

Terraprobe

*Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing*

**FOUNDATION INVESTIGATION REPORT
CULVERTS & CULVERT EXTENSIONS
HIGHWAY 406 TWINNING
PORT ROBINSON ROAD TO EAST MAIN STREET
AGREEMENT No. 2008-E-0016, W.P. 280-99-00
GEOCRES No. 30M3-269**

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TABLE OF CONTENTS

Part 1

1	INTRODUCTION.....	1
2	SITE DESCRIPTION & PHYSIOGRAPHY.....	2
3	SITE INVESTIGATION AND FIELD TESTING.....	2
4	LABORATORY TESTING.....	7
5	DESCRIPTION OF SUBSURFACE CONDITIONS.....	7
5.1	Culvert #2 (Hwy 406 Sta. 10+307).....	8
5.1.1	Topsoil.....	8
5.1.2	Fill – Sandy Gravel.....	8
5.1.3	Fill – Silty Clay.....	8
5.1.4	Silty Clay.....	9
5.1.5	Silty Clay Till.....	9
5.1.6	Water Levels.....	10
5.2	Culvert #5 (Hwy 406 Sta. 10+777).....	10
5.2.1	Topsoil.....	10
5.2.2	Fill – Sand and Gravel.....	10
5.2.3	Fill – Silty Clay.....	11
5.2.4	Silty Clay.....	11
5.2.5	Silty Clay Till.....	12
5.2.6	Water Levels.....	12
5.3	Culvert #6 (Highway 406 Sta. 11+499).....	13
5.3.1	Topsoil.....	13
5.3.2	Fill – Sand and Gravel.....	13
5.3.3	Fill – Silty Clay.....	13
5.3.4	Silty Clay.....	14
5.3.5	Silty Clay Till.....	15
5.3.6	Water Levels.....	15
5.4	Culvert #8 (Highway 406 Sta. 12+338).....	16
5.4.1	Topsoil.....	16
5.4.2	Fill – Silty Clay.....	16
5.4.3	Silty Clay.....	16
5.4.4	Silty Clay to Clayey Silt Till.....	17
5.4.5	Water Levels.....	18
5.5	Culvert #9 (Highway 406 Sta. 12+476).....	19
5.5.1	Topsoil & Peat.....	19
5.5.2	Fill – Silty Clay.....	19
5.5.3	Silty Clay.....	19
5.5.4	Clayey Silt to Silty Clay Till.....	20
5.5.5	Water Levels.....	21



5.6	Culvert #24 (Highway 406 Sta. 14+152).....	22
5.6.1	Silty Clay	22
5.6.2	Silt	23
5.6.3	Water Levels.....	23
5.7	Culvert #48 (Highway 406 Sta. 15+712).....	24
5.7.1	Topsoil.....	24
5.7.2	Fill – Gravelly Sand	24
5.7.3	Fill – Silt.....	24
5.7.4	Fill – Silty Clay	24
5.7.5	Silty Clay	25
5.7.6	Silt	26
5.7.7	Water Levels.....	27
5.8	Culvert #35 (Port Robinson Road Sta. 9+704)	27
5.8.1	Topsoil.....	27
5.8.2	Flexible Pavement	27
5.8.3	Fill – Sandy Gravel.....	28
5.8.4	Fill – Silty Sand	28
5.8.5	Fill – Silty Clay	28
5.8.6	Silty Clay	28
5.8.7	Silt	30
5.8.8	Clayey Silt	30
5.8.9	Water Levels.....	30
5.9	Culvert #49 (Highway 406 NBL Sta. 5+839).....	31
5.9.1	Topsoil.....	31
5.9.2	Flexible Pavement	31
5.9.3	Fill – Silty Clay	31
5.9.4	Silty Clay	32
5.9.5	Silt	33
5.9.6	Clayey Silt	33
5.9.7	Water Levels.....	34
5.10	Miscellaneous	34

Appendices

Culvert #2

Appendix A1 – Record of Borehole Sheets

Appendix B1 – Laboratory Test Results

Appendix C1 – Drawing titled “Borehole Locations and Soil Strata”

Culvert #5

Appendix A2 – Record of Borehole Sheets and Test Pit Logs

Appendix B2 – Laboratory Test Results

Appendix C2 – Drawing titled “Borehole Locations and Soil Strata”



Culvert #6

Appendix A3 – Record of Borehole Sheets and Test Pit Logs
Appendix B3 – Laboratory Test Results
Appendix C3 – Drawing titled “Borehole Locations and Soil Strata”

Culvert #8

Appendix A4 – Record of Borehole Sheets and Test Pit Logs
Appendix B4 – Laboratory Test Results
Appendix C4 – Drawing titled “Borehole Locations and Soil Strata”

Culvert #9

Appendix A5 – Record of Borehole Sheets and Test Pit Logs
Appendix B5 – Laboratory Test Results
Appendix C5 – Drawing titled “Borehole Locations and Soil Strata”

Culvert #24

Appendix A6 – Record of Borehole Sheets
Appendix B6 – Laboratory Test Results
Appendix C6 – Drawing titled “Borehole Locations and Soil Strata”

Culvert #48

Appendix A7 – Record of Borehole Sheets and Test Pit Logs
Appendix B7 – Laboratory Test Results
Appendix C7 – Drawing titled “Borehole Locations and Soil Strata”

Culvert #35

Appendix A8 – Record of Borehole Sheets and Test Pit Logs
Appendix B8 – Laboratory Test Results
Appendix C8 – Drawing titled “Borehole Locations and Soil Strata”

Culvert #49

Appendix A9 – Record of Borehole Sheets
Appendix B9 – Laboratory Test Results
Appendix C9 – Drawing titled “Borehole Locations and Soil Strata”



**FOUNDATION INVESTIGATION REPORT
CULVERTS & CULVERT EXTENSIONS
HIGHWAY 406 TWINNING**

ONTARIO

AGREEMENT No. 2008-E-0016, W.P. 280-99-00, SITE:

GEOCRES No. 30M3-269

PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from foundation investigations conducted at a number of sites on Highway 406 where either culvert extensions or replacements are required. The project area extends from East Main Street, City of Welland to about 1.0 km north of Port Robinson Road, City of Thorold, Ontario.

The purpose of this investigation was to explore the subsurface conditions at nine culvert sites and based on the data obtained, to provide borehole and test pit location plans, records of boreholes and test pits, stratigraphic profiles, laboratory test results and a description of the subsurface conditions. Models of the subsurface conditions were developed from the data obtained.

Terraprobe conducted the investigation as a sub-consultant to Giffels Associates Ltd./IBI Group, under the Ministry of Transportation Ontario (MTO) Agreement Number 2008-E-0016.

For reporting purposes the investigated sites are identified as:

- **Culvert #2:** Highway 406 - Sta. 10+307. An 800 mm diameter CSP culvert currently exists at this site.
- **Culvert #5:** Highway 406 - Sta. 10+777. A 1,850x1,250 RFB culvert is located at this site.
- **Culvert #6:** Highway 406 - Sta. 11+499. A 2,450x1,250 RFB culvert is located at this site.
- **Culvert #8:** Highway 406 - Sta. 12+338. A 3,050x1,850 RFB culvert is located at this site.
- **Culvert #9:** Highway 406 - Sta. 12+476. A 1,860x1,000 RFB culvert is located approximately 50 m north of this site.
- **Culvert #24:** Highway 406 - Sta. 14+152. A 2,000x1,250 RFB culvert is located at this site.
- **Culvert #48:** Highway 406 - Sta. 15+712. A 3,650x2,520 RFO culvert is located at this site.
- **Culvert #35:** Port Robinson Road - Sta. 9+704. Twin 2,500 mm CSP culverts currently exist at this site.
- **Culvert #49:** Highway 406 - Sta. 5+839. A 1,220x1,220 concrete culvert is located at this site.



2 SITE DESCRIPTION & PHYSIOGRAPHY

The south limit of the project is Sta. 10+000 located at the existing Highway 406 terminus at East Main Street in the City of Welland. The north limit is about Sta. 6+400 approximately 1.0 km north of Port Robinson Road in the City of Thorold. This approximately 6.5 km long route traverses across generally flat terrain and crosses Woodlawn Road, Merritt Road and Port Robinson Road. There is an at grade railway intersection (Trillium Railway) about 265 m south of Woodlawn Road. The alignment also crosses the Welland River and Old Welland Canal.

The project area is located between the Niagara Escarpment and Lake Erie in the physiographic region of Southern Ontario referred to as the Haldimand Clay Plain. The Haldimand Clay Plain is best described as falling into a series of parallel belts with the highest ground adjacent to the Escarpment. Generally this region is flat and poorly drained although it includes several distinctive landforms such as dunes, cobble, clay and sand beaches, limestone pavements and back-shore wetland basins¹.

The Niagara Region is underlain by a sequence of very gently south-dipping dolostones, limestones, shales and sandstones overlying Precambrian basement rock. The key elements in the bedrock geology of the region are the multiple layers of softer sedimentary limestones, shale, sandstone and dolostone.

The bedrock units within the project limits consist of the Salina Formation and Guelph Formation of Upper Silurian Age². The Salina Formation consists essentially of easily weathered, grey, very finely crystalline, laminated argillaceous dolostone with grey, calcareous shale partings and gypsum veins and lenses of varying thicknesses. The Guelph Formation consists essentially of unweathered, grey, laminated argillaceous dolostone.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing at the nine culvert sites are outlined below:

Culvert #2: Three boreholes numbered C2-1, C2-2 and C2-3, drilled and sampled to depths ranging from 12.7 m to 19.1 m during the period of June 21, 2010 to July 21, 2010. The approximate borehole locations are shown on the Borehole Locations and Soil Strata Drawing in Appendix C1.

Culvert #5: Two boreholes drilled and sampled to depths of 13.6 m and 14.1 m and one shallow test pit dug to a depth of 0.3 m during the period of June 17, 2010 to July 20, 2010. The boreholes were numbered C3-1 and C3-2 and the shallow test pit was numbered TP 3-1. Their approximate locations are shown on the Borehole Locations and Soil Strata drawing in Appendix C2.

¹ Chapman and Putnam, "The Physiography of South Ontario", 3rd Edition, 1984.

² Ontario Division of Mines, "Quaternary Geology Of The Welland Area", Preliminary Map P.796, 1972.



Culvert #6: Two boreholes (numbered C5-1 and C5-2) drilled and sampled to depths of 18.8 m and three shallow test pits (numbered TP 5-1, TP 5-2 and TP 5-3) dug to a depth of 0.3 m during the period of June 18, 2010 to July 05, 2010. A DCPT test was performed in Borehole C5-1 from 18.8 m to 19.4 m. The approximate borehole and test pit locations are shown on the Borehole Locations and Soil Strata drawing in Appendix C3.

Culvert #8: Four boreholes drilled and sampled to depths ranging from 12.7 m to 20.3 m and four shallow test pits dug to depths ranging from 1.2 m to 1.8 m during the period of November 12, 2009 to July 26, 2010. The boreholes were numbered C6-1, C6-2, S-EW 10+025Rt and WE-S 10+360Lt and the shallow test pits were numbered TP 6-1 to TP 6-4. Their approximate locations are shown on the Borehole Locations and Soil Strata drawing in Appendix C4.

Culvert #9: Four boreholes numbered C7-1 to C7-4 drilled and sampled to depths ranging from 12.6 m to 17.0 m and one shallow test pit (TP 7-1) dug to a depth of 1.2 m during the period of June 25, 2010 to July 07, 2010. The approximate borehole and test pit locations are shown on the Borehole Locations and Soil Strata drawing in Appendix C5.

Culvert #24: Two boreholes numbered C9-1 and C9-2 drilled and sampled to depths ranging from 12.7 m to 13.6 m during the period of November 17, 2009 to November 18, 2009. A DCPT test was performed in Borehole C9-2 from 13.6 m to 17.1 m. The approximate borehole locations are shown on the Borehole Locations and Soil Strata drawing in Appendix C6.

Culvert #48: Three boreholes drilled and sampled to depths ranging from 12.7 m to 23.4 m and two shallow test pits dug to depths ranging from 0.2 m to 0.6 m during the period of July 13, 2010 to July 14, 2010. The boreholes were numbered C10-1, C10-2 and C10-3 and the shallow test pits were numbered TP 10-1 and TP 10-2. Their approximate locations are shown on the Borehole Locations and Soil Strata drawing in Appendix C7.

Culvert #35: Three boreholes (numbered C11-1, C11-2 and C11-3) drilled and sampled to depths ranging from 18.8 m to 23.4 m and one shallow test pit (TP 11-1) dug to a depth of 0.3 m during the period of July 08, 2010 to July 16, 2010. Their approximate locations are shown on the Borehole Locations and Soil Strata drawing in Appendix C8.

Culvert #49: Three boreholes numbered C12-1, C12-2 and C12-3, drilled and sampled to depths ranging from 20.3 m to 21.8 m during the period of June 25, 2010 to July 15, 2010. The approximate borehole locations are shown on the Borehole Locations and Soil Strata drawing in Appendix C9.

The borehole locations were marked in the field by surveyors from Callon Dietz Inc. who also provided Terraprobe with their coordinates and geodetic elevations. Access to some borehole locations was difficult due to locally steep slopes and existing structures. These boreholes were therefore relocated to be as close as feasible to the staked out location while allowing safe operation of the drill rig. Utility clearances were obtained by Terraprobe prior to drilling.



Samples of the overburden soils were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT), as specified in ASTM Method D1586. In the cohesive (clayey) deposits the undrained shear strength of the soil was measured in-situ by means of field vane tests using an MTO type field vane. Relatively undisturbed soil samples were also collected with thin-walled Shelby Tube samplers.

In addition to the testing outlined above, Dynamic Cone Penetration Tests (DCPT) were conducted. This test consists of continuously driving into undisturbed ground a 50 mm diameter cone (60° vertex angle) attached to a drill rod, with a driving energy of 475 J per blow (63.5 kg hammer dropping freely a vertical distance of 0.76 m). The number of blows for each 300 mm of penetration is recorded and this provides an indication of the relative changes in the soil density/consistency with depth.

Ground water conditions in the open boreholes were observed throughout the drilling operations and standpipe piezometers consisting of 19 mm diameter PVC pipe with a slotted screen enclosed in sand were installed in selected boreholes to permit longer term ground water level monitoring. The remaining boreholes were abandoned in accordance with MOE Regulation 903 by sealing/grouting with a clay slurry mixture after drilling was complete.

The locations and completion details of the piezometers are provided in Tables 3.1 to 3.9.

Table 3.1 – Piezometer Installation Details

Piezometer Location	Piezometer Details (Culvert #2)	
	Tip Depth/ Elevation (m)	Completion Details
C2-1	9.9/173.4	Hole sealed with silty clay cuttings to 9.9 m, piezometer with 1.5 m slotted screen installed with filter sand to 7.8 m, bentonite seal from 7.8 m to 7.2 m, silty clay cuttings from 7.2 m to 0.6 m and bentonite seal from 0.6 m to ground surface with a flush mounted casing installation.
C2-3	12.2/169.4	Hole sealed to 12.2 m with bentonite, piezometer with 1.5 m slotted screen installed with filter sand to 10.1 m, bentonite seal from 10.1 m to 9.5 m, silty clay cuttings from 9.5 m to 0.6 m and bentonite seal from 0.6 m to ground surface.



Table 3.2 – Piezometer Installation Details

Piezometer Location	Piezometer Details (Culvert #5)	
	Tip Depth/ Elevation (m)	Completion Details
C3-1	12.2/171.0	Piezometer with 1.5 m slotted screen installed with filter sand to 10.4 m, bentonite seal from 10.4 m to 9.8 m, silty clay cuttings from 9.8 m to 0.6 m and bentonite seal from 0.6 m to ground surface with a flush mounted casing installation.
C3-2	13.7/170.1	Piezometer with 1.5 m slotted screen installed with filter sand to 11.6 m, bentonite seal from 11.6 m to 11.0 m, silty clay cuttings from 11.0 m to 0.6 m and bentonite seal from 0.6 m to ground surface.

Table 3.3 – Piezometer Installation Details

Piezometer Location	Piezometer Details (Culvert #6)	
	Tip Depth/ Elevation (m)	Completion Details
C5-1	18.3/172.1	Piezometer with 1.5 m slotted screen installed with filter sand to 16.4 m, bentonite seal from 16.4 m to 15.8 m, silty clay cuttings from 15.8 m to 0.6 m and bentonite seal from 0.6 m to ground surface with a flush mounted casing installation.
C5-2	15.2/172.0	Hole sealed to 15.2 m with bentonite, piezometer with 1.5 m slotted screen installed with filter sand to 13.1 m, bentonite seal from 13.1 m to 12.5 m, silty clay cuttings from 12.5 m to 0.6 m and bentonite seal from 0.6 m to ground surface.

Table 3.4 – Piezometer Installation Details

Piezometer Location	Piezometer Details (Culvert #8)	
	Tip Depth/ Elevation (m)	Completion Details
C6-1	9.1/170.1	Hole sealed to 9.1 m with bentonite, piezometer with 1.5 m slotted screen installed with filter sand to 7.0 m, bentonite seal from 7.0 m to 6.4 m, silty clay cuttings from 6.4 m to 0.6 m and bentonite seal from 0.6 m to ground surface.
C6-2	12.2/171.3	Hole sealed to 12.2 m with bentonite, piezometer with 1.5 m slotted screen installed with filter sand to 10.1 m, bentonite seal from 10.1 m to 9.5 m, silty clay cuttings from 9.5 m to 0.6 m and bentonite seal from 0.6 m to ground surface.
S-EW 10+025Rt	18.8/164.8	Piezometer with 3.0 m slotted screen installed with filter sand to 15.1 m, bentonite seal from 15.1 m to 14.5 m, silty clay cuttings from 14.5 m to 0.6 m and bentonite seal from 0.6 m to ground surface.
WE-S 10+360Lt	19.8/163.6	Piezometer with 3.0 m slotted screen installed with filter sand to 16.2 m, bentonite seal from 16.2 m to 15.5 m, silty clay cuttings from 15.5 m to 0.6 m and bentonite seal from 0.6 m to ground surface.



Table 3.5 – Piezometer Installation Details

Piezometer Location	Piezometer Details (Culvert #9)	
	Tip Depth/ Elevation (m)	Completion Details
C7-1	16.7/164.3	Piezometer with 1.5 m slotted screen installed with filter sand to 14.6 m, bentonite seal from 14.6 m to 14.0 m, silty clay cuttings from 14.0 m to 0.6 m and bentonite seal from 0.6 m to ground surface.
C7-2	13.7/167.8	Piezometer with 1.5 m slotted screen installed with filter sand to 11.6 m, bentonite seal from 11.6 m to 11.0 m, silty clay cuttings from 11.0 m to 0.6 m and bentonite seal from 0.6 m to ground surface.
C7-4	12.2/169.8	Piezometer with 1.5 m slotted screen installed with filter sand to 10.0 m, bentonite seal from 10.0 m to 9.4 m, silty clay cuttings from 9.4 m to 0.6 m and bentonite seal from 0.6 m to ground surface.

Table 3.6 – Piezometer Installation Details

Piezometer Location	Piezometer Details (Culvert #24)	
	Tip Depth/ Elevation (m)	Completion Details
C9-1	7.6/167.3	Hole sealed to 7.6 m with bentonite, piezometer with 1.5 m slotted screen installed with filter sand to 5.5 m, bentonite seal from 5.5 m to 4.6 m, silty clay cuttings from 4.6 m to 0.6 m and bentonite seal from 0.6 m to ground surface.
C9-2	12.1/163.9	Piezometer with 1.5 m slotted screen installed with filter sand to 10.0 m, bentonite seal from 10.0 m to 9.4 m, silty clay cuttings from 9.4 m to 0.6 m and bentonite seal from 0.6 m to ground surface.

Table 3.7 – Piezometer Installation Details

Piezometer Location	Piezometer Details (Culvert #48)	
	Tip Depth/ Elevation (m)	Completion Details
C10-1	10.7/166.4	Piezometer with 1.5 m slotted screen installed with filter sand to 8.5 m, bentonite seal from 8.5 m to 7.9 m, silty clay cuttings from 7.9 m to 0.6 m and bentonite seal from 0.6 m to ground surface.
C10-3	14.6/163.9	Piezometer with 1.5 m slotted screen installed with filter sand to 12.5 m, bentonite seal from 12.5 m to 11.9 m, silty clay cuttings from 11.9 m to 0.6 m and bentonite seal from 0.6 m to ground surface.



Table 3.8 – Piezometer Installation Details

Piezometer Location	Piezometer Details (Culvert #35)	
	Tip Depth/ Elevation (m)	Completion Details
C11-1	16.8/161.1	Hole sealed to 16.8 m with bentonite, piezometer with 1.5 m slotted screen installed with filter sand to 14.7 m, bentonite seal from 14.7 m to 14.1 m, silty clay cuttings from 14.1 m to 0.6 m and bentonite seal from 0.6 m to ground surface.
C11-3	17.2/161.9	Piezometer with 1.5 m slotted screen installed with filter sand to 15.1 m, bentonite seal from 15.1 m to 14.5 m, silty clay cuttings from 14.5 m to 0.6 m and bentonite seal from 0.6 m to ground surface.

Table 3.9 – Piezometer Installation Details

Piezometer Location	Piezometer Details (Culvert #49)	
	Tip Depth/ Elevation (m)	Completion Details
C12-2	15.2/164.6	Piezometer with 1.5 m slotted screen installed with filter sand to 13.1 m, bentonite seal from 13.1 m to 12.5 m, silty clay cuttings from 12.5 m to 0.6 m and bentonite seal from 0.6 m to ground surface.
C12-3	15.2/164.6	Piezometer with 1.5 m slotted screen installed with filter sand to 13.1 m, bentonite seal from 13.1 m to 12.5 m, silty clay cuttings from 12.5 m to 0.6 m and bentonite seal from 0.6 m to ground surface.

The drilling, sampling and in-situ testing operations were observed on a full time basis by members of Terraprobe’s technical staff who logged the boreholes and processed the recovered soil and rock samples for transport to Terraprobe’s Brampton laboratory for further examination and testing.

4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and natural moisture content determination. Select samples were also subjected to a laboratory testing programme consisting of gradation analysis and Atterberg Limits tests, consolidation tests, unit weight, and undrained shear strength testing with a laboratory vane. The results of this testing program are shown on the Record of Borehole sheets in Appendix A1 to A9 and the Figures in Appendix B1 to B9.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole Sheets and Test Pit Logs in Appendices A1 to A9. Details of the encountered soil stratigraphy are presented in these appendices and on the “Borehole Locations and Soil Strata” drawings in Appendices C1 to C9. An overall description of the stratigraphy at the culvert sites is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets and Test Pit Logs governs any interpretation of the site conditions.



5.1 Culvert #2 (Hwy 406 Sta. 10+307)

In general, the site is underlain by topsoil, fill material (sandy gravel and silty clay) and native overburden deposits of silty clay and silty clay till.

5.1.1 Topsoil

A 300 mm thick layer of topsoil was encountered at this site. Topsoil thickness may vary between and beyond the boreholes.

5.1.2 Fill – Sandy Gravel

Borehole C2-1 was advanced through the existing shoulder of Highway 406 where granular fill material consisting of sandy gravel was encountered. This fill extends to a depth of 1.4 m (Elev. ± 181.9 m) below ground surface.

The grain size distribution plot of a tested sample of this granular fill is depicted in Figure B1-1. The results show a grain size distribution consisting of 55% gravel, 34% sand, and 11% silt and clay size particles.

Standard Penetration tests in the granular fill gave ‘N’ values that ranged from 13 to 16 blows for 0.3 m penetration. Based on these results this fill is considered to have a compact relative density. The moisture content of samples of this fill ranged from 2% to 4% by weight.

5.1.3 Fill – Silty Clay

Silty clay fill material was encountered at this site extending to depths ranging from 0.7 m to 2.1 m below ground surface or to elevations of ± 181.2 m to ± 180.2 m.

A sample of the silty clay fill was subjected to a grain size distribution test and the results are presented in Figure B1-2. These results show a grain size distribution consisting of 0% gravel, 1% sand, 60% silt and 39% clay size particles.

A sample of the fill was also subjected to Atterberg Limits tests and the results are presented in Figure B1-3. The index values from these tests are summarized below:

Liquid Limit:	44%
Plastic Limit:	23%
Plasticity Index:	21%
Natural Moisture Content:	18%

These values are characteristic of clayey soils of intermediate plasticity.

Standard Penetration tests in the silty clay fill gave ‘N’ values that ranged from 3 to 19 blows for 0.3 m penetration. Based on these results the fill is considered to have a soft to very stiff consistency. The moisture content of samples of this fill ranged from 16% to 28% by weight.



5.1.4 Silty Clay

A silty clay deposit was encountered across the site extending to depths ranging from 8.6 m to 10.6 m below ground surface or to elevations ranging from ± 173.5 m to ± 171.0 m.

The grain size distribution curves of tested samples of the silty clay are presented in Figures B1-4 and B1-5. These results show a grain size distribution consisting of 0% gravel, 1-3% sand, 52-69% silt and 29-47% clay size particles.

Samples were also subjected to Atterberg Limits tests and the results are illustrated on the plasticity charts, Figures B1-6 and B1-7. The index values from these tests are summarized below:

Liquid Limit:	28-45%
Plastic Limit:	18-21%
Plasticity Index:	9-25%
Natural Moisture Content:	16-32%

These values indicate that the silty clay has a generally low to intermediate plasticity.

Standard Penetration tests in this stratum gave 'N' values that ranged from 5 to 42 blows for 0.3 m penetration and field vane tests gave in-situ undrained shear strengths ranging from 64 kPa to in excess of 120 kPa. These results indicate that the consistency of the silty clay is generally stiff to very stiff with occasional firm and hard zones. The moisture content of samples of the silty clay range from 16% to 32% by weight.

5.1.5 Silty Clay Till

A silty clay till deposit was encountered across this site extending to borehole termination depths ranging from 12.7 m (Elev. ± 169.0 m) to 19.1 m (Elev. ± 164.2 m) below ground surface.

The grain size distribution plot of a tested sample from this unit is depicted in Figure B1-8. The results show a grain size distribution consisting of 3% gravel, 18% sand, 54% silt and 25% clay size particles. Till soils will also contain random cobble and boulder inclusions and it is noted that auger refusal was encountered (probably on a boulder in this deposit) in Borehole C2-2 at depths of 10.5 m, 10.7 m and 10.8 m.

A sample was also subjected to Atterberg Limits tests and the results are plotted on the plasticity chart, Figure B1-9. The index values from these tests are summarized below:

Liquid Limit:	25%
Plastic Limit:	13%
Plasticity Index:	12%
Natural Moisture Content:	25%

These values are typical of clayey soils of low plasticity.

Standard Penetration tests in this stratum yielded 'N' values ranging widely from 1 to in excess of 100 blows per 0.3 m penetration and field vane tests performed in this deposit gave undrained shear strength ranging from 80 kPa to in excess of 120 kPa. Based on these results, the silty clay till is



considered to have a generally stiff to hard consistency with occasional soft zones. The moisture content of samples from this deposit varies from 13% to 25% by weight.

5.1.6 Water Levels

Standpipe piezometers were installed in selected boreholes. The water level readings measured on separate visits made after the completion of drilling are presented in Table 5.1.1.

Table 5.1.1 – Water Level Measurements

Borehole	Date	Water Levels	
		Depth (m)	Elevation (m)
C2-1	July 08, 2010	4.0	179.3
	July 13, 2010	3.7	179.6
	July 20, 2010	3.6	179.7
C2-3	July 28, 2010	5.9	175.7
	August 06, 2010	7.1	174.5
	August 13, 2010	6.5	175.1
	August 23, 2010	4.6	177.0
	September 25, 2010	7.4	174.2
	October 03, 2010	6.2	175.4
	October 14, 2010	6.6	175.0

The ground water table was estimated based on the recorded water levels in the standpipe piezometers and our review of moisture contents of the retrieved samples. This interpretation indicates a ground water table that is estimated to exist at about Elev. ±180.0 m. Perched water can also be expected to occur where permeable layers of sand and gravel are underlain by more impermeable silty clay soils.

All ground water observations at this site are short term and the levels are expected to fluctuate seasonally and after severe weather events. The ground water level will also be controlled by the free water level in the existing water course.

5.2 Culvert #5 (Hwy 406 Sta. 10+777)

In general, the site is underlain by topsoil, fill material (sand and gravel and silty clay) and native overburden deposits of silty clay and silty clay till.

5.2.1 Topsoil

A 100 mm thick layer of topsoil was encountered in Borehole C3-2 and Test Pit TP 3-1. Topsoil thickness may vary between and beyond the boreholes.

5.2.2 Fill – Sand and Gravel

Sand and gravel fill material was encountered in Borehole C3-1 which was drilled through the existing shoulder of Highway 406. This fill material extends to a depth of 1.4 m (Elev. ±181.8 m) below ground surface.

The grain size distribution curve of a tested sample of this fill is presented in Figure B2-1. The results show a grain size distribution consisting of 37% gravel, 46% sand, 13% silt and 4% clay size particles.



Standard Penetration tests in this fill gave 'N' values ranging from 27 to 33 blows for 0.3 m penetration, indicating a compact to dense relative density. The moisture content of samples of this fill was 5% by weight.

5.2.3 Fill – Silty Clay

Silty clay fill material was encountered at this site extending to depths of 2.1 m below ground surface or to elevations ranging from ± 181.7 m to ± 181.1 m.

Samples of the silty clay fill were subjected to grain size distribution tests and the results are presented in Figure B2-2. These results show grain size distributions consisting of 0-7% gravel, 5-13% sand, 40-46% silt and 40-49% clay size particles.

Samples of the fill were also subjected to Atterberg Limits tests and the results are presented in Figure B2-3. The index values from these tests are summarized below:

Liquid Limit:	42-49%
Plastic Limit:	20-24%
Plasticity Index:	22-25%
Natural Moisture Content:	17-24%

These values are characteristic of clayey soils of intermediate plasticity.

Standard Penetration tests in the silty clay fill gave 'N' values that ranged from 13 to 26 blows for 0.3 m penetration. Based on these results the fill is considered to have a stiff to very stiff consistency. The moisture content of samples of this fill ranged from 16% to 24% by weight.

5.2.4 Silty Clay

A silty clay deposit was encountered at this site extending to depths ranging from 9.4 m (Elev. ± 173.8 m) to 10.1 m (Elev. ± 173.7 m) below ground surface.

The grain size distribution plots of tested samples of the silty clay are presented in Figure B2-4. These results show a grain size distribution consisting of 0% gravel, 1-3% sand, 46-72% silt and 25-52% clay size particles.

Samples were also subjected to Atterberg Limits tests and the results are illustrated on the plasticity chart, Figure B2-5. The index values from these tests are summarized below:

Liquid Limit:	28-49%
Plastic Limit:	16-23%
Plasticity Index:	12-26%
Natural Moisture Content:	17-24%

These values indicate that the silty clay has a generally low to intermediate plasticity.



Standard Penetration tests in this stratum gave ‘N’ values that ranged from 11 to 28 blows for 0.3 m penetration and field vane tests gave in-situ undrained shear strengths ranging from 100 kPa to in excess of 120 kPa. These values indicate that the consistency of the silty clay is generally stiff to very stiff. Moisture content of samples of the silty clay ranged from 16% to 24% by weight.

5.2.5 Silty Clay Till

A deposit of silty clay till was encountered across this site extending to borehole termination depths ranging from 13.6 m (Elev. ±169.6 m) to 14.1 m (±169.7 m) below ground surface.

The results of a grain size distribution test conducted on a sample of silty clay till are shown in Figure B2-6. The curve shows a grain size distribution consisting of 6% gravel, 18% sand, 56% silt and 20% clay size particles. Till soils will also contain random cobble and boulder inclusions.

A sample of the silty clay till was also subjected to Atterberg Limits tests and the results are plotted on the plasticity chart, Figure B2-7. The summarized index values from these tests are presented herein.

Liquid Limit:	23%
Plastic Limit:	14%
Plasticity Index:	9%
Natural Moisture Content:	14%

These values are typical of clayey soils of low plasticity.

Standard Penetration tests in this stratum yielded ‘N’ values ranging from 11 to more than 100 blows for 0.3 m penetration and field vane tests performed in this deposit gave undrained shear strengths in excess of 120 kPa. Based on these results, the silty clay till is considered to have a stiff to hard consistency. The moisture content of samples from this deposit varies from 11% to 19% by weight.

5.2.6 Water Levels

The boreholes were instrumented with a standpipe piezometer. The water level readings measured on separate visits made after the completion of drilling are presented in Table 5.2.1.

