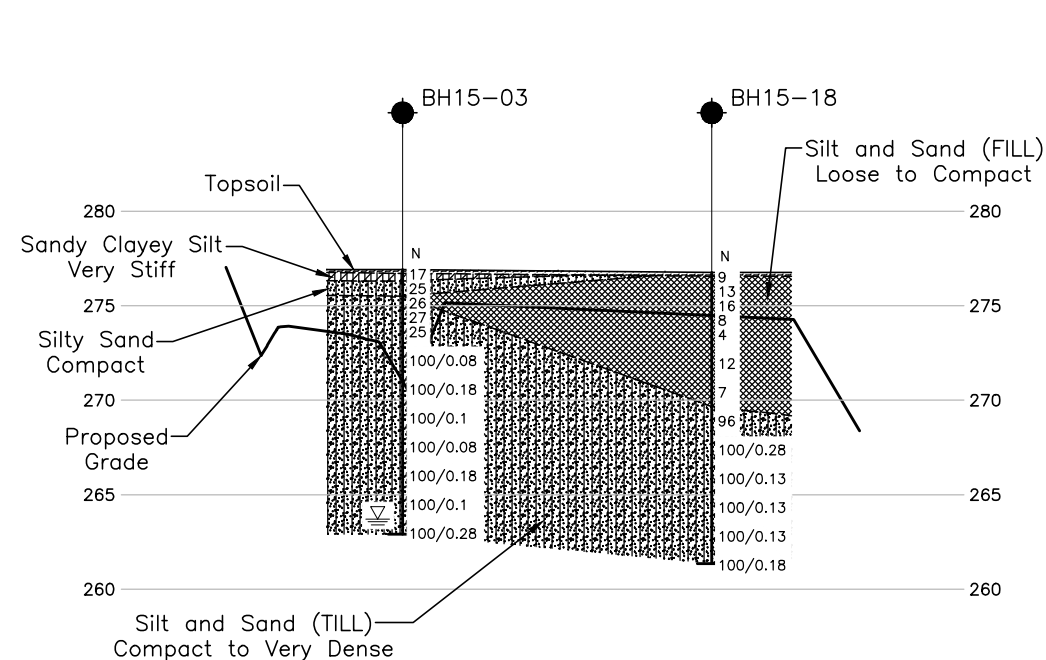
NOTES

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

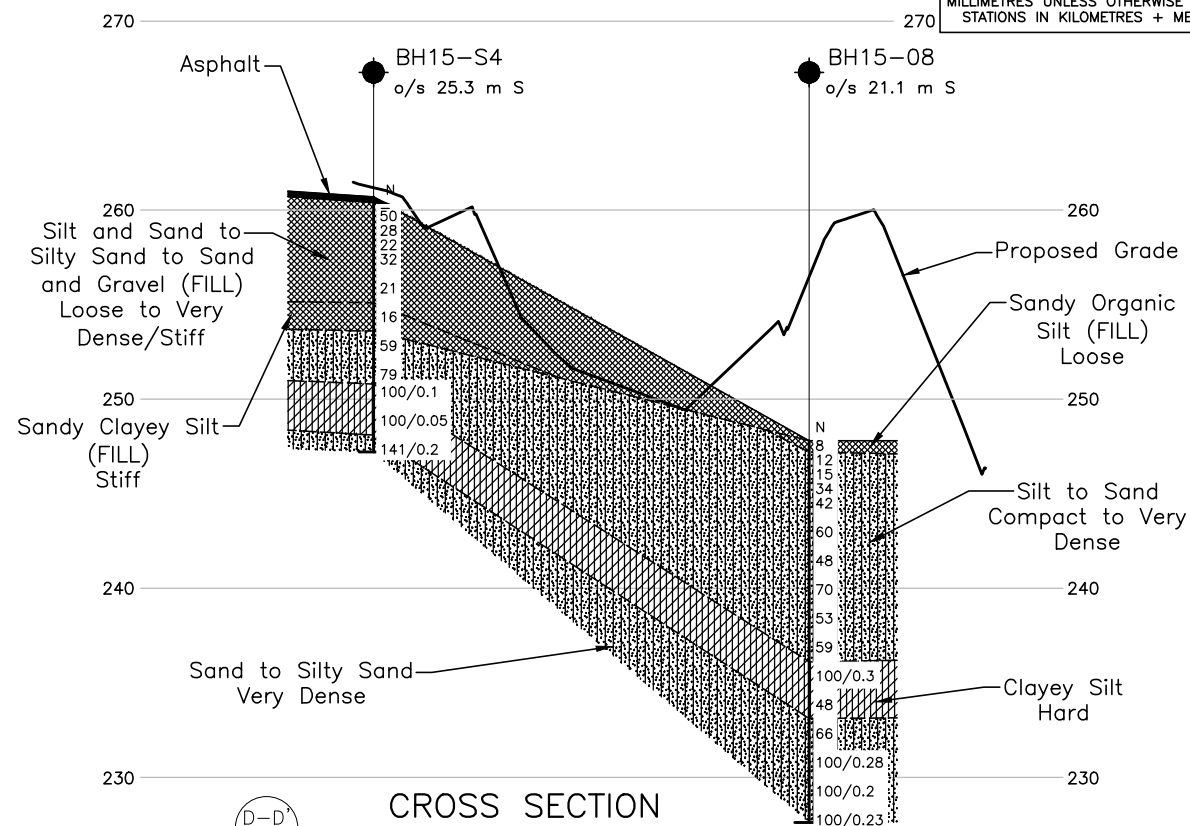
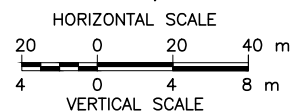
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

## REFERENCE

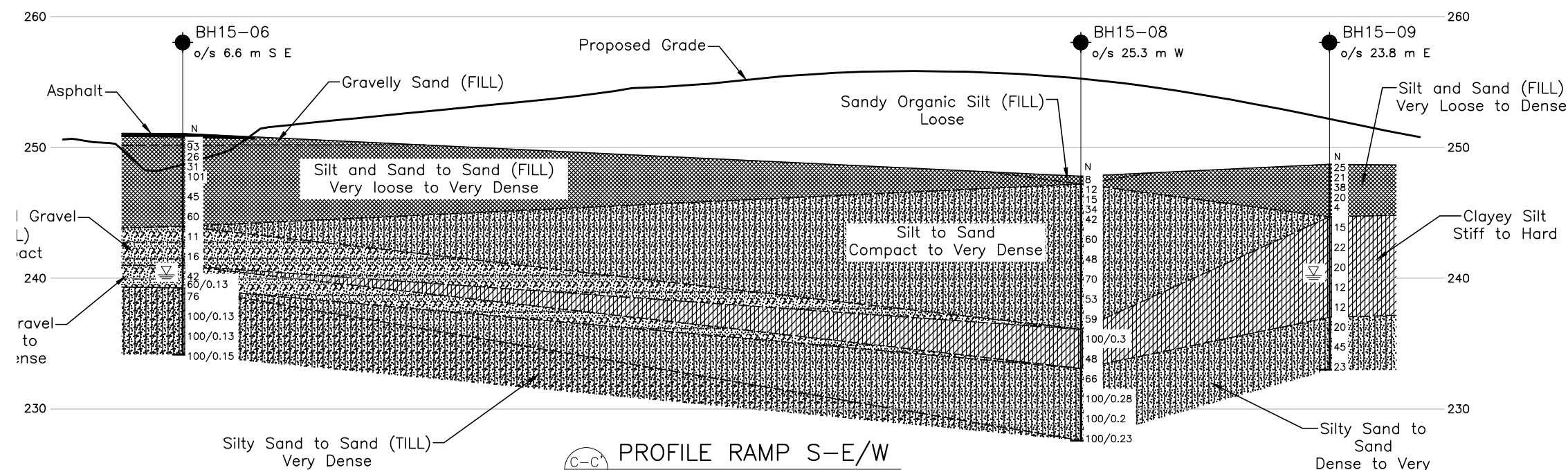
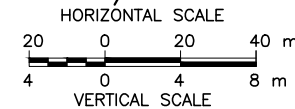
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Barrie Rd IC\_Corridors.dwg, received FEB 25, 2016.



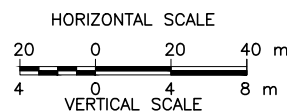
CROSS-SECTION  
RAMPS N-E/W AND E/W-S



CROSS SECTION  
RAMPS S-E/W AND W-N



PROFILE RAMP S-E/W



NO.		DATE		BY	
Geocres No. 31D-647				REVISION	
HWY. 12		PROJECT NO. 13-1111-0026		DIST. .	
SUBM'D.		CHKD. NK		DATE: 5/11/2017	
DRAWN: TB		CHKD. NLP		APPD. JM/C	
				DWG. 3	





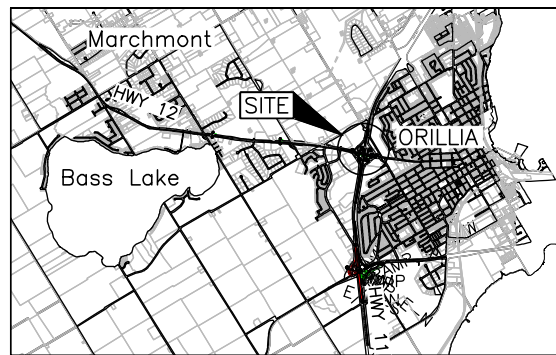
**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No.  
WO No.011-20002



HIGHWAY 12  
COLDWATER ROAD BRIDGE  
BOREHOLE LOCATIONS AND SOIL  
STRATA

SHEET



KEY PLAN  
SCALE  
1.5 0 1.5 3 km

### LEGEND

- Borehole Location
- Fill Area
- ⊥ Seal
- ⊥ Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- ▽ WL in piezometer, measured on SEP 30, 2015
- ▽ WL upon completion of drilling

### BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
BH15-10	259.8	4941196.4	308977.4
BH15-11	263.3	4941122.0	309272.1
BH15-12	257.6	4941159.4	309141.8
BH15-13	256.5	4941127.5	309192.2
BH15-N1	257.3	4941197.4	309188.6

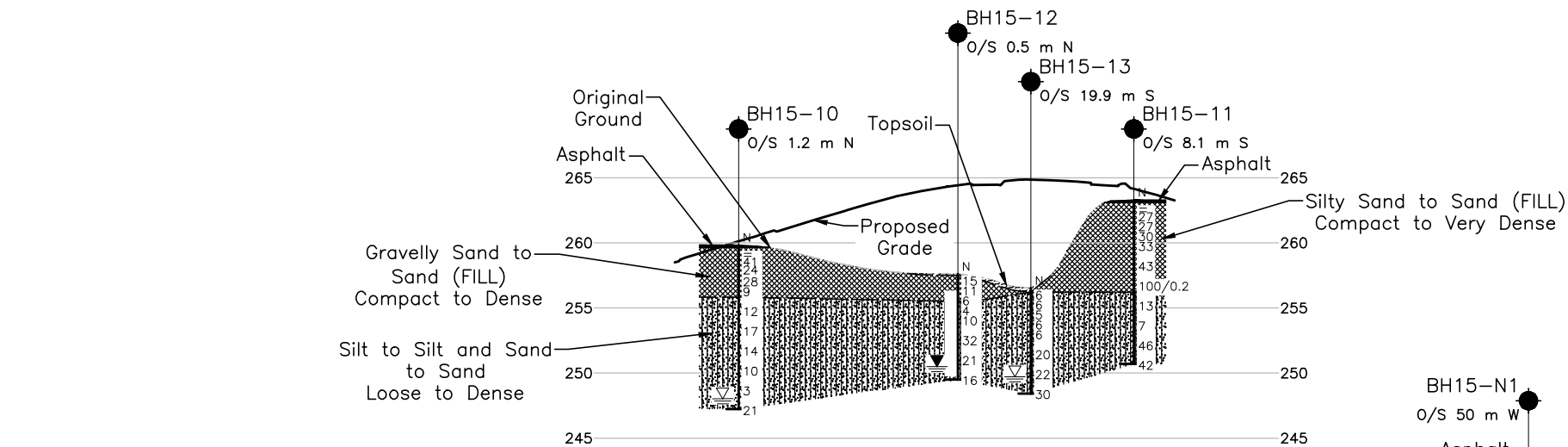
### NOTES

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

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

### REFERENCE

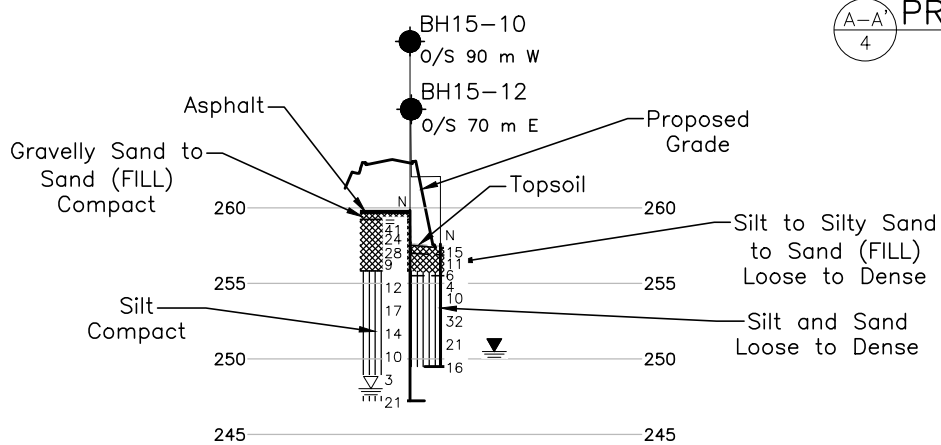
Base plans provided in digital format by AECON, drawing file ColdwaterC\_Corridors.dwg and X-Existing Surfaces.dwg, received Feb. 25, 2016.



### PROFILE ALONG HWY 12

A-A' 4

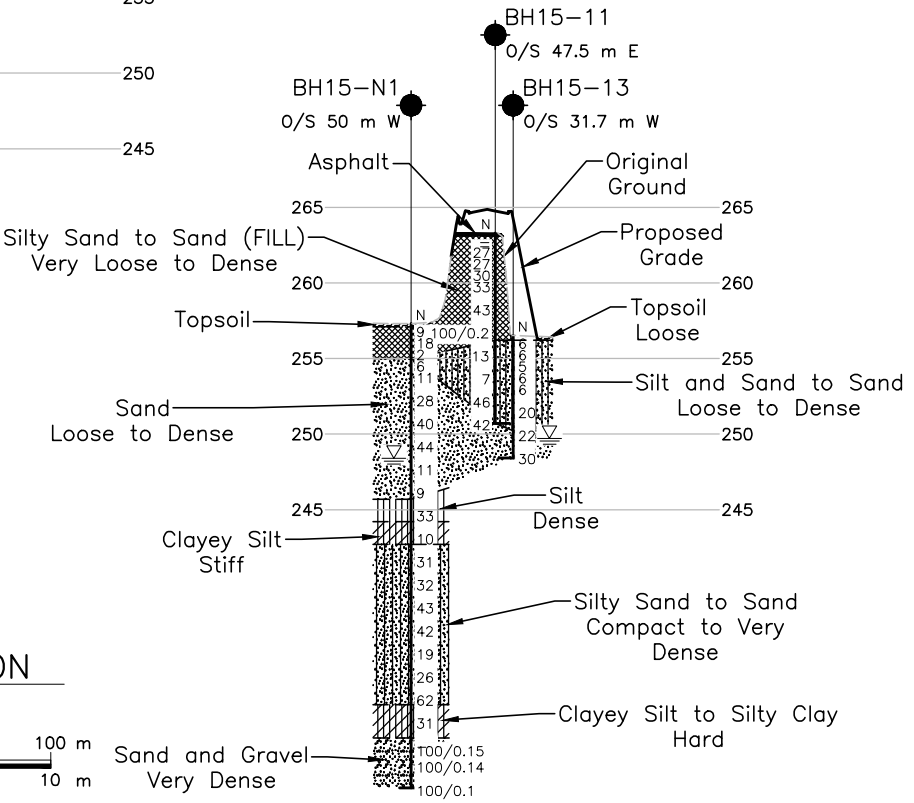
50 0 50 100 m  
5 0 5 10 m



### SECTION

B-B' 4

50 0 50 100 m  
5 0 5 10 m



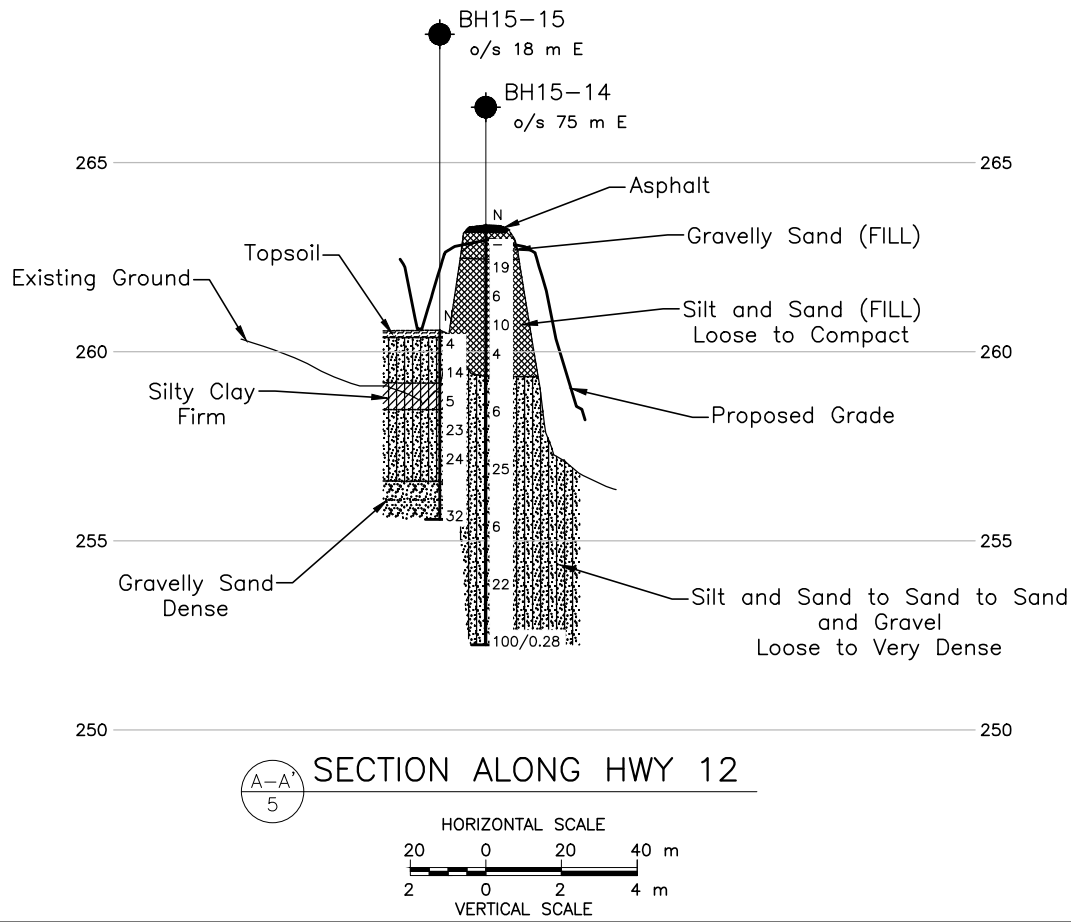
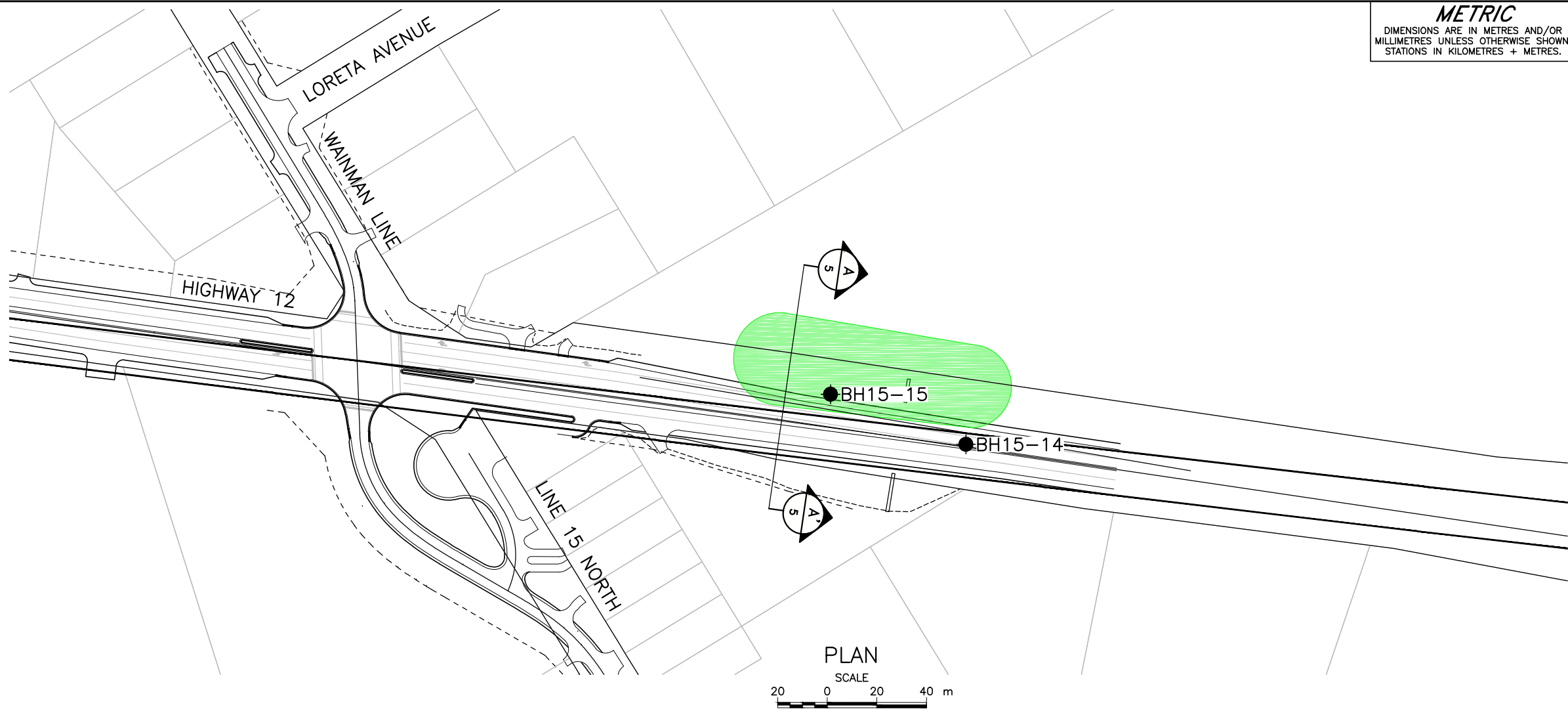
### SECTION

C-C' 4

50 0 50 100 m  
5 0 5 10 m

NO.	DATE	BY	REVISION
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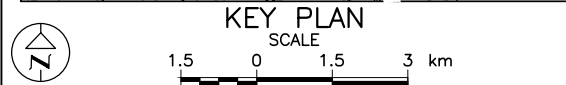
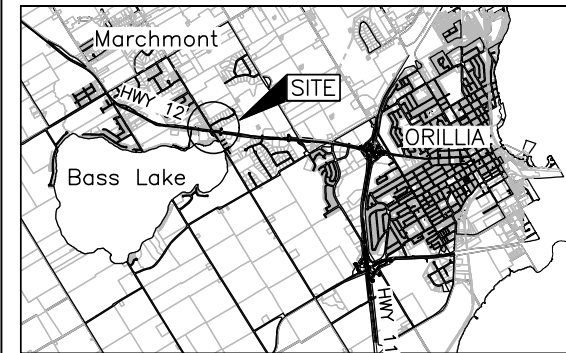


**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No.  
WO No.11-20002

HIGHWAY 12  
EMBANKMENT WIDENING AT WAINMAN LINE  
BOREHOLE LOCATIONS AND SOIL  
STRATA

SHEET



LEGEND

Borehole Location  
 Fill Area  
N Standard Penetration Test Value  
16 Blows/0.3m unless otherwise stated  
(Std. Pen. Test, 475 j/blow)

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
BH15-14	263.4	4941527.0	306223.6
BH15-15	260.6	4941547.2	306169.0

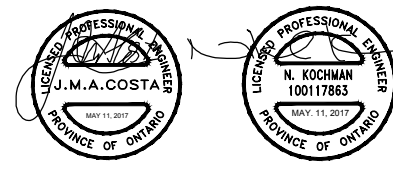
**NOTES**

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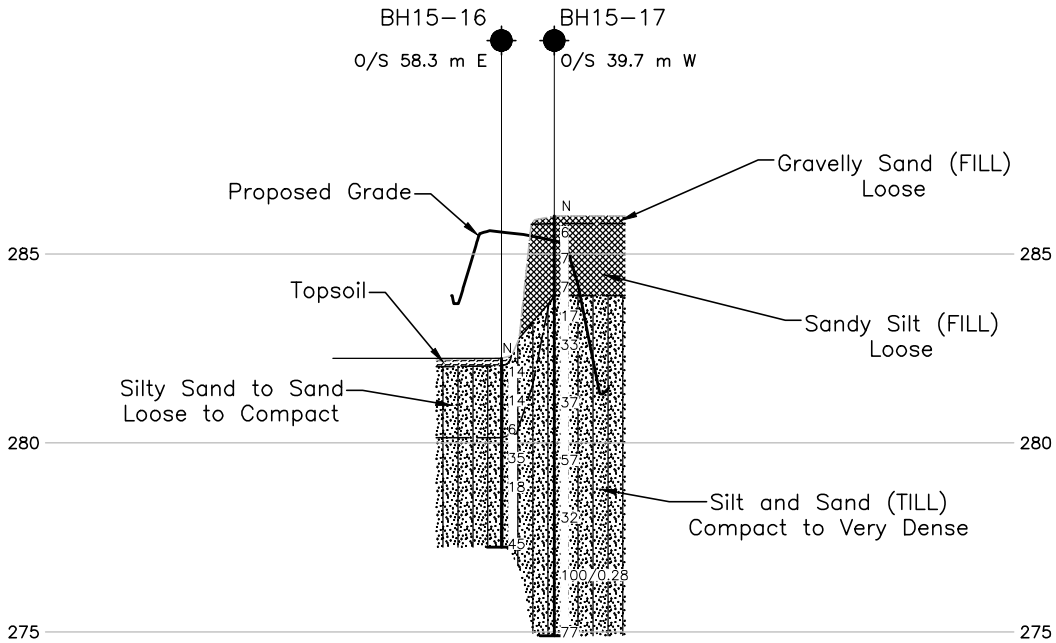
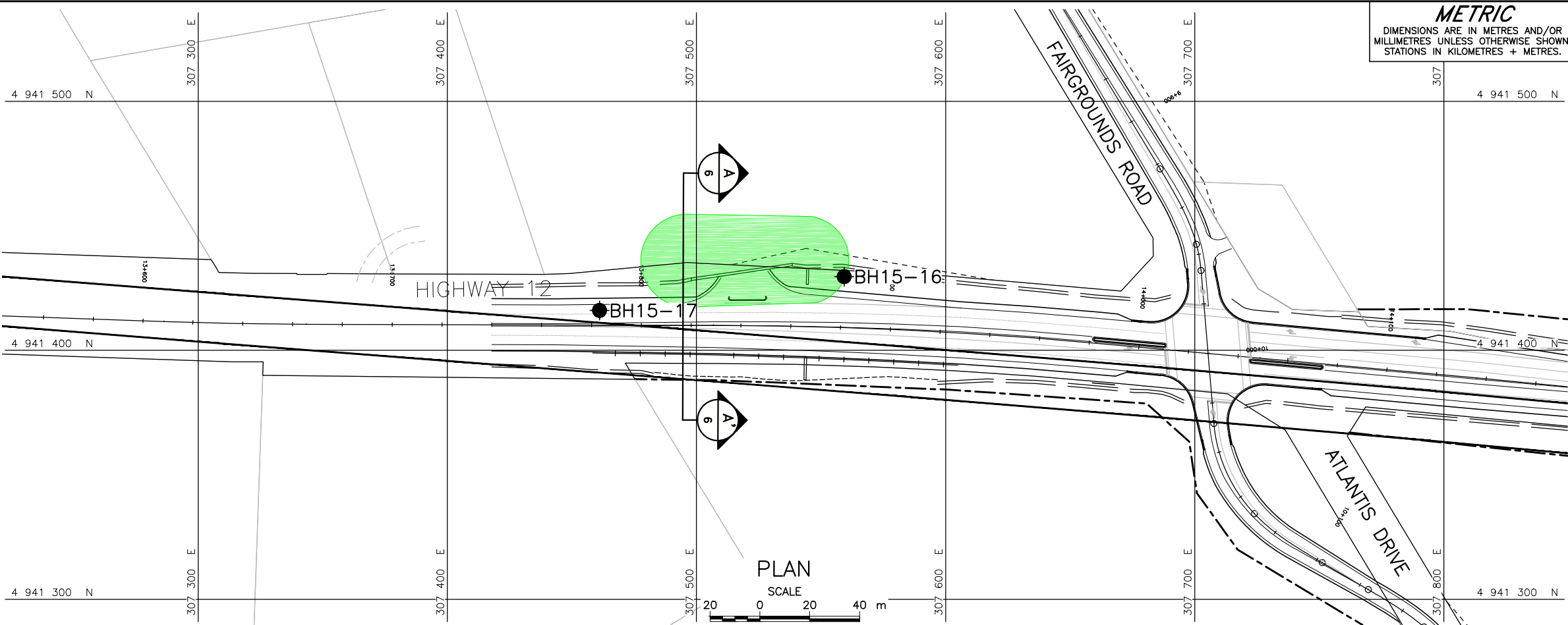
**REFERENCE**

Base plans provided in digital format by Aecorn, drawing file no. Wainman\_Intersection\_Corridors.dwg, received FEB 25, 2016.



NO.	DATE	BY	REVISION
Geocres No. 31D-647			
HWY. 12	PROJECT NO. 13-1111-0026	DIST.	
SUBM'D.	CHKD. NK	DATE: 5/11/2017	SITE:
DRAWN: TB	CHKD. NLP	APPD. JMAC	DWG. 5





A-A' SECTION ALONG HWY 12  
6

HORIZONTAL SCALE  
20 0 20 40 m  
2 0 2 4 m  
VERTICAL SCALE

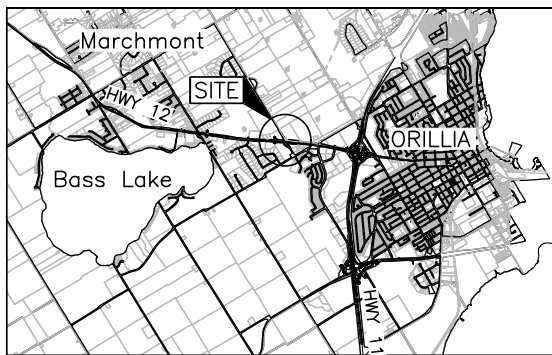
**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No.  
WO No.11-20002



**HIGHWAY 12**  
EMBANKMENT WIDENING AT FAIRGROUNDS ROAD  
BOREHOLE LOCATIONS AND SOIL  
STRATA

SHEET



KEY PLAN

SCALE

1.5 0 1.5 3 km

LEGEND



Borehole Location



Fill Area

N

Standard Penetration Test Value

16

Blows/0.3m unless otherwise stated  
(Std. Pen. Test, 475 j/blow)



WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
BH15-16	282.2	4941429.6	307559.3
BH15-17	286.0	4941416.0	307461.1

NOTES

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REFERENCE

Base plans provided in digital format by Aecon, drawing file no. Fairgrounds\_Intersection\_Corridors.dwg, received FEB 25, 2016.



NO.	DATE	BY	REVISION
Geocres No. 31D-647			
HWY. 12	PROJECT NO. 13-1111-0026	DIST. .	
SUBM'D.	CHKD. NK	DATE: 5/11/2017	SITE: .
DRAWN: TB	CHKD. NLP	APPD. JMAC	DWG. 6





# **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
$\nu$	Poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )
$\sigma'_{vo}$	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
$\sigma_{oct}$	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
$\tau$	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

### III. SOIL PROPERTIES

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

### (a) Index Properties (continued)

w	water content
$w_l$ 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

\* Density symbol is  $\rho$ . Unit weight symbol is  $\gamma$  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 cm<sup>2</sup> pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance ( $Q_t$ ), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

### III. SOIL DESCRIPTION

#### (a) 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 <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
$D_R$	relative density (specific gravity, $G_s$ )
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
$SO_4$	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



PROJECT		13-1111-0026		<b>RECORD OF BOREHOLE No BH15-01</b>		1 OF 1 <b>METRIC</b>							
W.P.		11-20002		LOCATION		N 4939276.9; E 308979.1							
DIST		CENTRAL HWY 12		BOREHOLE TYPE		200 mm Diameter Hollow Stem Augers							
DATUM		GEODETIC		DATE		September 29, 2015							
						ORIGINATED BY DM							
						COMPILED BY NL							
						CHECKED BY JMAC							
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
289.4	GROUND SURFACE						20 40 60 80 100						
0.0	ASPHALT (130 mm)						20 40 60 80 100						
0.1	Gravelly sand, trace silt (FILL)		1	SS	-								
288.9	Brown Moist												
0.5	SILT and SAND, trace to some gravel, trace to some clay (TILL) Compact to very dense Bown Moist		2	SS	11								10 48 35 7
			3	SS	21								
			4	SS	49								
			5	SS	39								
			6	SS	41								
			7	SS	46								
	Auger grinding at 6.1 m depth.		8	SS	36								11 47 32 10
			9	SS	100/0.23								
	Cobbles/boulders inferred from 9.2 to 9.5 m depth..		10	SS	56								
278.3	END OF BOREHOLE												
11.1	Note: 1. Borehole dry upon completion of drilling.												

SUD-MTO 001 131110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:



PROJECT 13-1111-0026			RECORD OF BOREHOLE No BH15-02			1 OF 2 METRIC																				
W.P. 11-20002			LOCATION N 4939050.1; E 308964.9			ORIGINATED BY DM																				
DIST CENTRAL HWY 12			BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers			COMPILED BY NL																				
DATUM GEODETIC			DATE September 29, 2015			CHECKED BY JMAC																				
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			SHEAR STRENGTH kPa			WATER CONTENT (%)			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		ELEVATION SCALE	20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>	γ	GR	SA	SI	CL						
282.4	GROUND SURFACE																									
0.0	ASPHALT (150 mm)		1	CS	-		282																			
0.2	Gravelly sand, trace silt, trace cobbles (FILL)																									
281.8	Brown Moist		2	SS	12		281																			
0.6	Silt and sand, trace to some gravel, trace to some clay (FILL)																									
	Compact Brown Moist		3	SS	20																					
	Trace organics noted in Sample 2.																									
280.3																										
2.1	SILT and SAND, trace to some gravel, trace to some clay (TILL)		4	SS	13		280																			
	Compact to very dense Brown to grey Moist																									
			5	SS	19		279																			
			6	SS	49		278																			
			7	SS	100/0.25		276																			
			8	SS	92		275																			
			9	SS	100/0.25		273																			
			10	SS	100/0.25		272																			
							271																			

Continued Next Page

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




PROJECT <u>13-1111-0026</u>		<b>RECORD OF BOREHOLE No BH15-02</b>				2 OF 2 <b>METRIC</b>																	
W.P. <u>11-20002</u>		LOCATION <u>N 4939050.1; E 308964.9</u>				ORIGINATED BY <u>DM</u>																	
DIST <u>CENTRAL</u> HWY <u>12</u>		BOREHOLE TYPE <u>200 mm Diameter Hollow Stem Augers</u>				COMPILED BY <u>NL</u>																	
DATUM <u>GEODETIC</u>		DATE <u>September 29, 2015</u>				CHECKED BY <u>JMAC</u>																	
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					W <sub>p</sub>	W			W <sub>L</sub>						
	--- CONTINUED FROM PREVIOUS PAGE ---						<div style="display: flex; justify-content: space-between;"> <span>20 40 60 80 100</span> <span>20 40 60 80 100</span> </div> <div style="display: flex; justify-content: space-between;"> <span>○ UNCONFINED   + FIELD VANE</span> <span>● QUICK TRIAXIAL   × REMOULDED</span> </div>																
	SILT and SAND, trace to some gravel, trace to some clay (TILL) Compact to very dense Brown to grey Moist	a				▽	270																
		a					269																
268.4		a	11	SS	100/0.25											o							
14.0	END OF BOREHOLE  Note:  1. Water level inside augers at a depth of 13.5 m below ground surface (Elev. 268.9 m) upon completion of drilling.																						



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

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:



PROJECT <u>13-1111-0026</u>		<b>RECORD OF BOREHOLE No BH15-03</b>				2 OF 2 <b>METRIC</b>										
W.P. <u>11-20002</u>		LOCATION <u>N 4938871.2; E 308899.6</u>				ORIGINATED BY <u>DM</u>										
DIST <u>CENTRAL</u> HWY <u>12</u>		BOREHOLE TYPE <u>200 mm Diameter Hollow Stem Augers</u>				COMPILED BY <u>NL</u>										
DATUM <u>GEODETIC</u>		DATE <u>September 29 and 30, 2015</u>				CHECKED BY <u>JMAC</u>										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
	--- CONTINUED FROM PREVIOUS PAGE ---						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%)				
							20	40	60	80	100	10	20	30		
262.9	SILT and SAND, trace to some gravel, trace to some clay (TILL) Compact to very dense Brown to grey Moist		11	SS	100/0.1											
263	END OF BOREHOLE		12	SS	100/0.25							○				
14.0	Note: 1. Water level at a depth of 13.2 m below ground surface (Elev. 263.7 m) upon completion of drilling.															

SUD-MTO 001 131110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:



PROJECT		13-1111-0026		RECORD OF BOREHOLE No BH15-04		1 OF 2 METRIC	
W.P.		11-20002		LOCATION		N 4938561.1; E 309062.0	
DIST		CENTRAL HWY 12		BOREHOLE TYPE		200 mm Diameter Hollow Stem Augers	
DATUM		GEODETTIC		DATE		September 24, 2015	
				ORIGINATED BY		DM	
				COMPILED BY		NL	
				CHECKED BY		JMAC	
SOIL PROFILE				SAMPLES		DYNAMIC CONE PENETRATION RESISTANCE PLOT	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
250.9	GROUND SURFACE		A	SS	8		
0.0	TOPSOIL		B				
250.6	SAND, trace silt, trace to some gravel Compact Brown Moist		1				
0.3	Cobbles and boulders inferred at 1.2 m depth.		2	SS	27		
249.5	SILT, trace to some sand, trace to some clay Compact to very dense Brown Moist to wet		3	SS	15		
1.4			4	SS	34		
			5	SS	27		
			6	SS	68		
245.3	CLAYEY SILT, trace sand, trace gravel Stiff to hard Grey Moist		7	SS	37		
5.6			8	SS	18		
			9	SS	16		
			10	SS	10		
239.8							
11.1							





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

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:



PROJECT 13-1111-0026		<b>RECORD OF BOREHOLE No BH15-05</b>				1 OF 2 <b>METRIC</b>							
W.P. 11-20002		LOCATION N 4938317.4; E 309096.5				ORIGINATED BY DM							
DIST CENTRAL HWY 12		BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers				COMPILED BY NL							
DATUM GEODETIC		DATE September 24, 2015				CHECKED BY JMAC							
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>			
238.0	GROUND SURFACE												
0.0	TOPSOIL		B 1	SS	27								
0.1	SAND and GRAVEL, trace to some silt Compact to very dense Brown Moist		A										
			2	SS	65								
	Augers grinding from 1.5 m to 2.3 m depth.		3	SS	64								
235.9													
2.1	SILT and SAND, trace to some clay Compact to dense Brown Moist to wet		4	SS	31								
	Increased clay content in Sample 5.		5	SS	35								
			6	SS	34								
	Increased clay content in Sample 7.		7	SS	24								
			8	SS	16								
229.4													
8.6	SILT, trace to some sand, trace to some clay Dense Grey Wet		9	SS	39								
227.9													
10.1	SAND Compact Grey Wet												
227.0			A 10	SS	29								
	CLAYEY SILT, some sand, varved		B										
11.1	Grey Moist												

SUD-MTO 001 131110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:

Continued Next Page

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





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

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:




PROJECT		13-1111-0026		RECORD OF BOREHOLE No BH15-06		1 OF 2 METRIC	
W.P.		11-20002		LOCATION		N 4938950.1; E 309452.2	
DIST		CENTRAL HWY 12		BOREHOLE TYPE		200 mm Diameter Hollow Stem Augers	
DATUM		GEODETIC		DATE		September 16 and 17, 2015	
				ORIGINATED BY		DM	
				COMPILED BY		NL	
				CHECKED BY		JMAC	
SOIL PROFILE				SAMPLES		DYNAMIC CONE PENETRATION RESISTANCE PLOT	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	
251.1	GROUND SURFACE						
0.0	ASPHALT (270 mm)						
0.3	Gravelly sand, trace silt, trace to some cobbles (FILL) Brown Moist		1	AS	-		
250.2	Silty sand to sand, trace gravel (FILL) Compact to very dense Brown Moist  Traces of wood debris noted between 1.5 m and 4.6 m depth.		2	SS	93		
			3	SS	26		
			4	SS	31		
			5	SS	101		
			6	SS	45		
			7	SS	60		
244.0	SAND and GRAVEL, some silt, trace to some clay, trace organics (TILL) Compact Brown to black Moist to wet		8	SS	11		
7.1							
			9	SS	16		
241.0	Sandy GRAVEL Dense to very dense Brown Wet  Cobbles and boulders inferred from augers grinding.		10	SS	42		
10.1							
			11	SS	60/0.13		
239.3							
11.8							



PROJECT <u>13-1111-0026</u>			<b>RECORD OF BOREHOLE No BH15-06</b>				2 OF 2 <b>METRIC</b>	
W.P. <u>11-20002</u>			LOCATION <u>N 4938950.1; E 309452.2</u>				ORIGINATED BY <u>DM</u>	
DIST <u>CENTRAL</u> HWY <u>12</u>			BOREHOLE TYPE <u>200 mm Diameter Hollow Stem Augers</u>				COMPILED BY <u>NL</u>	
DATUM <u>GEODETIC</u>			DATE <u>September 16 and 17, 2015</u>				CHECKED BY <u>JMAC</u>	

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	W <sub>p</sub>	W		
	--- CONTINUED FROM PREVIOUS PAGE ---															
	SILTY SAND to SAND, some gravel, trace clay (TILL) Very dense Brown to grey Moist to wet		12	SS	76							○				
			13	SS	100/0.13							○				
			14	SS	100/0.13							○				
234.2			15	SS	100/0.15											
16.9	END OF BOREHOLE  Note:  1. Water level at a depth of 10.8 m below ground surface in augers (Elev. 240.3 m) upon completion of drilling.															