Table 5.2.1 – Water Level Measurements

Borehole	Date	Water Levels	
		Depth (m)	Elevation (m)
C3-1	July 08, 2010	2.0	181.2
	July 14, 2010	1.9	181.3
	July 20, 2010	2.0	181.2
C3-2	July 28, 2010	5.6	178.2
	August 06, 2010	5.8	178.0

The ground water table was estimated based on the recorded water levels in the standpipe piezometers and our review of moisture contents of the retrieved samples. This interpretation indicates a ground water table that is estimated to exist at about Elev. ±181.0 m. Perched water can



also be expected to occur where relatively permeable soils are underlain by more impermeable silty clay soils.

All groundwater observations at this site are short term and the levels are expected to fluctuate seasonally and after severe weather events. The ground water level will also be controlled by the free water level in the existing water course.

5.3 Culvert #6 (Highway 406 Sta. 11+499)

In general, the site is underlain by topsoil, fill material (sand and gravel and silty clay) and native overburden deposits of silty clay and silty clay till.

Stereoscopic interpretations of 1970 air photos indicate that this section of Highway 406 was not yet constructed. The 1970 aerial photography show significant construction activity in this area and it appears that large quantities of excavated soil from the Welland Canal construction were being stockpiled at this site. The 1998 air photos show the current Highway 406 crossing this site and it would be reasonable to assume that the highway and culvert at this site are founded on fill material.

5.3.1 Topsoil

A 100 mm to 130 mm thick layer of topsoil was encountered at this site. Topsoil thickness may vary between and beyond the boreholes.

5.3.2 Fill – Sand and Gravel

Borehole C5-1 was extended through the existing shoulder of Highway 406 where it encountered a 610 mm thick layer of sand and gravel fill that extends to a depth of 0.6 m (Elev. ± 189.8 m) below ground surface.

The grain size distribution plot of a tested sample of this granular fill is depicted in Figure B3-1. The results show a grain size distribution consisting of 40% gravel, 41% sand, 14% silt and 5% clay size particles.

A Standard Penetration test in the granular fill gave an 'N' value of 22 blows for 0.3 m penetration indicating that the fill has a compact relative density. The moisture content of a sample of the fill was 6% by weight.

5.3.3 Fill – Silty Clay

Silty clay fill material was encountered at this site extending to depths ranging from 4.4 m (Elev. ± 182.8 m) to 7.1 m (Elev. ± 183.3 m) below ground surface.

The grain size distribution curve of a sample of this fill is shown in Figure B3-2. The results show a grain size distribution consisting of 0% gravel, 2% sand, 41% silt and 57% clay size particles.



A sample of the silty clay fill was also subjected to Atterberg Limits tests and the results are plotted on the plasticity chart in Figure B3-3. The summarized index values from these tests are presented below.

Liquid Limit:	50%
Plastic Limit:	24%
Plasticity Index:	26%
Natural Moisture Content:	21%

These values are characteristic of clayey soils of intermediate to high plasticity.

Standard Penetration tests in the silty clay fill gave 'N' values ranging from 9 to 45 blows for 0.3 m penetration. Based on these results the fill is considered to have a stiff to hard consistency. The moisture content of samples of this fill ranged from 10% to 32% by weight.

5.3.4 Silty Clay

A native silty clay stratum was encountered in both boreholes at this site. This deposit was fully penetrated in Borehole C5-2 where it extends to a depth of 16.8 m (Elev. ± 170.4 m) below ground surface. Borehole C5-1 was terminated in this deposit at a depth of 18.8 m (Elev. ± 171.6 m) below ground surface.

The grain size distribution curves of tested samples of the silty clay are presented in Figures B3-4 and B3-5. These results show a grain size distribution consisting of 0-3% gravel, 2-6% sand, 44-69% silt and 28-40% clay size particles. One tested sample from Borehole C5-2 at approximately 4.7 m depth (Elev. ± 182.5 m) contained 21% sand and was described as sandy.

Samples were also subjected to Atterberg Limits tests and the results are shown on the plasticity charts, Figures B3-6 and B3-7. The index values from these tests are summarized below:

Liquid Limit:	28-40%
Plastic Limit:	15-20%
Plasticity Index:	11-20%
Natural Moisture Content:	14-24%

These values indicate that the silty clay has a generally low to intermediate plasticity.

Standard Penetration tests in this deposit gave 'N' values that ranged from 2 to more than excess of 100 blows for 0.3 m penetration and field vane tests gave in-situ undrained shear strengths ranging from 20 kPa to in excess of 100 kPa. These results indicate that the consistency of the silty clay is generally firm to hard with occasional soft zones. The moisture content of samples from this deposit ranged from 14% to 24% by weight.



5.3.5 Silty Clay Till

Borehole C5-2 encountered a silty clay till deposit that extends to a borehole termination depth of 18.8 m (Elev. ±168.4 m) below ground surface.

The grain size distribution plot of a tested sample of the silty clay till is shown in Figure B3-8. The results show a grain size distribution consisting of 3% gravel, 16% sand, 49% silt and 32% clay size particles. Till soils will also contain random cobble and boulder inclusions.

One sample was also subjected to Atterberg Limits tests and the results are illustrated on the plasticity chart, Figure B3-9. The index values from these tests are presented herein.

Liquid Limit:	28%
Plastic Limit:	14%
Plasticity Index:	14%
Natural Moisture Content:	16%

These results are typical for low plasticity silty clay soils.

Standard Penetration tests in the silty clay till yielded ‘N’ values ranging from 50 to 52 blows for 0.3 m penetration indicating that the silty clay till has a hard consistency. Moisture contents of samples from this deposit ranged from 11% to 16% by weight.

5.3.6 Water Levels

Both boreholes were instrumented with a standpipe piezometer. The water level readings measured on separate visits made after drilling was complete are presented in Table 5.3.1.

Table 5.3.1 – Water Level Measurements

Borehole	Date	Water Levels	
		Depth (m)	Elevation (m)
C5-1	July 05, 2010	9.0	181.4
	July 14, 2010	4.9	185.5
	July 21, 2010	8.3	182.1
	July 28, 2010	8.6	181.8
C5-2	July 14, 2010	6.7	180.5
	July 21, 2010	6.3	180.9
	July 28, 2010	6.4	180.8

The ground water table was estimated based on the recorded water levels in the standpipe piezometers and our review of moisture contents of the retrieved samples. This interpretation indicates a ground water table that is estimated to exist at Elev. ±181.8 m. Perched water can also be expected to occur where relatively permeable soils are underlain by more impermeable silty clay soils.

All ground water observations at this site are short term and the levels are expected to fluctuate seasonally and after severe weather events. The ground water level will also be controlled by the free water level in the existing water course.



5.4 Culvert #8 (Highway 406 Sta. 12+338)

In general, the site is underlain by topsoil, silty clay fill, and native overburden deposits of silty clay and silty clay to clayey silt till.

5.4.1 Topsoil

Topsoil ranging from 50 mm to 200 mm in thickness was encountered at this site. Topsoil thickness may vary between and beyond the boreholes.

5.4.2 Fill – Silty Clay

Silty clay fill material was encountered at this site extending to depths ranging from 1.4 m (Elev. ± 182.1 m) to 4.4 m (Elev. ± 179.2 m) below ground surface.

Samples of the silty clay fill were subjected to grain size distribution tests and the results are presented in Figure B4-1. These results show a grain size distribution consisting of 0% gravel, 3-11% sand, 38-59% silt and 30-59% clay size particles.

Samples of the fill were also subjected to Atterberg Limits tests and the results are presented in Figure B4-2. The index values from these tests are summarized below:

Liquid Limit:	26-57%
Plastic Limit:	14-26%
Plasticity Index:	12-31%
Natural Moisture Content:	9-20%

These values indicate a silty clay fill with low to high plasticity.

Standard Penetration tests in the fill gave 'N' values ranging from 8 to 93 blows for 0.3 m penetration. Based on these results the fill is considered to have a stiff to hard consistency. The moisture content of samples of this fill ranged from 8% to 26% by weight.

5.4.3 Silty Clay

A major silty clay deposit was encountered across the site extending to depths ranging from 10.1 m (Elev. ± 169.1 m) to 16.2 m (Elev. ± 167.3 m) below ground surface.

The grain size distribution plots of tested samples of the silty clay are presented in Figures B4-3 to B4-5 inclusive. These results show a grain size distribution consisting of 0-2% gravel, 0-4% sand, 59-87% silt and 13-38% clay size particles.

Samples were also subjected to Atterberg Limits tests and the results are illustrated on the plasticity charts, Figures B4-6 to B4-8 inclusive. The index values from these tests are summarized below:

Liquid Limit:	24-37%
Plastic Limit:	16-20%
Plasticity Index:	6-17%
Natural Moisture Content:	17-22%



These values indicate that the silty clay has a generally low to intermediate plasticity with infrequent zones of low plasticity clayey silt.

The Atterberg Limits test results are plotted against elevation, Figure B4-11. These results illustrate that the natural moisture contents are generally at or below the plastic limit down to about Elev. ±177.5 m. Below Elev. ±177.5 m the data indicates that the moisture content values generally exist between the plastic and liquid limits.

Standard Penetration tests in this stratum gave ‘N’ values that ranged from 8 to 36 blows for 0.3 m penetration. Field vane tests gave in-situ undrained shear strengths ranging from 72 kPa to in excess of 120 kPa and a laboratory vane test on a relatively undisturbed Shelby tube sample gave an undrained shear strength of 78 kPa. These values indicate that the consistency of the silty clay is generally stiff to hard. The moisture content of samples of the silty clay ranged from 11% to 23% by weight and the unit weight of a tested sample was 21.0 kN/m³.

The variation of undrained shear strength with elevation is depicted in Figure B4-12. The plot illustrates a wide scatter in the data with no obvious trend with depth and an interpreted dashed line is shown representing a lower bound trend with depth for the data. The upper portion of this deposit down to about Elev. ±178.0 m is estimated to have relatively high shear strength i.e. in excess of 100 kPa. Below Elev. ±178.0 m the undrained shear strength decreases with depth and is about 75 kPa from Elev. ±173.0 m to Elev. ±171.0 m. Below Elev. ±171.0 m the trend indicates increasing undrained shear strength with depth.

Consolidation tests were also performed on Shelby tube samples retrieved from Boreholes SEW 10+025Rt and WES 10+360Lt and the results are presented in Figures B4-13 to B4-18 inclusive. Preconsolidation pressures were estimated from the e-log p curves. Due to the rounded nature of the curves the preconsolidation pressures were also assessed based on the ‘Work’ – method proposed by Becker et al. (1987). The details of the test results are summarized below.

Borehole/Sample No.	Sample Depth/Elevation (m)	P _c (kPa)	C _c	C _r	e _o
S-EW 10+025Rt TW12	12.2/171.4	310 – 400	0.119	0.013	0.47
WE-S 10+360Lt TW11	12.2/171.2	220 – 260	0.157	0.029	0.59

Where: P_c = Preconsolidation pressure
C_c = Compression index
C_r = Recompression index
e_o = Initial void ratio

5.4.4 Silty Clay to Clayey Silt Till

A deposit of silty clay to clayey silt till was encountered across this site. All of the boreholes were terminated within this deposit at depths ranging from 12.7 m to 20.3 m below ground surface or to elevations ranging from ±167.8 m to ±163.1 m.

The grain size distribution curves of samples of the silty clay to clayey silt till are presented in Figure B4-9. These results show grain size distributions consisting of 2-15% gravel, 13-34% sand, 38-58% silt and 13-27% clay size particles.



Samples were also subjected to Atterberg Limits tests and the results are illustrated on the plasticity chart, Figure B4-10. The index values from these tests are summarized below:

Liquid Limit:	17-25%
Plastic Limit:	11-14%
Plasticity Index:	5-11%
Natural Moisture Content:	7-18%

These values are characteristic of clayey soils of low plasticity.

Standard Penetration tests in this stratum gave ‘N’ values that ranged from 37 to in excess of 100 blows for 0.3 m penetration and a field vane test gave an in-situ undrained shear strength of 104 kPa. Based on these values the silty clay to clayey silt till is considered to have a very stiff to hard consistency. The moisture content of samples from this deposit ranged from 7% to 18% by weight.

5.4.5 Water Levels

A standpipe piezometer was installed in selected boreholes. The water level readings measured on separate visits made after the completion of drilling are presented in Table 5.4.1.

Table 5.4.1 – Water Level Measurements

Borehole	Date	Water Levels	
		Depth (m)	Elevation (m)
C6-1	July 28, 2010	Dry	Dry
	August 06, 2010	4.7	174.5
	August 13, 2010	2.5	176.7
	August 23, 2010	2.0	177.2
	September 25, 2010	2.0	177.2
C6-2	July 28, 2010	4.1	179.4
	August 06, 2010	1.8	181.7
	August 13, 2010	3.6	179.9
	August 23, 2010	4.1	179.4
	September 25, 2010	4.1	179.4
S-EW 10+025Rt	December 08, 2009	17.7	165.9
	December 15, 2009	16.1	167.5
	January 04, 2010	5.0	178.6
	January 11, 2010	3.9	179.7
	January 19, 2010	4.0	179.6
WE-S 10+360Lt	November 20, 2009	6.3	177.1
	November 30, 2009	7.7	175.7
	December 15, 2009	5.9	177.5
	January 04, 2010	5.7	177.7
	January 11, 2010	5.5	177.9

The ground water table was estimated based on the recorded water levels in the standpipe piezometers and our review of moisture contents of the retrieved samples. This interpretation indicates a ground water table that is estimated to exist at Elev. ±179.5 m. Perched water can also be expected to occur where permeable layers of sand and gravel and sand and silts are underlain by more impermeable silty clay soils.



All groundwater observations at this site are short term and the levels are expected to fluctuate seasonally and after severe weather events. The ground water level will also be controlled by the free water level in the existing water course.

5.5 Culvert #9 (Highway 406 Sta. 12+476)

In general, the site is underlain by topsoil and peat, silty clay fill, and native overburden deposits of silty clay and clayey silt to silty clay till.

5.5.1 Topsoil & Peat

Topsoil ranging from 80 mm to 130 mm in thickness was encountered at this site. Topsoil thickness may vary between and beyond the boreholes.

A surficial peat deposit ranging from 200 mm to 230 mm in thickness was encountered in Borehole C7-4 and in Test Pit TP 7-1. This material will be encountered at the east end of the proposed culvert alignment (below the culvert footprint), a horizontal distance of about ± 32.0 m extending westerly from the culvert outlet.

5.5.2 Fill – Silty Clay

Silty clay fill material was encountered in Borehole C7-2 extending to a depth of 0.7 m (Elev. ± 180.8 m) below ground surface.

A sample of this fill material was subjected to a grain size distribution test and the results are presented in Figure B5-1. These results show a grain size distribution consisting of 0% gravel, 6% sand, 57% silt and 37% clay size particles. An Atterberg Limits test was not performed on this sample because of limited sample recovery.

A Standard Penetration test in the silty clay fill gave an 'N' value of 11 blows for 0.3 m penetration. Based on this result the fill is considered to have a stiff consistency. The moisture content of a sample of this fill was 15% by weight.

5.5.3 Silty Clay

A silty clay deposit was encountered across the site extending to depths ranging from 12.3 m (Elev. ± 169.7 m) to 14.0 m (Elev. ± 167.0 m) below ground surface.

The grain size distribution plots of tested samples of the silty clay are presented in Figures B5-2 and B5-3. These results show a grain size distribution consisting of 0-1% gravel, 1-3% sand, 42-79% silt and 20-57% clay size particles.

Samples were also subjected to Atterberg Limits tests and the results are illustrated on the plasticity charts, Figures B5-4 and B5-5. The index values from these tests are summarized below:

Liquid Limit:	26-50%
Plastic Limit:	17-23%
Plasticity Index:	8-27%
Natural Moisture Content:	16-24%



These values indicate that the silty clay has a generally low to intermediate plasticity.

The Atterberg Limits test results are plotted against elevation, Figure B5-8. These results illustrate that the natural moisture contents are generally at or below the plastic limit down to about Elev. ±177.0 m. Below Elev. ±177.0 m the data indicates that the moisture contents generally exist between the plastic and liquid limits.

Standard Penetration tests in this stratum gave ‘N’ values that ranged from 10 to 71 blows for 0.3 m penetration and field vane tests gave in-situ undrained shear strengths ranging from 64 kPa to in excess of 120 kPa. A laboratory vane test on a relatively undisturbed Shelby tube sample gave an undrained shear strength of 103 kPa. These values indicate that the consistency of the silty clay is generally stiff to hard. The moisture content of samples of the silty clay ranged from 14% to 44% by weight and the unit weight of a tested sample was 21.0 kN/m³.

The variation of undrained shear strength with elevation is depicted in Figure B5-9. The plot illustrates a wide scatter in the data with no obvious trend with depth and an interpreted dashed line is shown representing a lower bound trend with depth for the data. The upper portion of this deposit down to about Elev. ±177.0 m is estimated to have relatively high shear strength i.e. in excess of 100 kPa. Below Elev. ±177.0 m the undrained shear strength decreases with depth and is about 60 kPa from Elev. ±172.0 m to Elev. ±171.0 m. Below Elev. ±171.0 m the trend indicates increasing undrained shear strength with depth.

Consolidation tests were also performed on a Shelby tube sample retrieved from Borehole C7-2 and the results are presented in Figures B5-10 to B5-12 inclusive. The preconsolidation pressure was estimated from the e-log p curve. Due to the rounded nature of the curve the preconsolidation pressure was also assessed based on the ‘Work’ – method proposed by Becker et al. (1987). The details of the test results are summarized below.

Borehole/Sample No.	Sample Depth/Elevation (m)	P _c (kPa)	C _c	C _r	e _o
C7-2 TW8	6.1/175.4	310 – 600	0.291	0.030	0.52

Where: P_c = Preconsolidation pressure
C_c = Compression index
C_r = Recompression index
e_o = Initial void ratio

5.5.4 Clayey Silt to Silty Clay Till

Clayey silt to silty clay till was encountered across this site extending to borehole termination depths ranging from 12.6 m (Elev. ±169.4 m) to 17.0 m (Elev. ±164.0 m) below ground surface.

The grain size distribution plots of tested samples of the clayey silt to silty clay till are presented in Figure B5-6. These results show grain size distributions consisting of 0-8% gravel, 2-26% sand, 49-78% silt and 17-20% clay size particles.



Samples were also subjected to Atterberg Limits tests and the results are illustrated on the plasticity chart, Figure B5-7. The index values from these tests are summarized below:

Liquid Limit:	20-26%
Plastic Limit:	12-18%
Plasticity Index:	7-8%
Natural Moisture Content:	10-18%

These values are characteristic of clayey soils of low plasticity.

Standard Penetration tests in this stratum gave ‘N’ values that ranged from 17 to in excess of 100 blows for 0.3 m penetration. Based on these results the till is considered to have a very stiff to hard consistency. The moisture content of samples from this deposit ranged from 7% to 18% by weight.

5.5.5 Water Levels

A standpipe piezometer was installed in selected boreholes. The water level readings measured on separate visits made after the completion of drilling are presented in Table 5.5.1.

Table 5.5.1 – Water Level Measurements

Borehole	Date	Water Levels	
		Depth (m)	Elevation (m)
C7-1	July 05, 2010	5.5	175.5
	July 13, 2010	4.2	176.8
	July 19, 2010	4.1	176.9
C7-2	July 05, 2010	6.4	175.1
	July 13, 2010	2.5	179.0
	July 19, 2010	3.0	178.5
	July 28, 2010	2.8	178.7
C7-4	July 12, 2010	3.6	178.4
	July 19, 2010	2.3	179.7
	July 27, 2010	2.3	179.7

The ground water table was estimated based on the recorded water levels in the standpipe piezometers and our review of moisture contents of the retrieved samples. This interpretation indicates a phreatic surface that is estimated exist at about Elev. ±179.7 m at the east end of the site falling gradually to Elev. ±176.9 m at the west end of the site. Perched water can also be expected to occur where permeable layers of sand and gravel and sand and silts are underlain by more impermeable silty clay soils.

All groundwater observations at this site are short term and the levels are expected to fluctuate seasonally and after severe weather events. The ground water level will also be controlled by the free water level in the existing water course.



5.6 Culvert #24 (Highway 406 Sta. 14+152)

In general, the site is underlain by native overburden deposits of silty clay and silt.

5.6.1 Silty Clay

A silty clay deposit was encountered across this site. Both boreholes were terminated within this stratum at depths of 12.7 m (Elev. ± 162.2 m) and 13.6 m (Elev. ± 162.4 m) below ground surface.

The grain size distribution plots of tested samples of the silty clay are presented in Figures B6-1 and B6-2. These results show a grain size distribution consisting of 0-1% gravel, 0-5% sand, 43-76% silt and 22-56% clay size particles.

Samples were also subjected to Atterberg Limits tests and the results are illustrated on the plasticity charts, Figures B6-3 and B6-4. The index values from these tests are summarized below:

Liquid Limit:	25-52%
Plastic Limit:	16-24%
Plasticity Index:	7-28%
Natural Moisture Content:	19-24%

These values indicate that the silty clay has a generally low plasticity with occasional intermediate and highly plastic clayey inclusions.

The Atterberg Limits test results are plotted against elevation, Figure B6-6. These results illustrate that the natural moisture contents are generally at or below the plastic limit down to about Elev. ± 170.0 m. Below Elev. ± 170.0 m the data indicates that the moisture contents generally exist between the plastic and liquid limits.

Standard Penetration tests in this stratum gave 'N' values that ranged from 2 to 22 blows for 0.3 m penetration. Field vane tests gave in-situ undrained shear strengths ranging from 36 kPa to in excess of 120 kPa and a laboratory vane test on a relatively undisturbed Shelby tube sample gave an undrained shear strength of 52 kPa. These values indicate that the consistency of the silty clay is generally firm to very stiff. The moisture content of samples from this stratum ranged from 16% to 26% by weight and the unit weight of a tested sample was 20.6 kN/m³.

The variation of undrained shear strength with elevation is depicted in Figure B6-7. The plot shows an interpreted dashed line that represents a lower bound trend with depth for the data. At Elev. ± 171.0 m the estimated shear strength is about 30 kPa and the trend indicates increasing shear strength with depth.

A consolidation test was performed on a Shelby tube sample retrieved from Borehole C9-1 and the results are presented in Figures B6-8 to B6-10 inclusive. The preconsolidation pressure was estimated from the e-log p curve. Due to the rounded nature of the curve the preconsolidation pressure was also assessed based on the 'Work' – method proposed by Becker et al. (1987). The details of the test results are summarized below.



Borehole/Sample No.	Sample Depth/Elevation (m)	P _c (kPa)	C _c	C _r	e _o
C9-1 TW7	6.1/168.8	170 – 280	0.158	0.027	0.58

Where: P_c = Preconsolidation pressure
C_c = Compression index
C_r = Recompression index
e_o = Initial void ratio

5.6.2 Silt

The silty clay stratum is divided by a 0.4 m to 2.0 m thick layer of silt that extends to depths ranging from 2.1 m (Elev. ±172.8 m) to 4.1 m (Elev. ±171.9 m) below ground surface.

The grain size distribution plot of a tested sample of the silt is presented in Figure B6-5. The result shows a grain size distribution consisting of 0% gravel, 3% sand, 82% silt and 15% clay size particles.

Standard Penetration tests in this deposit gave ‘N’ values that ranged from 7 to 20 blows per 0.3 m penetration. Based on these results the deposit is considered to have a loose to compact relative density. The moisture content of samples from this soil ranged from 16% to 23% by weight.

5.6.3 Water Levels

Standpipe piezometers were installed in both of the boreholes at this site and water level readings were taken on separate visits made after the completion of drilling. The water level records are presented in Table 5.6.1.

Table 5.6.1 – Water Level Measurements

Borehole	Date	Water Levels	
		Depth (m)	Elevation (m)
C9-1	November 30, 2009	3.0	171.9
	December 08, 2009	2.1	172.8
	January 04, 2010	0.4	174.5
	January 11, 2010	0.6	174.3
	January 14, 2010	0.5	174.4
C9-2	November 30, 2009	3.9	172.1
	December 08, 2009	3.4	172.6
	January 04, 2010	1.7	174.3
	January 11, 2010	1.7	174.3
	January 14, 2010	1.5	174.5

The ground water table was estimated based on the recorded water levels in the standpipe piezometers and our review of moisture contents of the retrieved samples. This interpretation indicates that the local ground water level at this site exists at Elev. ±174.5 m. Perched water can also be expected to occur where relatively permeable soils are underlain by more impermeable soils.



All ground water observations at this site are short term and the levels are expected to fluctuate seasonally and after severe weather events. The ground water level will also be controlled by the free water level in the existing water course.

5.7 Culvert #48 (Highway 406 Sta. 15+712)

In general, the site is underlain by topsoil, fill material (gravelly sand, silt and silty clay), and native overburden deposits of silty clay and silt.

5.7.1 Topsoil

An approximately 230 mm thick layer of topsoil was encountered at this site. Topsoil thickness may vary between and beyond the boreholes.

5.7.2 Fill – Gravelly Sand

Borehole C10-2 was advanced through the existing shoulder of Highway 406 where granular fill material consisting of gravelly sand was encountered. This fill extends to a depth of 0.7 m (Elev. ± 181.0 m) below ground surface.

The grain size distribution plot of a tested sample of this granular fill is depicted in Figure B7-1. These results show a grain size distribution consisting of 26% gravel, 56% sand, 14% silt and 4% clay size particles.

A Standard Penetration test in the granular fill gave an 'N' value of 17 blows for 0.3 m penetration. Based on this result the fill is considered to have a compact relative density. The moisture content of a sample of this fill was 6% by weight.

5.7.3 Fill – Silt

Test Pits TP 10-1 and TP 10-2 encountered a surficial layer of fill material consisting of a mixture of silt with some organics. This fill is approximately 200 mm to 300 mm thick.

5.7.4 Fill – Silty Clay

Silty clay fill was encountered extending to depths ranging from 2.1 m to 5.6 m below ground surface or to elevations ranging from ± 176.4 m to ± 176.1 m.

A sample of the silty clay fill was subjected to a grain size distribution test and the results are presented in Figure B7-2. These results show a grain size distribution consisting of 0% gravel, 3% sand, 57% silt and 40% clay size particles.

A sample of this fill was also subjected to Atterberg Limits tests and the results are presented in Figure B7-3. The index values from these tests are summarized below:

Liquid Limit:	37%
Plastic Limit:	20%
Plasticity Index:	17%
Natural Moisture Content:	28%



These values indicate that the silty clay fill is of intermediate plasticity.

Standard Penetration tests in this layer gave 'N' values ranging from 3 to 14 blows for 0.3 m penetration. Based on these results the fill is considered to have a soft to stiff consistency. The moisture content of samples of this fill ranged from 18% to 38% by weight.

5.7.5 Silty Clay

Discontinuous deposits of native silty clay were encountered across this site. An upper silty clay stratum was fully explored in all of the boreholes where it was found to extend to depths ranging from 10.5 m to 16.2 m below ground surface or to elevations ranging from ± 166.6 m to ± 165.3 m. A lower silty clay deposit was encountered in Boreholes C10-2 and C10-3 extending to borehole termination depths of 17.3 m (Elev. ± 161.2 m) and 23.4 m (Elev. ± 158.3 m) below ground surface. The upper and lower silty clay deposits are divided by layers of silt.

The grain size distribution plots of tested samples of the silty clay are presented in Figures B7-4 and B7-5. These results show a grain size distribution consisting of 0% gravel, 0-8% sand, 30-82% silt and 18-42% clay size particles. One tested sample from Borehole C10-1 contained 41% sand and was described as sandy.

Samples were also subjected to Atterberg Limits tests and the results are illustrated on the plasticity charts, Figures B7-6 and B7-7. The index values from these tests are summarized below:

Liquid Limit:	22-42%
Plastic Limit:	15-20%
Plasticity Index:	7-23%
Natural Moisture Content:	17-30%

These values indicate that the silty clay has a generally low to intermediate plasticity.

The Atterberg Limits test results (upper silty clay deposit) are plotted against elevation, Figure B7-9. These results illustrate that the natural moisture contents are generally at or close to the plastic limit down to about Elev. ± 175.0 m. Below Elev. ± 175.0 m the data generally indicates a trend of increasing moisture content with depth with values plotting between the plastic and liquid limits.

Standard Penetration tests in the upper silty clay gave 'N' values that ranged widely from 0 to 31 blows for 0.3 m penetration and field vane tests gave in-situ undrained shear strengths ranging from 32 kPa to in excess of 100 kPa. A laboratory vane test on a relatively undisturbed Shelby tube sample gave an undrained shear strength of 32 kPa. These values indicate that the consistency of the upper silty clay is generally firm to hard. The moisture content of samples of the upper silty clay ranged from 19% to 39% by weight and the unit weight of a tested sample was 20.7 kN/m^3 .

The variation of undrained shear strength with elevation (upper silty clay) is depicted in Figure B7-10. The plot illustrates a wide scatter in the data with no obvious trend with depth and an interpreted dashed line is shown representing a lower bound trend with depth for the data. The upper portion of this deposit down to about Elev. ± 171.0 m is estimated to have relatively high



shear strength i.e. in excess of 100 kPa. Below Elev. ±171.0 m the undrained shear strength decreases with depth and is about 30 kPa from Elev. ±169.5 m to Elev. ±168.5 m. Below Elev. ±168.5 m the trend indicates increasing undrained shear strength with depth.

Standard Penetration tests in the lower silty clay gave ‘N’ values that ranged from 8 to 33 blows for 0.3 m penetration indicating a stiff to hard consistency. The moisture content of samples of the lower silty clay ranged from 17% to 22% by weight.

A consolidation test was also performed on a Shelby tube sample retrieved from Borehole C10-1 and the results are presented in Figures B7-11 to B7-13 inclusive. The preconsolidation pressure was estimated from the e-log p curve and due to the rounded nature of the curve the preconsolidation pressure was also assessed based on the ‘Work’ – method proposed by Becker et al. (1987). The details of the test results are summarized below.

Borehole/Sample No.	Sample Depth/Elevation (m)	P _c (kPa)	C _c	C _r	e _o
C10-1 TW10	9.1/168.0	210 – 300	0.323	0.034	0.84

Where: P_c = Preconsolidation pressure
C_c = Compression index
C_r = Recompression index
e_o = Initial void ratio

5.7.6 Silt

Discontinuous silt deposits were encountered across this site. In Boreholes C10-2 and C10-3 a ±3.0 m thick layer of silt was encountered extending to depths of 16.2 m (Elev. ±162.3 m) and 19.2 m (Elev. ±162.5 m) below ground surface. Borehole C10-1 was terminated within this silt layer at a depth of 12.7 m (Elev. ±164.4 m) below ground surface. A ±1.2 m thick silt layer was also encountered in Borehole C10-1 extending to a depth of 5.6 m (Elev. ±171.5 m).

The grain size distribution plots of tested samples from these silt deposits are presented in Figure B7-8. The results show a grain size distribution consisting of 0% gravel, 0-3% sand, 78-89% silt and 11-19% clay size particles. Based on visual and tactile examinations of the retrieved samples, the units are essentially cohesionless silts with frequent cohesive silty clay seams and partings.

Standard Penetration tests in these deposits gave ‘N’ values that ranged from 0 to 37 blows for 0.3 m penetration. Based on these results the deposit is considered to have a very loose to dense relative density. The moisture content of samples from this soil ranged from 19% to 26% by weight.



5.7.7 Water Levels

A standpipe piezometer was installed in selected boreholes. The water level readings measured on separate visits made after the completion of drilling are presented in Table 5.7.1.

Table 5.7.1 – Water Level Measurements

Borehole	Date	Water Levels	
		Depth (m)	Elevation (m)
C10-1	July 19, 2010	0.1	177.0
	August 06, 2010	0.0	177.1
	August 13, 2010	0.0	177.1
	August 23, 2010	0.0	177.1
C10-3	July 20, 2010	1.5	177.0
	July 27, 2010	1.1	177.4
	August 06, 2010	1.1	177.4

The ground water table was estimated based on the recorded water levels in the standpipe piezometers and our review of moisture contents of the retrieved samples. This interpretation indicates a ground water table that is estimated to exist at an elevation of ±177.4 m. Perched water can also be expected to occur where permeable layers of gravelly sand and sand and silts are underlain by more impermeable silty clay soils.

All groundwater observations at this site are short term and the levels are expected to fluctuate seasonally and after severe weather events. The ground water level will also be controlled by the free water level in the existing water course.

5.8 Culvert #35 (Port Robinson Road Sta. 9+704)

In general, the site is underlain by topsoil, a flexible pavement, fill material (sandy gravel, silty sand and silty clay) and native overburden deposits of silty clay, silt and clayey silt.