SUD-MTO 001 131110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:





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



PROJECT <u>13-1111-0026</u>		<b>RECORD OF BOREHOLE No BH15-08</b>				2 OF 2 <b>METRIC</b>										
W.P. <u>11-20002</u>		LOCATION <u>N 4938741.0; E 309182.3</u>				ORIGINATED BY <u>DM</u>										
DIST <u>CENTRAL</u> HWY <u>12</u>		BOREHOLE TYPE <u>200 mm Diameter Hollow Stem Augers</u>				COMPILED BY <u>NL</u>										
DATUM <u>GEODETIC</u>		DATE <u>September 28, 2015</u>				CHECKED BY <u>JMAC</u>										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
--- CONTINUED FROM PREVIOUS PAGE ---																
233.1 14.7	CLAYEY SILT, trace to some sand, trace to some gravel Hard Brown Moist to wet		11	SS	100/0.3	235								o		12 8 68 12
			12	SS	48	234								o		
233 232 231 230 229 228	SILTY SAND to SAND Very dense Brown to grey		13	SS	66											
			14	SS	100/0.28									o		
			15	SS	100/0.2											
227.6 20.2	END OF BOREHOLE															
Note: 1. Water level could not be observed upon completion of drilling due to use of drilling mud within the augers.																

SUD-MTO 001 131110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:



PROJECT <u>13-1111-0026</u>		<b>RECORD OF BOREHOLE No BH15-09</b>		1 OF 2 <b>METRIC</b>	
W.P. <u>11-20002</u>		LOCATION <u>N 4938634.0; E 309180.3</u>		ORIGINATED BY <u>DM</u>	
DIST <u>CENTRAL</u> HWY <u>12</u>		BOREHOLE TYPE <u>200 mm Diameter Hollow Stem Augers</u>		COMPILED BY <u>NL</u>	
DATUM <u>GEODETIC</u>		DATE <u>September 28, 2015</u>		CHECKED BY <u>JMAC</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)		
								○ UNCONFINED   + FIELD VANE	● QUICK TRIAXIAL   × REMOULDED								
248.7	GROUND SURFACE							20	40	60	80	100	10	20	30		
0.0	Silt and sand, some gravel, trace clay, trace organics (FILL) Very loose to dense Brown Moist  Trace cohesive fines below 0.8 m depth. Asphalt fragments observed at 0.8 m depth.  Augers grinding at 1.5 m depth.   Trace organics below 2.3 m depth.   Trace organics below 3.0 m depth.		1	SS	25												
			2	SS	21								○				
			3	SS	38												
			4	SS	20								○			15   33   47   5	
			5	SS	4												
244.7																	
4.0	CLAYEY SILT, trace sand, varved Stiff to very stiff Brown Moist		6	SS	15									○			
			7	SS	22												
			8	SS	20								●			0   2   83   15	
			9	SS	12												
			10	SS	12									○			
237.0																	
11.7																	

SUD-MTO 001 131110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:

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



PROJECT <u>13-1111-0026</u>			<b>RECORD OF BOREHOLE No BH15-09</b>				2 OF 2 <b>METRIC</b>	
W.P. <u>11-20002</u>			LOCATION <u>N 4938634.0; E 309180.3</u>				ORIGINATED BY <u>DM</u>	
DIST <u>CENTRAL</u> HWY <u>12</u>			BOREHOLE TYPE <u>200 mm Diameter Hollow Stem Augers</u>				COMPILED BY <u>NL</u>	
DATUM <u>GEODETIC</u>			DATE <u>September 28, 2015</u>				CHECKED BY <u>JMAC</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
233.0 15.7	SAND, trace to some silt Compact Brown Wet          Sandy silt seam encountered at 14.1 m depth.		11	SS	20												
						236											
						235											
			12	SS	45												
						234											
			13	SS	23												
	END OF BOREHOLE  Note:  1. Water level at a depth of 8.5 m below ground surface in augers (Elev. 240.2 m) upon completion of drilling.																

SUD-MTO 001 131110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:



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SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:



PROJECT <u>13-1111-0026</u>			<b>RECORD OF BOREHOLE No BH15-10</b>				2 OF 2 <b>METRIC</b>	
W.P. <u>11-20002</u>			LOCATION <u>N 4941196.4; E 308977.4</u>				ORIGINATED BY <u>DM</u>	
DIST <u>CENTRAL</u> HWY <u>12</u>			BOREHOLE TYPE <u>200 mm Diameter Hollow Stem Augers</u>				COMPILED BY <u>NL</u>	
DATUM <u>GEODETIC</u>			DATE <u>September 20, 2015</u>				CHECKED BY <u>JMAC</u>	

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	W <sub>p</sub>	W		
247.2	1" thick coarse sand pocket observed at 12.2 m depth.	12	SS	21												
12.6	END OF BOREHOLE  Note:  1. Water level at a depth of 11.8 m below ground surface in augers (Elev. 248.0 m) upon completion of drilling.															




[illegible]



PROJECT <u>13-1111-0026</u>		<b>RECORD OF BOREHOLE No BH15-11</b>				2 OF 2 <b>METRIC</b>	
W.P. <u>11-20002</u>		LOCATION <u>N 4941122.0; E 309272.1</u>				ORIGINATED BY <u>DM</u>	
DIST <u>CENTRAL</u> HWY <u>12</u>		BOREHOLE TYPE <u>200 mm Diameter Hollow Stem Augers</u>				COMPILED BY <u>NL</u>	
DATUM <u>GEODETIC</u>		DATE <u>September 20, 2015</u>				CHECKED BY <u>JMAC</u>	

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					W <sub>p</sub>	W		
						○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × REMOULDED					WATER CONTENT (%)					
						20	40	60	80	100						
250.7	SILT and SAND Loose to dense Brown to grey Moist to wet		12	SS	42											
12.6	END OF BOREHOLE  Note: 1. Borehole dry upon completion of drilling.															



PROJECT 13-1111-0026		<b>RECORD OF BOREHOLE No BH15-12</b>				1 OF 1 <b>METRIC</b>						
W.P. 11-20002		LOCATION N 4941159.4; E 309141.8				ORIGINATED BY DM						
DIST CENTRAL HWY 12		BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers				COMPILED BY NL						
DATUM GEODETIC		DATE September 21, 2015				CHECKED BY JMAC						
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>			
257.6	GROUND SURFACE											
0.0	TOPSOIL											
0.1	Gravelly sand, trace silt, trace bituminous material (FILL)		1	SS	15							
257.0	Compact Brown Moist											
0.6	Silt and sand, trace to some clay, some gravel, trace organics (FILL)		2	SS	11							
256.2	Compact Brown Moist											
1.4	Silty sand, trace gravel, trace organics (FILL)		3	SS	6							
255.5	Loose Brown Moist											
2.1	SILT and SAND Loose to dense Brown Moist		4	SS	4							
			5	SS	10							
			6	SS	32							
			7	SS	21							
	Grey below 7.6 m depth.		8	SS	16							
249.5	END OF BOREHOLE											
8.1	Note: 1. Water level in piezometer at a depth of 7.1 m below ground surface (Elev. 250.5 m) upon completion of installation. 2. Groundwater level at a depth of 7.1 m below ground surface (Elev. 250.5 m) in monitoring piezometer on September 30, 2015.											

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:



PROJECT		13-1111-0026		<b>RECORD OF BOREHOLE No BH15-13</b>		1 OF 1 <b>METRIC</b>												
W.P.		11-20002		LOCATION		N 4941127.5; E 309192.2												
DIST		CENTRAL HWY 12		BOREHOLE TYPE		200 mm Diameter Hollow Stem Augers												
DATUM		GEODETIC		DATE		September 23, 2015												
						ORIGINATED BY DM												
						COMPILED BY NL												
						CHECKED BY JMAC												
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV	DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ	GR SA SI CL
								20 40 60 80 100	○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × REMOULDED	W <sub>p</sub>	W	W <sub>L</sub>	20 40 60 80 100	10 20 30			
256.5	0.0	GROUND SURFACE																
256.2	0.3	Sandy ORGANIC SILT, TOPSOIL, some fibrous organics		A 1	SS	6		256										
		Loose Dark brown Moist		B														
		SAND, some silt		2	SS	6		255										
		Loose Brown Moist																
		Minor oxidation staining below 0.8 m depth.		3	SS	5		254										
				4	SS	6		253										
				5	SS	6												
252.5	4.0	SILTY SAND						252										
		Compact Brown Moist to wet		6	SS	20		251										
250.2	6.3	SAND, trace to some silt		A 7	SS	22		250										
		Compact to dense Brown Wet		B				249										
				8	SS	30												
248.4	8.1	END OF BOREHOLE																
		Note:																
		1. Water level at a depth of 6.8 m below ground surface (Elev. 249.7 m) upon completion of drilling.																

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:



PROJECT		13-1111-0026		<b>RECORD OF BOREHOLE No BH15-14</b>		1 OF 1 <b>METRIC</b>											
W.P.		11-20002		LOCATION		N 4941527.0; E 306223.6											
DIST		CENTRAL HWY 12		BOREHOLE TYPE		200 mm Diameter Hollow Stem Augers											
DATUM		GEODETIC		DATE		September 30, 2015											
				ORIGINATED BY		DM											
				COMPILED BY		NL											
				CHECKED BY		JMAC											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>	γ	GR	SA	SI	CL
263.4	GROUND SURFACE																
0.0	ASPHALT (220 mm)																
0.2	Gravelly sand, some silt (FILL) Brown Moist		1	SS	-		263										
262.5																	
0.9	Silt and sand, trace gravel, trace to some clay (FILL) Loose to compact Brown Moist		2	SS	19		262										
			3	SS	6		261										
			4	SS	10		260										
			5	SS	4												
259.4																	
4.0	SILT and SAND, trace clay, trace gravel, trace organics Loose to very dense Brown Moist		6	SS	6		259										
							258										
			7	SS	25		257										
							256										
			8	SS	6												
							255										
			9	SS	22		254										
							253										
			10	SS	100/0.28												
252.3																	
11.1	END OF BOREHOLE																
	Note: 1. Borehole dry upon completion of drilling.																

SUD-MTO 001 131110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:

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



PROJECT		13-1111-0026		<b>RECORD OF BOREHOLE No BH15-15</b>				1 OF 1 <b>METRIC</b>									
W.P.		11-20002		LOCATION		N 4941547.2; E 306169.0		ORIGINATED BY									
DIST		CENTRAL HWY 12		BOREHOLE TYPE		200 mm Diameter Hollow Stem Augers		COMPILED BY									
DATUM		GEODETIC		DATE		September 30, 2015		CHECKED BY									
JMAC																	
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
260.6	GROUND SURFACE																
0.0	TOPSOIL		A														
0.2	SILTY SAND, trace organics Loose to compact Reddish brown Moist		1 B	SS	4												
259.2			2	SS	14												
1.4	SILTY CLAY, some sand Firm Brown Moist		3	SS	5												
258.5																	
2.1	SAND, some gravel to SAND and GRAVEL, some silt, trace clay (TILL) Compact Brown Moist		4	SS	23												
			5	SS	24												
256.6																	
4.0	Gravelly SAND, trace silt Dense Brown Moist		6	SS	32												
255.6																	
5.0	END OF BOREHOLE																
Note: 1. Borehole dry upon completion of drilling.																	

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:



PROJECT		13-1111-0026		<b>RECORD OF BOREHOLE No BH15-16</b>				1 OF 1 <b>METRIC</b>								
W.P.		11-20002		LOCATION		N 4941429.6; E 307559.3		ORIGINATED BY								
DIST		CENTRAL HWY 12		BOREHOLE TYPE		200 mm Diameter Hollow Stem Augers		COMPILED BY								
DATUM		GEODETIC		DATE		October 6, 2015		CHECKED BY								
								JMAC								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
282.2	GROUND SURFACE															
0.0	TOPSOIL		A													
0.2	SILTY SAND to SAND, some silt, trace gravel Loose to compact Brown Moist to wet		1 B	SS	14											
			2	SS	14											
			3	SS	6											
280.1																
2.1	SILT and SAND, trace to some gravel, trace to some clay (TILL) Compact to dense Brown to grey Moist		4	SS	35											
			5	SS	18											
277.2			6	SS	45											
5.0	END OF BOREHOLE															
	Note: 1. Borehole dry upon completion of drilling.															



PROJECT		13-1111-0026		<b>RECORD OF BOREHOLE No BH15-17</b>		1 OF 1 <b>METRIC</b>											
W.P.		11-20002		LOCATION		N 4941416.0; E 307461.1											
DIST		CENTRAL HWY 12		BOREHOLE TYPE		200 mm Diameter Hollow Stem Augers											
DATUM		GEODETIC		DATE		October 6, 2015											
				ORIGINATED BY		DM											
				COMPILED BY		NL											
				CHECKED BY		JMAC											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>	γ	GR	SA	SI	CL
286.0	GROUND SURFACE																
0.0	Gravelly sand, trace silt (FILL)																
0.2	Loose Brown Moist		1	SS	6												
	Sandy silt, some gravel, trace organics (FILL)																
	Loose Brown to black Moist		2	SS	7		285										
			3	SS	7		284										
283.9																	
2.1	SILT and SAND, some gravel, trace clay (TILL) Compact to very dense Brown Moist		4	SS	17												
			5	SS	33		283										
							282										
			6	SS	37		281										
							280										
			7	SS	57		279										
			8	SS	32		278										
							277										
			9	SS	100/0.28		276										
							275										
274.9			10	SS	77												
11.1	END OF BOREHOLE																
	Note: 1. Borehole dry upon completion of drilling.																

SUD-MTO 001 131110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:

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



[illegible]

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





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

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:



[illegible]

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



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



[illegible]

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



PROJECT <u>13-1111-0026</u>		<b>RECORD OF BOREHOLE No BH15-S4</b>				2 OF 2 <b>METRIC</b>						
W.P. <u>11-20002</u>		LOCATION <u>N 4938799.8; E 309083.1</u>				ORIGINATED BY <u>DM</u>						
DIST <u>CENTRAL</u> HWY <u>12</u>		BOREHOLE TYPE <u>200 mm Diameter Hollow Stem Augers</u>				COMPILED BY <u>NL</u>						
DATUM <u>GEODETIC</u>		DATE <u>September 14, 2015</u>				CHECKED BY <u>JMAC</u>						
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa		WATER CONTENT (%)		
								20 40 60 80 100	20 40 60 80 100	10 20 30		
248.1												
12.6	Silty SAND Very dense Brown Moist						248					
247.2			12	SS	141/0.2							
13.5	END OF BOREHOLE  Note:  1. Water level could not be observed upon completion of drilling due to use of drilling mud in augers.											

SUD-MTO 001 131110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:



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

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:



PROJECT 13-1111-0026			RECORD OF BOREHOLE No BH15-S5			2 OF 2 METRIC						
W.P. 11-20002			LOCATION N 4938838.0; E 309128.1			ORIGINATED BY DM						
DIST CENTRAL HWY 12			BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers			COMPILED BY NL						
DATUM GEODETIC			DATE October 1, 2015			CHECKED BY JMAC						
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	"N" VALUES					
	--- CONTINUED FROM PREVIOUS PAGE ---					20 40 60 80 100	20 40 60 80 100	10 20 30				
	Silt and sand to silty sand, trace to some clay, some gravel to gravelly (FILL) Loose to very dense Brown Moist Minor organic staining, trace fibrous organics observed at 12.2 m depth.		11	SS	28							
						254						
			12	SS	9							16 51 26 7
						253						
						252						
	Organic staining, some fibrous organics observed at 15.2 m depth.		13	SS	18							
						251						
250.6												
16.2	SILT and SAND, trace to some gravel, trace to some clay (TILL) Very dense Grey Moist		14	SS	57							4 60 31 5
						250						
						249						
			15	SS	100							
						248						
						247						
	A 150 mm thick silty sand pocket observed at 20.0 m depth.		16	SS	100/0.25							
						246						
245.3												
21.5	Sandy SILT Very dense Brown Moist		17	SS	100/0.25							
						245						
243.7						244						
23.1	END OF BOREHOLE		18	SS	100/0.25							
	Note: 1. Water level could not be observed upon completion of drilling due to the use of drilling mud.											

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:



PROJECT		13-1111-0026		<b>RECORD OF BOREHOLE No BH15-N1</b>		1 OF 3 <b>METRIC</b>								
W.P.		11-20002		LOCATION		N 4941197.4; E 309188.3								
DIST		CENTRAL HWY 12		BOREHOLE TYPE		200 mm Diameter Hollow Stem Augers								
DATUM		GEODETIC		DATE		December 2 and 10, 2014								
						ORIGINATED BY OS								
						COMPILED BY NL								
						CHECKED BY JMAC								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
257.3	GROUND SURFACE							20 40 60 80 100	20 40 60 80 100					
0.0	TOPSOIL													
0.2	Gravelly silty sand, trace rootlets (FILL) Loose to compact Brown Moist		1	SS	9		257							
			2	SS	18		256							
255.8														
1.5	Silty sand, some gravel, trace clay (FILL) Very loose Brown Wet		3	SS	2		255							
255.0														
2.3	SAND, trace to some silt Loose to dense Brown Moist		4	SS	6		254							
			5	SS	11		253							
	A 50 mm silty clay seam at 4.6 m depth.		A 6 B	SS	28		252							
			7	SS	40		251							
							250							
	Increase silt content noted in Sample 8.		8	SS	44		249							
							248							
			9	SS	11		247							
			A 10 B	SS	9		246							
245.7														
11.6														

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:

Continued Next Page

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



PROJECT <u>13-1111-0026</u>			<b>RECORD OF BOREHOLE No BH15-N1</b>			2 OF 3 <b>METRIC</b>		
W.P. <u>11-20002</u>			LOCATION <u>N 4941197.4; E 309188.3</u>			ORIGINATED BY <u>OS</u>		
DIST <u>CENTRAL</u> HWY <u>12</u>			BOREHOLE TYPE <u>200 mm Diameter Hollow Stem Augers</u>			COMPILED BY <u>NL</u>		
DATUM <u>GEODETIC</u>			DATE <u>December 2 and 10, 2014</u>			CHECKED BY <u>JMAC</u>		



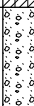
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
--- CONTINUED FROM PREVIOUS PAGE ---																				
244.2	SILT, trace to some clay, trace sand Dense Brown Moist		11	SS	33		245										0 3 90 7			
13.1	CLAYEY SILT, trace sand, trace to some gravel Stiff Grey Wet		12	SS	10		244										7 2 71 20			
242.7	SILTY SAND to SAND Compact to very dense Brown Wet		13	SS	31		243													
14.6			14	SS	32		242													
			15	SS	43		241													
			16	SS	42		240													
			17	SS	19		239													
			18	SS	26		238													
							237													
							236													
							235													
							234													

SUD-MTO 001 131110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:

Continued Next Page

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



PROJECT		13-1111-0026		<b>RECORD OF BOREHOLE No BH15-N1</b>				3 OF 3		<b>METRIC</b>							
W.P.		11-20002		LOCATION		N 4941197.4; E 309188.3				ORIGINATED BY OS							
DIST		CENTRAL HWY 12		BOREHOLE TYPE		200 mm Diameter Hollow Stem Augers				COMPILED BY NL							
DATUM		GEODETIC		DATE		December 2 and 10, 2014				CHECKED BY JMAC							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	--- CONTINUED FROM PREVIOUS PAGE ---						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100					WATER CONTENT (%) 10 20 30					
232.1	SILTY SAND to SAND Compact to very dense Brown Wet		19	SS	62		233										
25.2	CLAYEY SILT to SILTY CLAY, trace sand, trace gravel Hard Grey Wet		20	SS	31		232										
							231										
229.9							230										
27.4	SAND and GRAVEL, trace to some silt Very dense Grey Wet		21	RC	-		229										
			22	SS	100/0.15												
			23	SS	100/0.14		228										
							227										
226.6			24	SS	100/0.1												
30.7	END OF BOREHOLE  Note:  1. Water level at a depth of 8.9 m below ground surface (Elev. 248.4 m) inside casing upon completion of drilling.																