5.8.1 Topsoil

Topsoil ranging in thickness from 150 mm to 180 mm was encountered. Topsoil thickness may vary between and beyond the boreholes.

5.8.2 Flexible Pavement

A flexible pavement structure consisting of 110 mm of asphalt and 410 mm of gravelly sand was encountered in Borehole C11-2.

The grain size distribution plot of a tested sample of the granular fill is depicted in Figure B8-1. The result shows a grain size distribution consisting of 26% gravel, 58% sand, and 16% silt and clay size particles.

A Standard Penetration test in this fill gave an ‘N’ value of 83 blows for 0.3 m penetration indicating a very dense relative density. The moisture content of a sample of this fill was 5% by weight.



5.8.3 Fill – Sandy Gravel

A layer of sandy gravel fill was encountered in Borehole C11-1 extending to a depth of 2.1 m (Elev. ± 175.8 m) below ground surface.

A Standard Penetration test in this fill gave an 'N' value of 100 blows for less than 0.3 m penetration. Based on this result the fill is considered to have a very dense relative density. The moisture content of a sample of this fill was 10% by weight.

5.8.4 Fill – Silty Sand

Fill material consisting of silty sand with some organics was encountered in Test Pit TP 11-1 dug near the outlet of the existing culvert. This fill material is approximately 180 mm thick.

5.8.5 Fill – Silty Clay

Silty clay fill was encountered in all of the boreholes extending to depths ranging from 0.7 m to 2.1 m below ground surface or to elevations ranging from ± 178.4 m to ± 176.7 m.

The grain size distribution curves of two representative samples from this fill are shown in Figure B8-2. The results show grain size distributions consisting of 4-28% gravel, 6-21% sand, 25-44% silt and 26-46% clay size particles.

Samples of the silty clay fill were also subjected to Atterberg Limits testing and the results are plotted on the plasticity chart in Figure B8-3. The summarized index values from these tests are presented below.

Liquid Limit:	37-47%
Plastic Limit:	18-23%
Plasticity Index:	19-24%
Natural Moisture Content:	15-18%

These values are characteristic of clayey soils of intermediate plasticity.

Standard Penetration tests in this fill gave 'N' values ranging from 5 to in excess of 100 blows for 0.3 m penetration. Based on these results the fill is considered to have a firm to hard consistency. The moisture content of samples of this fill ranged from 15% to 27% by weight.

5.8.6 Silty Clay

A silty clay stratum was encountered across the site. This deposit extends to depths ranging from 14.0 m to 15.5 m below ground surface or to elevations ranging from ± 164.3 m to ± 163.6 m.

The grain size distribution plots of tested samples of the silty clay are presented in Figures B8-4 and B8-5. These results show a grain size distribution consisting of 0% gravel, 0-5% sand, 49-68% silt and 31-50% clay size particles.



Samples were also subjected to Atterberg Limits tests and the results are illustrated on the plasticity charts, Figures B8-6 and B8-7. The index values from these tests are summarized below:

Liquid Limit:	29-42%
Plastic Limit:	15-22%
Plasticity Index:	13-23%
Natural Moisture Content:	19-32%

These values indicate that the silty clay has a generally low to intermediate plasticity.

The Atterberg Limits test results are plotted against elevation, Figure B8-11. These results illustrate that the natural moisture contents are generally at or close to the plastic limit down to about Elev. ±175.0 m. Below Elev. ±175.0 m the data generally indicates a trend of increasing moisture content with depth with values generally plotting between the plastic and liquid limits.

Standard Penetration tests in this stratum gave ‘N’ values that ranged widely from 0 to 55 blows for 0.3 m penetration. Field vane tests gave in-situ undrained shear strengths ranging from 28 kPa to in excess of 120 kPa and a laboratory vane test on a relatively undisturbed Shelby tube sample gave an undrained shear strength of 42 kPa. These values indicate that the consistency of the silty clay is generally firm to hard. The moisture content of samples from this stratum ranged from 19% to 46% by weight and the unit weight of a tested sample was 20.8 kN/m³.

The variation of undrained shear strength with elevation is depicted in Figure B8-12. An interpreted dashed line representing a lower bound trend with depth for the data is shown on this plot. The upper portion of this deposit down to about Elev. ±171.0 m is estimated to have relatively high shear strength i.e. in excess of 100 kPa. Below Elev. ±171.0 m the undrained shear strength decreases with depth and is about 35 kPa from Elev. ±168.0 m to Elev. ±167.0 m. Below Elev. ±167.0 m the trend indicates increasing undrained shear strength with depth.

A consolidation test was also performed on a Shelby tube sample retrieved from Borehole C11-3 and the results are presented in Figures B8-13 to B8-15 inclusive. The preconsolidation pressure was estimated from the e-log p curve. Due to the rounded nature of the curve the preconsolidation pressure was also assessed based on the ‘Work’ – method proposed by Becker et al. (1987). The details of the test results are summarized below.

Borehole/Sample No.	Sample Depth/Elevation (m)	P _c (kPa)	C _c	C _r	e _o
C11-3 TW11	10.7/168.4	270 – 390	0.309	0.033	0.77

Where: P_c = Preconsolidation pressure
C_c = Compression index
C_r = Recompression index
e_o = Initial void ratio



5.8.7 Silt

Silt approximately 1.5 m to 4.2 m thick was encountered in all of the boreholes extending to depths ranging from 17.0 m (Elev. ± 162.1 m) to 18.9 m (Elev. ± 160.1 m) below ground surface.

The grain size distribution plot of a tested sample of the silt is presented in Figure B8-8. The result shows a grain size distribution consisting of 1% gravel, 5% sand, 77% silt and 17% clay size particles. Based on visual and tactile examinations of the retrieved samples, the unit is essentially a cohesionless silt with frequent cohesive silty clay seams and partings.

Standard Penetration tests in this deposit gave 'N' values that ranged from 0 to 16 blows per 0.3 m penetration. Based on these results the deposit is considered to have a very loose to compact relative density. The moisture content of samples from this soil ranged from 18% to 27% by weight.

5.8.8 Clayey Silt

All of the boreholes were terminated in a clayey silt deposit at depths ranging from 18.8 m (Elev. ± 159.1 m) to 23.4 m (Elev. ± 155.6 m) below ground surface.

The grain size distribution plots of samples retrieved from this deposit are presented in Figure B8-9. These results show a grain size distribution consisting of 0% gravel, 0-1% sand, 83-86% silt and 14-16% clay size particles.

Samples from this stratum were also subjected to Atterberg Limits tests and the results are presented in Figure B8-10. The index values from these tests are summarized below:

Liquid Limit:	23%
Plastic Limit:	17%
Plasticity Index:	6%
Natural Moisture Content:	18-20%

These values are characteristic of clayey silt soils of low plasticity.

Standard Penetration tests in this deposit yielded 'N' values ranging from 6 to 59 blows for 0.3 m penetration and field vane tests gave in-situ undrained shear strengths ranging from 96 kPa to in excess of 100 kPa. Based on these results, the clayey silt is considered to have a generally stiff to hard consistency with occasional firm zones. The moisture content of samples from this deposit ranged from 13% to 25% by weight.

5.8.9 Water Levels

Standpipe piezometers were installed in selected boreholes and water level readings were taken on separate visits made after the completion of drilling. The water level records are presented in Table 5.8.1.



Table 5.8.1 – Water Level Measurements

Borehole	Date	Water Levels	
		Depth (m)	Elevation (m)
C11-1	July 12, 2010	4.5	173.4
	July 19, 2010	4.4	173.5
C11-3	July 19, 2010	5.1	174.0
	July 26, 2010	3.5	175.6
	August 06, 2010	2.0	177.1
	August 13, 2010	1.9	177.2

The ground water table was estimated based on the recorded water levels in the standpipe piezometers and our review of moisture contents of the retrieved samples. This interpretation indicates a ground water table that is estimated to exist at Elev. ± 177.0 m. Perched water can also be expected to occur where relatively permeable soils are underlain by more impermeable silty clay soils.

All ground water observations at this site are short term and the levels are expected to fluctuate seasonally and after severe weather events. The ground water level will also be controlled by the free water level in the existing water course.

5.9 Culvert #49 (Highway 406 NBL Sta. 5+839)

In general, the site is underlain by topsoil, a flexible pavement, silty clay fill and native overburden deposits of silty clay, silt and clayey silt.

5.9.1 Topsoil

A layer of topsoil approximately 200 mm to 330 mm thick was encountered at this site. Topsoil thickness may vary between and beyond the boreholes.

5.9.2 Flexible Pavement

Borehole C12-1 was drilled through the partially paved shoulder of Highway 406 and encountered 130 mm of asphalt underlain by 180 mm of sandy gravel. The sandy gravel fill extends to a depth of 0.3 m (Elev. ± 181.0 m) below ground surface. The moisture content of a sample of this fill was 3% by weight.

5.9.3 Fill – Silty Clay

Silty clay fill was encountered at this site extending to depths of 1.4 m (Elev. ± 178.4 m) and 2.1 m (Elev. ± 179.2 m) below ground surface.

The grain size distribution curves of two samples of this fill are shown in Figure B9-1. The results show grain size distributions consisting of 2-28% gravel, 8-16% sand, 28-41% silt and 28-49% clay size particles.

Samples of the silty clay fill were also subjected to Atterberg Limits testing and the results are plotted on the plasticity chart in Figure B9-2. The summarized index values from these tests are presented below.



Liquid Limit:	39-53%
Plastic Limit:	20-24%
Plasticity Index:	19-29%
Natural Moisture Content:	17-19%

These values are characteristic of clayey soils of intermediate to high plasticity.

Standard Penetration tests in this fill gave 'N' values ranging from 3 to 22 blows for 0.3 m penetration. Based on these results the fill is considered to have a soft to very stiff consistency. The moisture content of samples of this fill ranged from 17% to 34% by weight.

5.9.4 Silty Clay

Silty clay deposits were encountered in all of the boreholes. An upper silty clay stratum was encountered extending to depths ranging from 15.2 m to 16.2 m below ground surface or to elevations ranging from ± 165.1 m to ± 163.6 m. A lower silty clay deposit was encountered across the site extending at least to borehole termination depths ranging from 20.3 m to 21.8 m below ground surface corresponding to elevations of ± 159.5 m.

The grain size distribution plots of tested samples of the silty clay are presented in Figures B9-3 and B9-4. These results show a grain size distribution consisting of 0-4% gravel, 0-4% sand, 19-77% silt and 22-80% clay size particles.

Samples were also subjected to Atterberg Limits tests and the results are illustrated on the plasticity charts, Figures B9-5 and B9-6. The index values from these tests are summarized below:

Liquid Limit:	25-61%
Plastic Limit:	14-26%
Plasticity Index:	9-35%
Natural Moisture Content:	17-47%

These values indicate that the silty clay has a generally low to intermediate plasticity with infrequent zones of high plasticity clay inclusions.

Standard Penetration tests in these deposits gave 'N' values that ranged widely from 0 to 52 blows for 0.3 m penetration and field vane tests gave in-situ undrained shear strengths ranging from 48 kPa to in excess of 100 kPa. A laboratory vane test on a relatively undisturbed Shelby tube sample gave an undrained shear strength of 99 kPa. These values indicate that the consistency of the silty clay is generally firm to hard. The moisture content of samples of the silty clay ranged from 17% to 47% by weight and the unit weight of a tested sample was 21.1 kN/m^3 .

Consolidation tests were also performed on a Shelby tube sample retrieved from Borehole C12-3 and the results are presented in Figures B9-10 to B9-12 inclusive. The preconsolidation pressure was estimated from the e-log p curves. Due to the rounded nature of the curve the preconsolidation pressure was also assessed based on the 'Work' – method proposed by Becker et al. (1987). The details of the test results are summarized below.



Borehole/Sample No.	Sample Depth/Elevation (m)	P _c (kPa)	C _c	C _r	e _o
C12-3 TW7	4.6/175.2	250 – 430	0.255	0.049	0.66

Where: P_c = Preconsolidation pressure
C_c = Compression index
C_r = Recompression index
e_o = Initial void ratio

5.9.5 Silt

Silt approximately 1.6 m to 4.1 m thick was encountered at this site extending to depths ranging from 17.8 m (Elev. ±162.0 m) to 20.3 m (Elev. ±161.0 m) below ground surface.

The grain size distribution plot of a tested sample of the silt is presented in Figure B9-7. The result shows a grain size distribution consisting of 0% gravel, 0% sand, 93% silt and 7% clay size particles. Based on visual and tactile examinations of the retrieved samples, the unit is essentially a cohesionless silt with frequent cohesive silty clay seams and partings.

Standard Penetration tests in this deposit gave ‘N’ values that ranged from 0 to 16 blows per 0.3 m penetration indicating a very loose to compact relative density. The moisture content of samples of this soil ranged from 21% to 28% by weight.

5.9.6 Clayey Silt

A 1.5 m thick deposit of clayey silt was encountered in Borehole C12-3 where it extends to a depth of 13.2 m (Elev. ±166.6 m) below ground surface.

The grain size distribution plot of a sample retrieved from this deposit is presented in Figure B9-8. The results show a grain size distribution consisting of 0% gravel, 0% sand, 87% silt and 13% clay size particles.

A sample from this stratum was also subjected to Atterberg Limits tests and the results are presented in Figure B9-9. The index values from these tests are summarized below:

Liquid Limit:	22%
Plastic Limit:	18%
Plasticity Index:	4%
Natural Moisture Content:	24%

These values are characteristic of clayey silt soils of low plasticity.

A Standard Penetration test in this deposit yielded an ‘N’ value of 17 blows for 0.3 m penetration and a field vane test performed in this deposit gave in-situ undrained shear strength of 104 kPa. Based on these results, the clayey silt is considered to have a generally very stiff consistency. The moisture content of a sample of the clayey silt was 24% by weight.



5.9.7 Water Levels

Standpipe piezometers were installed in selected boreholes and water level readings were measured on separate visits made after the completion of drilling. The water level records are presented in Table 5.9.1.

Table 5.9.1 – Water Level Measurements

Borehole	Date	Water Levels	
		Depth (m)	Elevation (m)
C12-2	July 20, 2010	4.5	175.3
	July 26, 2010	3.7	176.1
	August 06, 2010	2.7	177.1
	August 13, 2010	2.7	177.1
C12-3	July 20, 2010	2.8	177.0
	July 28, 2010	2.8	177.0

The ground water table was estimated based on the recorded water levels in the standpipe piezometers and our review of moisture contents of the retrieved samples. This interpretation indicates a ground water table that is estimated to exist at about Elev. ± 177.0 m. Perched water can also be expected to occur where relatively permeable soils are underlain by more impermeable silty clay soils.

All ground water observations at this site are short term and the levels are expected to fluctuate seasonally and after severe weather events. The ground water level will also be controlled by the free water level in the existing water course.

5.10 Miscellaneous

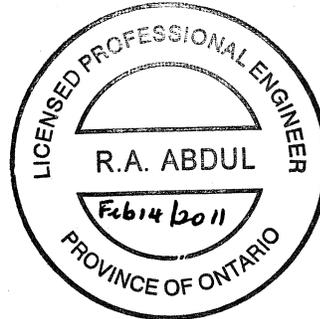
The drilling, sampling and in-situ testing operations were conducted with track and truck mounted drill rigs owned and operated by Groundworks Drilling Limited of Toronto, Ontario, DBW Drilling Limited of Ajax, Ontario, Determination Drilling & Soil Investigations of Hamilton, Ontario, Strong Soil Search Inc. of Claremont, Ontario, and Kodiak Drilling of Oakville, Ontario. The boreholes were advanced using both solid stem and hollow-stem auger drilling techniques.

Messrs. Phil Khoo, B.A.T., Alexander Winkelmann, E.I.T., Lucas Yu, E.I.T., and Brady Lin, P.Eng. observed and recorded the field work. The laboratory testing was performed at Terraprobe's Brampton laboratory and the Mississauga laboratory of Golder Associates. The report was written by Rehman Abdul, P.Eng. and reviewed by Michael Tanos, P.Eng.



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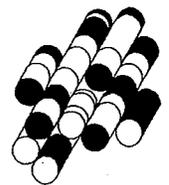
Michael Tanos

Report Reviewed by:
Michael Tanos, P.Eng.,
Review Principal



APPENDICES

TERRAPROBE INC.



LIMITATIONS AND RISK

Procedures

The soil conditions were confirmed at the borehole and test pit locations only and conditions may vary between and beyond the boreholes. The boundaries between the various strata as shown on the logs are based on non-continuous sampling. These boundaries represent an inferred transition between the various strata, rather than a precise plane of stratigraphic change.

This investigation has been carried out using investigation techniques and engineering analysis methods consistent with those ordinarily exercised by Terraprobe and other engineering practitioners, working under similar conditions and subject to the time, financial and physical constraints applicable to this project. The discussions and recommendations that have been presented are based on the factual data obtained.

It must be recognized that there are special risks whenever engineering or related disciplines are applied to identify subsurface conditions. Even a comprehensive sampling and testing programme implemented in accordance with the most stringent level of care may fail to detect certain conditions. Terraprobe has assumed for the purposes of providing design parameters and advice, that the conditions that exist between sampling points are similar to those found at the sample locations. The conditions that Terraprobe has interpreted to exist between sampling points can differ from those that actually exist.

It may not be possible to drill a sufficient number of boreholes or sample and report them in a way that would provide all the subsurface information that could affect construction costs, techniques, equipment and scheduling. Contractors bidding on or undertaking work on the project should be directed to draw their own conclusions as to how the subsurface conditions may affect them, based on their own investigations and their own interpretations of the factual investigation results, cognizant of the risks implicit in the subsurface investigation activities.

Changes In Site And Scope

It must be recognized that the passage of time, natural occurrences, and direct or indirect human intervention at or near the site have the potential to alter subsurface conditions. Groundwater levels are particularly susceptible to seasonal fluctuations.

The design advice is based on the factual data obtained from this investigation made at the site by Terraprobe and are intended for use by the owner and its retained designers in the design phase of the project. If there are changes to the project scope and development features, or there is any additional information relevant to the interpretations made of the subsurface information, the geotechnical design parameters and comments relating to constructibility issues and quality control may not be relevant or complete for the revised project. Terraprobe should be retained to review the implications of such changes with respect to the contents of this report

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EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0-12	12-25	25-50	50-100	100-200	>200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0-5	5-10	10-30	30-50	>50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND/OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY IS:

RQD (%)	0-25	25-50	50-75	75-90	90-100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50-300mm	0.3m-1m	1m-3m	>3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

STRESS AND STRAIN

U_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

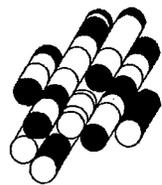
m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_{α}	1	RATE OF SECONDARY CONSOLIDATION
C_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_s	1	SENSITIVITY = c_u / τ_r

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	e	1%	VOID RATIO	e_{min}	1%	VOID RATIO IN DENSEST STATE
γ_s	kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1%	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	1%	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m ³	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m ³	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m ³	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m ² /s	RATE OF DISCHARGE
γ_d	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $(w_L - w_p)$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	L	1	LIQUIDITY INDEX = $(w - w_p) / I_p$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m ³	UNIT WEIGHT OF SATURATED SOIL	L_c	1	CONSISTENCY INDEX = $(w_L - w) / I_p$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	1%	VOID RATIO IN LOOSEST STATE	j	kN/m ²	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						

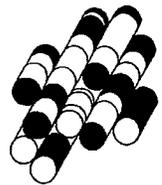
CULVERT #2

TERRAPROBE INC.



A1

TERRAPROBE INC.



RECORD OF BOREHOLE No C2-1

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4761869.4 E:327476.3 ORIGINATED BY BL
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers, D.C.P.T. COMPILED BY DB
 DATUM Geodetic DATE 06.21.10 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100						
183.3 0.0	Ground Surface		1	SS	16									55 34 (11)	
181.9	FILL - Sandy Gravel, some silt, compact, grey, damp to moist		2	SS	13										
181.4			3	SS	3										
181.2	FILL - Silty Clay, trace sand, trace to some organics, soft, dark brown/black, moist		4	SS	22										
2.1	SILTY CLAY trace sand, stiff to very stiff, brown, damp to moist		5	SS	24							43		0 2 55 43	
			6	SS	21										
			7	SS	19								41		0 2 57 41
			8	SS	11										
			9	SS	10										0 1 69 30
			10	SS	5										
			11	SS	6										
			12	SS	3										3 18 54 25
			13	SS	2										
			14	SS	8										
173.5 9.8	SILTY CLAY some sand, trace gravel, soft to stiff, brown, damp to moist (GLACIAL TILL)														

ONTARIO MOT 1-09-4135 CULVERTS2.GPJ ONTARIO MOT.GDT 10/01/10

Continued Next Page

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No C2-1

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4761869.4 E:327476.3 ORIGINATED BY BL
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers, D.C.P.T. COMPILED BY DB
 DATUM Geodetic DATE 06.21.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		NATURAL MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20 40 60 80 100	PLASTIC LIMIT	W _p	W		
168			15	SS	1								
167													
166													
165													
164.2			16	SS	15								
164.2	19.1		End of Borehole Dynamic Cone Penetration Test performed from 16.2 to 18.6m. Borehole was dry (not stabilized) and hole open to 13.7m on completion. Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 1.52m slotted screen. Water Level Readings: Date Depth(m) Elevation(m) Jul. 08. 10 4.0 179.3 Jul. 13. 10 3.7 179.6 Jul. 20. 10 3.6 179.7										

ONTARIO.MOT_1-09-4135_CULVERTS2.GPJ ONTARIO.MOT.GDT 10/01/10

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No C2-2

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4761866.4 E:327497.5 ORIGINATED BY BL
 DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 07.20.10 - 07.21.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
181.7	Ground Surface												
0.0 181.4	300mm TOPSOIL												
0.3 181.0	FILL - Silty Clay, trace sand, some organics, stiff, dark brown, moist		1	SS	13								
0.7	SILTY CLAY trace sand, stiff to very stiff, brown, damp to moist		2	SS	27								
	—		3	SS	29								
	— hard		4	SS	42						45	0 1 52 47	
	—		5	SS	27								
			6	SS	24								
			7	SS	13							0 1 61 38	
			8	SS	9							0 2 69 29	
			9	TW	PH								
173.1 8.6	SILTY CLAY some sand to sandy, trace to some gravel, hard, brown, damp to moist (GLACIAL TILL)		10	SS	31								
			11	SS	100/ 10cm								
			12	SS	100/ 10cm								
			13	SS	13cm/ 100/ 10cm								
			14	SS	68								
169.0 12.7	End of Borehole Obstruction to augering at 10.5m. Probably on a boulder. Borehole moved 1.5m south and 1.5m east and redrilled. Obstruction to augering at 10.8m. Probably on a boulder. Borehole moved 3.5m south and 0.5m east and redrilled. Obstruction to augering at 10.7m. Probably on a												

ONTARIO MOT 1-09-4135 CULVERTS2.GPJ_ONTARIO MOT.GDT 10/01/10

Continued Next Page

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

RECORD OF BOREHOLE No C2-2

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4761866.4 E:327497.5 ORIGINATED BY BL
 DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 07.20.10 - 07.21.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
						20	40	60	80	100						
	boulder. Borehole moved 5.0m south and 6.0m east and redrilled. Borehole was dry (not stabilized) and hole open to 10.4m on completion.															

ONTARIO.MOT.1-09-4135.CULVERTS2.GPJ_ONTARIO.MOT.GDT_10/01/10

+³, X³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

RECORD OF BOREHOLE No C2-3

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4761859.0 E:327522.2 ORIGINATED BY BL
 DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 07.20.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20					
181.6	Ground Surface												
0.0	300mm TOPSOIL												
181.3			1	SS	12							44	0 1 60 39
0.3	FILL - Silty Clay, trace sand, trace organics, stiff to very stiff, brown, damp to moist		2	SS	19								
180.2			3	SS	22								
1.4	SILTY CLAY trace sand, stiff to very stiff, brown, damp to moist		4	SS	32								0 3 58 39
	hard		5	SS	31								
			6	SS	17								0 3 60 37
			7	SS	12								
			8	SS	9								
			9	SS	10								0 2 63 35
			10	SS	7								0 1 55 44
171.0													
10.6	SILTY CLAY trace to some sand, trace gravel, very stiff, brown, damp to moist (GLACIAL TILL)		11	SS	13								
			12	SS	28								
			13	SS	25								
167.4	End of Borehole												
14.2	Sampler wet at 10.7m												

ONTARIO MOT. 1-09-4135 CULVERTS2.GPJ ONTARIO MOT.GDT 10/01/10

Continued Next Page

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

RECORD OF BOREHOLE No C2-3

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4761859.0 E:327522.2 ORIGINATED BY BL
 DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 07.20.10 CHECKED BY RA

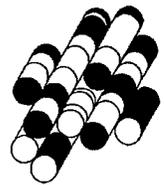
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80						100	20	40	60
	Borehole was dry (not stabilized) and hole open to full depth on completion. Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 1.52m slotted screen. Water Level Readings: Date Depth(m) Elevation(m) Jul. 28. 10 5.9 175.7 Aug. 06. 10 7.1 174.5 Aug. 13. 10 6.5 175.1 Aug. 23. 10 4.6 177.0 Sept. 25. 10 7.4 174.2 Oct. 03. 10 6.2 175.4 Oct. 14. 10 6.6 175.0																			

ONTARIO MOT. 1-09-4135 CULVERTS2.GPJ_ONTARIO MOT.GDT. 10/01/10

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

B1

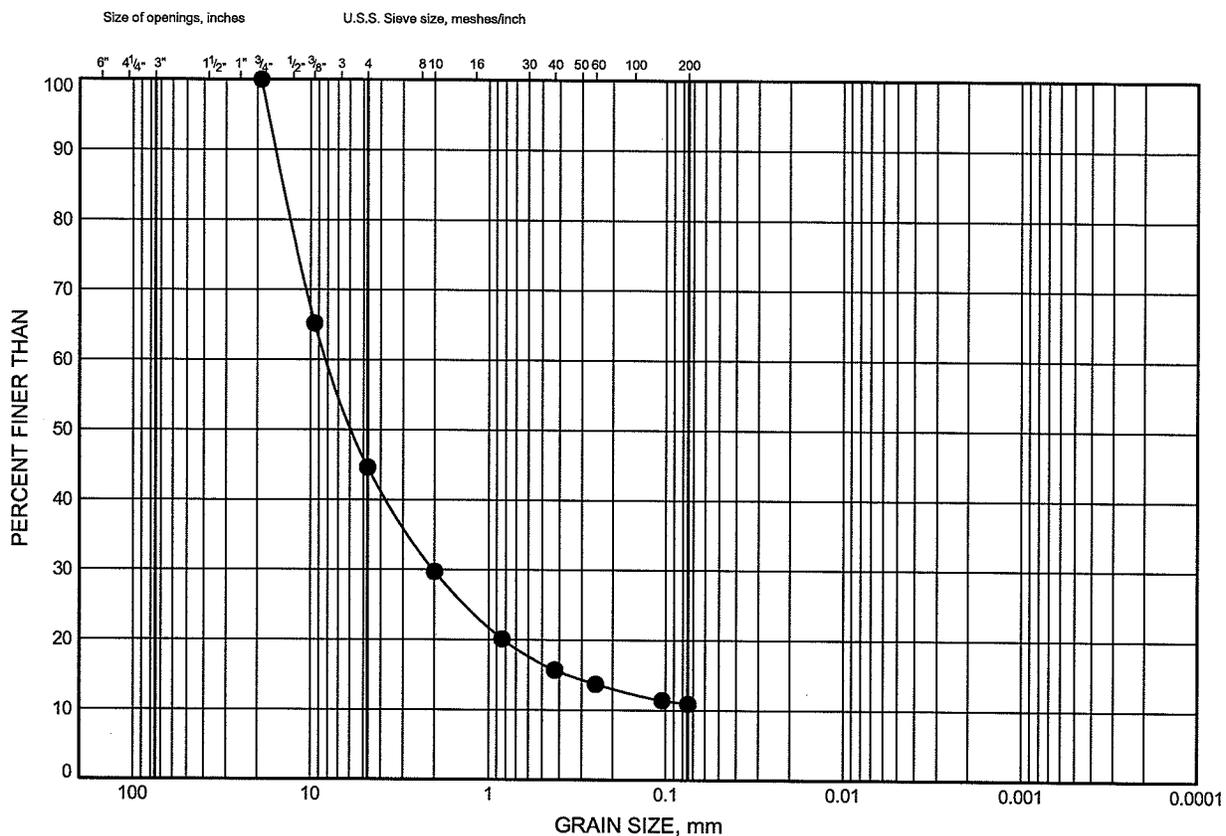
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GRAIN SIZE DISTRIBUTION

FIGURE B1-1

FILL - SANDY GRAVEL



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C2-1	0.3	183.0

GSD 1-09-4135 CULVERTS2.GPJ 9/3/10

Date November 2010

Project 1-09-4135



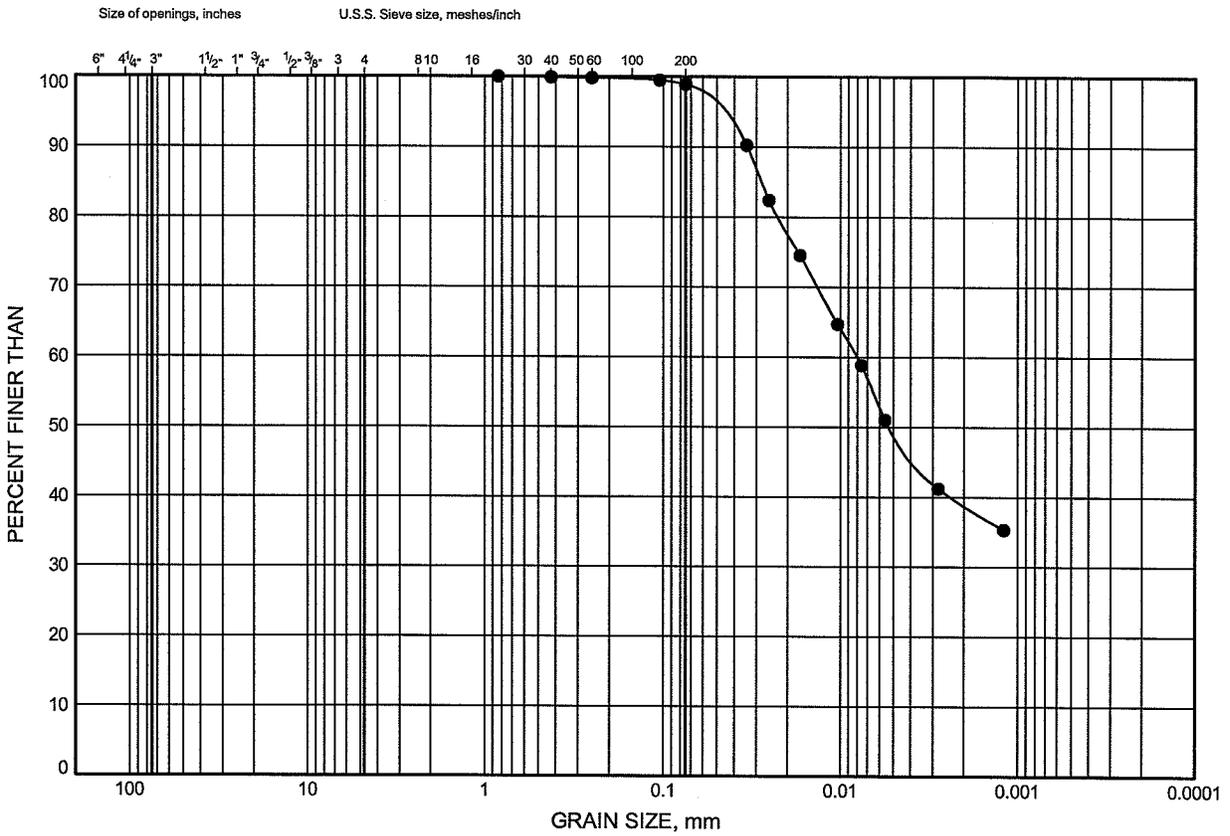
Prep'd JS

Chkd. MP

GRAIN SIZE DISTRIBUTION

FIGURE B1-2

FILL - Silty Clay

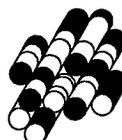


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY FINE GRAINED
	GRAVEL		SAND			

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C2-3	0.4	181.2

GSD 1-09-4135 CULVERTS2.GPJ 09/15/10

Date November 2010
 Project 1-09-4135

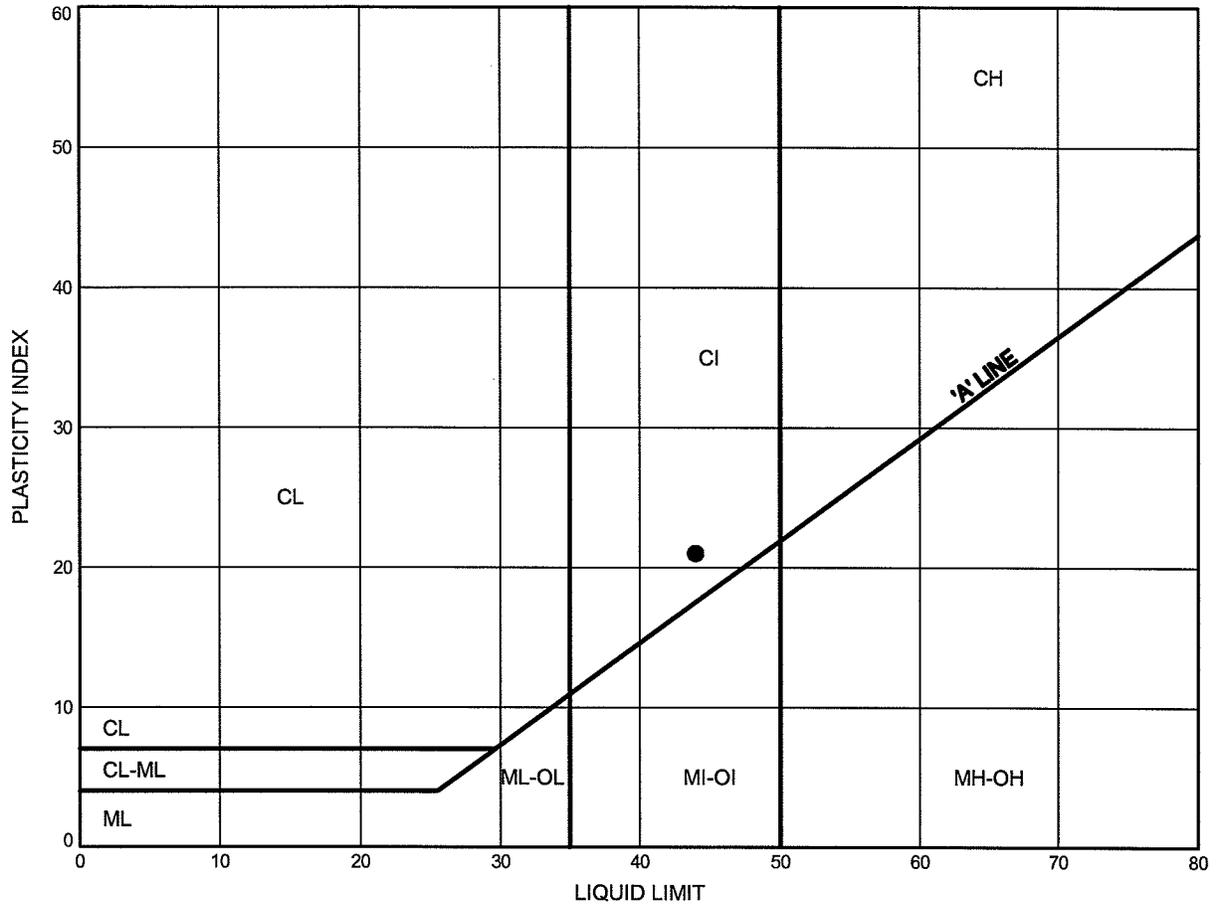


Prep'd K.L.
 Chkd. M.P.

ATTERBERG LIMITS TEST RESULTS

FIGURE B1-3

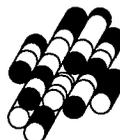
FILL - Silty Clay



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C2-3	0.4	181.2

ALTR 1-09-4135 CULVERTS2.GPJ 09/15/10

Date November 2010
 Project 1-09-4135

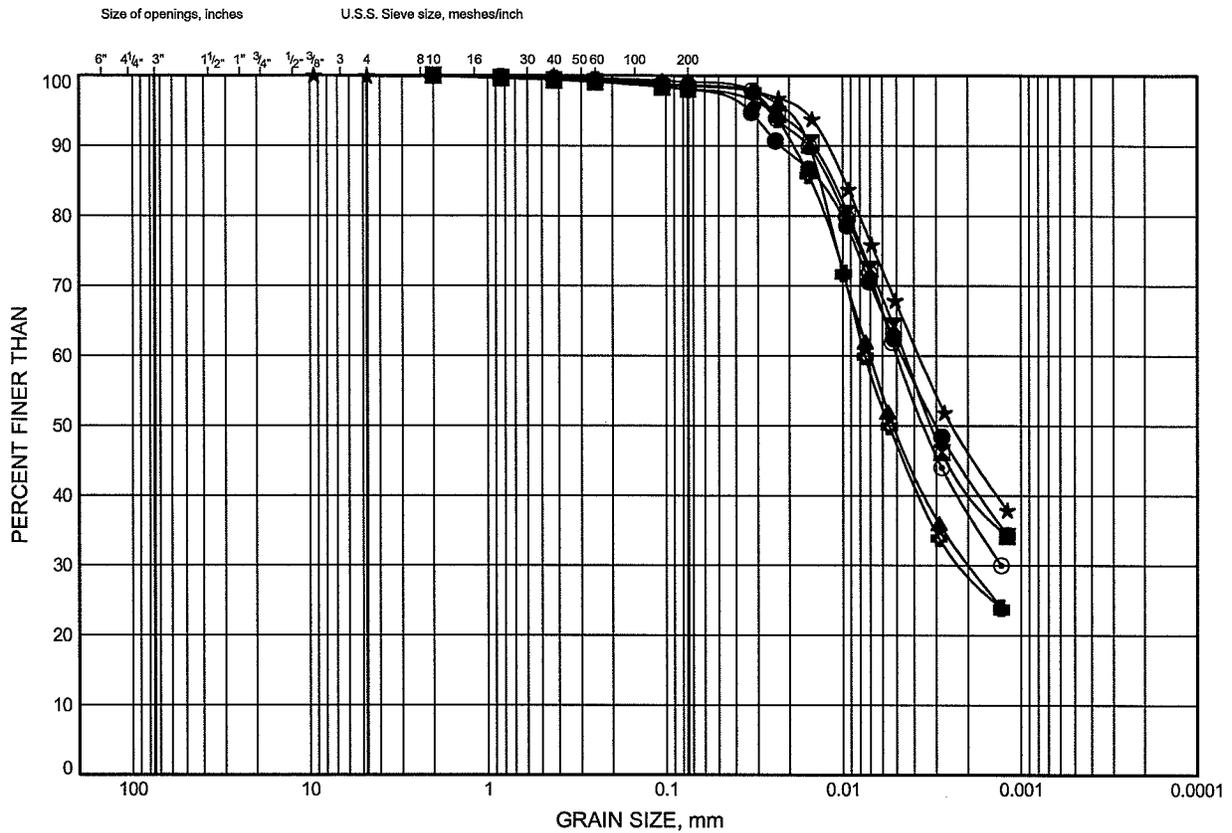


Prep'd K.L.
 Chkd. M.P.

GRAIN SIZE DISTRIBUTION

FIGURE B1-4

SILTY CLAY



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			

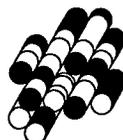
SYMBOL BOREHOLE DEPTH (m) ELEVATION (m)

●	C2-1	3.2	180.1
⊠	C2-1	4.7	178.6
▲	C2-1	7.8	175.5
★	C2-2	2.5	179.2
⊙	C2-2	4.7	177.0
⊛	C2-2	6.3	175.4

GSD 1-09-4135 CULVERTS2.GPJ 9/3/10

Date ..November 2010....

Project ..1-09-4135....



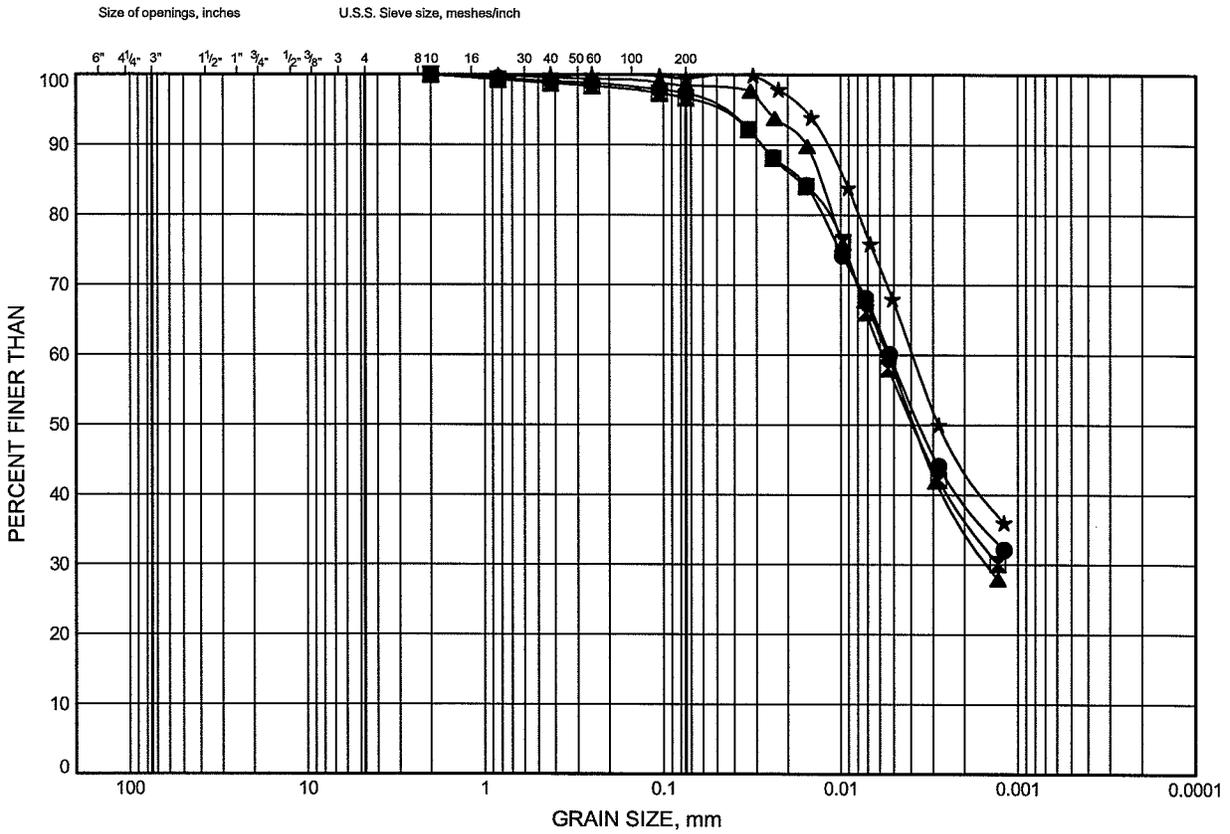
Prep'dJS.....

Chkd.MP.....

GRAIN SIZE DISTRIBUTION

FIGURE B1-5

SILTY CLAY

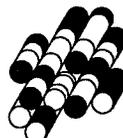


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C2-3	2.5	179.1
■	C2-3	4.0	177.6
▲	C2-3	7.8	173.8
★	C2-3	9.3	172.3

GSD 1-09-4135 CULVERTS2.GPJ 9/3/10

Date November 2010
 Project 1-09-4135

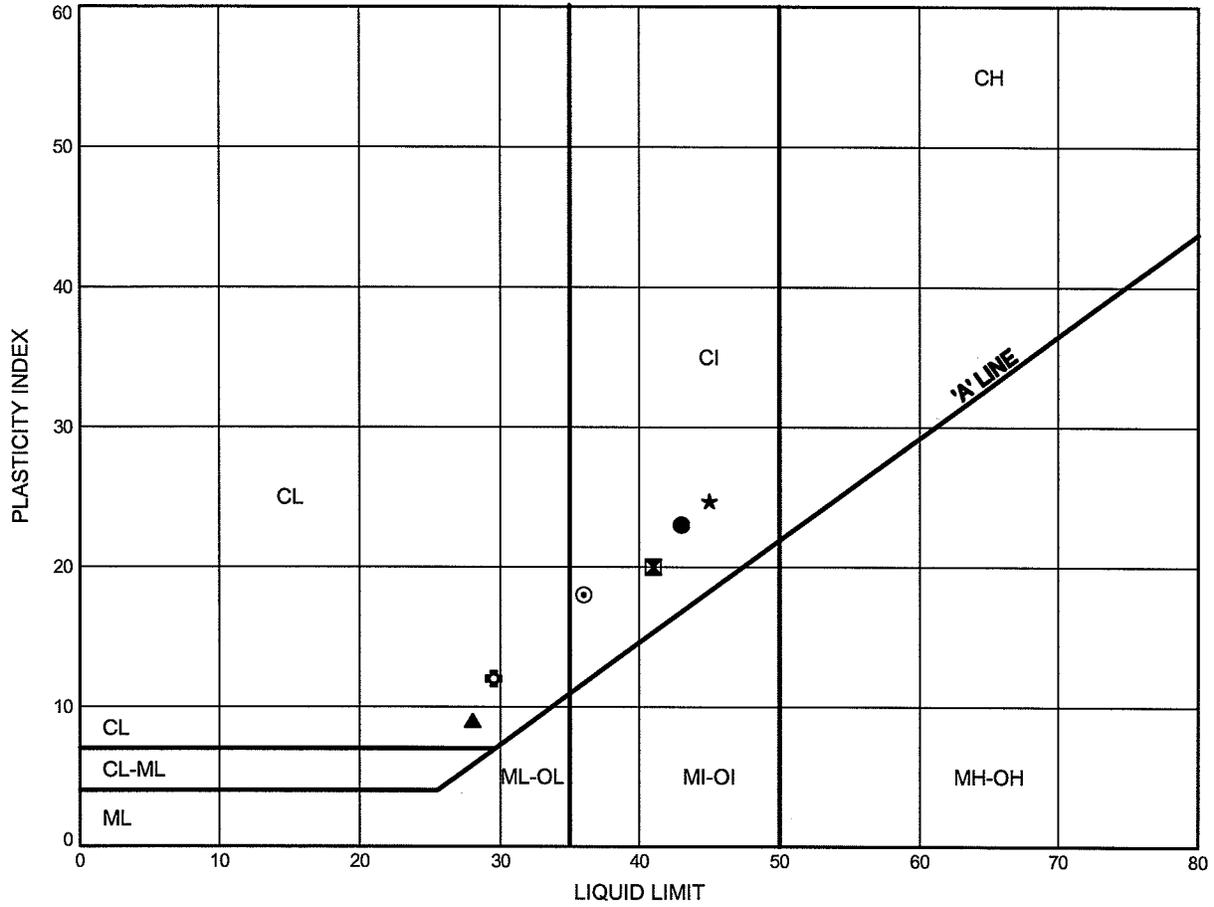


Prep'd JS
 Chkd. MP

ATTERBERG LIMITS TEST RESULTS

FIGURE B1-6

SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C2-1	3.2	180.1
⊠	C2-1	4.7	178.6
▲	C2-1	7.8	175.5
★	C2-2	2.5	179.2
⊙	C2-2	4.7	177.0
⊕	C2-2	6.3	175.4

ALTR 1-09-4135 CULVERTS2.GPJ 9/3/10

Date November 2010
 Project 1-09-4135

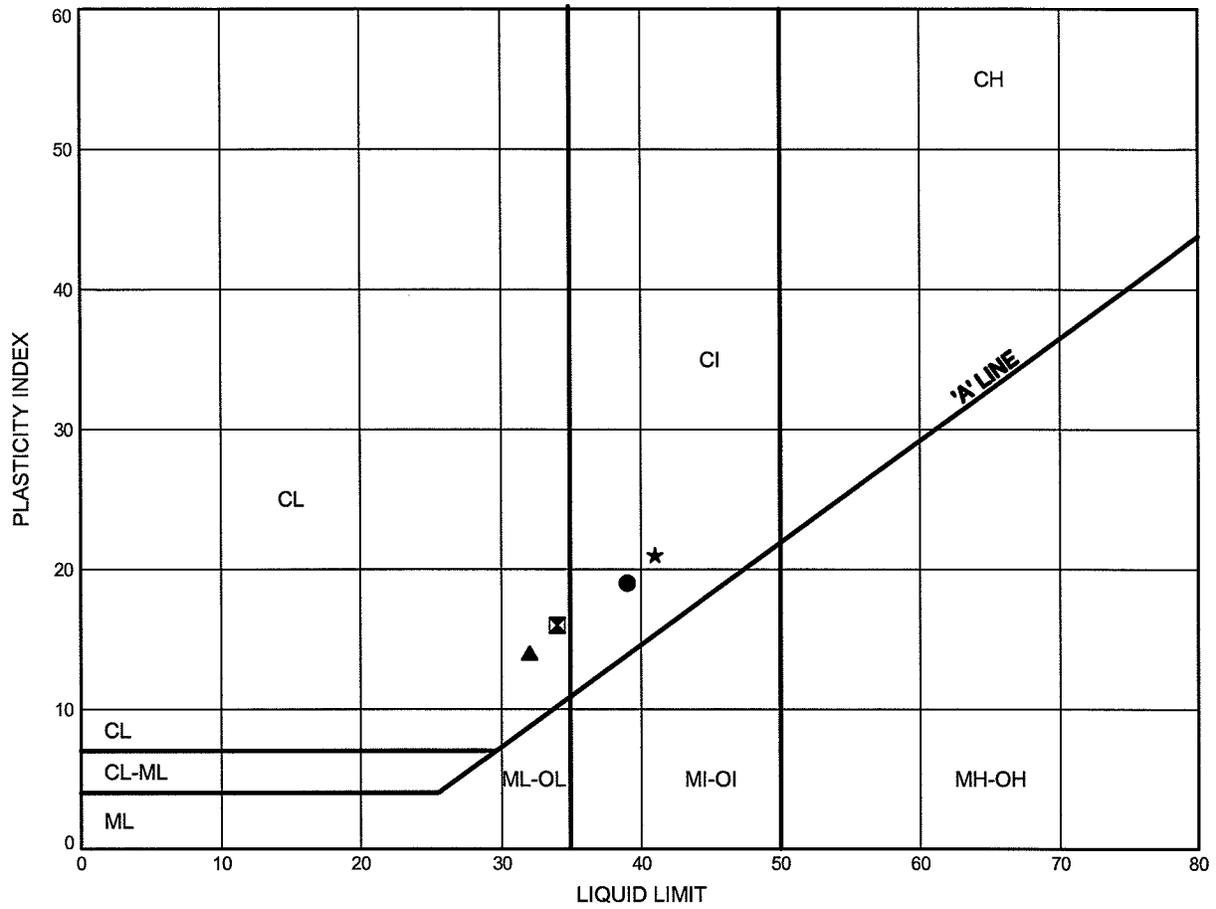


Prep'd JS
 Chkd. MP

ATTERBERG LIMITS TEST RESULTS

FIGURE B1-7

SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C2-3	2.5	179.1
⊠	C2-3	4.0	177.6
▲	C2-3	7.8	173.8
★	C2-3	9.3	172.3

ALTR 1-09-4135 CULLVERTS2.GPJ 9/3/10

Date November 2010
 Project 1-09-4135

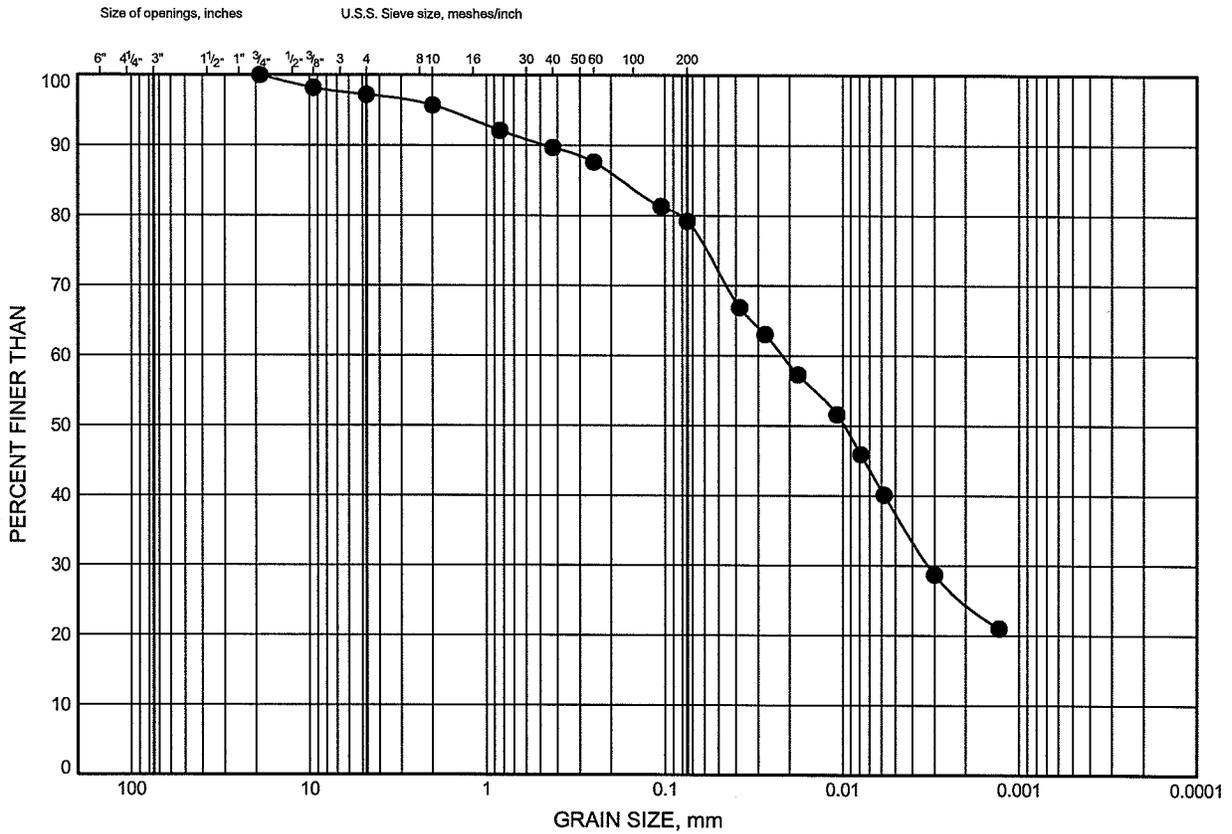


Prep'd JS
 Chkd. MP

GRAIN SIZE DISTRIBUTION

FIGURE B1-8

SILTY CLAY TILL



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C2-1	10.9	172.4

Date November 2010
 Project ...1-09-4135...

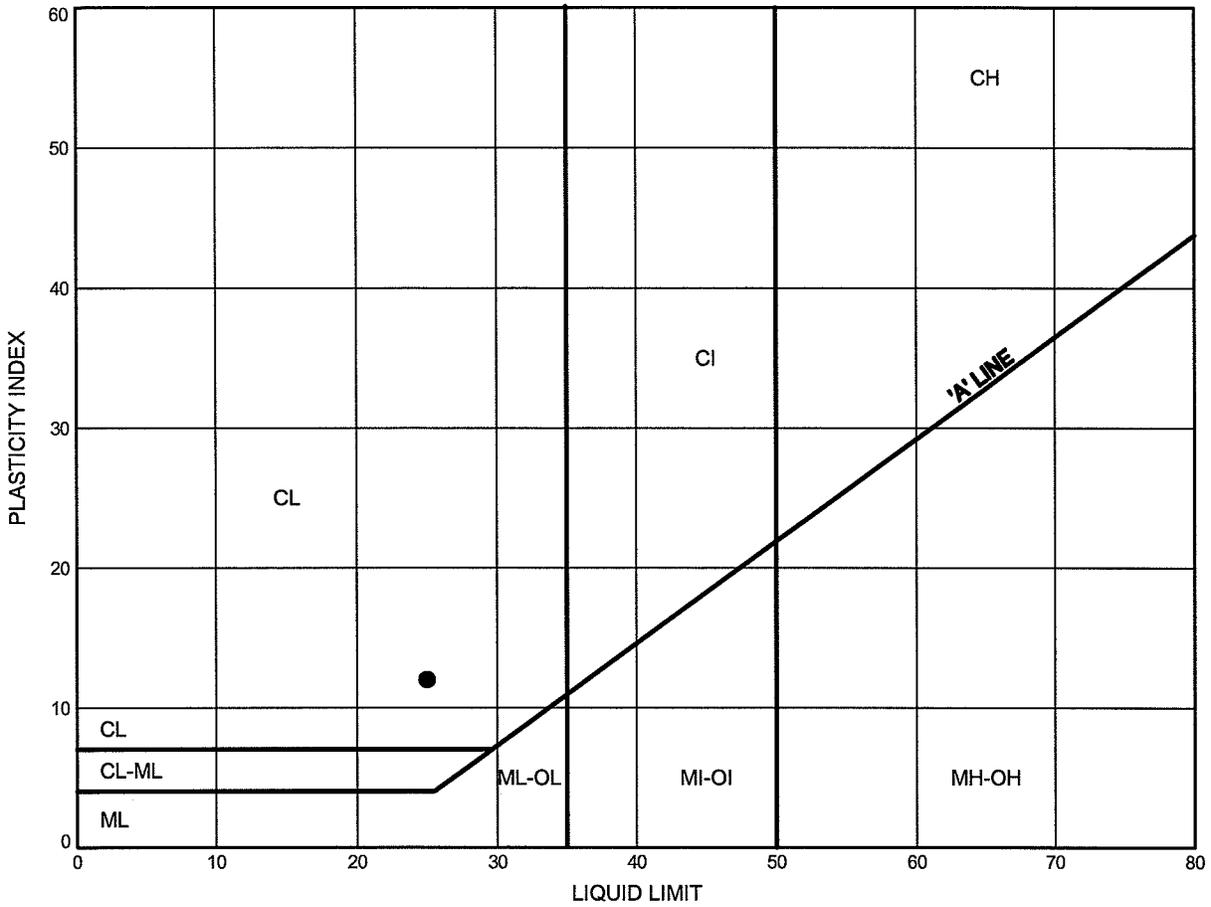


Prep'd JS
 Chkd. MP

ATTERBERG LIMITS TEST RESULTS

FIGURE B1-9

SILTY CLAY TILL



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C2-1	10.9	172.4

ALTR 1-09-4135 CULVERTS2.GPJ 9/8/10

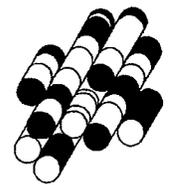
Date November 2010
 Project 1-09-4135

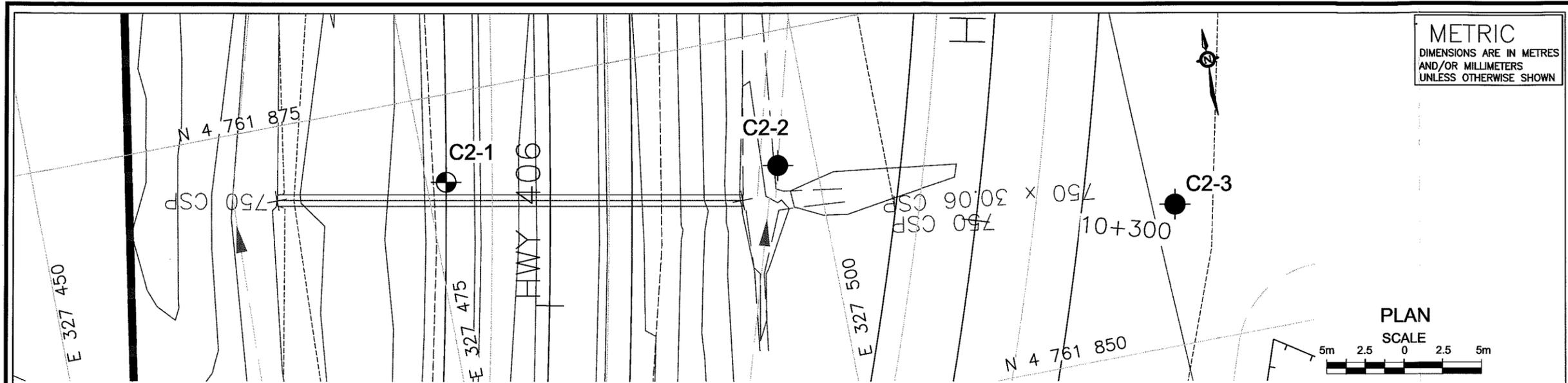


Prep'd JS
 Chkd. MP

C1

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METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETERS
UNLESS OTHERWISE SHOWN

CONT No 2011-2005
WP No 280-99-00

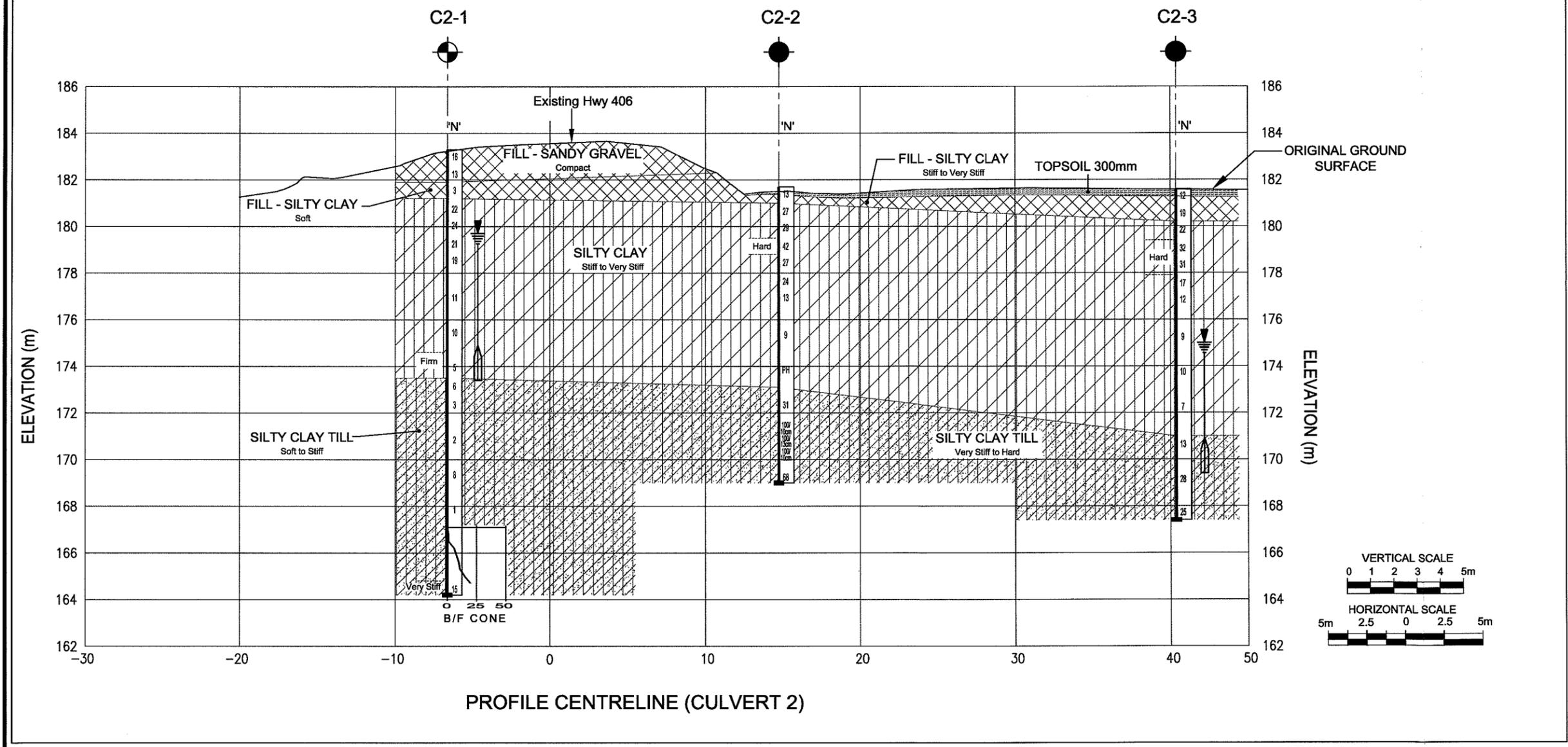
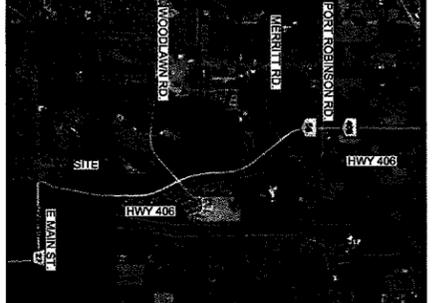
HIGHWAY 406
CULVERT # 2

BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
1 OF

IBI GROUP

Terraprobe Inc.
Consulting Geotechnical & Environmental Engineering
Construction Materials Engineering, Inspection & Testing
10 Bram Court - Brampton Ontario L6W 3R6 (905) 796-2650



KEY PLAN

LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test
- ⊙ Bore Hole And Cone
- 'N' Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- ≡ WL at Time of Investigation
- ⊕ WL in Piezometer (OCT. 2010)
- ⊕ Piezometer
- 90% Rock Quality Designation
- A/R Auger Refusal

No	ELEV.	COORDINATES	
		NORTHING	EASTING
C2-1	183.3	4 761 869.4	327 476.3
C2-2	181.7	4 761 866.4	327 497.5
C2-3	181.6	4 761 859.0	327 522.2

NOTE

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

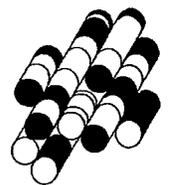
This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

REVISIONS	DATE	BY	DESCRIPTION

DESIGN	R.A.	CODE	CHBDC2006	LOAD	DATE	FEB. 2011
DRAWN	K.C.	CHK	R.A.	STRUCT	GEORES 30M3-289	

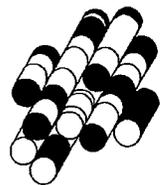
CULVERT #5

TERRAPROBE INC.