SUD-MTO 001 131110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:





# **APPENDIX B**

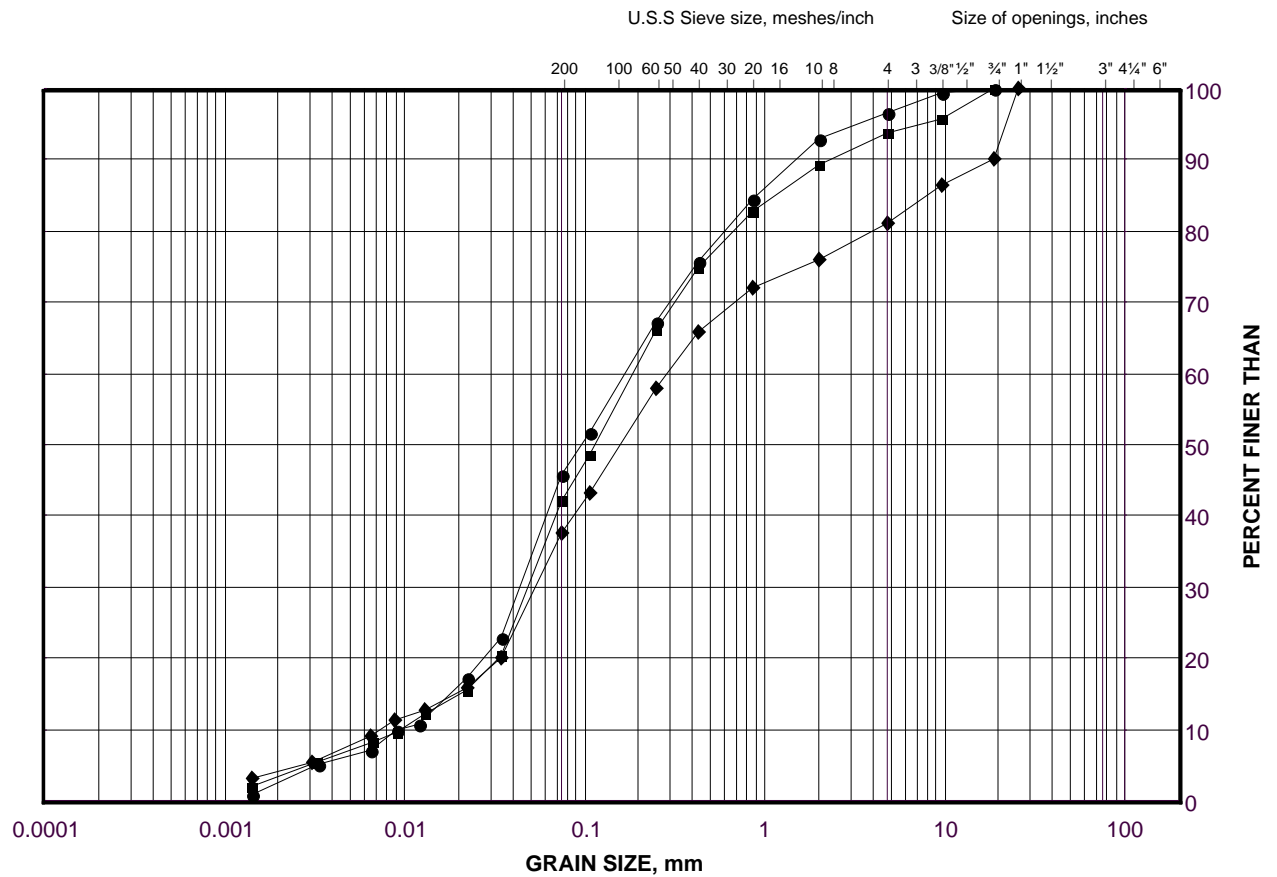
## **Geotechnical Laboratory Test Results**



# GRAIN SIZE DISTRIBUTION

Silt and Sand (Fill)

FIGURE B1



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-18	4	247.3
■	15-S1	5	265.7
◆	15-02	3	280.7

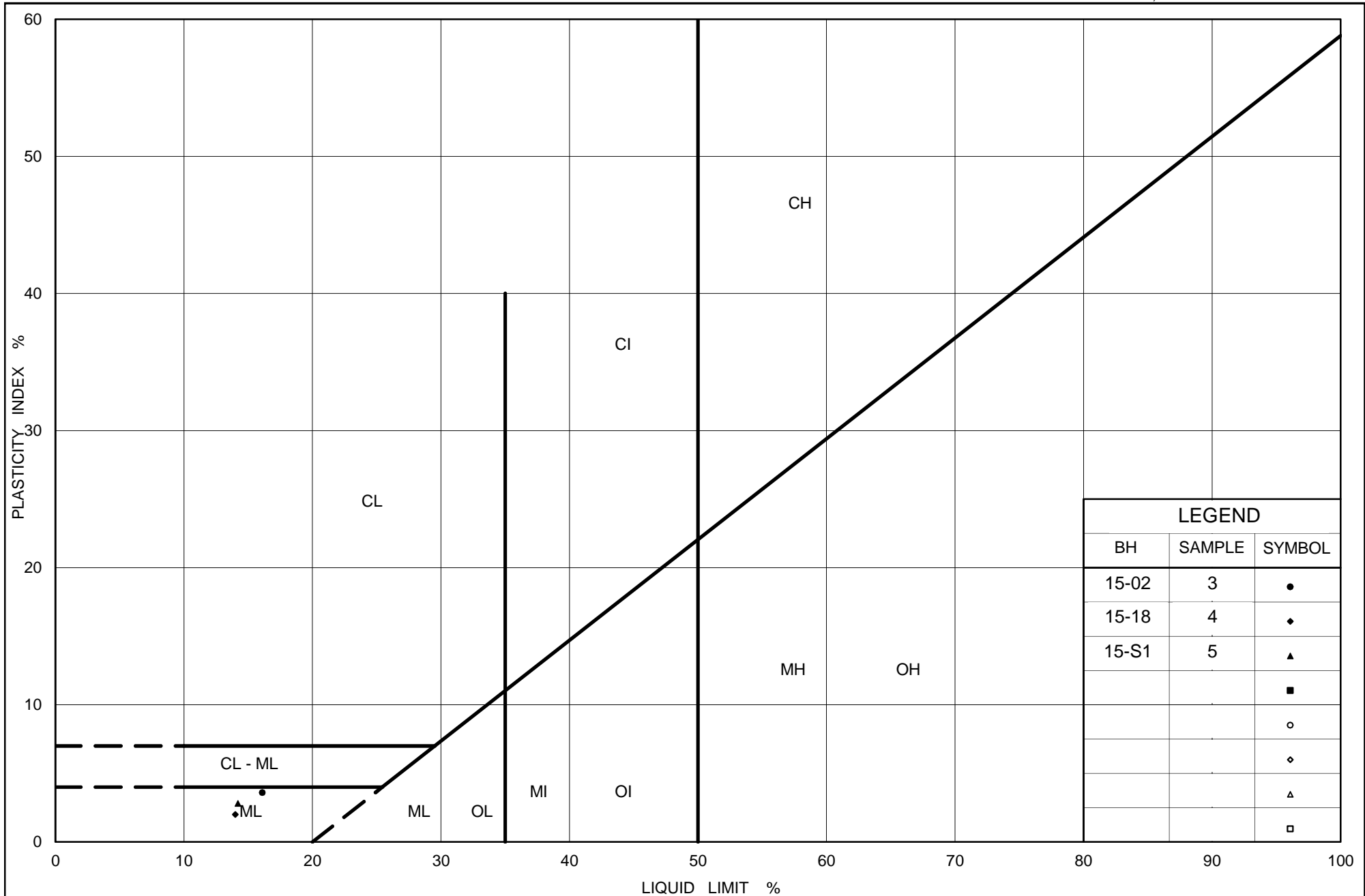
Project Number: 13-1111-0026

Checked By: NK

**Golder Associates**

Date: 06-May-16





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# PLASTICITY CHART Silt and Sand (Fill)

Figure No. B2

Project No. 13-1111-0026

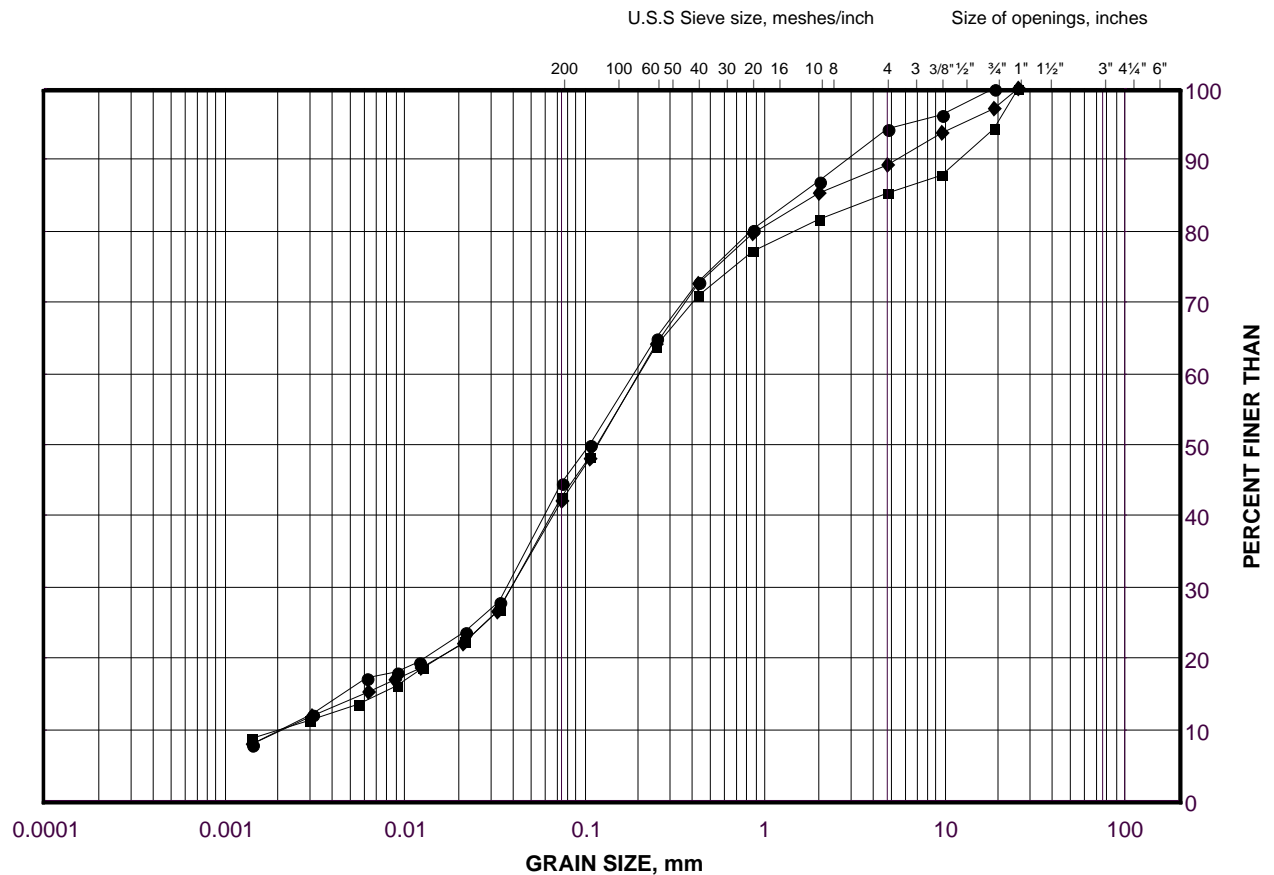
Checked By: NK



# GRAIN SIZE DISTRIBUTION

Silt and Sand (Till)

FIGURE B3



## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-03	6	272.3
■	15-02	7	276.1
◆	15-01	8	281.6

Project Number: 13-1111-0026

Checked By: NK

**Golder Associates**

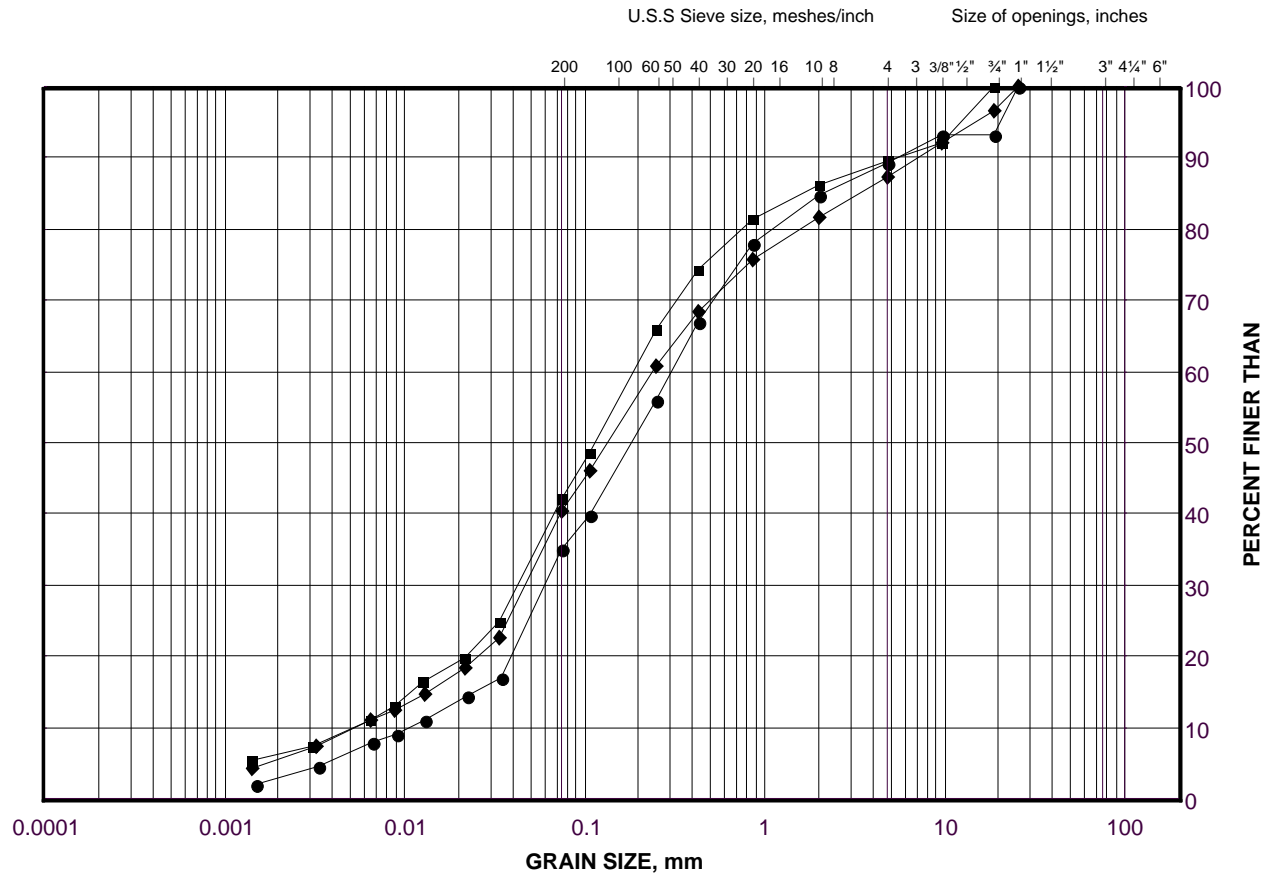
Date: 04-Mar-16



# GRAIN SIZE DISTRIBUTION

Silt and Sand (Till)

FIGURE B4



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-18	12	263.0
■	15-01	2	288.4
◆	15-18	8	268.9

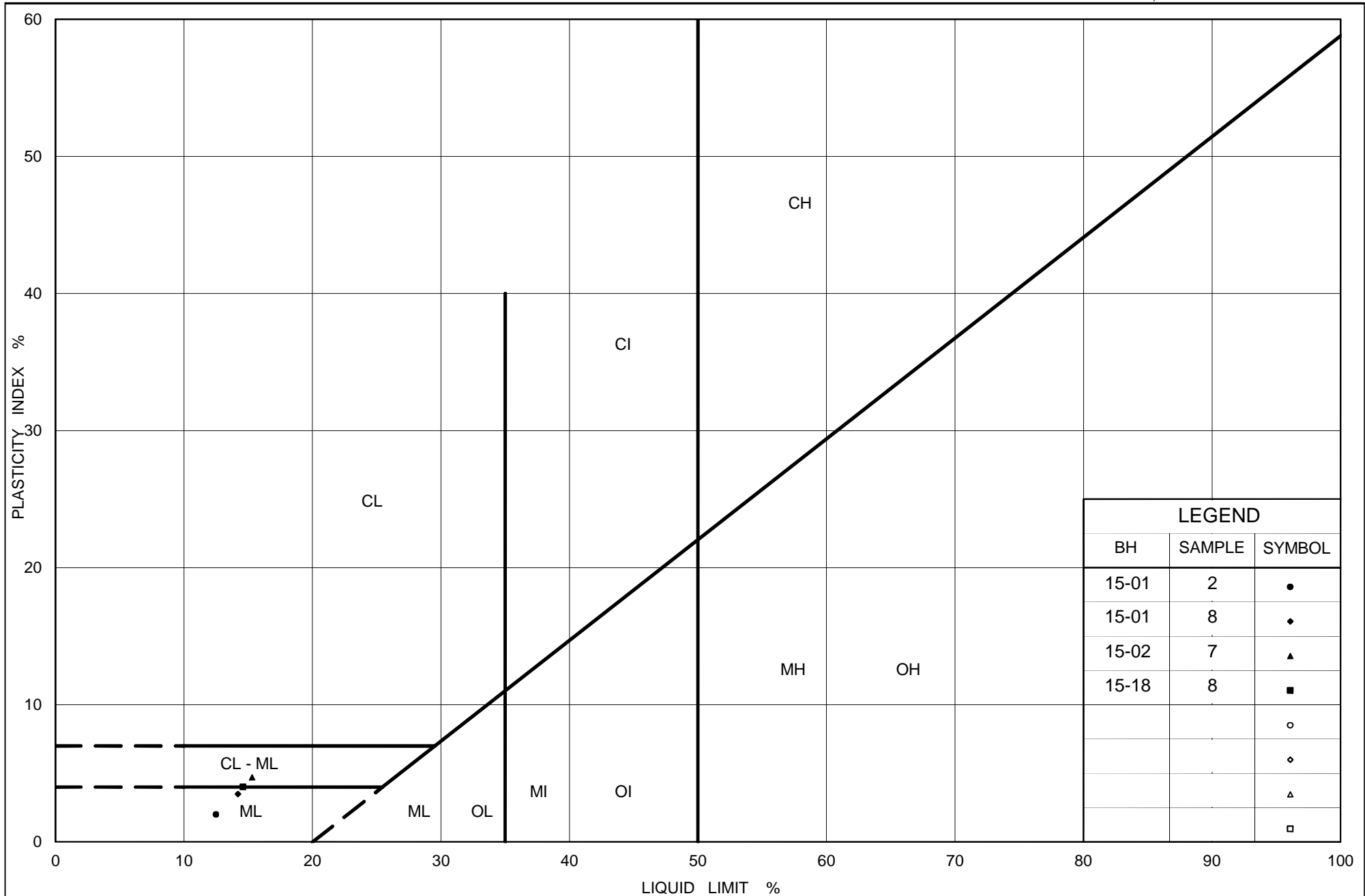
Project Number: 13-1111-0026

Checked By: NK

**Golder Associates**

Date: 04-Mar-16





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# PLASTICITY CHART Silt and Sand (Till)

Figure No. B5

Project No. 13-1111-0026

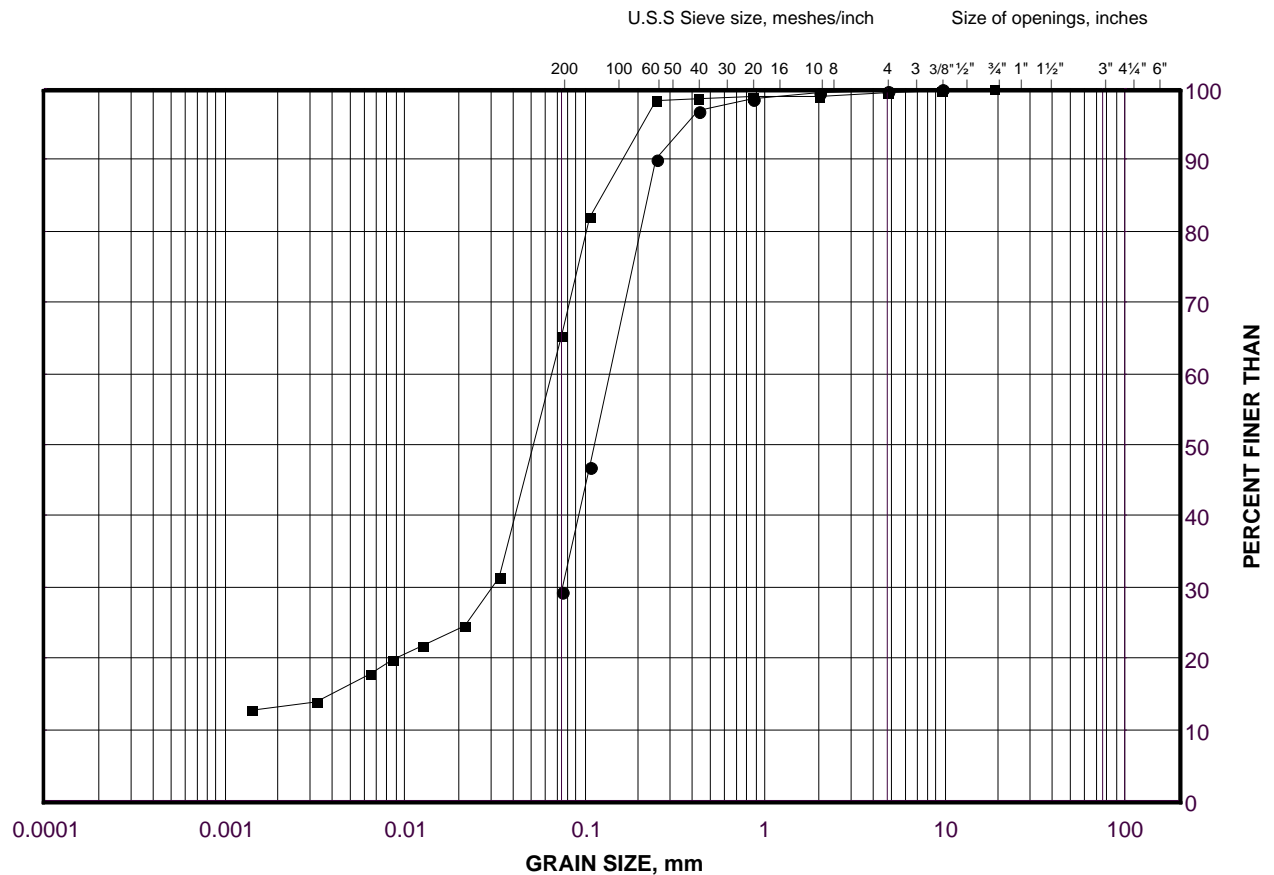
Checked By: NK



# GRAIN SIZE DISTRIBUTION

Silt and Sand to Silty Sand

FIGURE B6



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-03	2	275.9
■	15-05	5	234.7

Project Number: 13-1111-0026

Checked By: NK

**Golder Associates**

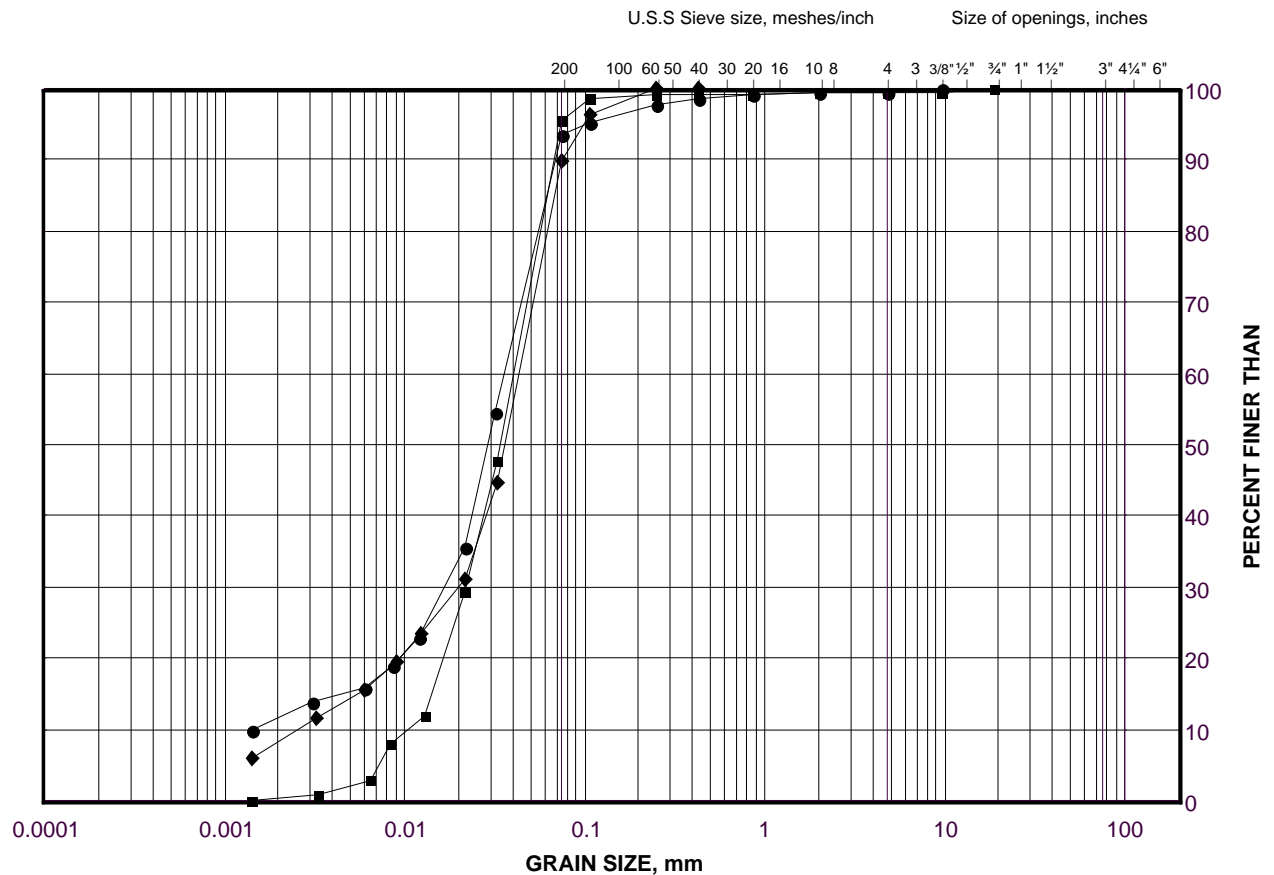
Date: 07-Jan-16



# GRAIN SIZE DISTRIBUTION

Silt

FIGURE B7



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-04	3	249.2
■	15-04	5	247.7
◆	15-05	9	228.7

Project Number: 13-1111-0026

Checked By: NK

**Golder Associates**

Date: 07-Jan-16



## Sand and Gravel

U.S.S Sieve size, meshes/inch

Size of openings, inches

PERCENT FINER THAN

GRAIN SIZE, mm

Grain Size (mm)	Percent Finer Than (%)
0.075	10
0.085	11
0.15	15
0.25	18
0.425	22
0.75	28
1.18	35
2.0	48
3.0	55
4.75	65
7.5	82
10.0	82
15.0	95
20.0	100

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

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-05	3	236.2

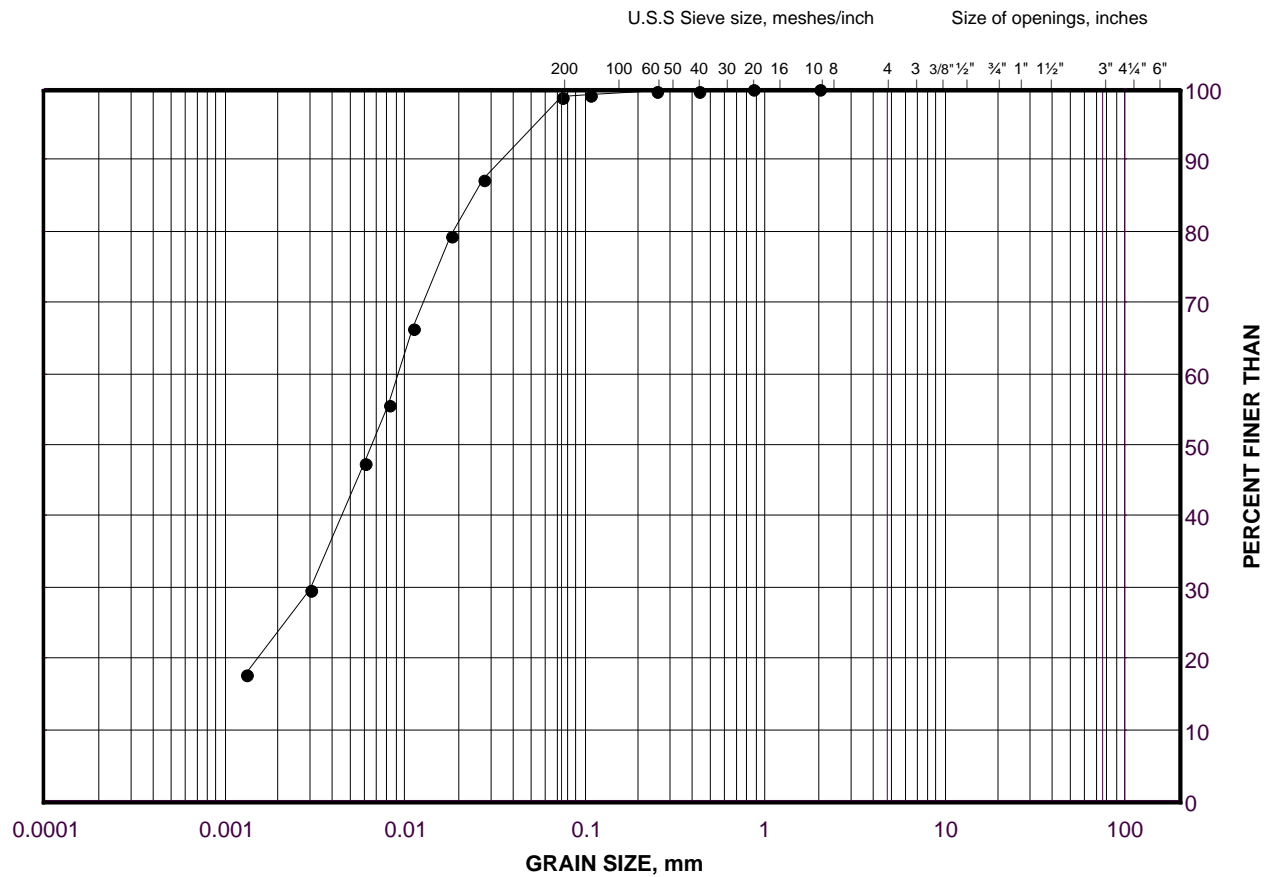
Date: 07-Jan-16



# GRAIN SIZE DISTRIBUTION

Clayey Silt

FIGURE B9



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	15-04	9	241.6

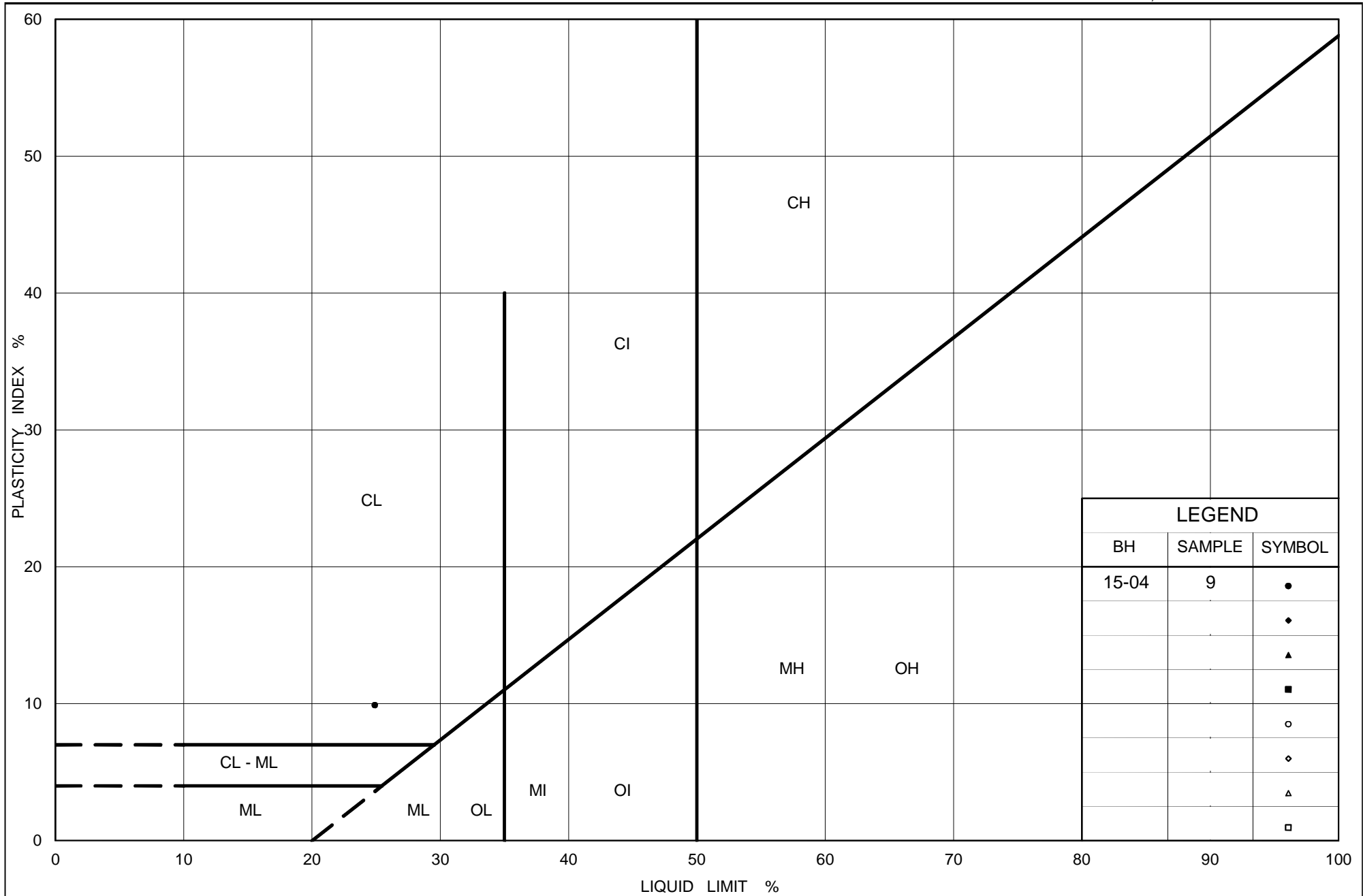
Project Number: 13-1111-0026

Checked By: NK

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LEGEND		
BH	SAMPLE	SYMBOL
15-04	9	•
		◊
		▲
		■
		◦
		◈
		△
		◻