A2

TERRAPROBE INC.



RECORD OF BOREHOLE No C3-1

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4762329.4 E:327576.6 ORIGINATED BY PK
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 6.17.10 CHECKED BY RA

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
			NUMBER	TYPE	"N" VALUES			20	40					
183.2 0.0	Ground Surface													
	1420mm FILL - Sand and Gravel, some silt, trace clay, compact to dense, brown/grey, damp to moist		1	SS	27		183							37 46 13 4
			2	SS	33		182							
181.8 1.4	FILL - Silty Clay, some sand, trace gravel, trace organics, very stiff, brown, damp to moist		3	SS	26		181					42		7 13 40 40
181.1 2.1	SILTY CLAY trace sand, stiff to very stiff, brown, damp to moist		4	SS	15		180							
			5	SS	17		179							0 1 64 35
			6	SS	15		178							
			7	SS	11		177							
			8	SS	11		176							0 3 66 31
			9	TW	PH		175							
173.8 9.4	SILTY CLAY some sand, trace gravel, stiff to very stiff, brown, damp to moist (GLACIAL TILL)		10	SS	16		174							
			11	SS	11		173							
			12	SS	17		172							
169.6 13.6	End of Borehole						171							6 18 56 20
	Resistance to augering at 2.3m						170							
	Sampler wet at 7.6m													
	Unable to push vane beyond 11.1m													

ON MOT 1-09-4135 CULVERTS2.GPJ ON MOT.GDT 9/8/10

Continued Next Page

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No C3-1

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4762329.4 E:327576.6 ORIGINATED BY PK
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 6.17.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
					20	40	60	80	100							
	Borehole was dry (not stabilized) and hole open to full depth on completion. Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 1.52m slotted screen. Water Level Readings: Date Depth(m) Elevation(m) Jul. 08. 10 2.0 181.2 Jul. 14. 10 1.9 181.3 Jul. 20. 10 2.0 181.2															

ON_MOT_1-09-4135_CULVERTS2.GPJ ON_MOT_GDT_9/8/10

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No C3-2

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4762327.3 E:327602.0 ORIGINATED BY BL
 DIST HWY 406 BOREHOLE TYPE Solid Stem Augers / Hollow Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 7.8.10 - 7.20.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
183.8	Ground Surface												
0.1	100mm TOPSOIL		1	SS	14								
	FILL - Silty Clay, trace sand, trace organics, stiff, brown, damp to moist		2	SS	14								0 5 46 49
			3	SS	13								
181.7			4	SS	21								
2.1	SILTY CLAY trace sand, very stiff, brown, damp to moist		5	SS	19								0 2 46 52
			6	SS	28								
			7	SS	21								
			8	SS	20								0 2 67 31
			9	SS	23								0 3 72 25
			10	SS	17								0 2 58 40
173.7			11	SS	62/20cm								
10.1	SILTY CLAY trace to some sand, trace gravel, very stiff to hard, brown, damp to moist (GLACIAL TILL)		12	SS	27								
			13	SS	100/25cm								
169.7	End of Borehole												
14.1	Borehole was dry (not stabilized) and hole open to full depth on completion.												

ON_MOT_1-09-4135 CULVERTS2.GPJ ON_MOT.GDT 9/8/10

Continued Next Page

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No C3-2

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4762327.3 E:327602.0 ORIGINATED BY BL
 DIST HWY 406 BOREHOLE TYPE Solid Stem Augers / Hollow Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 7.8.10 - 7.20.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
						20	40	60	80	100						
	Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 1.52m slotted screen. Water Level Readings: Date Depth(m) Elevation(m) Jul. 28. 10 5.6 178.2 Aug. 06. 10 5.8 178.0															

ON_MOT_1-09-4135_CULVERTS2.GPJ ON_MOT_GDT_9/8/10

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

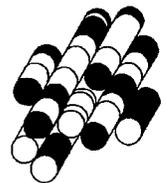
Test Pit Logs
Culvert #3 (Highway 406 Sta. 10+782)

Test Pit# TP 3-1

0	-	100	Tps
100	-	300	Fill, Br Si(y) Cl, Tr Sa, Tr Gr, Damp

B2

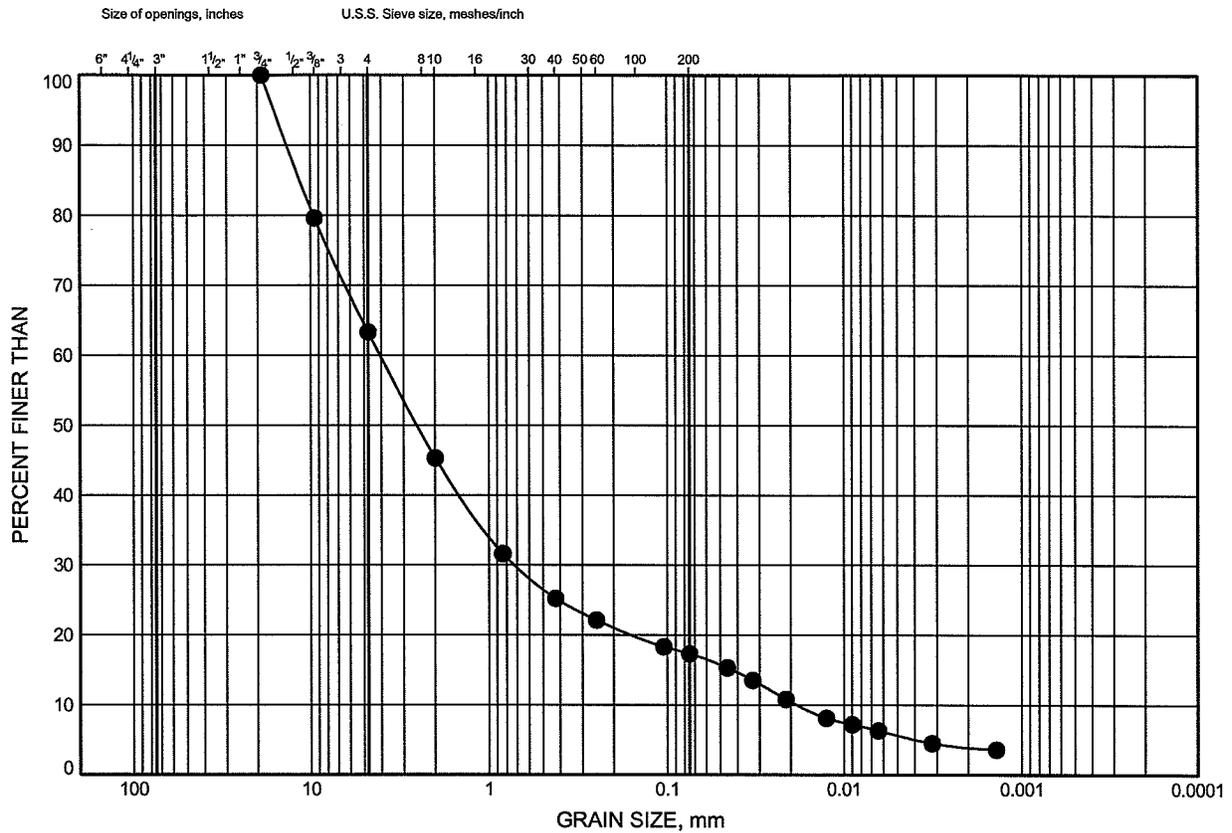
TERRAPROBE INC.



GRAIN SIZE DISTRIBUTION

FIGURE B2-1

FILL - Sand and Gravel



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			

SYMBOL BOREHOLE DEPTH (m) ELEVATION (m)

● C3-1 0.3 182.9

GSD 1-09-4135 CULVERTS2.GPJ 9/3/10

Date ..November 2010....
 Project1-09-4135..

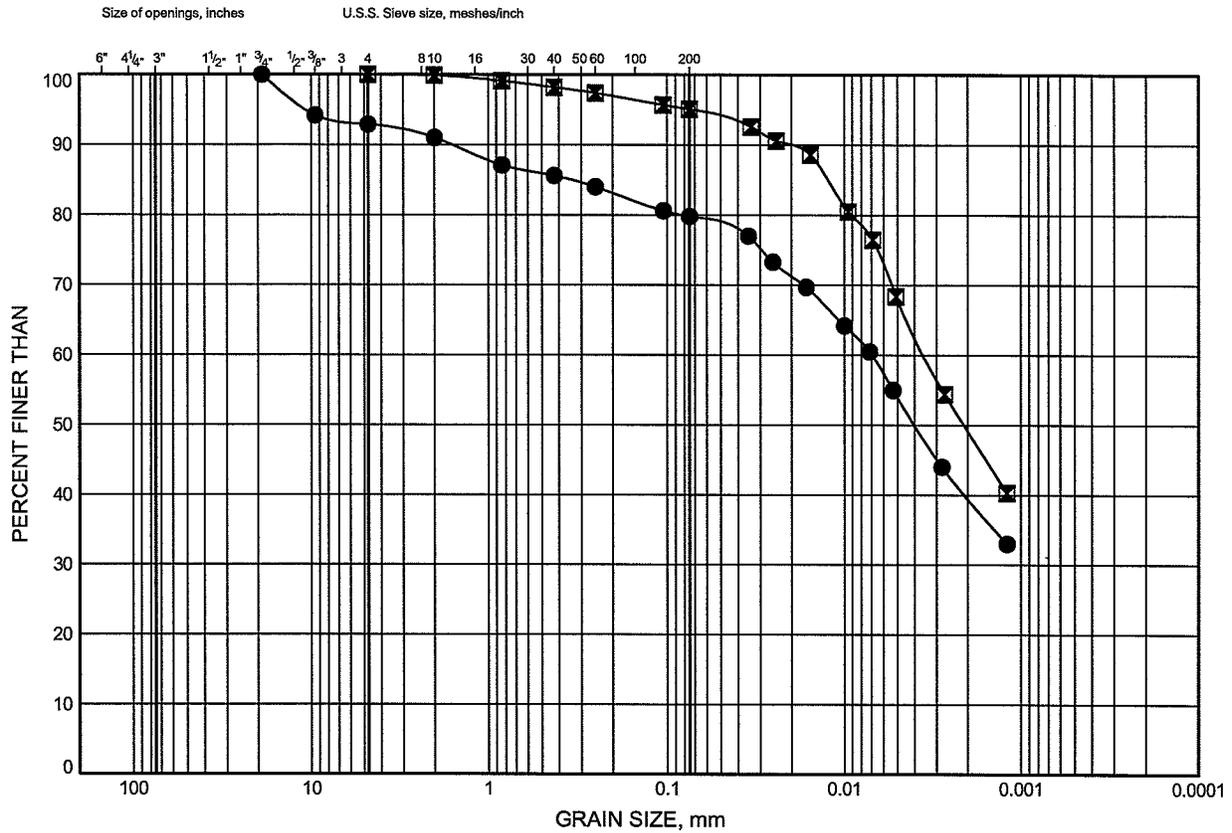


Prep'dJS.....
 Chkd.MP.....

GRAIN SIZE DISTRIBUTION

FIGURE B2-2

FILL - Silty Clay



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C3-1	1.7	181.5
■	C3-2	1.1	182.7

GSD 1-09-4135 CULVERTS2.GPJ 9/3/10

Date November 2010
 Project 1-09-4135

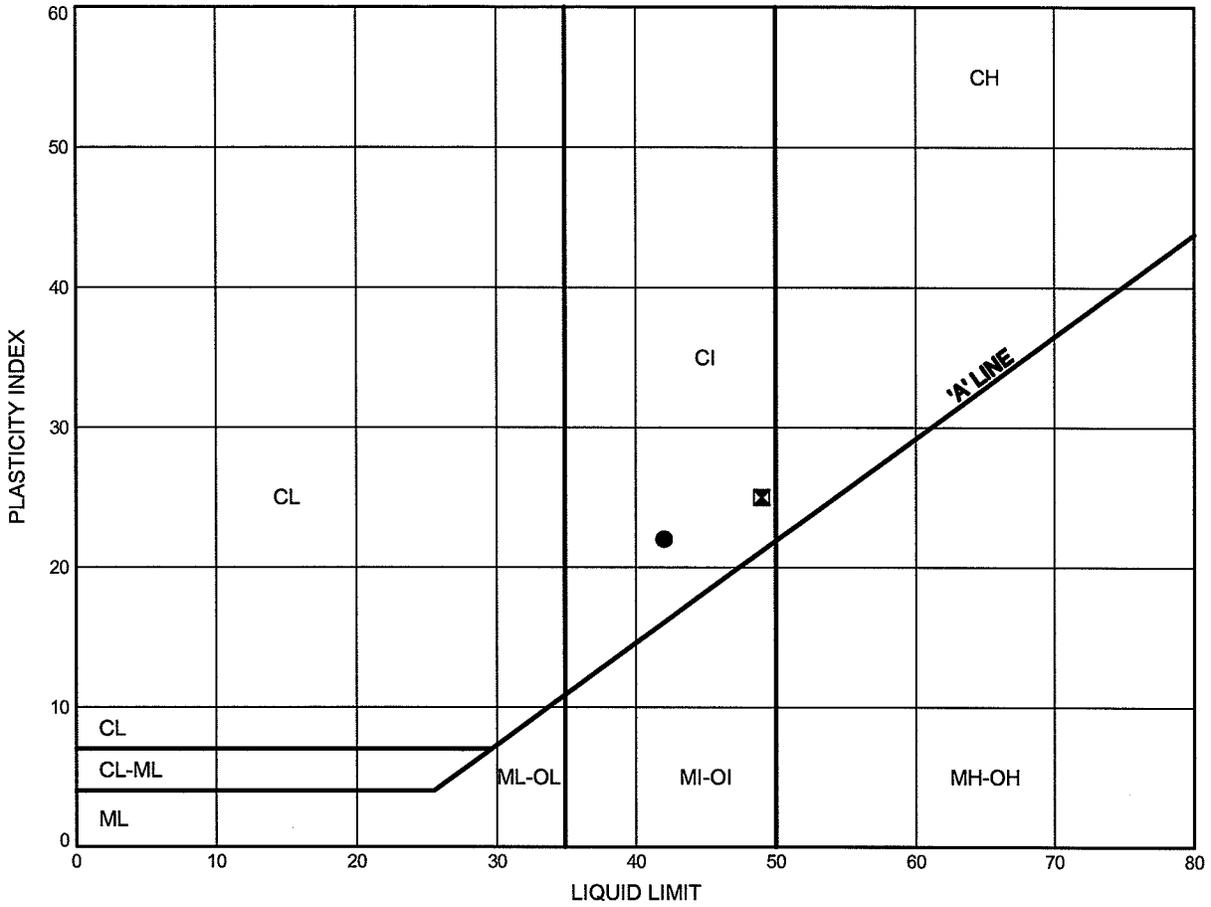


Prep'd JS
 Chkd. MP

ATTERBERG LIMITS TEST RESULTS

FIGURE B2-3

FILL - Silty Clay



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C3-1	1.7	181.5
⊠	C3-2	1.1	182.7

ALTR 1-09-4135.CULVERTS2.GPJ 9/3/10

Date November 2010
 Project 1-09-4135

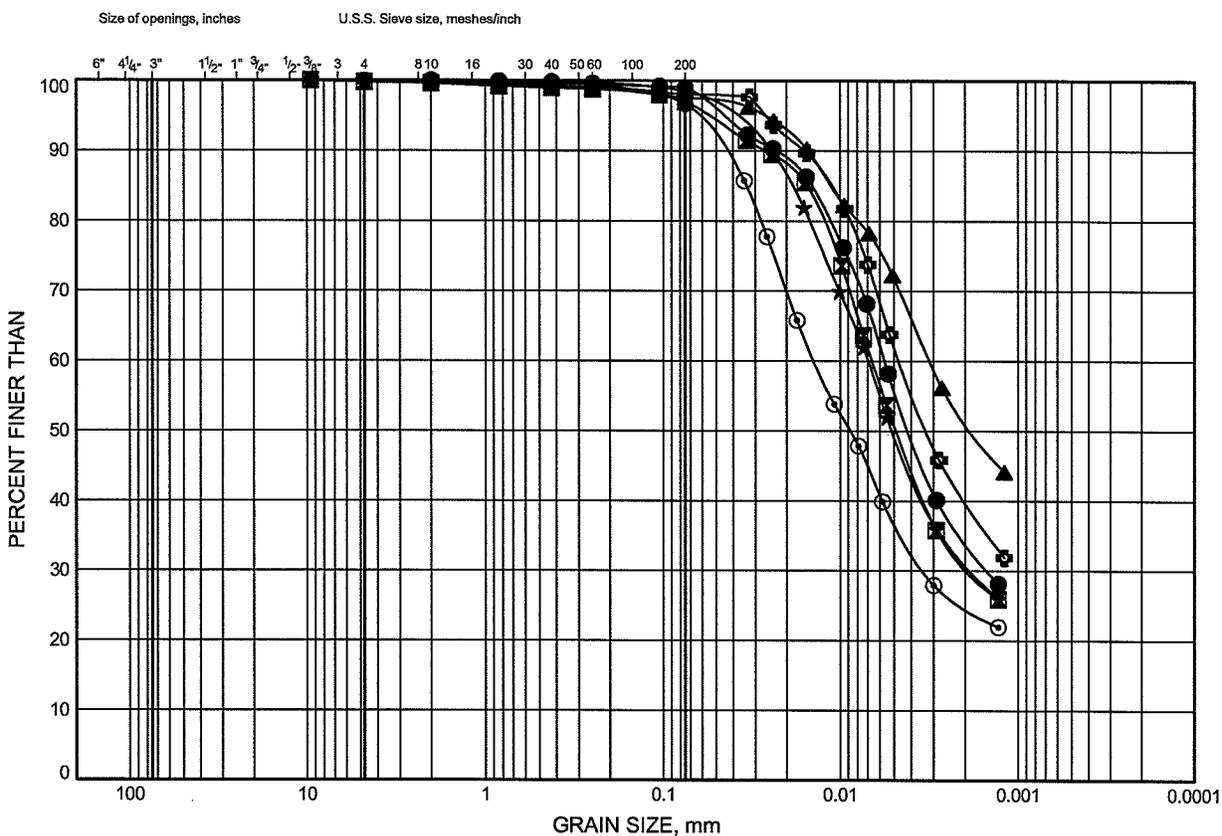


Prep'd JS
 Chkd. MP

GRAIN SIZE DISTRIBUTION

FIGURE B2-4

SILTY CLAY



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C3-1	4.0	179.2
⊠	C3-1	6.3	176.9
▲	C3-2	3.3	180.6
★	C3-2	6.4	177.5
⊙	C3-2	7.9	175.9
⊕	C3-2	9.4	174.5

GSD_1-09-4135_CULVERTS2.GPJ 9/9/10

Date November 2010

Project 1-09-4135



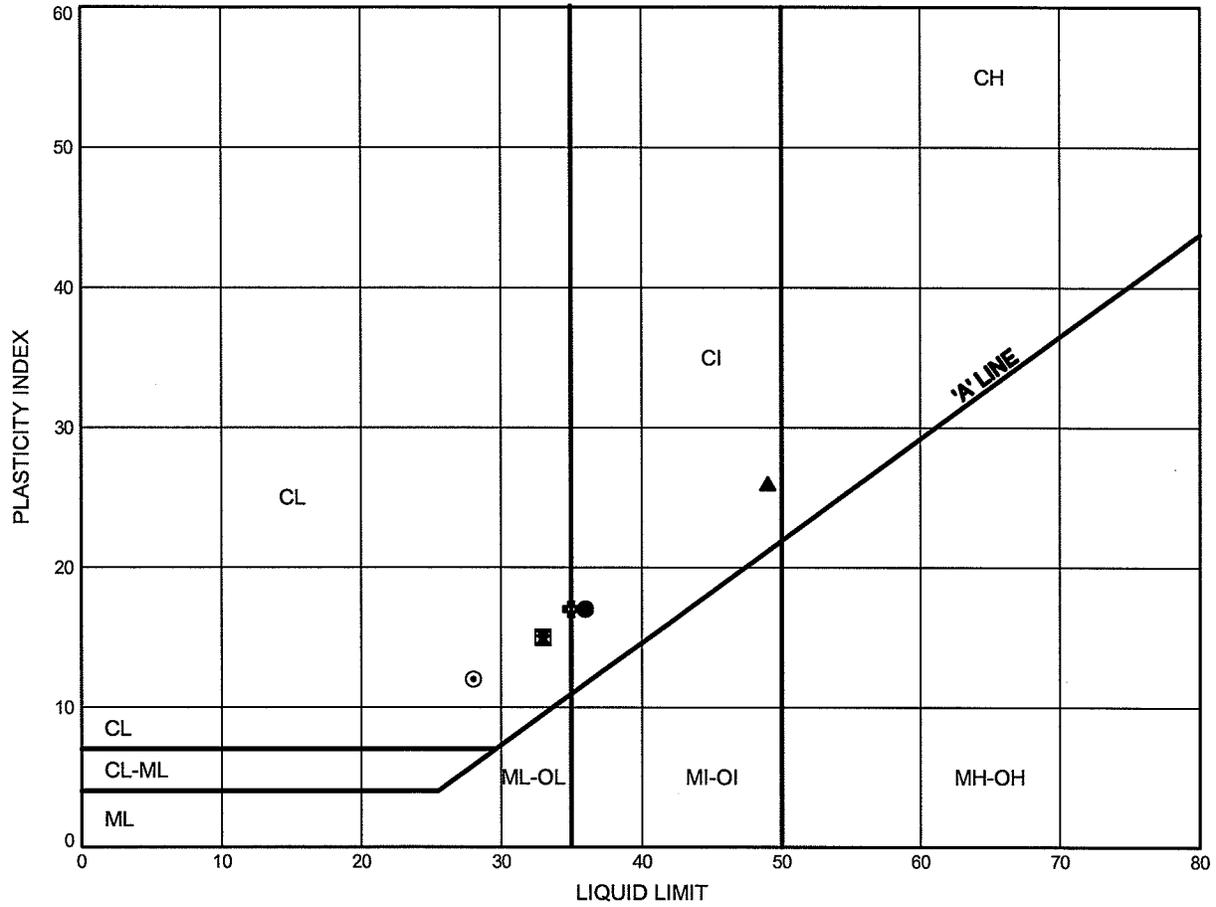
Prep'd JS

Chkd. MP

ATTERBERG LIMITS TEST RESULTS

FIGURE B2-5

SILTY CLAY



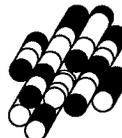
SYMBOL BOREHOLE DEPTH (m) ELEVATION (m)

●	C3-1	4.0	179.2
⊠	C3-1	6.3	176.9
▲	C3-2	3.3	180.6
★	C3-2	6.4	177.5
⊙	C3-2	7.9	175.9
⊕	C3-2	9.4	174.5

ALTR 1-09-4135 CULVERTS2.GPJ 9/3/10

Date September 2010

Project 1-09-4135



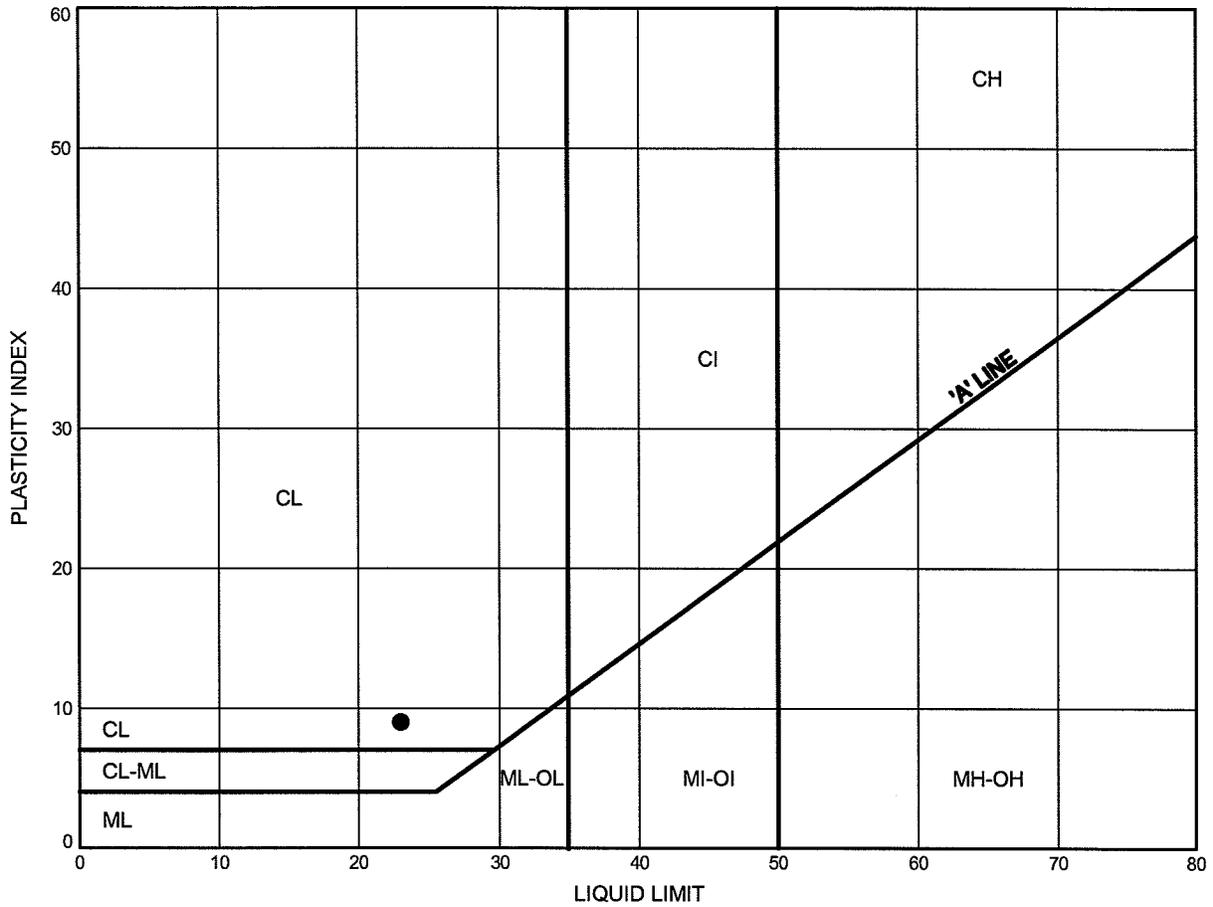
Prep'd JS

Chkd. MP

ATTERBERG LIMITS TEST RESULTS

FIGURE B2-7

SILTY CLAY TILL



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C3-1	12.4	170.8

ALTR 1-09-4135 CULVERTS2.GPJ 9/3/10

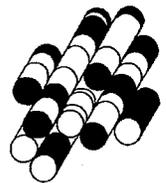
Date ..November 2010...
 Project1-09-4135..

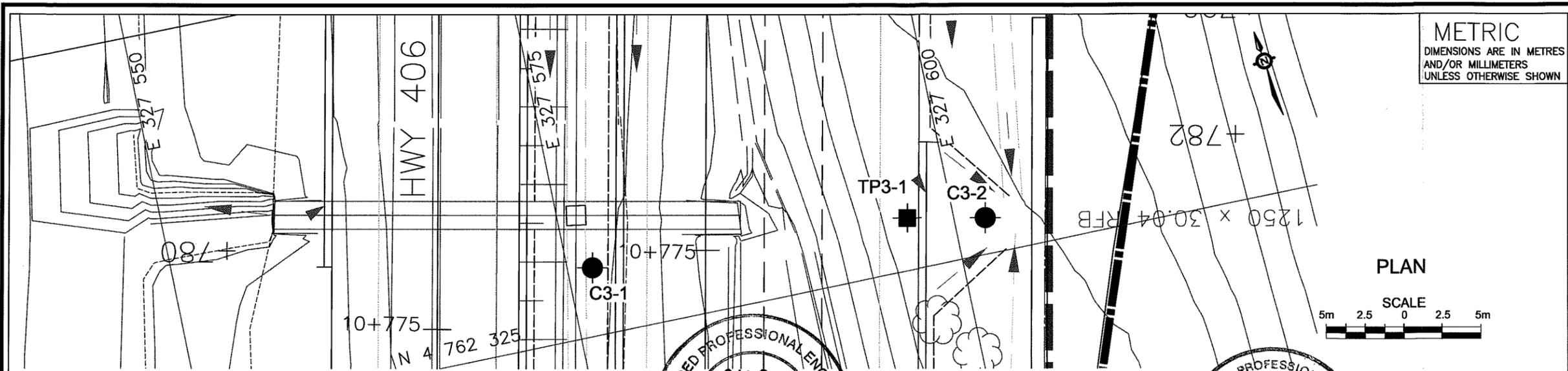


Prep'dJS.....
 Chkd.MP.....

C2

TERRAPROBE INC.





METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETERS
UNLESS OTHERWISE SHOWN

CONT No 2011-2005
WP No 280-99-00

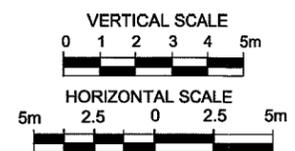
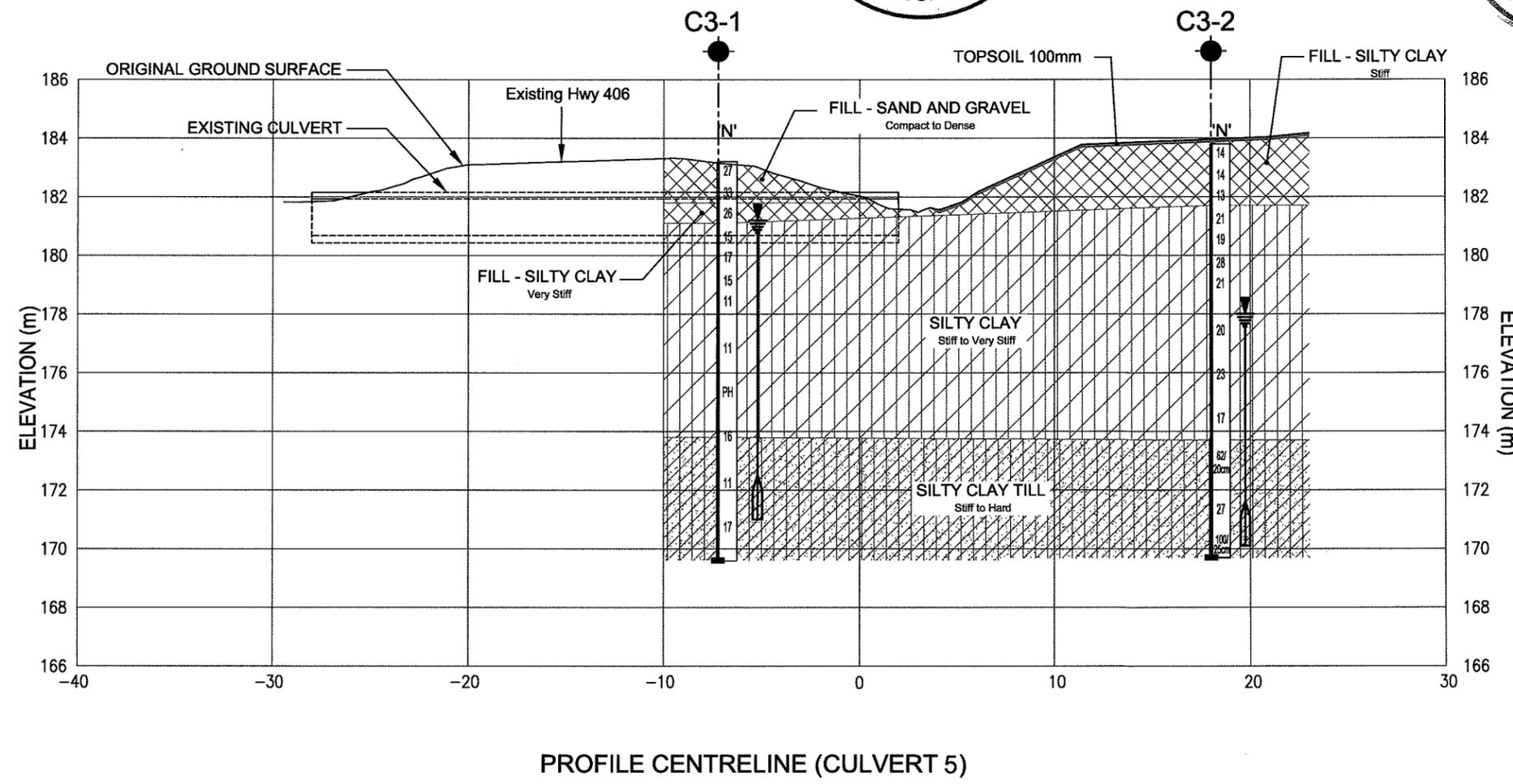
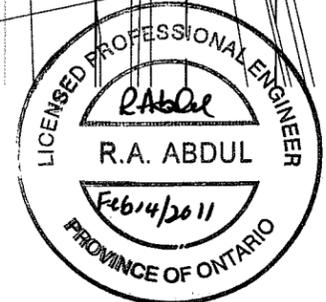
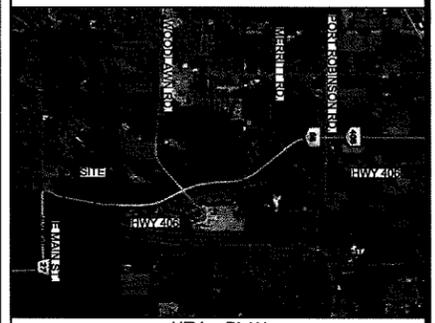
HIGHWAY 406
CULVERT # 5
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET
1 OF



Terraprobe Inc.
Consulting Geotechnical & Environmental Engineering
Construction Materials Engineering, Inspection & Testing
10 Bram Court - Brampton Ontario L6W 3R6 (905) 796-2650



KEY PLAN

LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test
- ⊙ Bore Hole And Cone
- ⊛ Test Pit
- 'N' Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60' Cone, 475 J/blow)
- ≡ WL at Time of Investigation
- ⊖ WL in Piezometer (AUG. 2010)
- ⊕ Piezometer
- 90% Rock Quality Designation
- A/R Auger Refusal

No	ELEV.	COORDINATES	
		NORTHING	EASTING
C3-1	183.2	4 762 329.4	327 576.6
C3-2	183.8	4 762 327.3	327 602.0

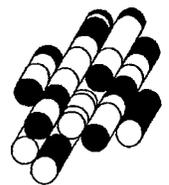
NOTE
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.
This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

REVISIONS	DATE	BY	DESCRIPTION

DESIGN	R.A.	CODE	CHDC2006	LOAD	DATE	FEB. 2011
DRAWN	K.C.	CHK	R.A.	STRUCT		

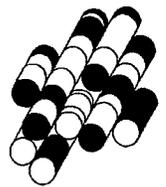
CULVERT #6

TERRAPROBE INC.



A3

TERRAPROBE INC.



RECORD OF BOREHOLE No C5-1

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4763047.5 E:327637.7 ORIGINATED BY PK
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers, D.C.P.T. COMPILED BY DB
 DATUM Geodetic DATE 06.18.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa							
190.4	Ground Surface														
0.0	610mm FILL - Sand and Gravel, some silt, trace clay, compact, brown/grey, damp		1	SS	22										40 41 14 5
189.8	FILL - Silty Clay, trace sand, stiff to very stiff, brown, damp to moist		2	SS	20										
0.6			3	SS	21										
			4	SS	14										0 2 41 57
			5	SS	11										
			6	SS	20										
			7	SS	16										
	trace to some organics, black		8	SS	9										
183.3	SILTY CLAY trace sand, occasional gravel inclusions, very stiff to hard, brown, damp to moist		9	SS	27										1 6 62 31
7.1			10	SS	51										
			11	SS	25										0 2 65 33
	firm to stiff		12	SS	2										
			13	TW	PH										

ONTARIO MOT 1-09-4135 CULVERTS2.GPJ ONTARIO MOT.GDT 10/01/10

Continued Next Page

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No C5-1

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4763047.5 E:327637.7 ORIGINATED BY PK
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers, D.C.P.T. COMPILED BY DB
 DATUM Geodetic DATE 06.18.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa							
						20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100						
171.6			14	SS	5									0 3 67 30	
174							1.4								
173	inferred hard		15	SS	100/5cm									Sampler refusal probably on a cobble	
172			16	SS	6										
18.8	End of Borehole														
19.4	End of Dynamic Cone Penetration Test														
	Dynamic Cone Penetration Test performed from 18.8m to 19.4m. Resistance to augering at 2.0m. Borehole was dry (not stabilized) and hole open to full depth on completion. Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 1.52m slotted screen. Water Level Readings: Date Depth(m) Elevation(m) Jul. 05. 10 9.0 181.4 Jul. 14. 10 4.9 185.5 Jul. 21. 10 8.3 182.1 Jul. 28. 10 8.6 181.8														

ONTARIO MOT. 1-09-4135 CULVERTS2.GPJ ONTARIO MOT.GDT 10/01/10

+ 3, X 3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No C5-2

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4763044.7 E:327676.8 ORIGINATED BY BL
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 6.30.10 - 7.5.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W _L	UNIT WEIGHT γ KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa							
						20	40	60	80	100					
170.4			14	TW	PH										
168.4	SILTY CLAY some sand, trace gravel, hard, brown, damp (GLACIAL TILL)		15	SS	50			1.6							
168.4			16	SS	52			1.3							
18.8	End of Borehole Sampler wet at 13.7m. Borehole was dry (not stabilized) and hole open to full depth on completion. Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 1.52m slotted screen. Water Level Readings: Date Depth(m) Elevation(m) Jul. 14. 10 6.7 180.5 Jul. 21. 10 6.3 180.9 Jul. 28. 10 6.4 180.8														3 16 49 32

ON_MOT_1-09-4135 CULVERTS2.GPJ ON_MOT.GDT 9/9/10

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

Test Pit Logs
Culvert #5 (Highway 406 Sta. 11+499)

Test Pit# TP 5-1

0	-	100	Tps
100	-	300	Fill, Br Si(y) Cl, Moist

Test Pit# TP 5-2

0	-	130	Tps
130	-	300	Fill, Br Si(y) Cl, Moist

Test Pit# TP 5-3

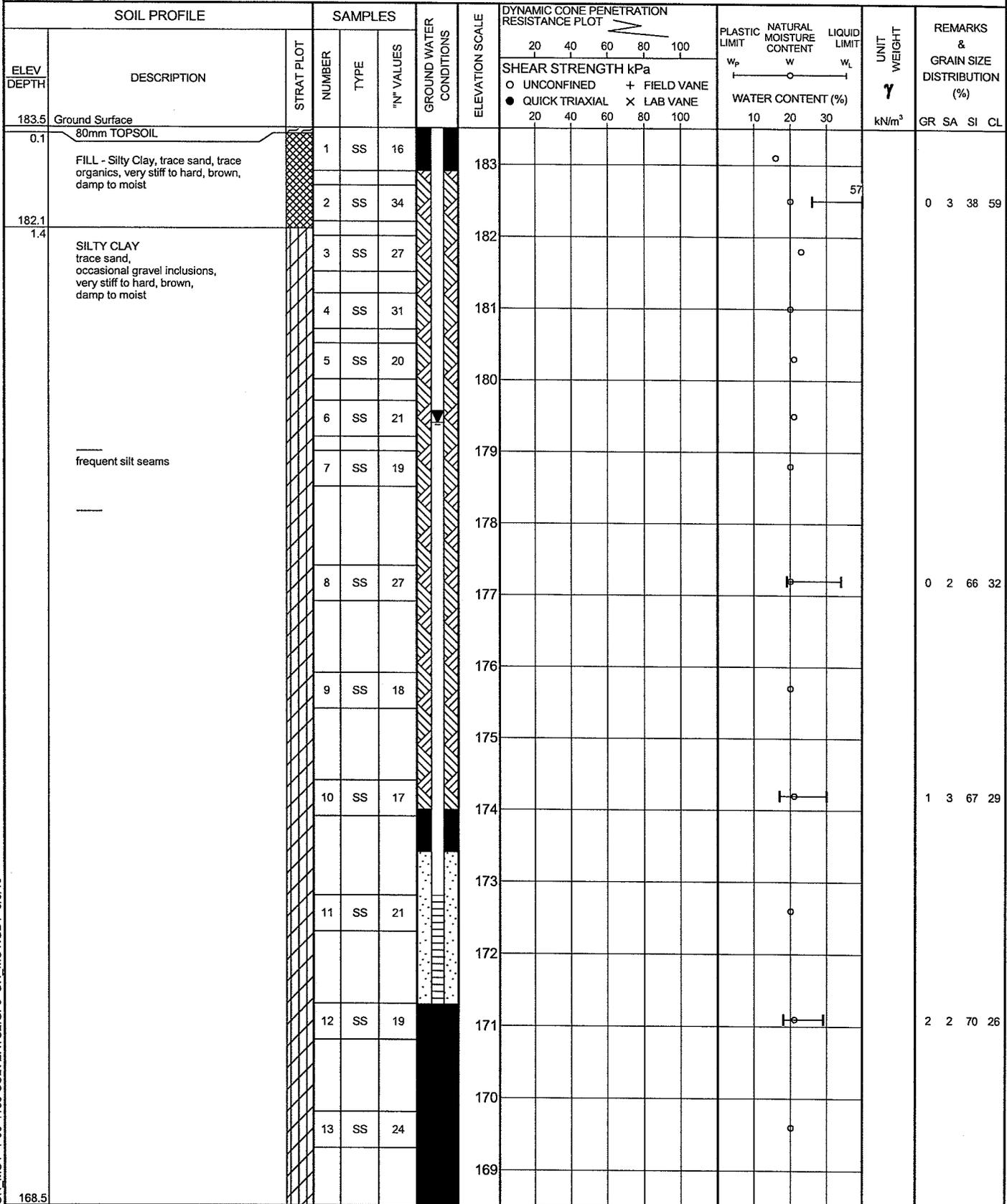
0	-	100	Tps
100	-	300	Fill, Br Si(y) Cl, Damp

RECORD OF BOREHOLE No C6-2

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4763794.6 E:327454.9 ORIGINATED BY BL
 DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 7.21.10 CHECKED BY RA



ON_MOT_1-09-4135_CULVERTS2.GPJ ON_MOT.GDT 9/9/10

Continued Next Page

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No C6-2

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4763794.6 E:327454.9 ORIGINATED BY BL
 DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 7.21.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									
						20	40	60	80	100							
15.0	SILTY CLAY TO CLAYEY SILT some sand, trace gravel, hard, brown, damp (GLACIAL TILL)		14	SS	37											2 13 58 27	
15.7	End of Borehole Borehole was dry (not stabilized) and hole open to full depth on completion. Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 1.52m slotted screen. Water Level Readings: Date Depth(m) Elevation(m) Jul. 28. 10 4.1 179.4 Aug. 06. 10 1.8 181.7 Aug. 13. 10 3.6 179.9 Aug. 23. 10 4.1 179.4 Sept. 25. 10 4.1 179.4																

ON_MOT_1-09-4135_CULVERTS2.GPJ ON_MOT_GDT_9/9/10

+ 3, X 3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No S-EW 10+025Rt 1 OF 2 METRIC

W.P. 280-99-00 LOCATION Coords: N:4763892.5 E:327500.9 ORIGINATED BY AW
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY KL
 DATUM Geodetic DATE 12.03.09 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20						40	60	80
183.6	Ground Surface															
0.1	70mm TOPSOIL															
	FILL - Silty Clay, trace to some sand, trace organics, occasional gravel inclusions, occasional concrete debris, stiff to hard, brown, damp to moist		1	SS	13						o					
			2	SS	93						o					
			3	SS	50						o	-----			0 11 59 30	
			4	SS	15							o				
			5	SS	12							o				
			6	SS	14							o				
179.2	SILTY CLAY trace sand, stiff to very stiff, brown, damp to moist		7	SS	25							o				
4.4			8	SS	17							-----			0 2 67 31	
			9	SS	21						>> 1.5					
			10	SS	11						>> 1.5					
			11	SS	15						>> 1.1	-----			0 2 68 30	
			12	TW	PH						+ 1.6					
			13	SS	28						>> 1.1					
											>> 1.8	-----	21.0		0 4 75 21	
											>> 1.3					
											>> 1.3	-----			0 2 66 32	
											>> 1.3					
											>> 1.3					

ONTARIO MOT 1-09-4136 CULVERTS2.GPJ ONTARIO MOT.GDT 10/01/10

Continued Next Page

+ 3, X 3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No S-EW 10+025Rt 2 OF 2 METRIC

W.P. 280-99-00 LOCATION Coords: N:4763892.5 E:327500.9 ORIGINATED BY AW
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY KL
 DATUM Geodetic DATE 12.03.09 CHECKED BY RA

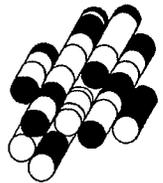
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w_p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w_L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
						20	40	60	80	100						
167.4	CLAYEY SILT TO SILTY CLAY sandy, some gravel, hard, brown, damp (GLACIAL TILL)		14	SS	26											
16.2																
					15	SS	81									15 34 38 13
164.8			16	SS	125											
18.8	End of Borehole															
	Unable to push vane beyond 15.7m. Borehole was dry (not stabilized) and hole open to full depth on completion. Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 3.0m slotted screen. Water Level Readings: Date Depth(m) Elevation(m) Dec. 08.09 17.7 165.9 Dec. 15.09 16.1 167.5 Jan. 04.10 5.0 178.6 Jan. 11.10 3.9 179.7 Jan. 19.10 4.0 179.6 Consolidation Test performed on TW12															

ONTARIO MOT 1-09-4195 CULVERTS2.GPJ ONTARIO MOT.GDT 10/01/10

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

B3

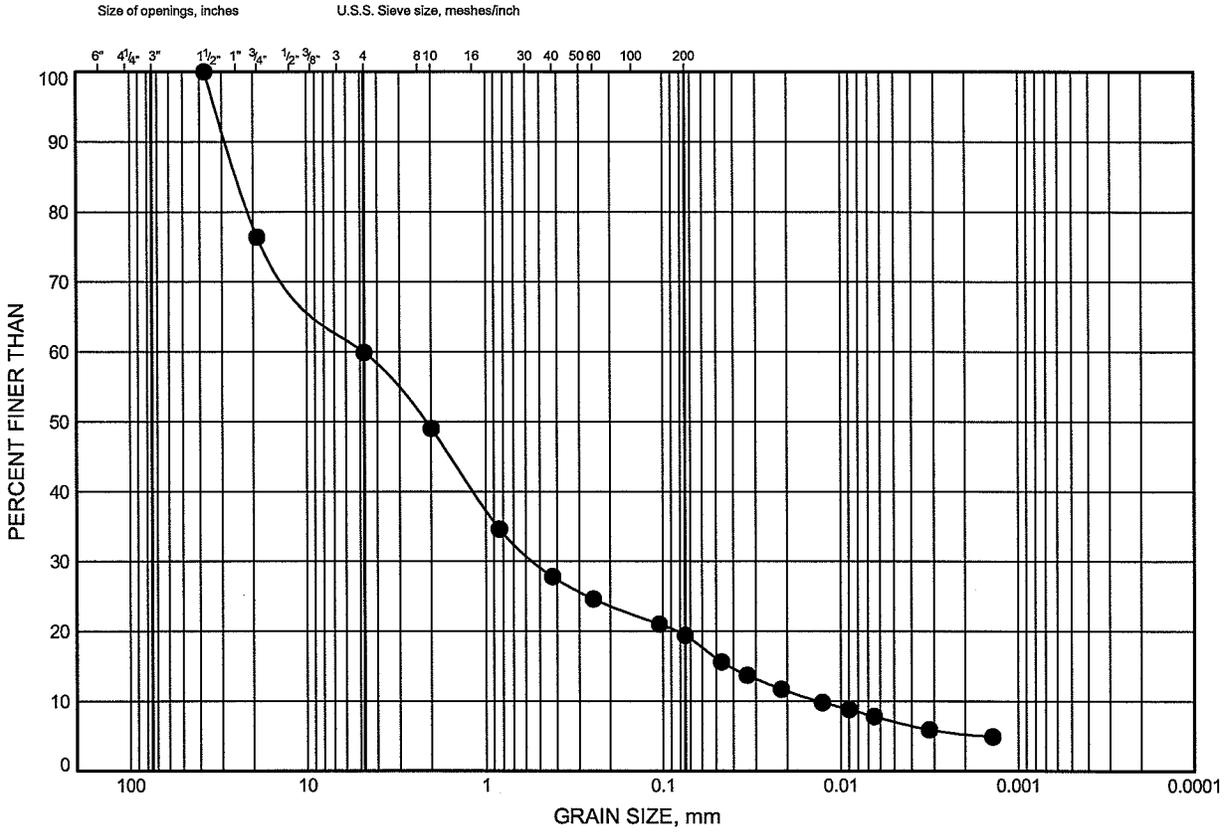
TERRAPROBE INC.



GRAIN SIZE DISTRIBUTION

FIGURE B3-1

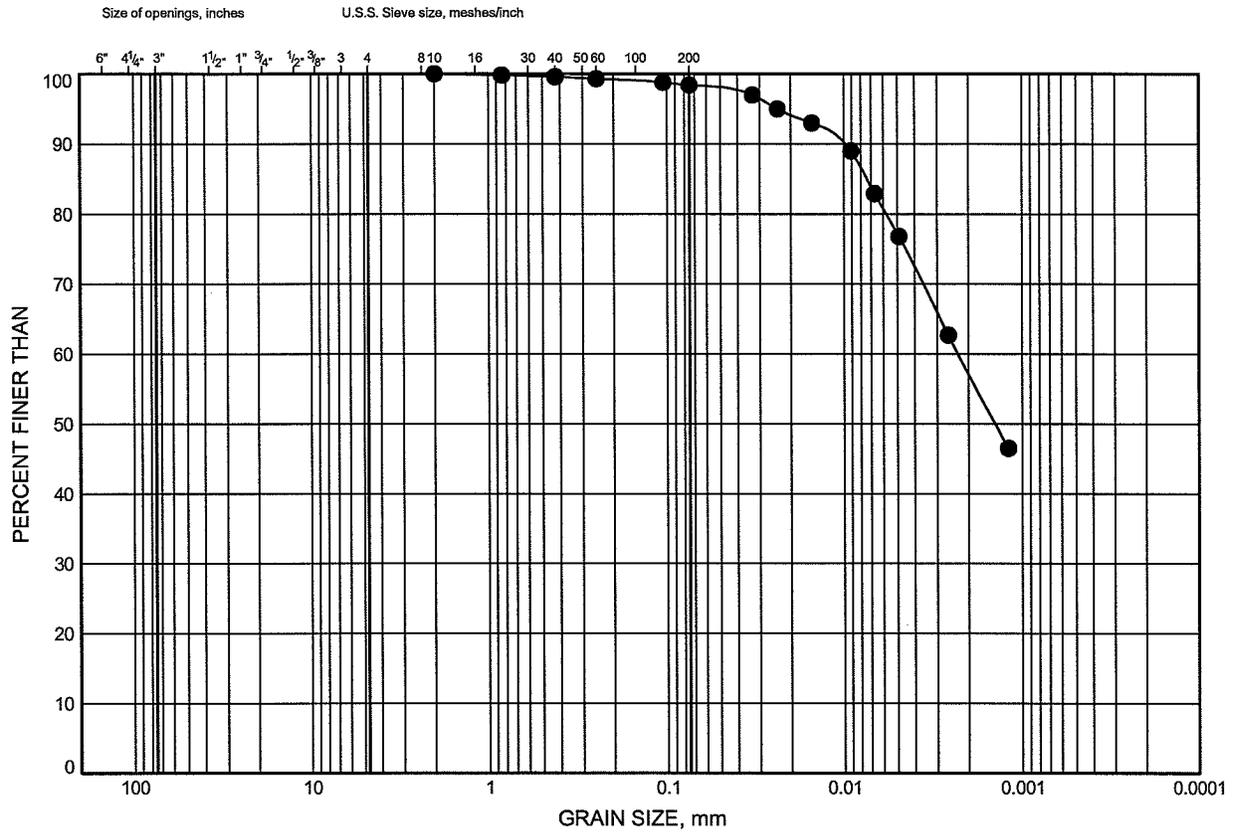
FILL - Sand and Gravel



GRAIN SIZE DISTRIBUTION

FIGURE B3-2

FILL - Silty Clay



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C5-1	2.5	187.9

GSD 1-09-4135 CULVERTS2.GPJ 9/7/10

Date November 2010
 Project 1-09-4135

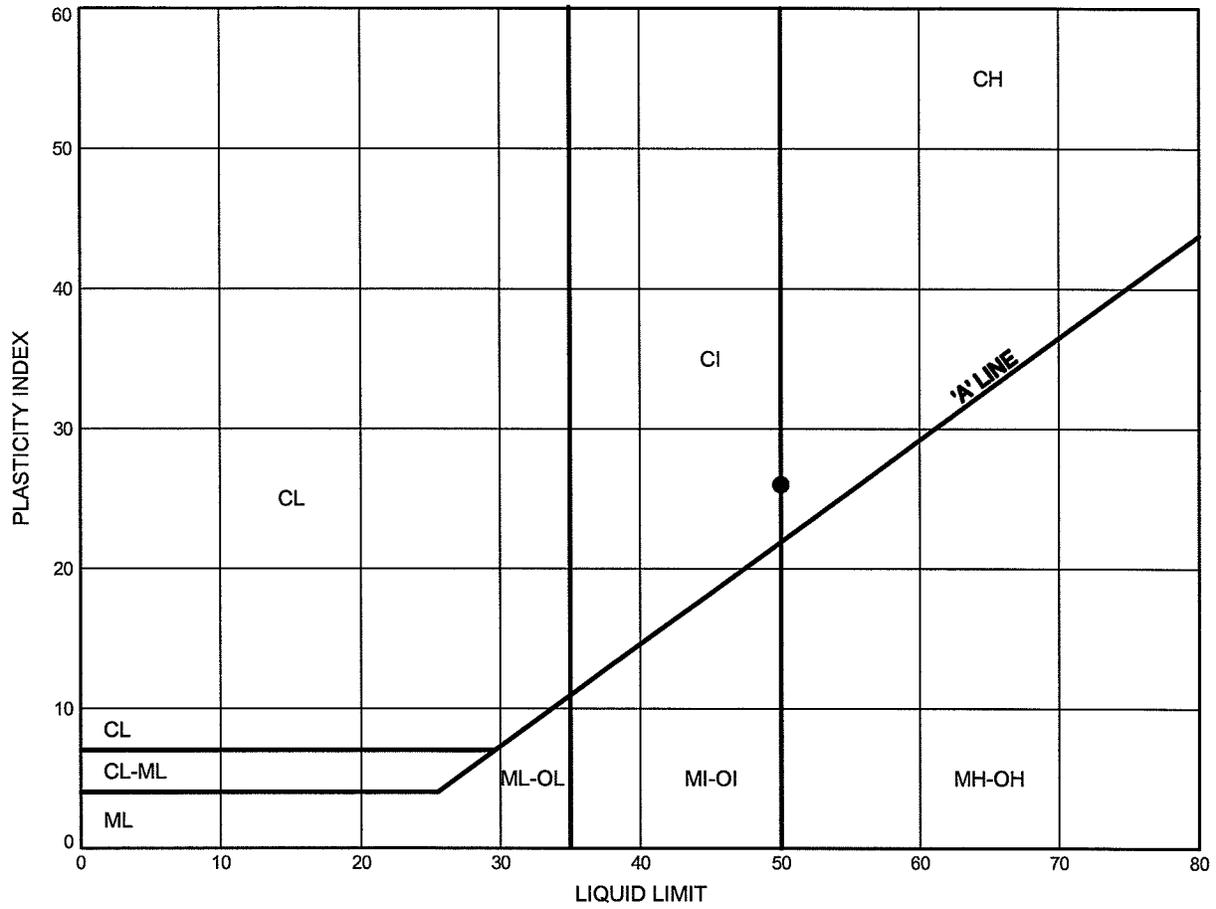


Prep'd JS
 Chkd. MP

ATTERBERG LIMITS TEST RESULTS

FIGURE B3-3

FILL - Silty Clay



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C5-1	2.5	187.9

ALTR 1-09-4135 CULVERTS2.GPJ 9/3/10

Date November 2010
 Project 1-09-4135

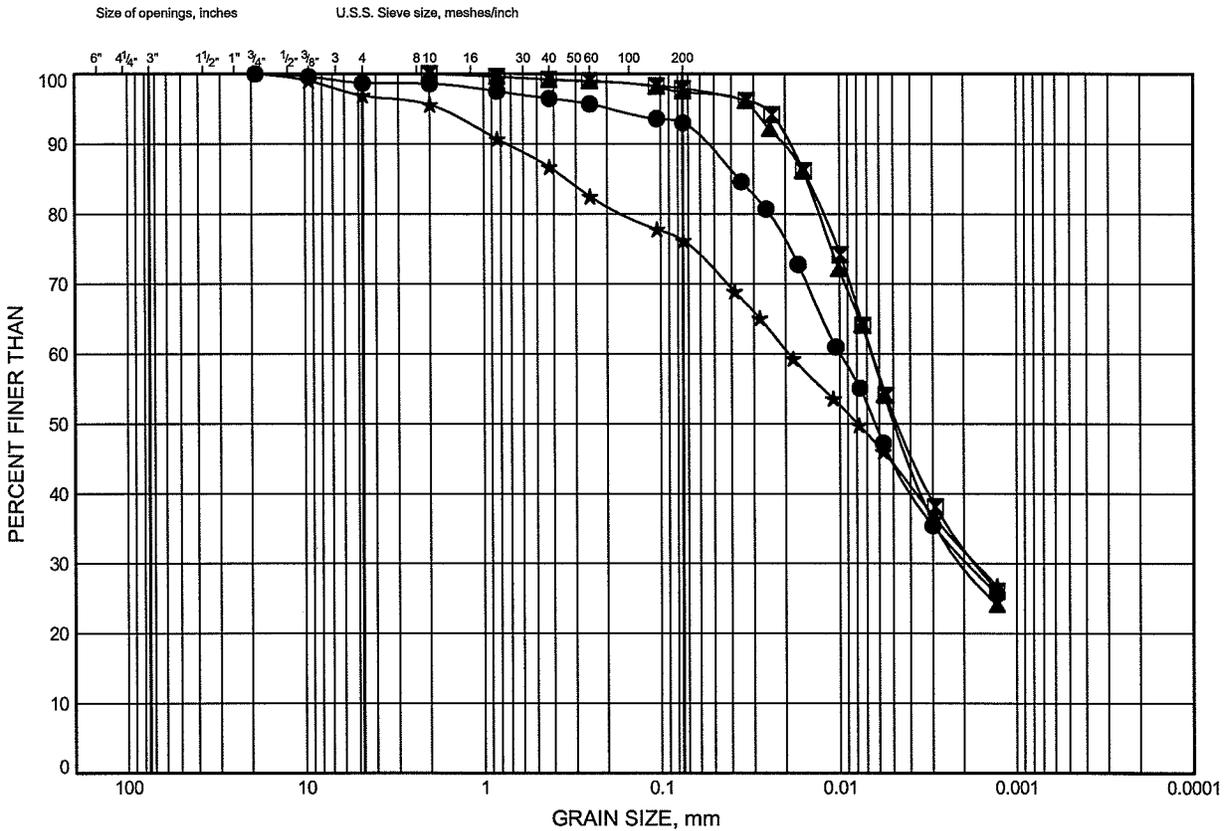


Prep'd JS
 Chkd. MP

GRAIN SIZE DISTRIBUTION

FIGURE B3-4

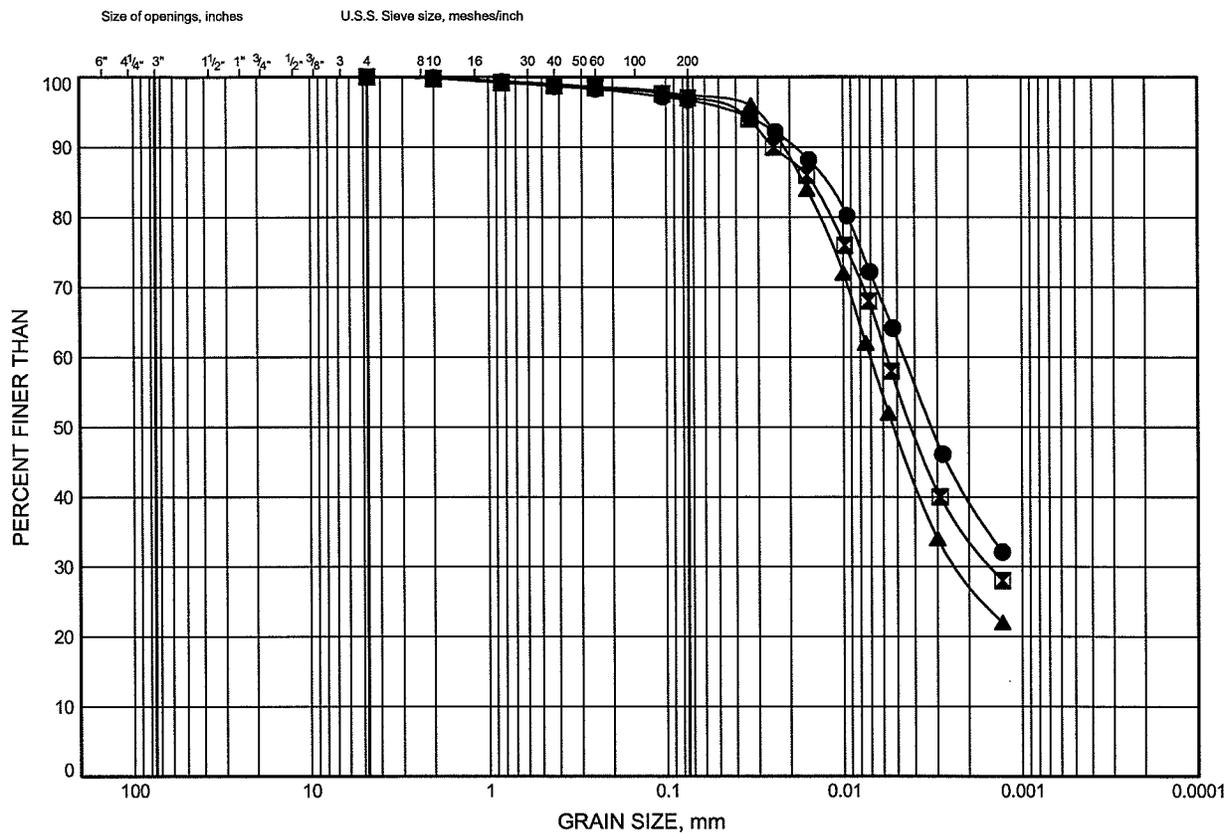
SILTY CLAY



GRAIN SIZE DISTRIBUTION

FIGURE B3-5

SILTY CLAY



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

SYMBOL BOREHOLE DEPTH (m) ELEVATION (m)

●	C5-2	7.8	179.4
■	C5-2	12.4	174.8
▲	C5-2	13.9	173.3

GSD 1-09-4135 CULVERTS2.GPJ 9/7/10

Date November 2010
Project 1-09-4135

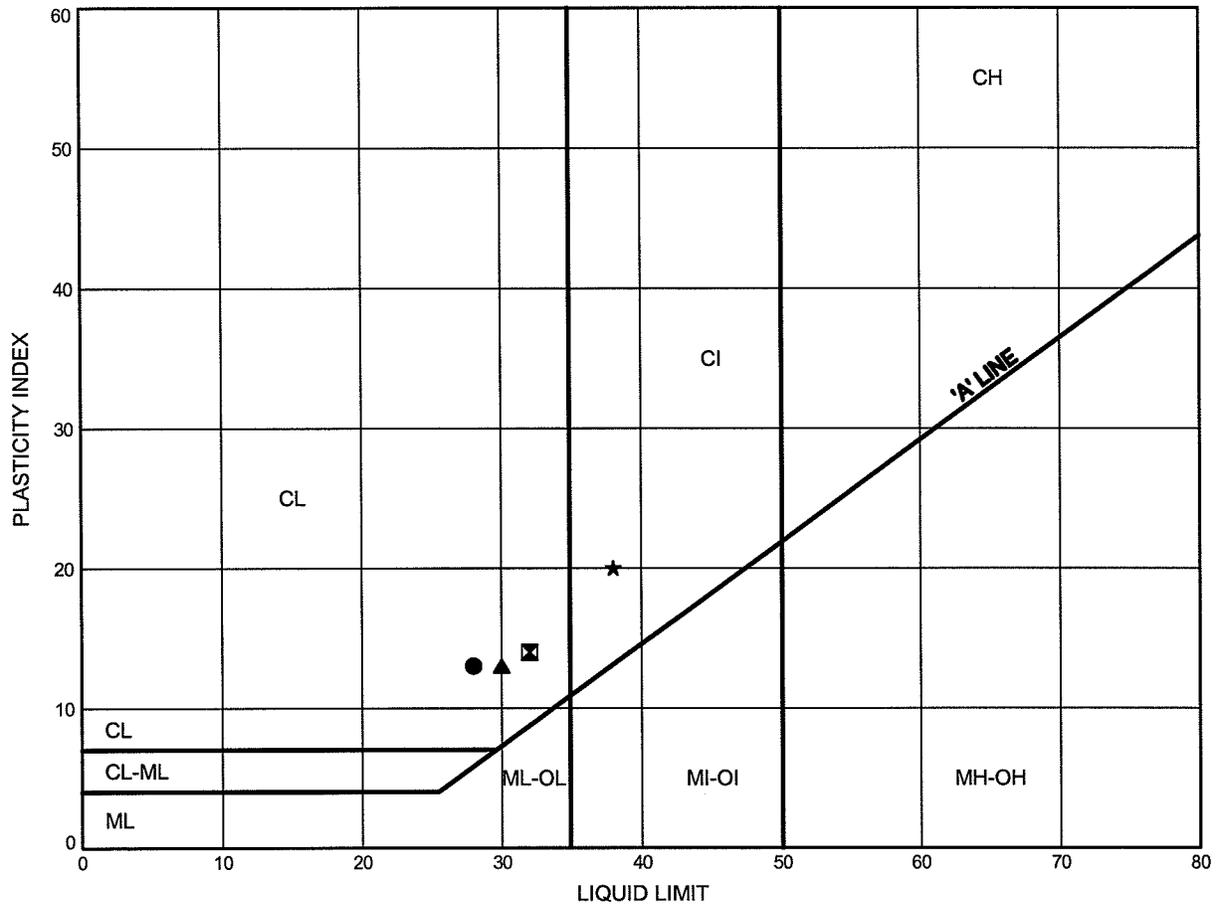


Prep'd JS
Chkd. MP

ATTERBERG LIMITS TEST RESULTS

FIGURE B3-6

SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C5-1	7.8	182.6
⊠	C5-1	10.9	179.5
▲	C5-1	15.7	174.7
★	C5-2	4.7	182.5

ALTR 1-09-4135 CULVERTS2.GPJ 9/3/10

Date November 2010
 Project 1-09-4135

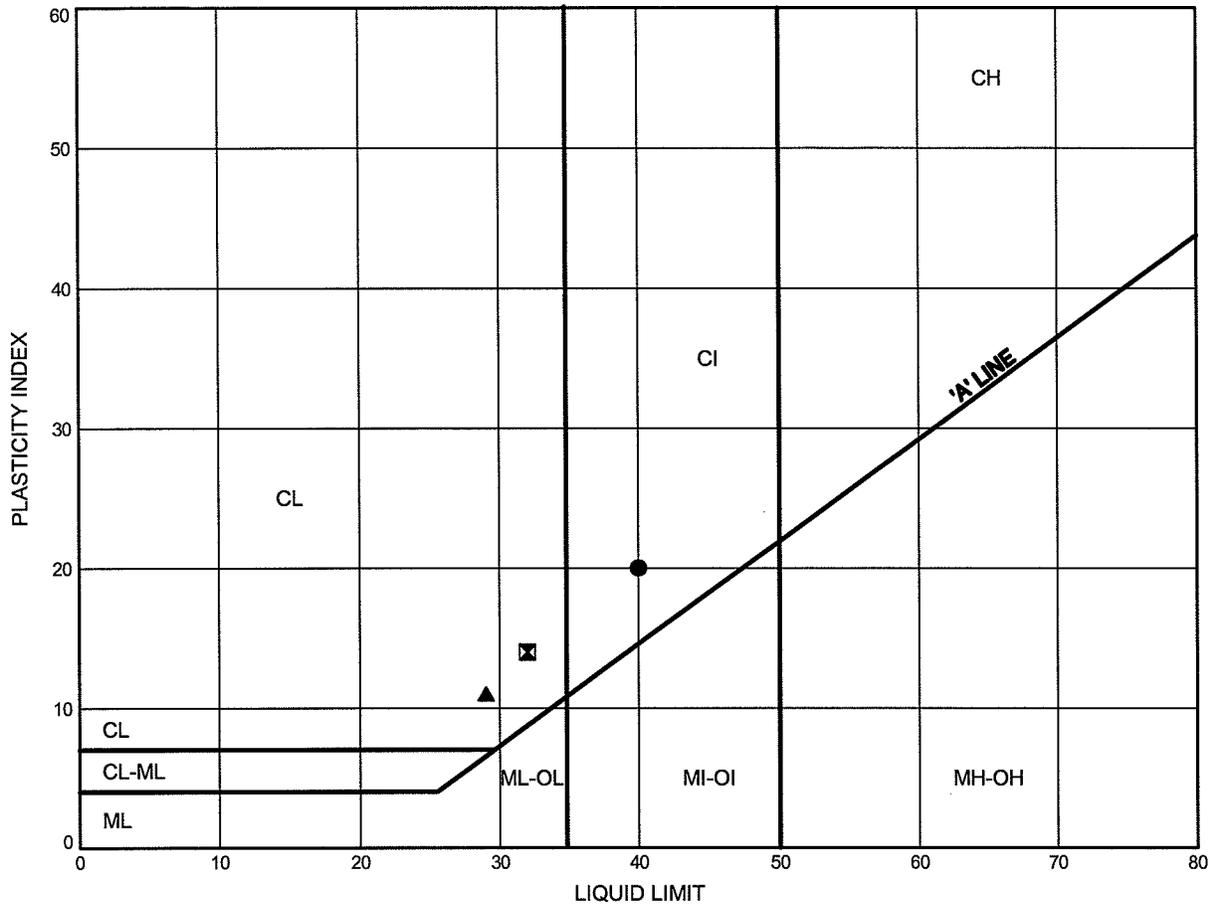


Prep'd JS
 Chkd. MP

ATTERBERG LIMITS TEST RESULTS

FIGURE B3-7

SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C5-2	7.8	179.4
⊠	C5-2	12.4	174.8
▲	C5-2	13.9	173.3

ALTR 1-09-4135 CULVERTS2.GPJ 9/8/10

Date November 2010
 Project 1-09-4135

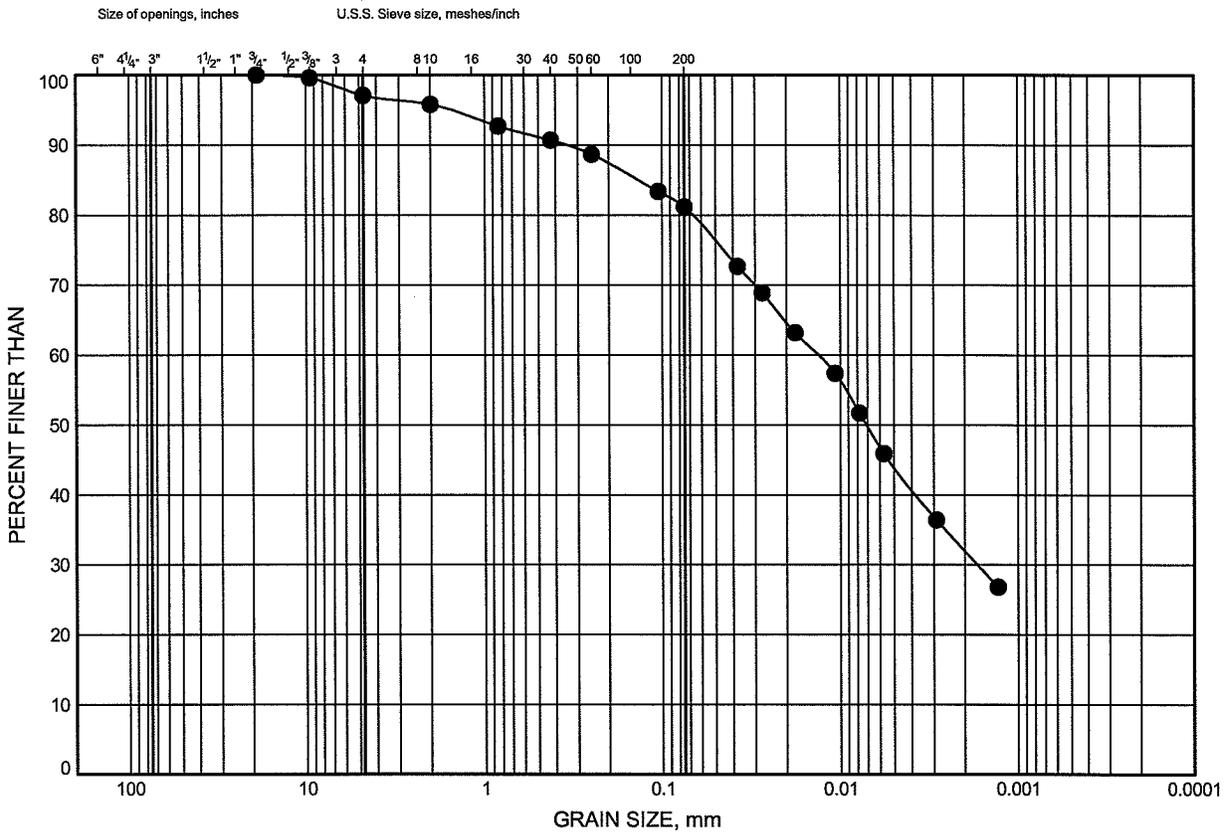


Prep'd JS
 Chkd. MP

GRAIN SIZE DISTRIBUTION

FIGURE B3-8

SILTY CLAY TILL



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C5-2	18.5	168.7

Date November 2010
 Project 1-09-4135

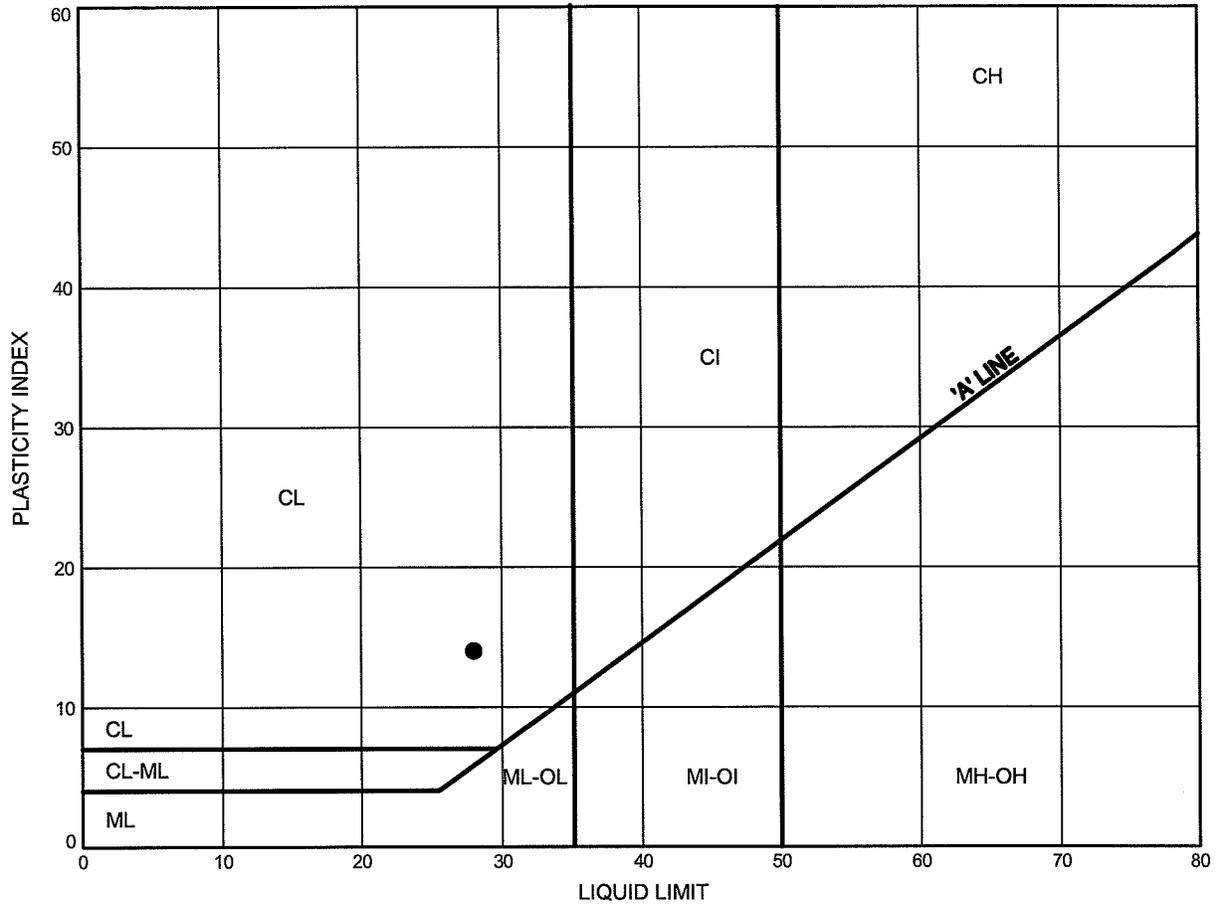


Prep'd JS
 Chkd. MP

ATTERBERG LIMITS TEST RESULTS

FIGURE B3-9

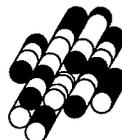
SILTY CLAY TILL



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C5-2	18.5	168.7

ALTR 1-09-4135 CULVERTS2.GPJ 9/7/10

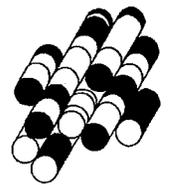
Date November 2010
 Project 1-09-4135...

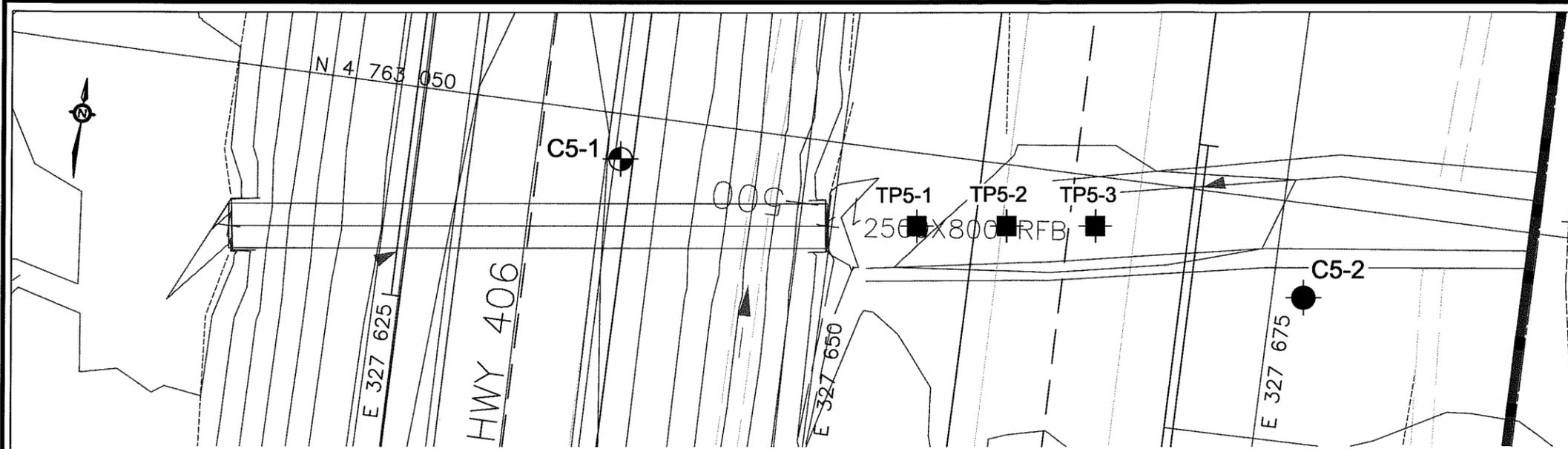


Prep'd JS
 Chkd. MP

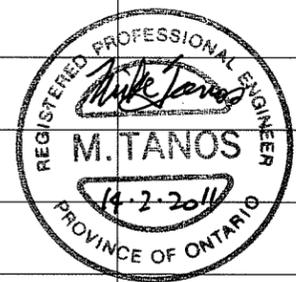
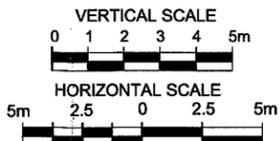
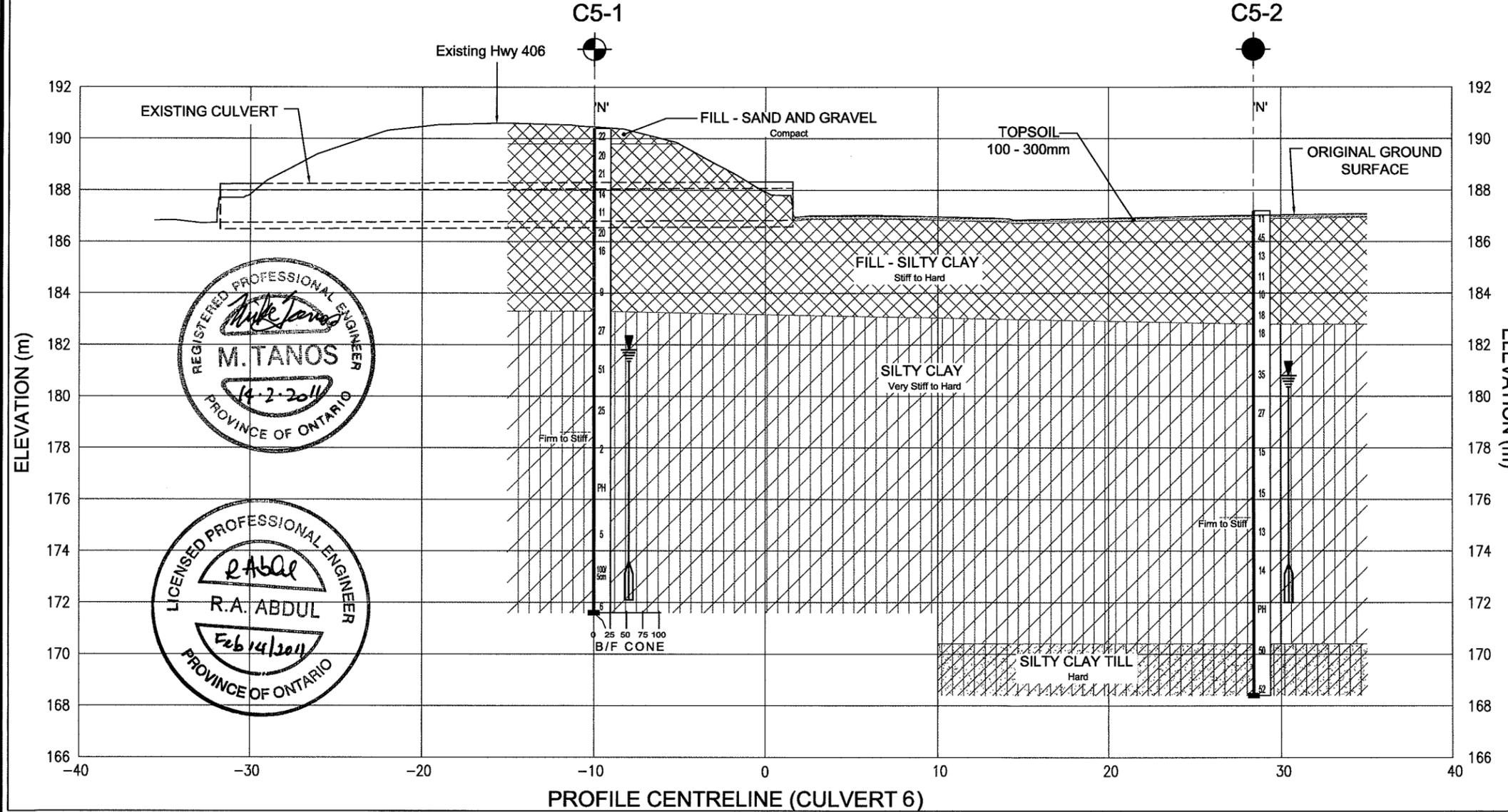
C3

TERRAPROBE INC.





METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETERS
UNLESS OTHERWISE SHOWN

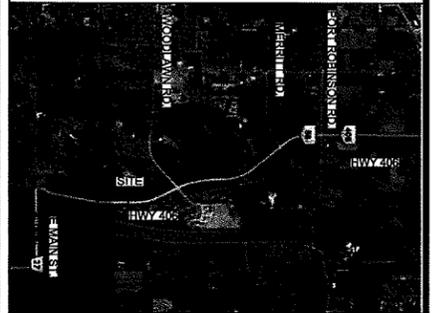


CONT No 2011-2005
WP No 280-99-00

HIGHWAY 406
CULVERT # 6
BOREHOLE LOCATIONS AND SOIL STRATA



Terraprobe Inc.
Consulting Geotechnical & Environmental Engineering
Construction Materials Engineering, Inspection & Testing
10 Bram Court - Brampton Ontario L6W 3R6 (905) 796-2650



KEY PLAN

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test
- Bore Hole And Cone
- Test Pit
- Blows/0.3m (Std Pen Test, 475 J/blow)
- Blows/0.3m (60° Cone, 475 J/blow)
- WL at Time of Investigation
- WL in Piezometer (JULY. 2010)
- Piezometer
- 90% Rock Quality Designation
- A/R Auger Refusal

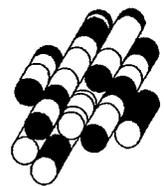
No	ELEV.	COORDINATES	
		NORTHING	EASTING
C5-1	190.4	4 763 047.5	327 637.7
C5-2	187.2	4 763 044.7	327 676.8

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

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	R.A.	CODE	CHBDC2006
DRAWN	K.C.	CHK	R.A.
		LOAD	DATE FEB. 2011
		STRUCT	GEORES 30M3-269

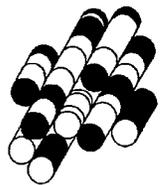
CULVERT #8

TERRAPROBE INC.



A4

TERRAPROBE INC.



RECORD OF BOREHOLE No C6-1

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4763918.4 E:327528.0 ORIGINATED BY JS
 DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY JS
 DATUM Geodetic DATE 7.26.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
179.2	Ground Surface													
179.0	200mm TOPSOIL													
0.2	SILTY CLAY trace sand, stiff to hard, brown, damp to moist frequent silt seams	1	SS	10		179							0 3 59 38	
		2	SS	15		178								
		3	SS	36		177								0 0 87 13
		4	SS	23		176								
		5	SS	18		175								0 3 69 28
		6	SS	28		174								
		7	SS	17		173								0 3 68 29
		8	SS	21		172								
		9	TW	PH		171								
		10	SS	36		170								
169.1	SILTY CLAY TO CLAYEY SILT sandy, trace gravel, hard, brown, damp (GLACIAL TILL)					169								
10.1		11	SS	48		168							4 25 53 18	
166.5	End of Borehole Borehole was dry (not stabilized) and hole open to full depth on completion.					167								
12.7		12	SS	86										

ON MOT 1-09-4135 CULVERTS2.GPJ ON MOT.GDT 9/9/10

Continued Next Page

+³, X³. Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No C6-1

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4763918.4 E:327528.0 ORIGINATED BY JS
 DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY JS
 DATUM Geodetic DATE 7.26.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
					20	40	60	80	100							
	Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 1.52m slotted screen. Water Level Readings: Date Depth(m) Elevation(m) Jul. 28. 10 Dry Dry Aug. 06. 10 4.7 174.5 Aug. 13. 10 2.5 176.7 Aug. 23. 10 2.0 177.2 Sept. 25. 10 2.0 177.2															

ON_MOT_1-09-4135_CULVERTS2.GPJ ON_MOT.GDT 9/9/10

+³, X³. Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Test Pit Logs
Culvert #6 (Highway 406 Sta. 12+354)

Test Pit# TP 6-1

0	-	200	Dk Br Si(y) Cl, Some Org, Some Rootlets, Moist
200	-	1.22	Br Si(y) Cl, Tr Sa, Damp to Moist

Test Pit# TP 6-2

0	-	610	Br Si(y) Cl, Some Org, Some Rootlets, Moist
610	-	910	Br Si(y) Cl, Tr Sa, Tr Rootlets, Moist
910	-	1.22	Br Si(y) Cl, Damp to Moist

Test Pit# TP 6-3

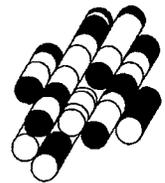
0	-	610	Br Si(y) Cl, Tr Sa, Some Org, Some Rootlets, Moist
610	-	1.83	Br Si(y) Cl, Occ Sa Lense, Damp to Moist

Test Pit# TP 6-4

0	-	300	Br Si(y) Cl, Tr Sa, Some Org, Some Rootlets, Moist
300	-	1.83	Br Si(y) Cl, Tr Sa, Damp to Moist

B4

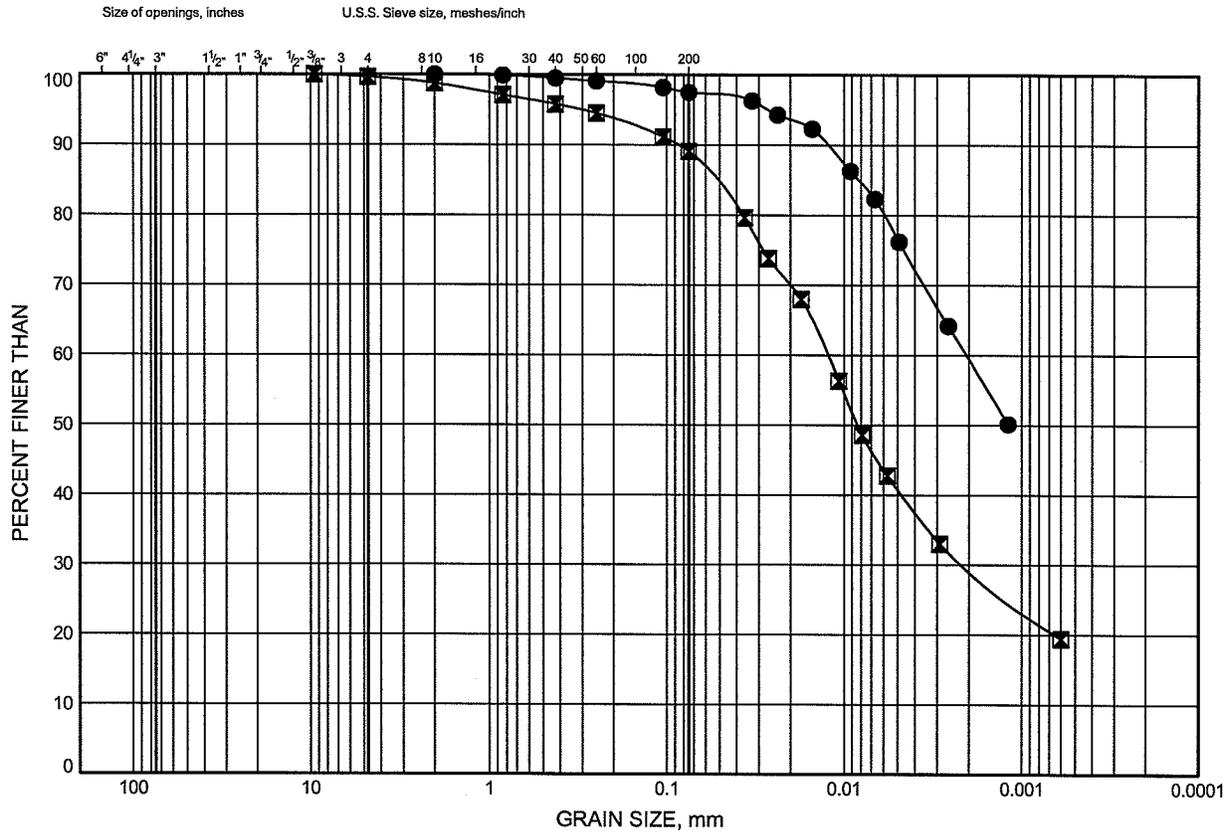
TERRAPROBE INC.



GRAIN SIZE DISTRIBUTION

FIGURE B4-1

FILL - Silty Clay



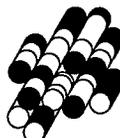
COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL BOREHOLE DEPTH (m) ELEVATION (m)

- C6-2 1.0 182.5
- S-EW 10+025Rt 1.7 181.9

GSD FIG B5-11.GPJ 9/7/10

Date ..November 2010...
 Project ...1-09-4135..

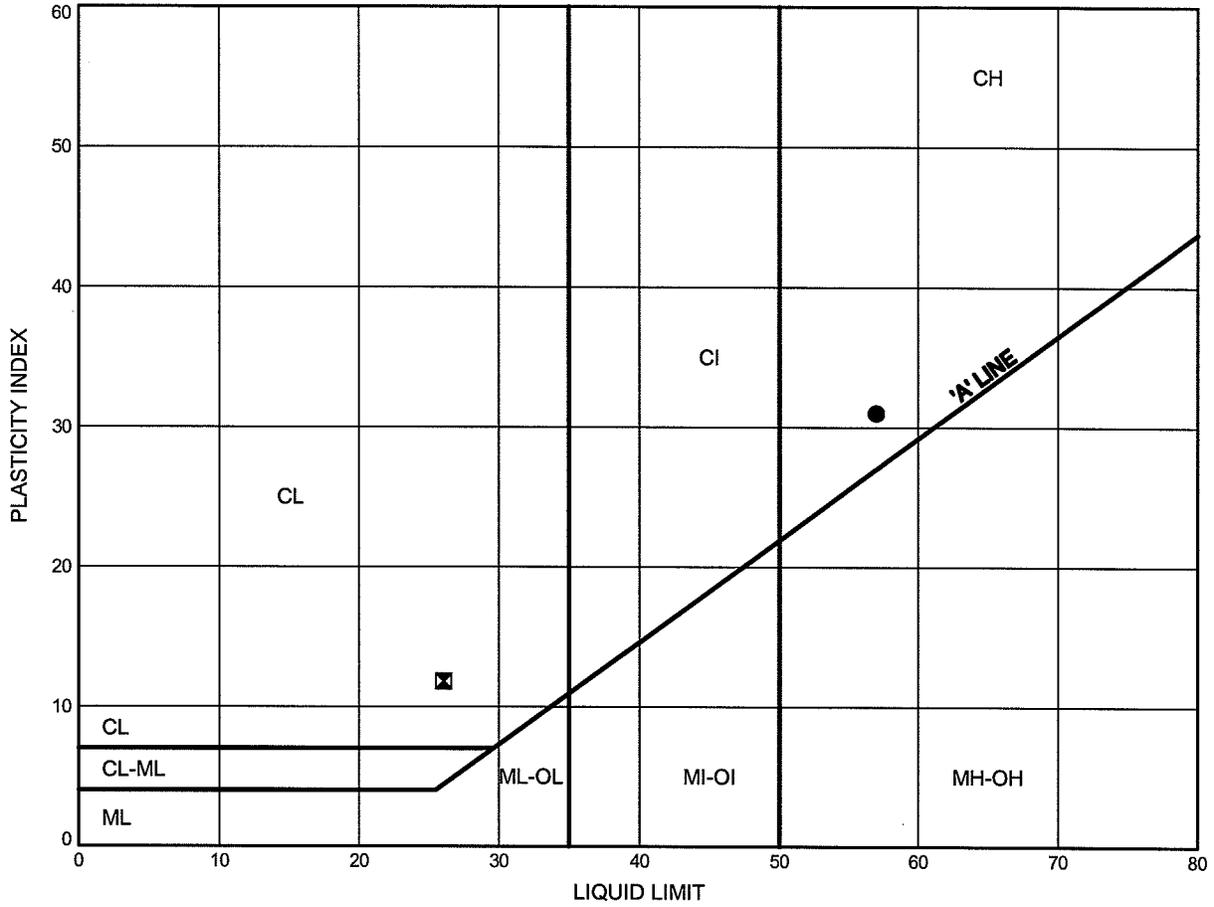


Prep'dJS.....
 Chkd.MP.....