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## PLASTICITY CHART

### Clayey Silt

Figure No. B10

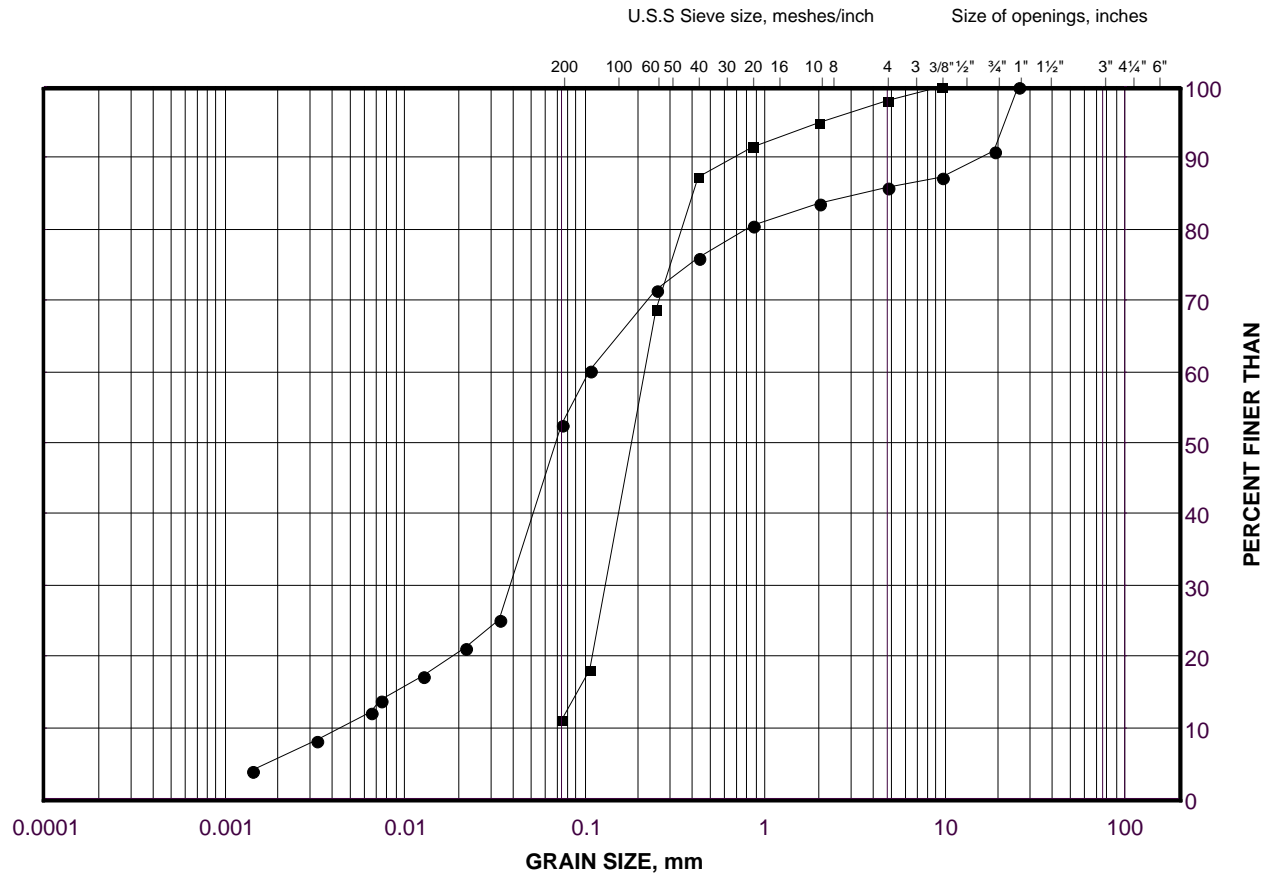
Project No. 13-1111-0026

Checked By: NK



### Silt and Sand to Sand (Fill)

FIGURE B11



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-09	4	246.2
■	15-06	6	246.3

Project Number: 13-1111-0026

Checked By: NK

## Golder Associates

Date: 07-Jan-16



### Clayey Silt

U.S.S Sieve size, meshes/inch

Size of openings, inches

PERCENT FINER THAN

GRAIN SIZE, mm

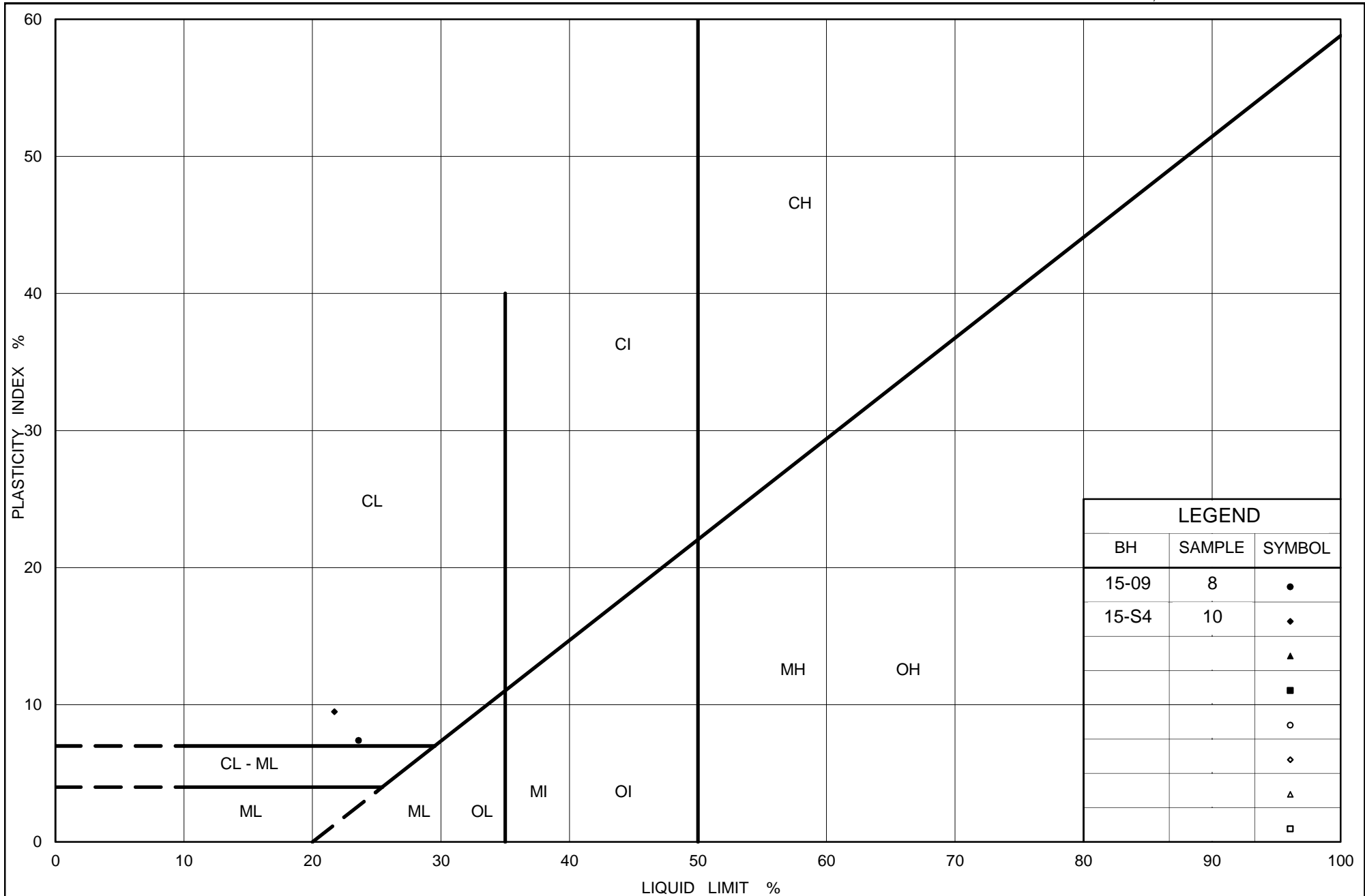
Grain Size (mm)	Percent Finer (%) - Diamond	Percent Finer (%) - Circle	Percent Finer (%) - Square
0.002	15	10	8
0.004	25	18	15
0.006	35	28	25
0.008	45	38	35
0.01	55	45	42
0.015	75	55	50
0.02	85	60	55
0.03	95	70	65
0.05	100	80	75
0.075	100	85	80
0.1	100	88	85
0.15	100	90	88
0.2	100	92	90
0.3	100	95	92
0.425	100	100	95
0.6	100	100	98
0.850	100	100	100

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

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-S4	10	250.5
■	15-08	11	237.7
◆	15-09	8	239.9

Date: 06-May-16





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# PLASTICITY CHART Clayey Silt

Figure No. B13

Project No. 13-1111-0026

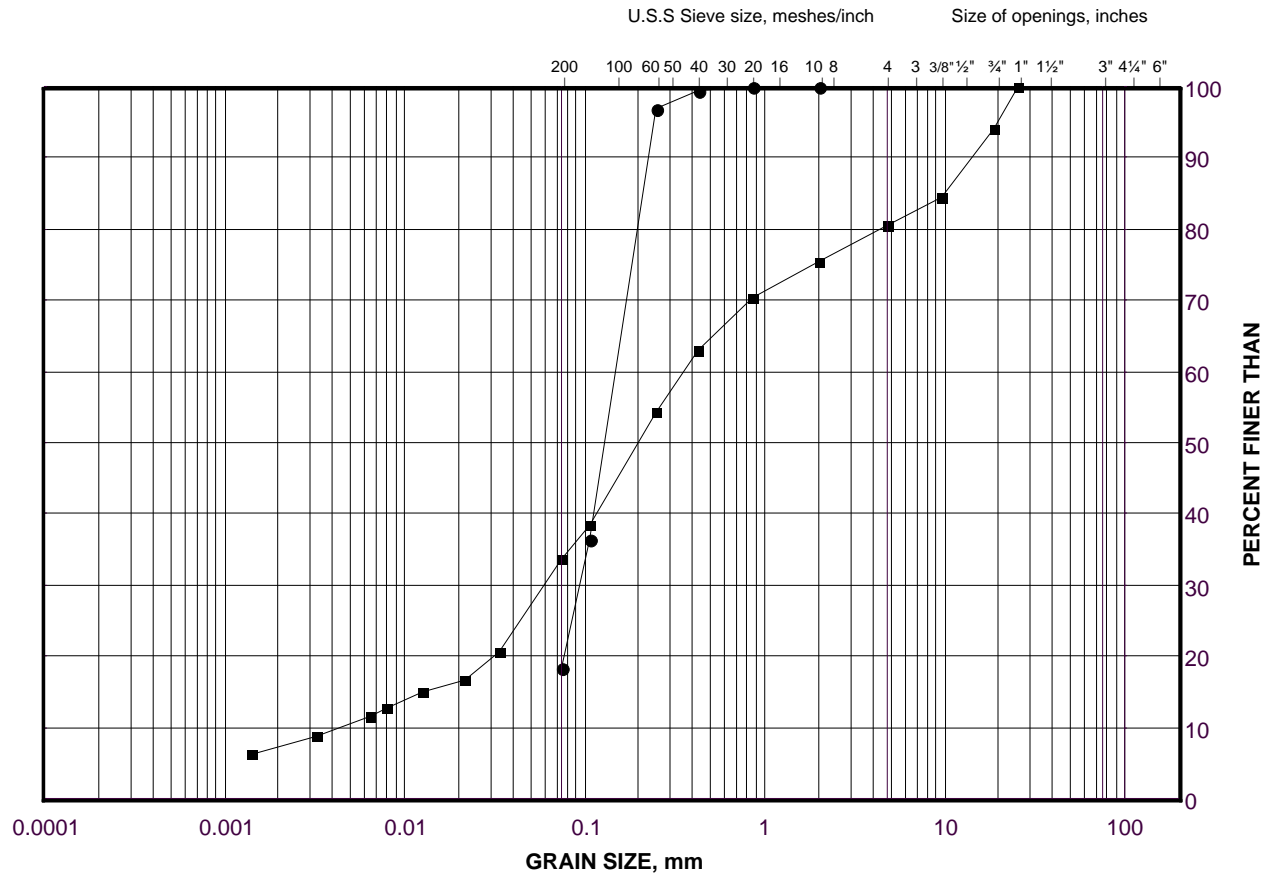
Checked By: NK



# GRAIN SIZE DISTRIBUTION

Silty Sand to Sand

FIGURE B14



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-08	6	243.0
■	15-S4	8A	252.9

Project Number: 13-1111-0026

Checked By: NK

**Golder Associates**

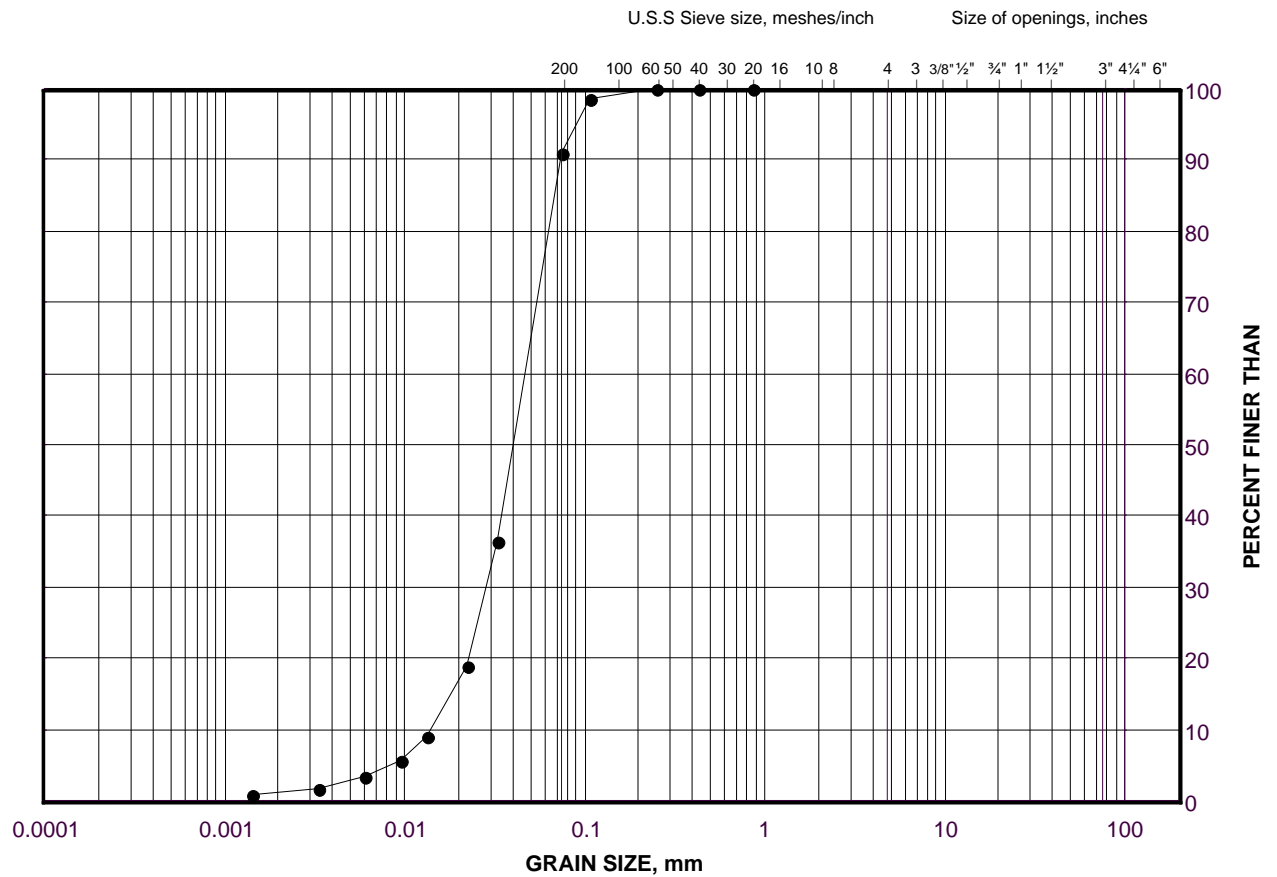
Date: 06-May-16



# GRAIN SIZE DISTRIBUTION

Silt

FIGURE B15

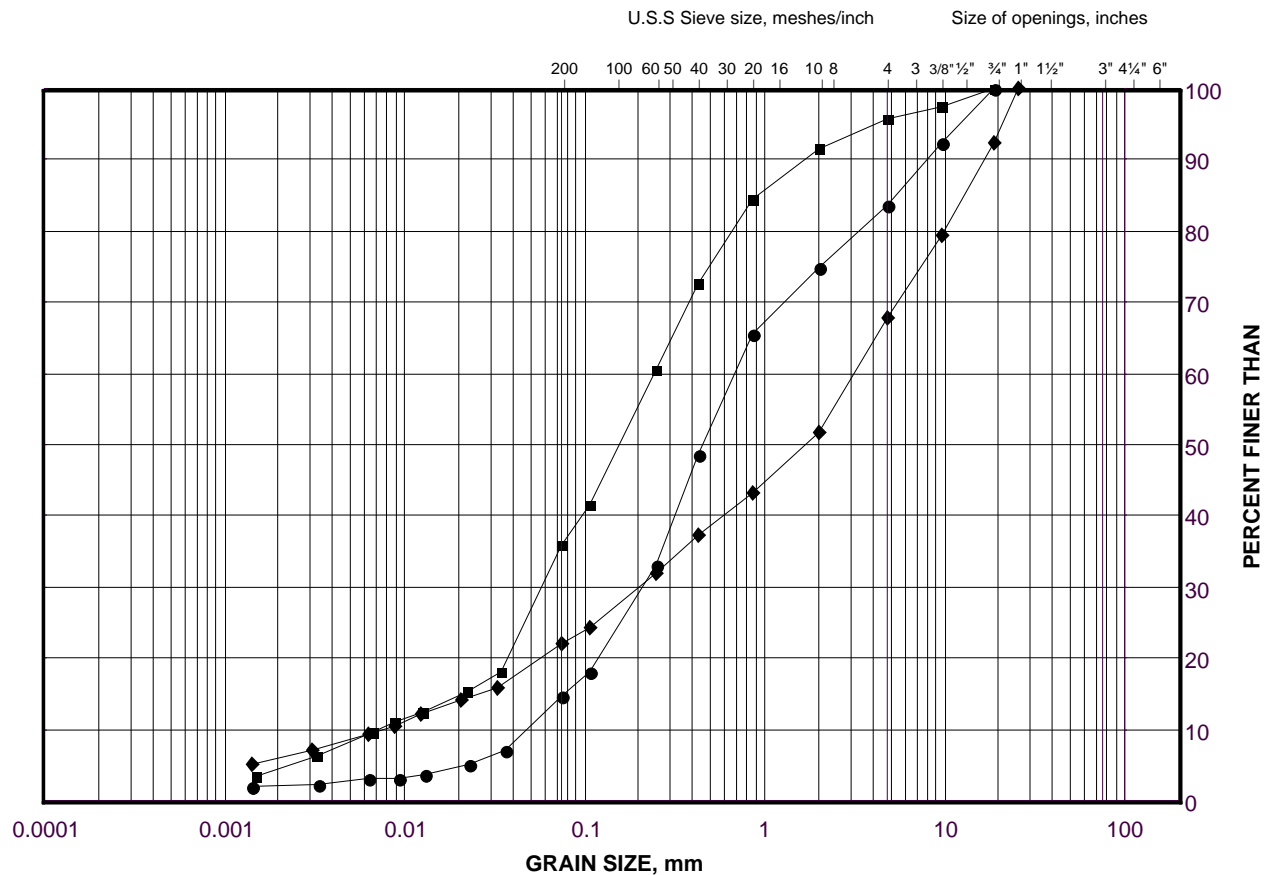




# GRAIN SIZE DISTRIBUTION

Sand (Till)

FIGURE B16



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-06	13	237.4
■	15-S5	14	249.9
◆	15-06	9	241.8

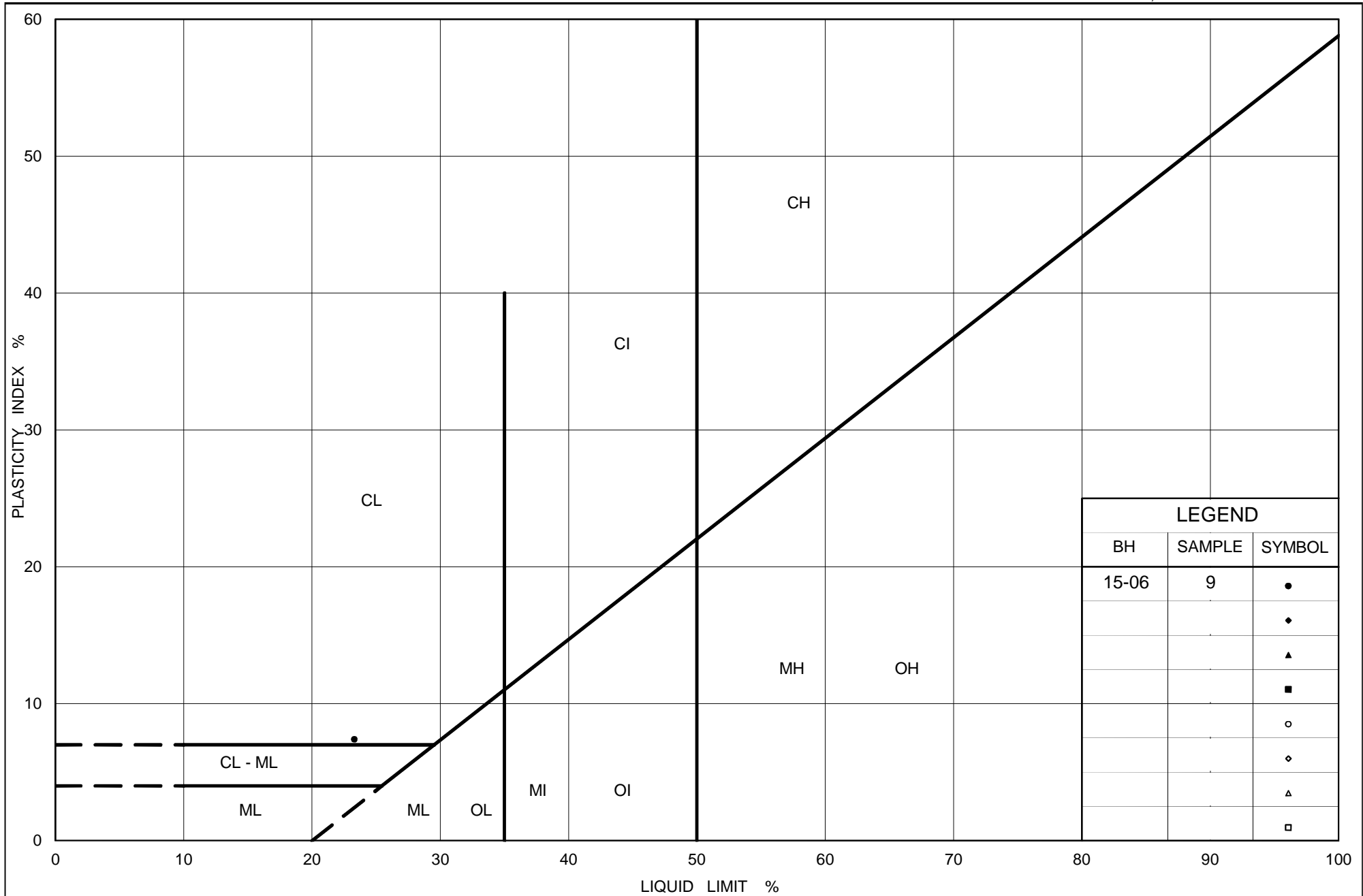
Project Number: 13-1111-0026

Checked By: NK

**Golder Associates**

Date: 06-May-16





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## PLASTICITY CHART

### Sand and Gravel (Till)

Figure No. B17

Project No. 13-1111-0026

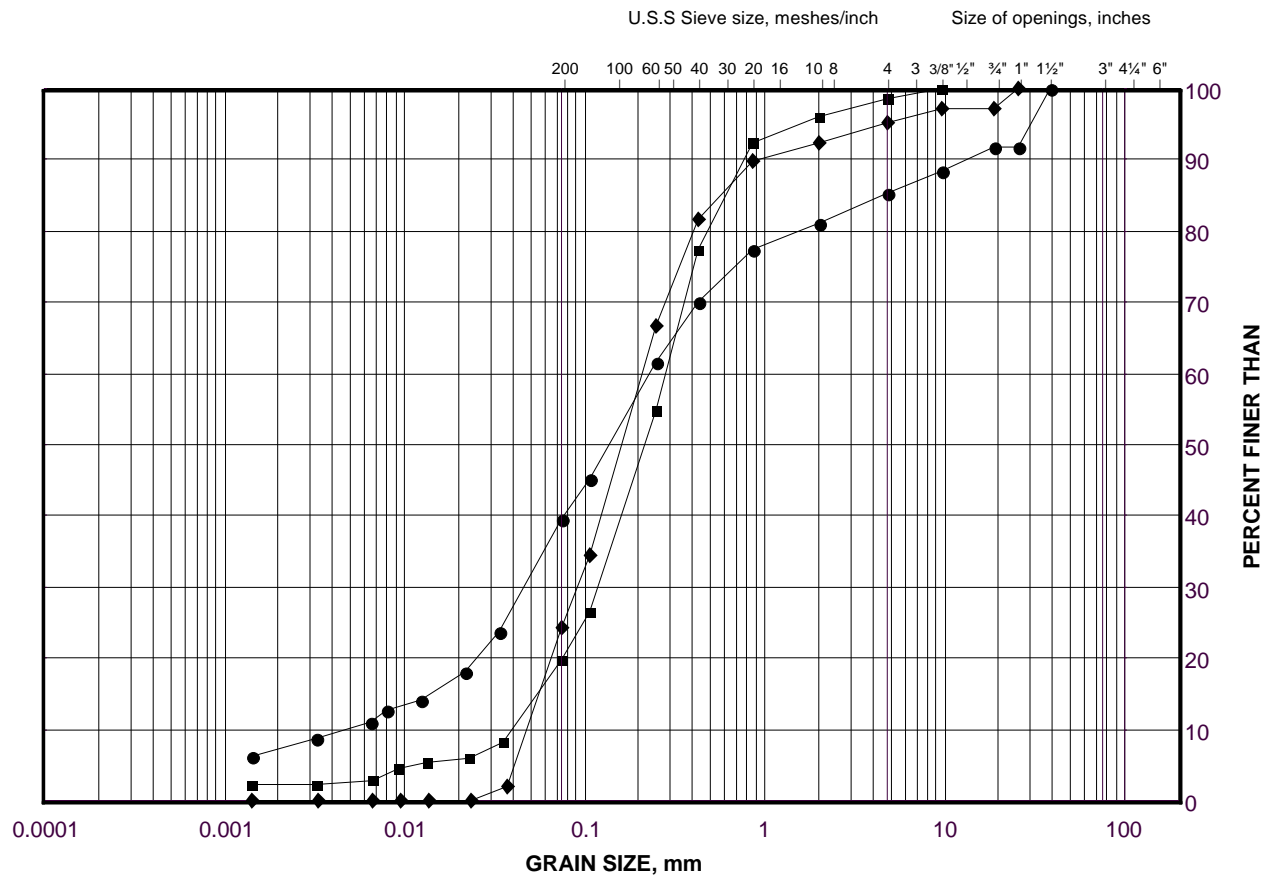
Checked By: NK



# GRAIN SIZE DISTRIBUTION

Silt and Sand to Sand (Fill)

FIGURE B18



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-12	2	256.6
■	15-10	5	257.3
◆	15-11	6	260.0

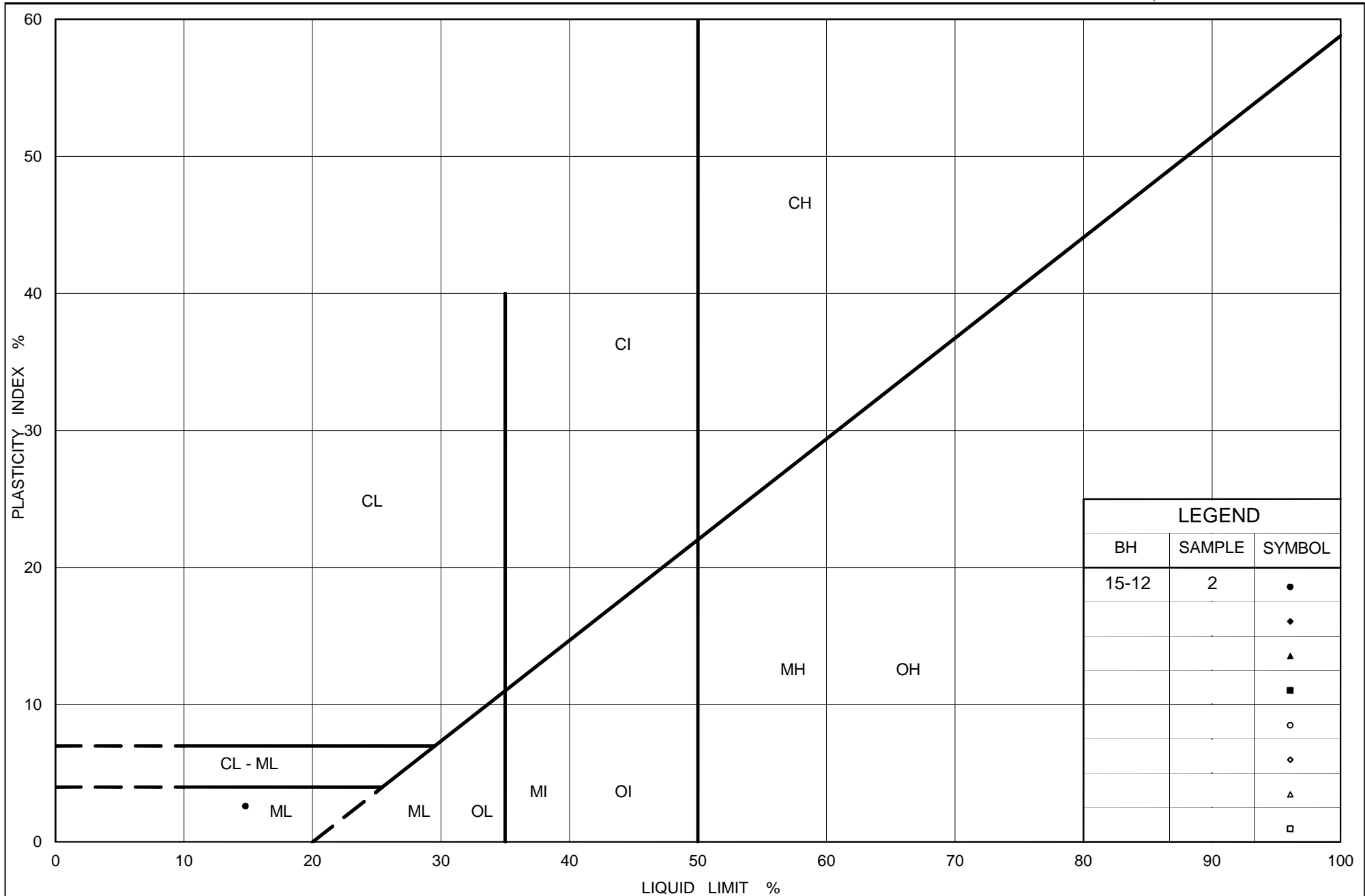
Project Number: 13-1111-0026

Checked By: NK

**Golder Associates**

Date: 11-Apr-16





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# PLASTICITY CHART Silt and Sand (Fill)

Figure No. B19

Project No. 13-1111-0026

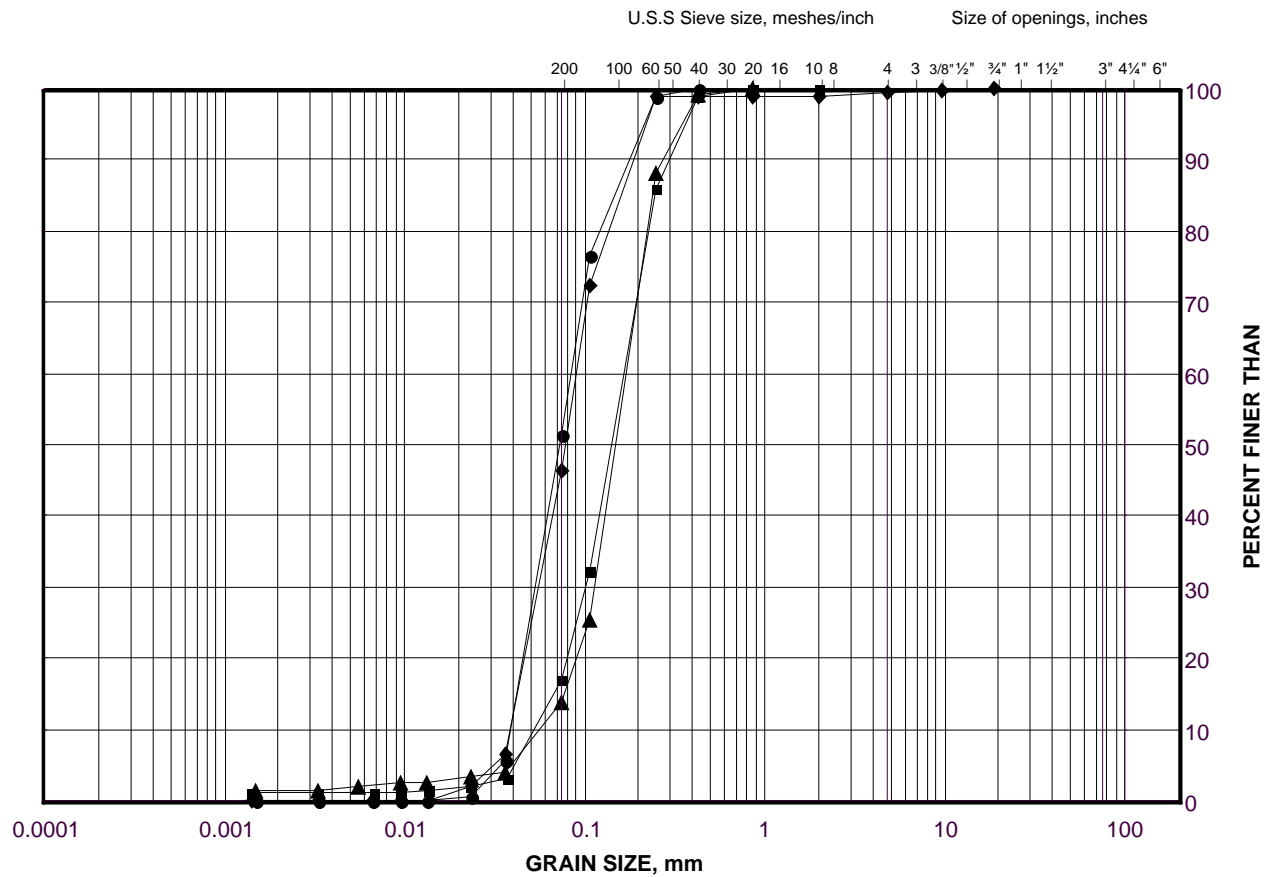
Checked By: NK



# GRAIN SIZE DISTRIBUTION

Silt and Sand to Sand

FIGURE B20



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-11	10	253.9
■	15-13	4	254.0
◆	15-12	6	252.8
▲	15-13	8	248.6

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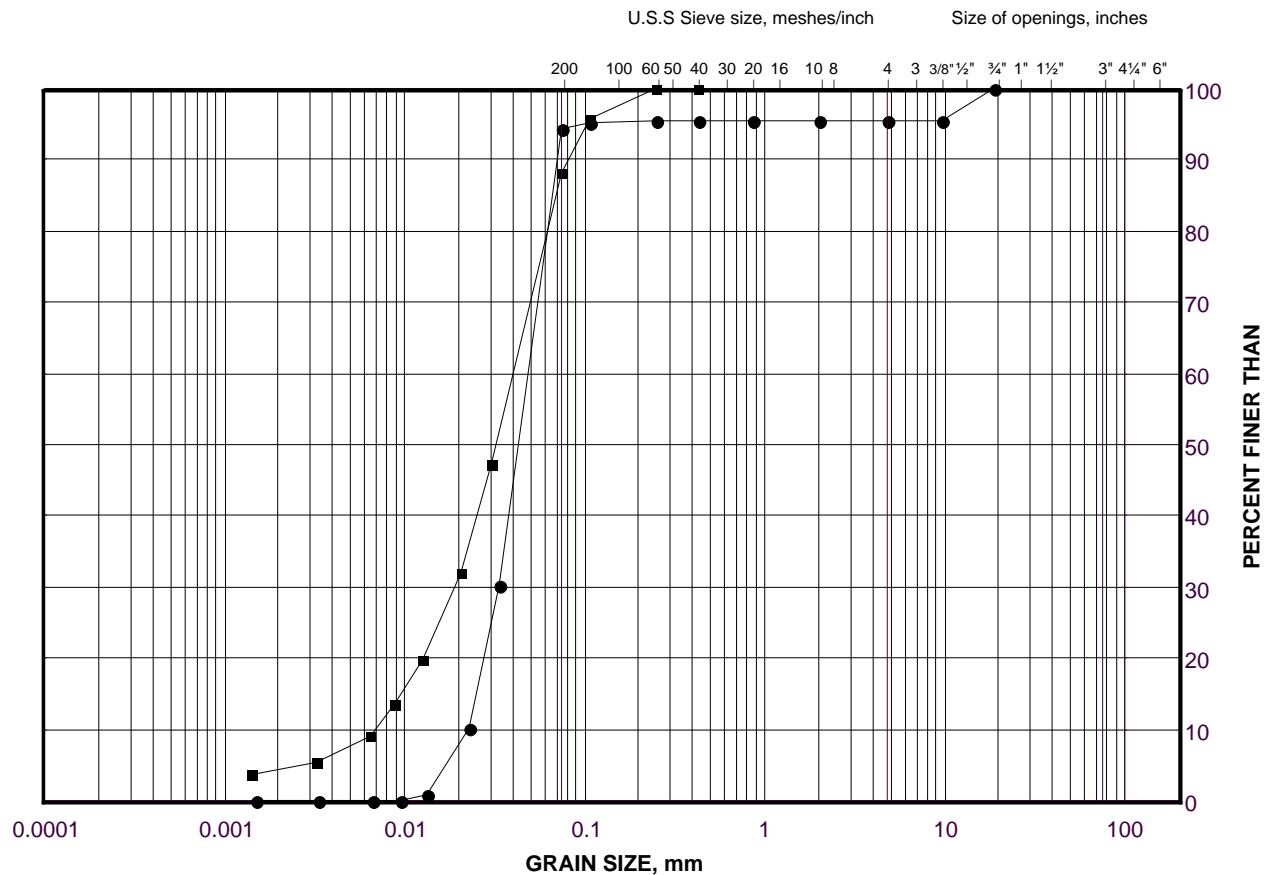
Date: 07-Jan-16



# GRAIN SIZE DISTRIBUTION

Silt

FIGURE B21



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-10	11	248.9
■	15-10	7A	255.2

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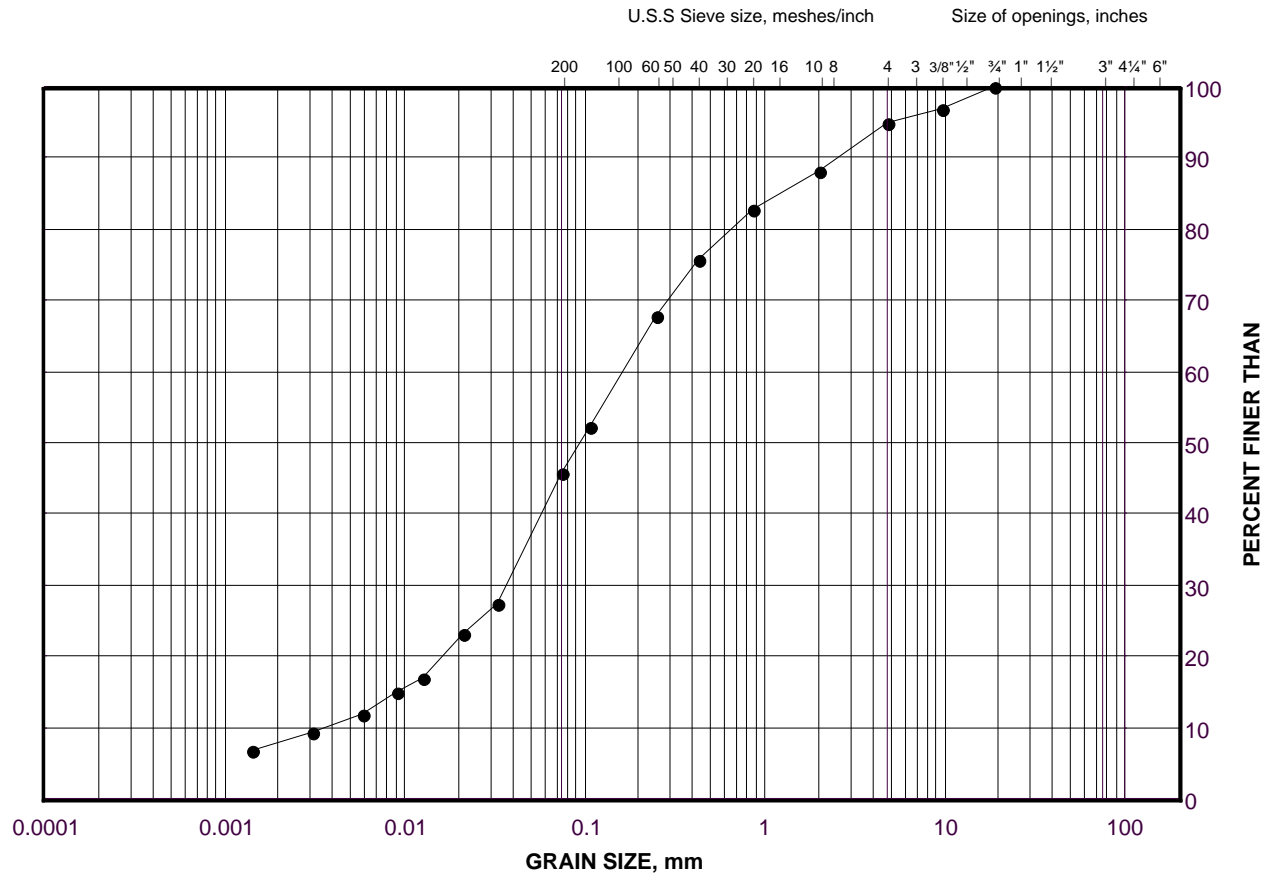
Date: 07-Jan-16



# GRAIN SIZE DISTRIBUTION

Silt and Sand (Fill)

FIGURE B22



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	15-14	4	260.9

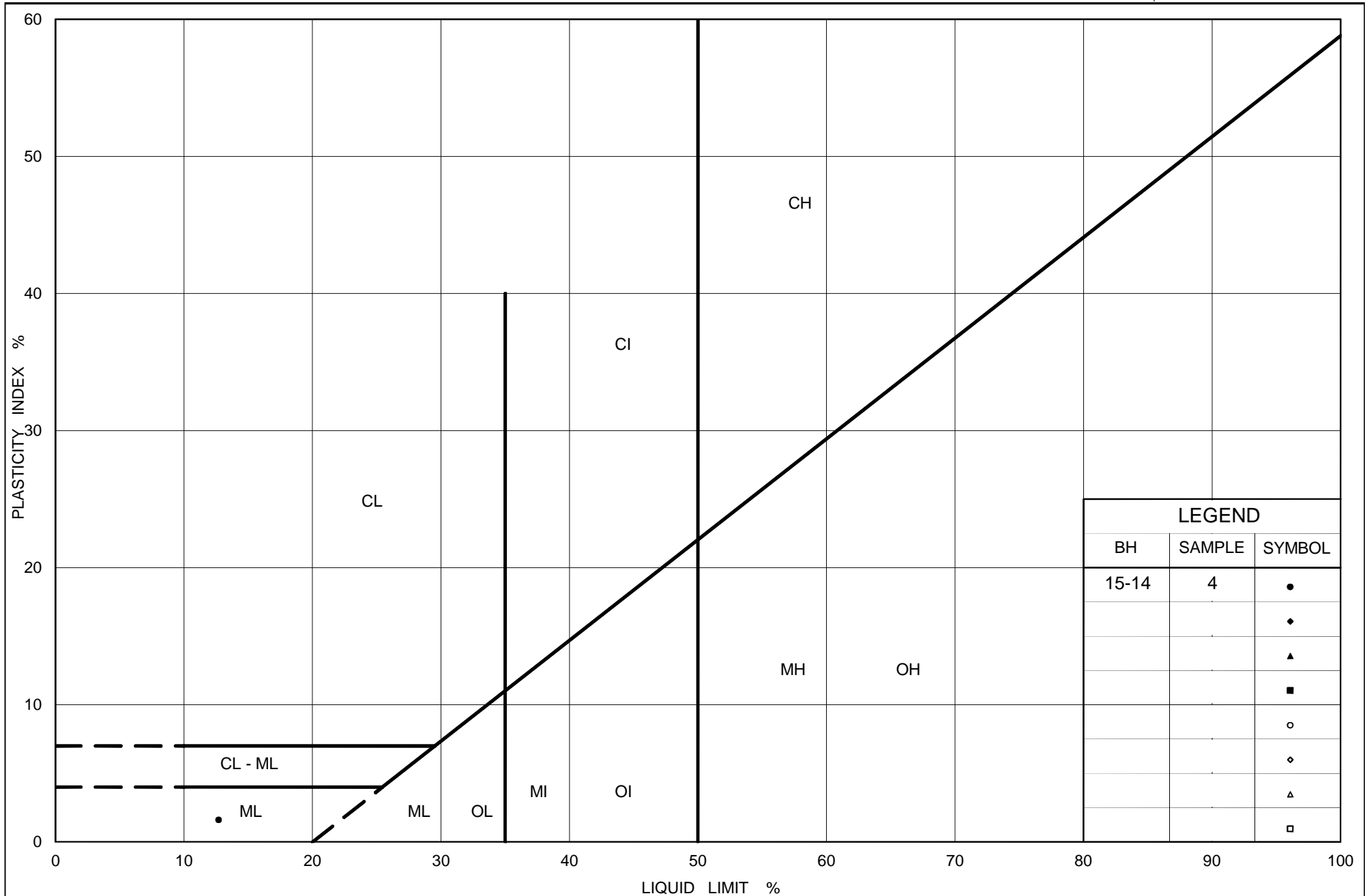
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# PLASTICITY CHART

## Silt and Sand (Fill)

Figure No. B23

Project No. 13-1111-0026

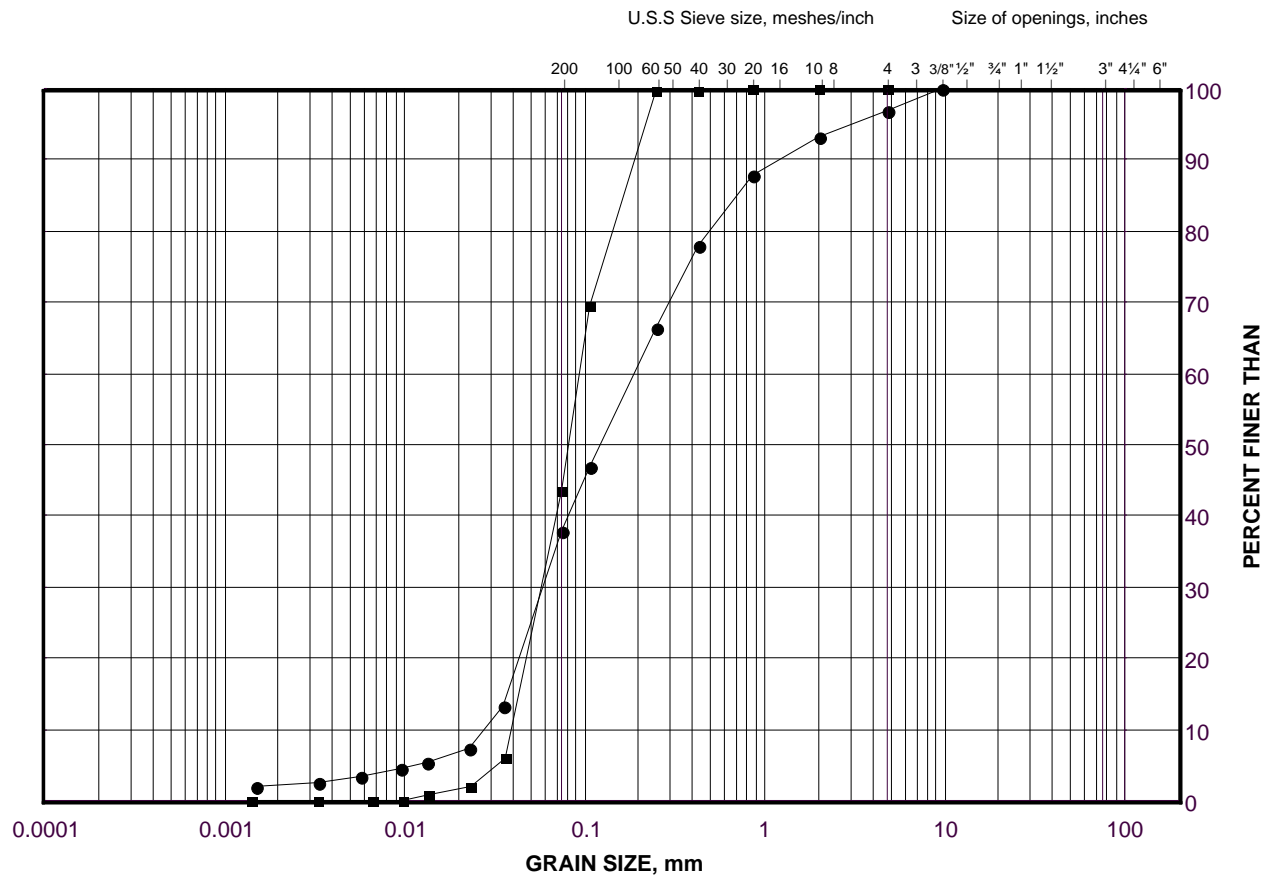
Checked By: NK



# GRAIN SIZE DISTRIBUTION

Silt and Sand

FIGURE B24



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-14	10	252.5
■	15-14	6	258.6

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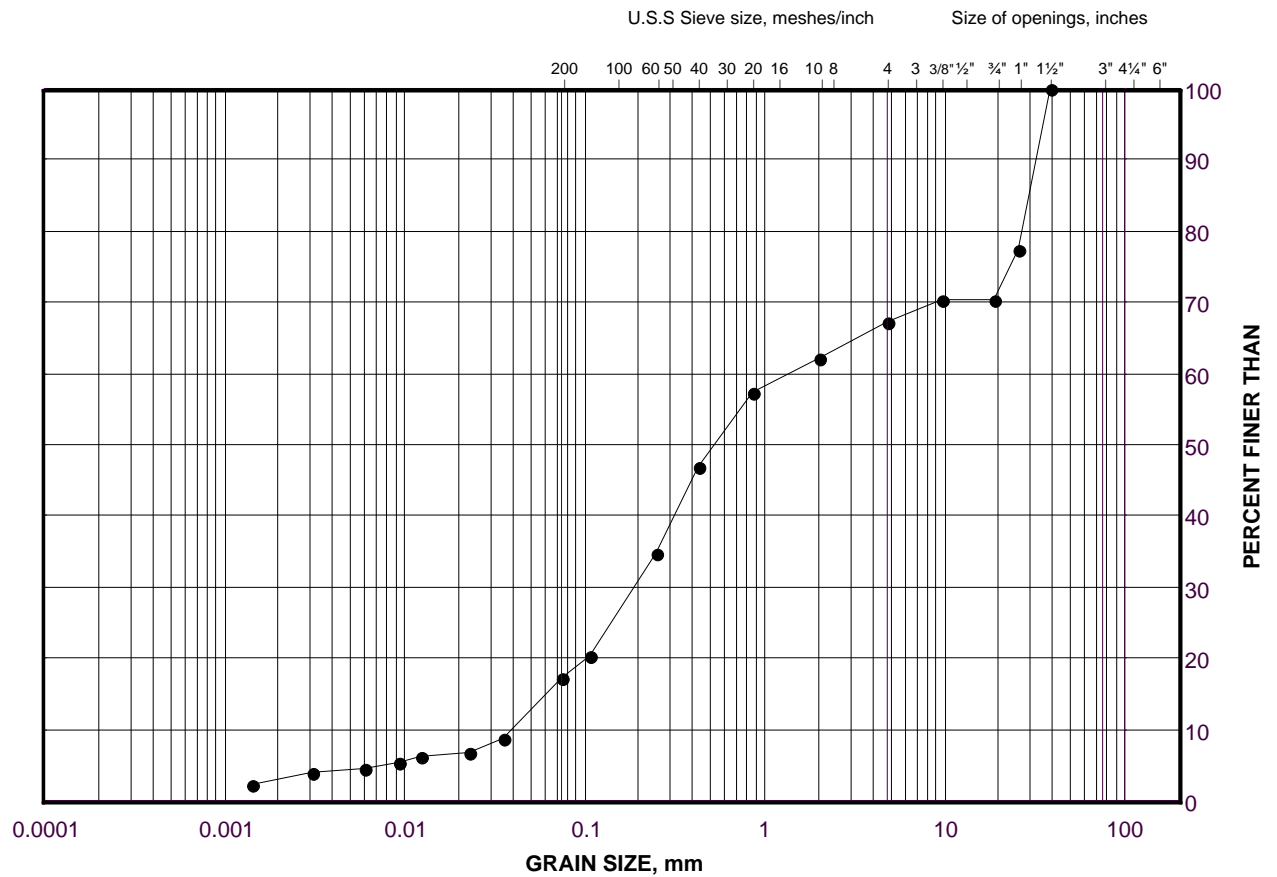
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Date: 07-Jan-16



Sand and Gravel (Till)

FIGURE B25



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-15	4	258.1

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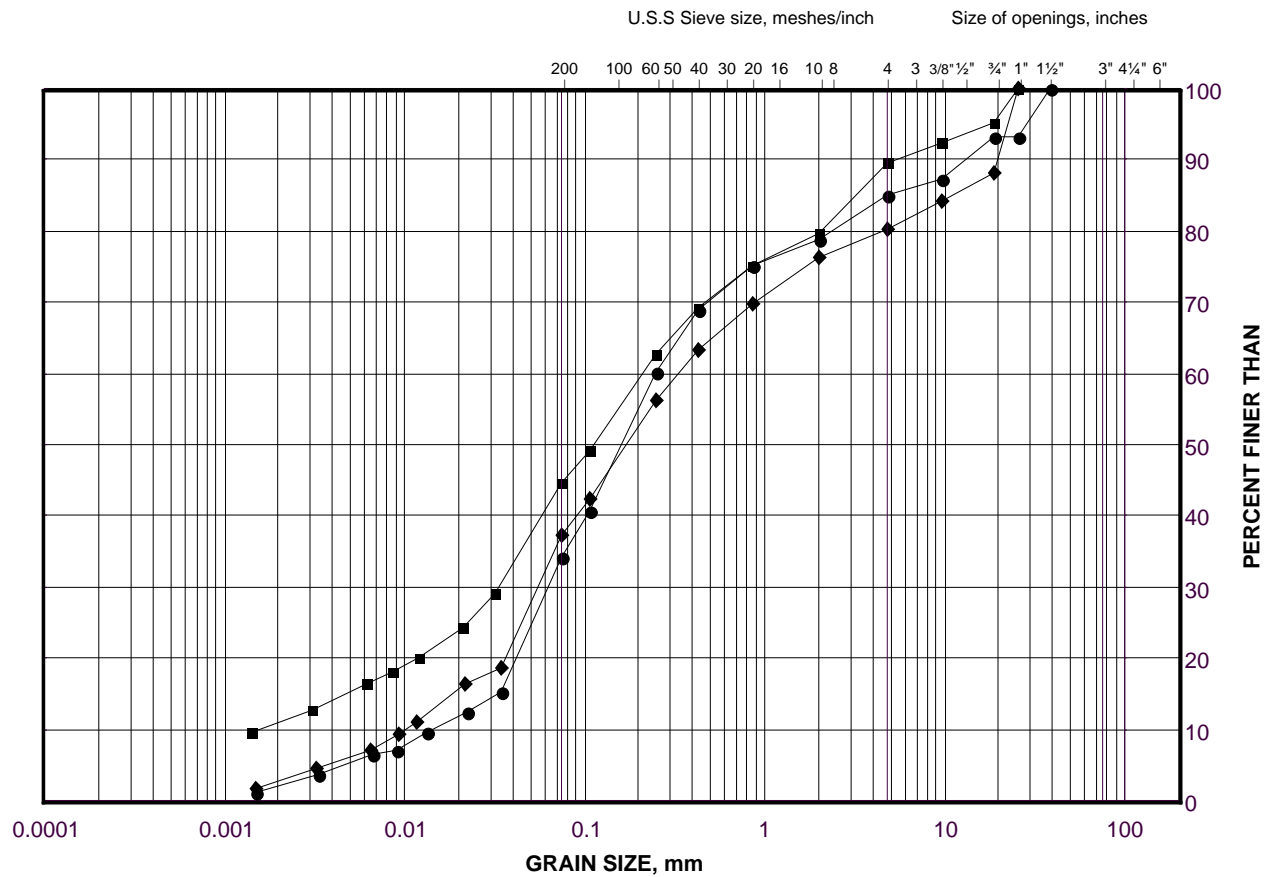
Date: 07-Jan-16



# GRAIN SIZE DISTRIBUTION

Silt and Sand (Till)

FIGURE B26



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-17	4	283.6
■	15-16	6	277.4
◆	15-17	8	278.2

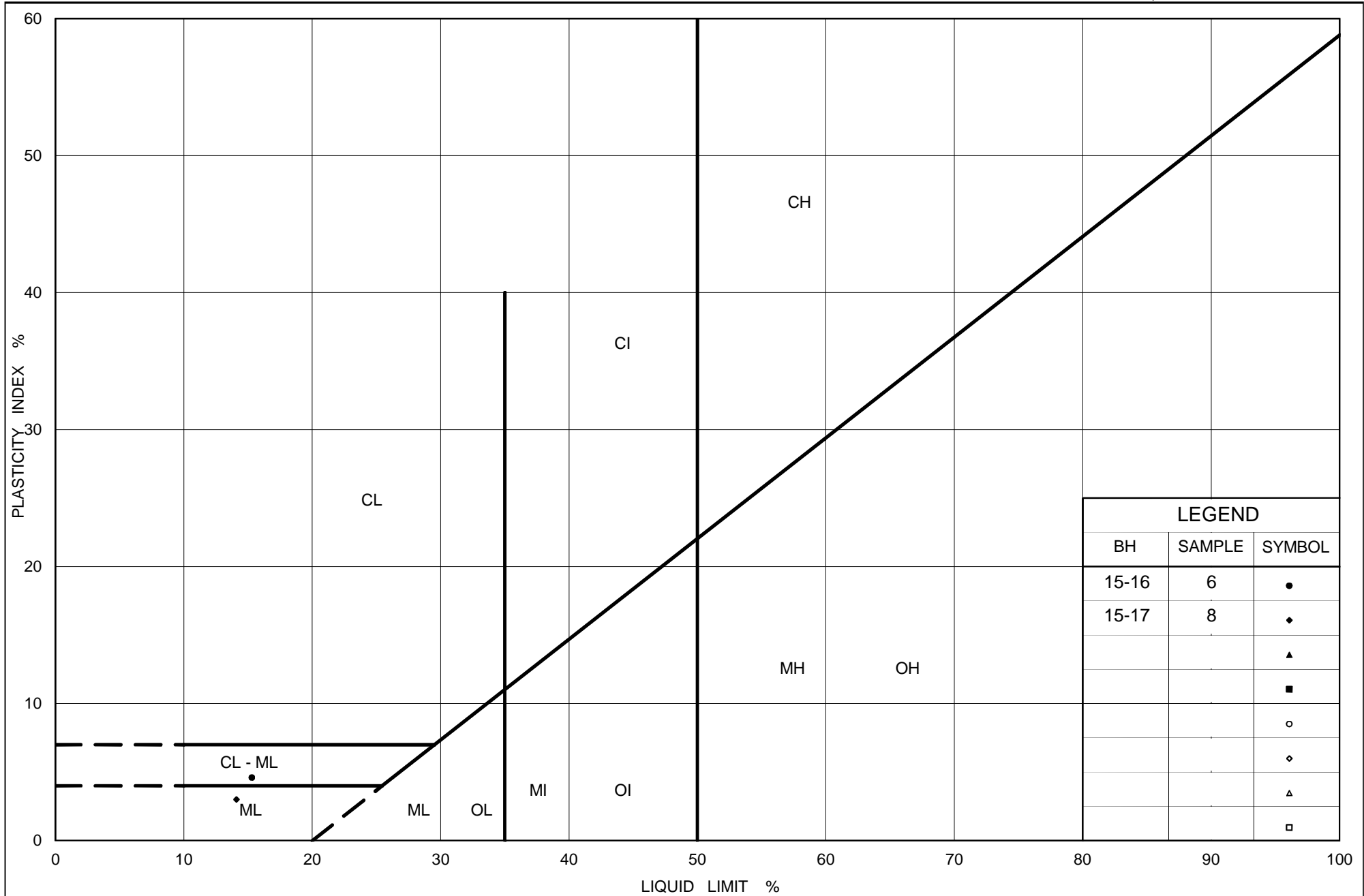
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# PLASTICITY CHART Silt and Sand (Till)

Figure No. B27

Project No. 13-1111-0026

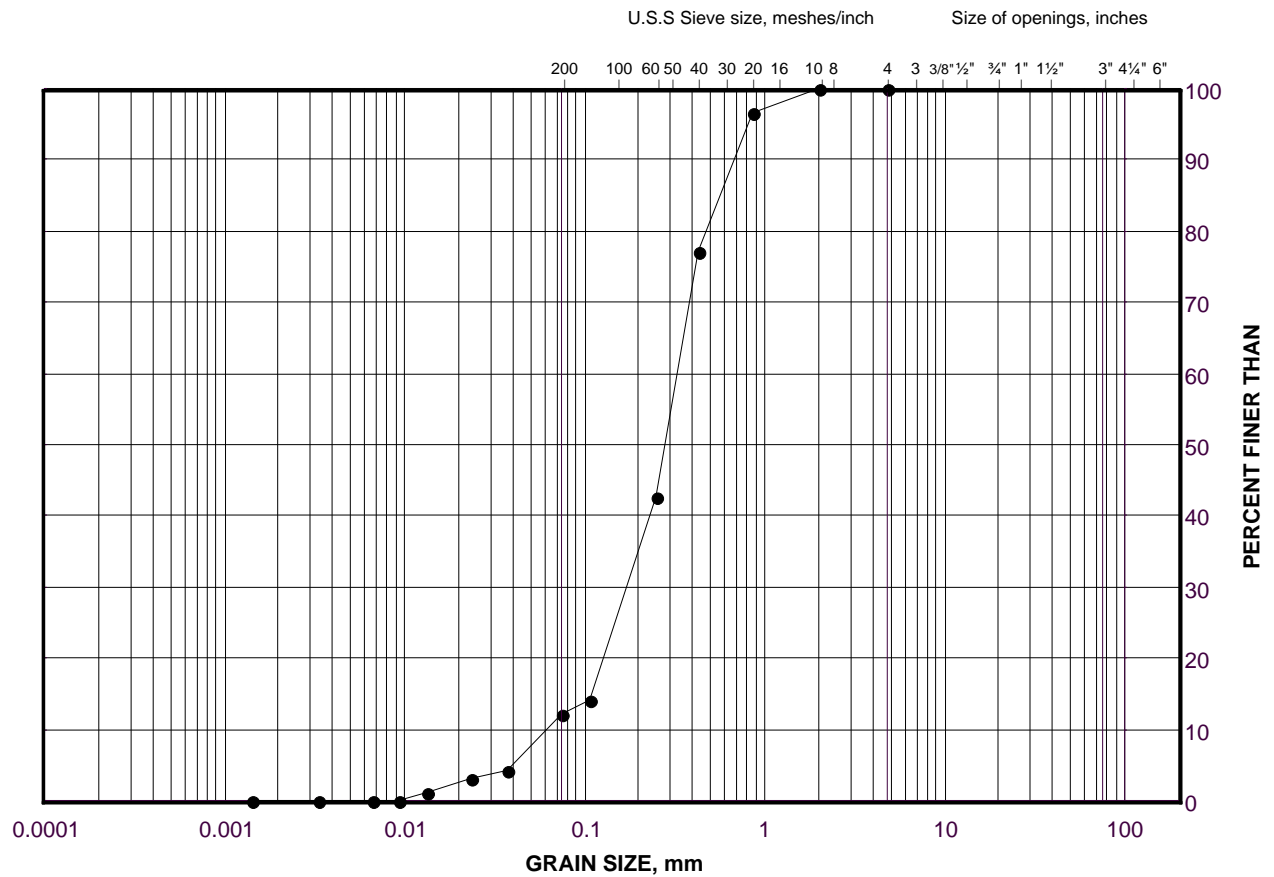
Checked By: NK



# GRAIN SIZE DISTRIBUTION

Sand

FIGURE B28



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	15-16	2	281.2

Project Number: 13-1111-0026

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Date: 04-Mar-16



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