ATTERBERG LIMITS TEST RESULTS

FIGURE B4-2

FILL - Silty Clay



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C6-2	1.0	182.5
⊠	S-EW 10+025Rt	1.7	181.9

ALTR 1-09-4135 S-E QUADRANT.GPJ 09/13/10

Date November 2010
 Project 1-09-4135

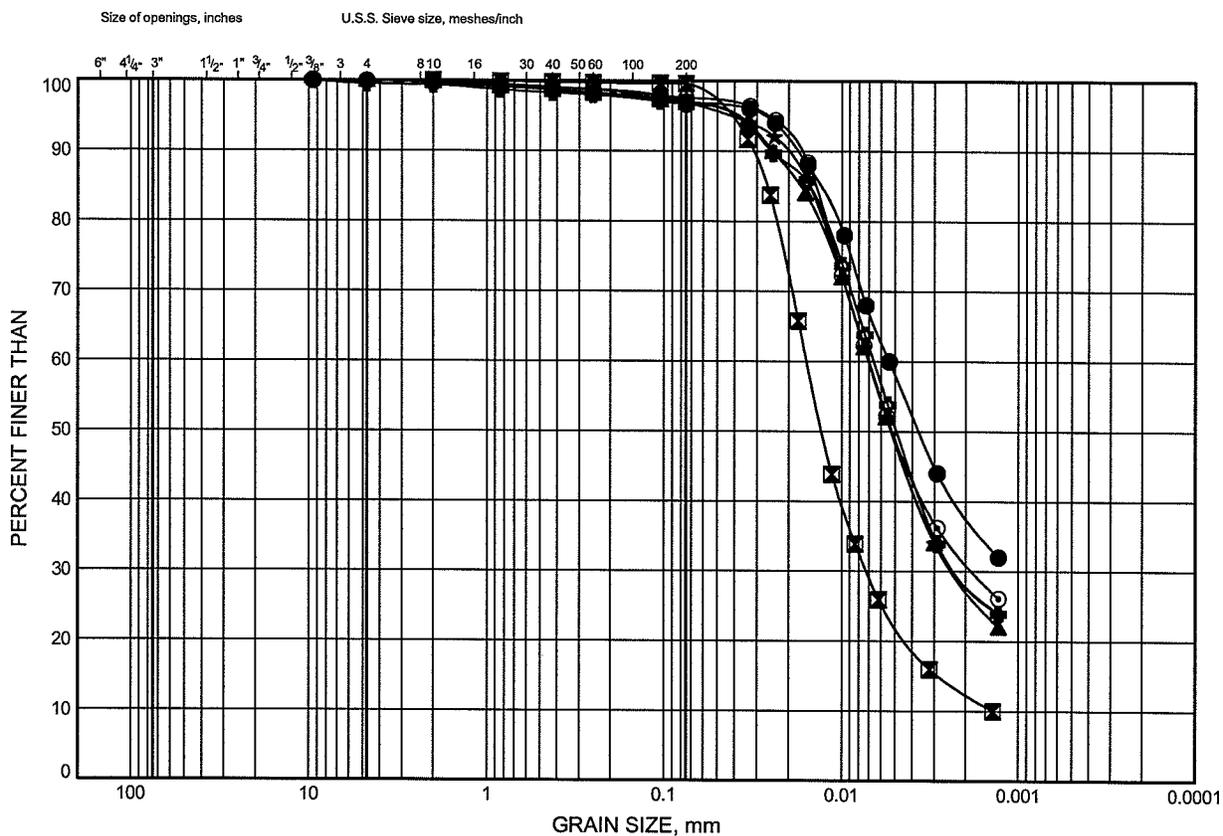


Prep'd K.L.
 Chkd. M.P.

GRAIN SIZE DISTRIBUTION

FIGURE B4-3

SILTY CLAY



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

SYMBOL BOREHOLE DEPTH (m) ELEVATION (m)

●	C6-1	0.4	178.8
⊠	C6-1	1.7	177.5
▲	C6-1	3.2	176.0
★	C6-1	4.7	174.5
⊙	C6-2	6.3	177.2
⊕	C6-2	9.3	174.2

GSD 1-09-4135 CULVERTS2.GPJ 9/7/10

Date November 2010

Project 1-09-4135



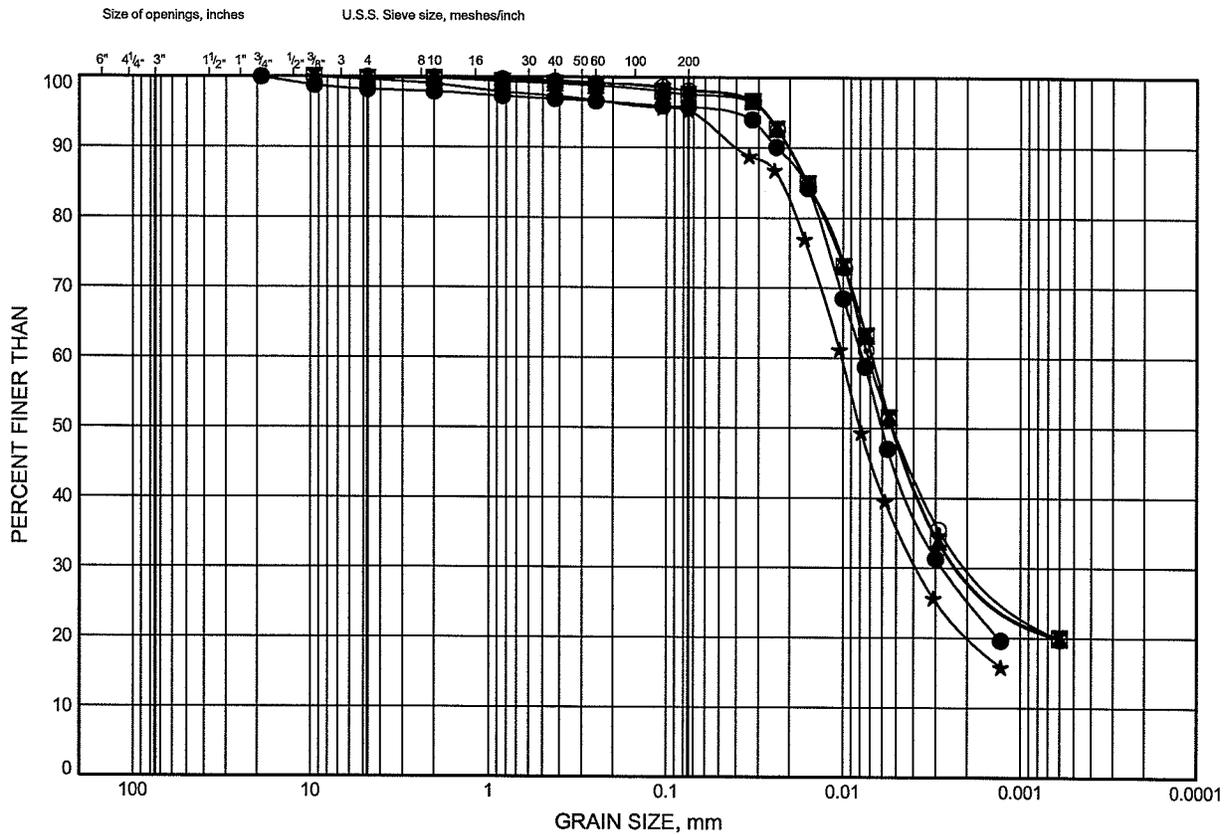
Prep'd JS

Chkd. MP

GRAIN SIZE DISTRIBUTION

FIGURE B4-4

SILTY CLAY



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			

SYMBOL BOREHOLE DEPTH (m) ELEVATION (m)

- C6-2 12.4 171.1
- ⊠ S-EW 10+025Rt 6.3 177.3
- ▲ S-EW 10+025Rt 9.3 174.3
- ★ S-EW 10+025Rt 12.4 171.2
- ⊙ S-EW 10+025Rt 13.9 169.7

GSD FIG FOR GRAIN.GPJ 9/9/10

Date November 2010

Project 1-09-4135



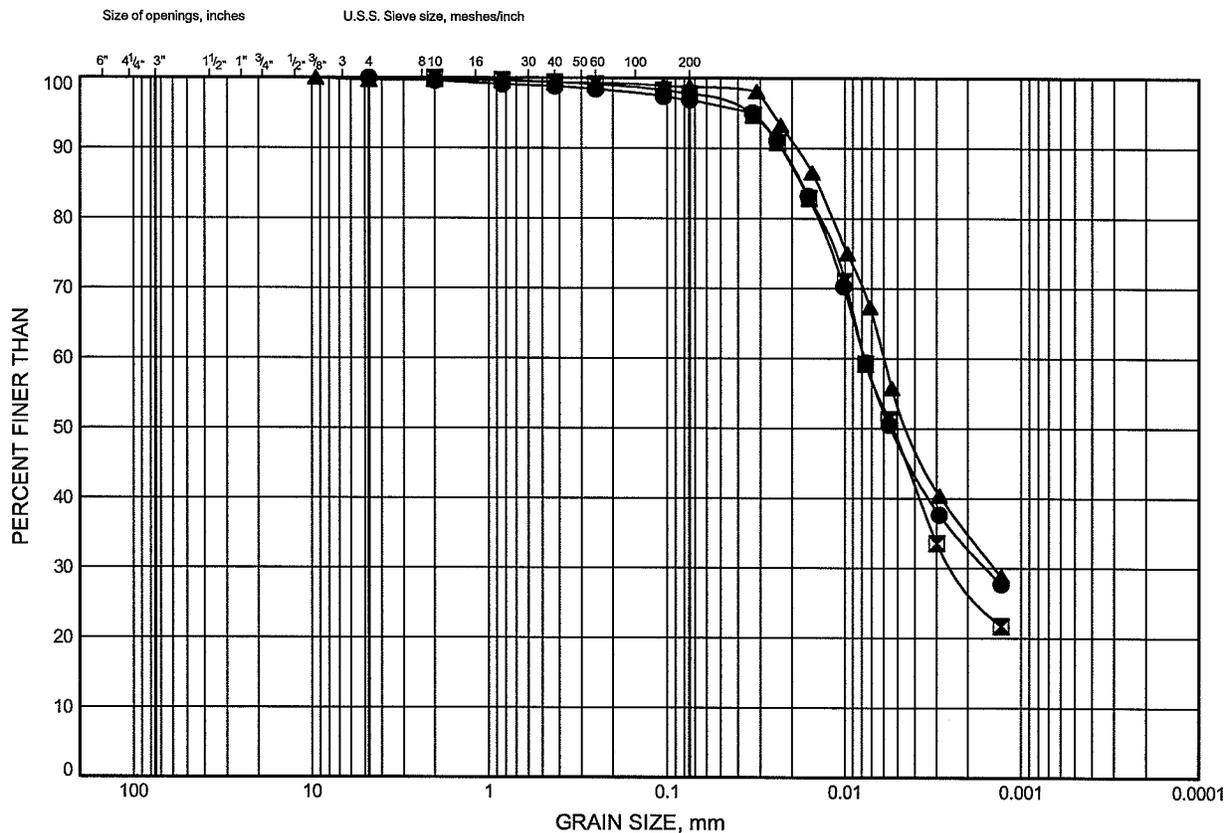
Prep'd JS

Chkd. MP

GRAIN SIZE DISTRIBUTION

FIGURE B4-5

SILTY CLAY



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

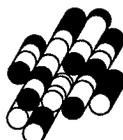
SYMBOL BOREHOLE DEPTH (m) ELEVATION (m)

●	WE-S 10+360lt	3.2	180.2
⊠	WE-S 10+360lt	6.3	177.1
▲	WE-S 10+360lt	13.9	169.5

GSD. FIG FOR GRAIN.GPJ 9/9/10

Date November 2010

Project 1-09-4135



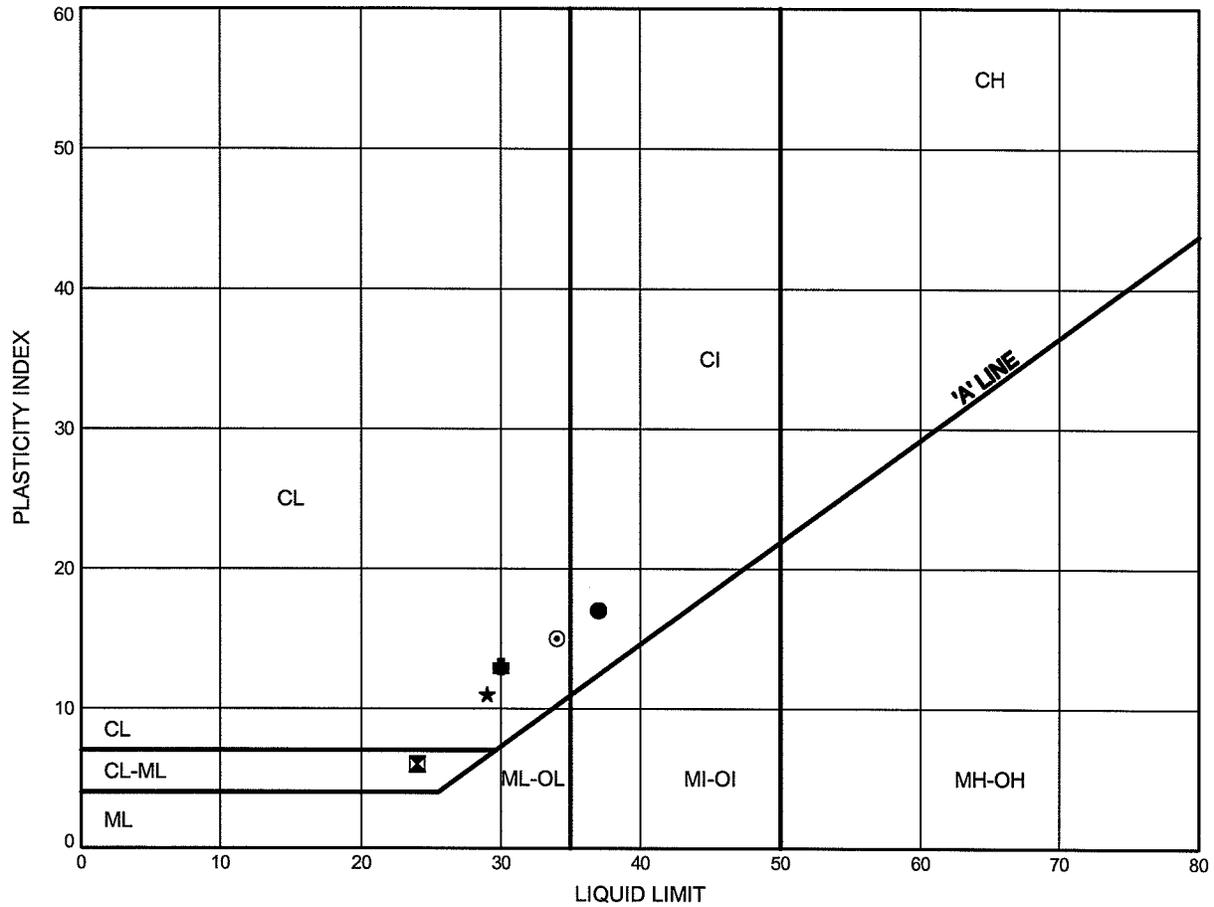
Prep'd JS

Chkd. MP

ATTERBERG LIMITS TEST RESULTS

FIGURE B4-6

SILTY CLAY



SYMBOL **BOREHOLE** **DEPTH (m)** **ELEVATION (m)**

●	C6-1	0.4	178.8
⊠	C6-1	1.7	177.5
▲	C6-1	3.2	176.0
★	C6-1	4.7	174.5
⊙	C6-2	6.3	177.2
⊛	C6-2	9.3	174.2

ALTR 1-09-4135 CULVERTS2.GPJ 09/14/10

Date November 2010
 Project 1-09-4135

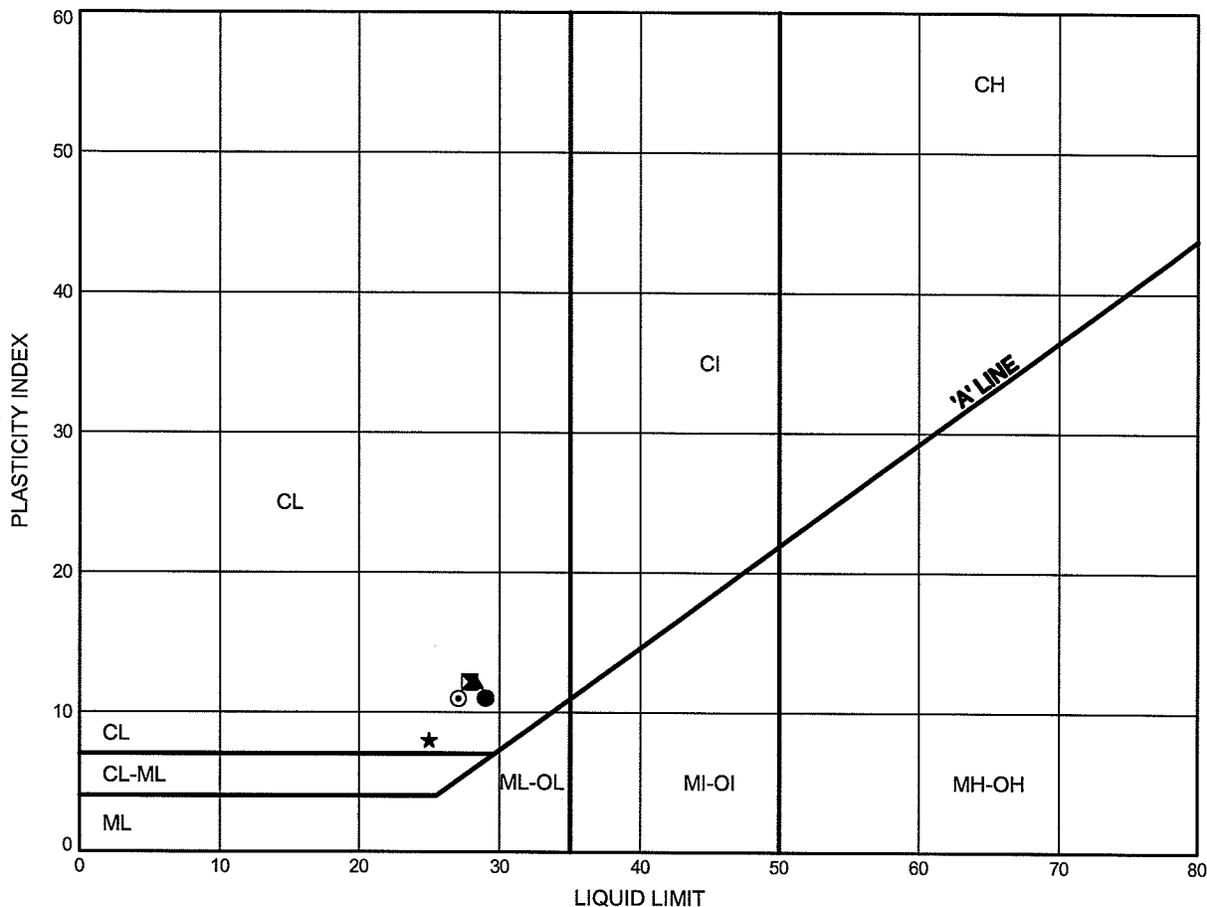


Prep'd K.L.
 Chkd. M.P.

ATTERBERG LIMITS TEST RESULTS

FIGURE 4-7

SILTY CLAY



SYMBOL BOREHOLE DEPTH (m) ELEVATION (m)

●	C6-2	12.4	171.2
⊠	S-EW 10+025Rt	6.3	177.3
▲	S-EW 10+025Rt	9.3	174.3
★	S-EW 10+025Rt	12.4	171.2
⊙	S-EW 10+025Rt	13.9	169.7

ALTR 1-09-4135 CULVERTS2.GPJ 09/29/10

Date November 2010

Project 1-09-4135



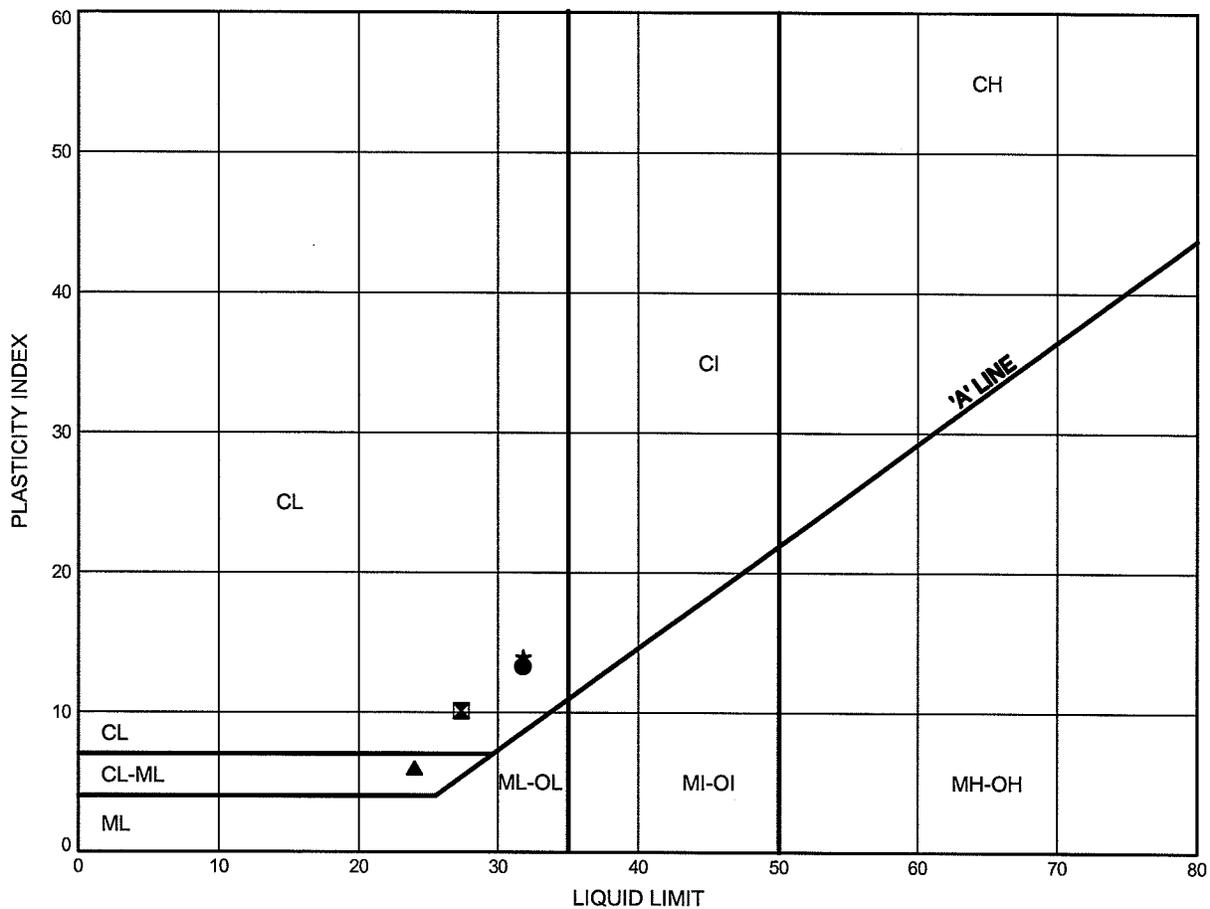
Prep'd K.L.

Chkd. M.P.

ATTERBERG LIMITS TEST RESULTS

FIGURE B4-8

SILTY CLAY



SYMBOL BOREHOLE DEPTH (m) ELEVATION (m)

●	WE-S 10+360t	3.2	180.2
⊠	WE-S 10+360t	6.3	177.1
▲	WE-S 10+360t	12.4	171.0
★	WE-S 10+360t	13.9	169.5

ALTR 1-09-4135 W-ES RAMP.GPJ 9/9/10

Date November 2010

Project 1-09-4135



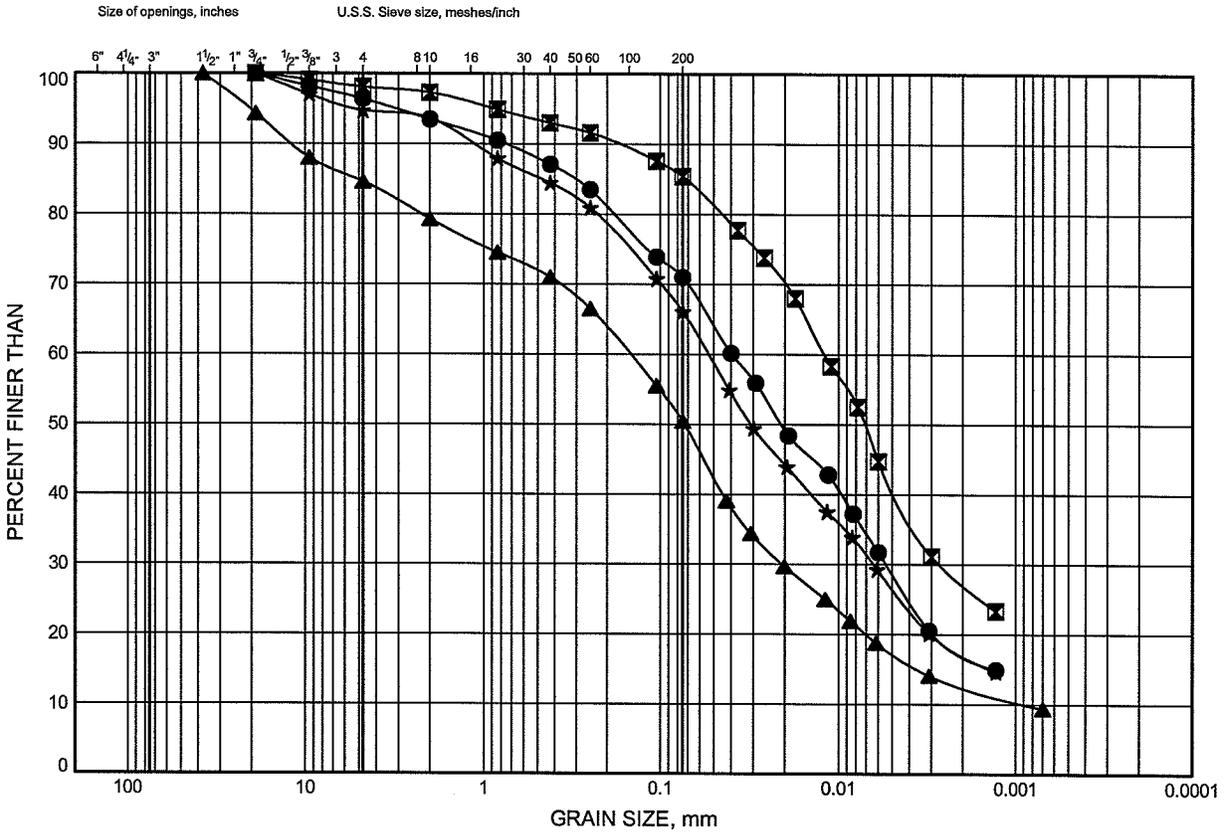
Prep'd JS

Chkd. MP

GRAIN SIZE DISTRIBUTION

FIGURE B4-9

SILTY CLAY TO CLAYEY SILT TILL



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			

SYMBOL **BOREHOLE** **DEPTH (m)** **ELEVATION (m)**

●	C6-1	10.9	168.3
⊠	C6-2	15.4	168.1
▲	S-EW 10+025Rt	17.0	166.6
★	WE-S 10+360Lt	18.5	164.9

GSD FIG B5-11.GPJ 9/7/10

Date November 2010

Project 1-09-4135



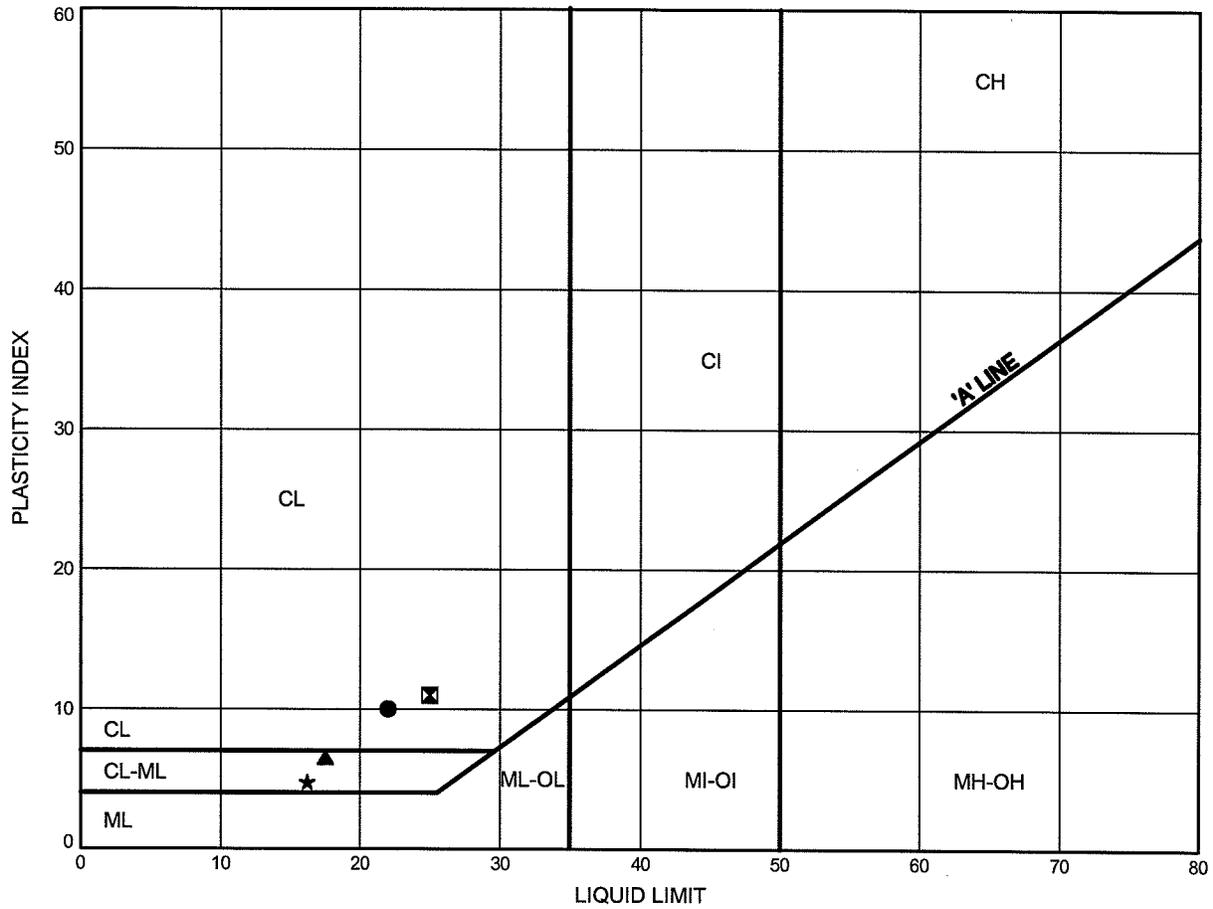
Prep'd JS

Chkd. MP

ATTERBERG LIMITS TEST RESULTS

FIGURE B4-10

SILTY CLAY TO CLAYEY SILT TILL



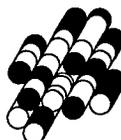
SYMBOL BOREHOLE DEPTH (m) ELEVATION (m)

●	C6-1	10.9	168.3
⊠	C6-2	15.4	168.1
▲	WE-S 10+025Lt	17.0	166.6
★	WE-S 10+360Lt	18.5	164.9

ALTR 1-09-4135 CULVERTS2.GPJ 9/3/10

Date November 2010

Project 1-09-4135



Prep'd JS

Chkd. MP

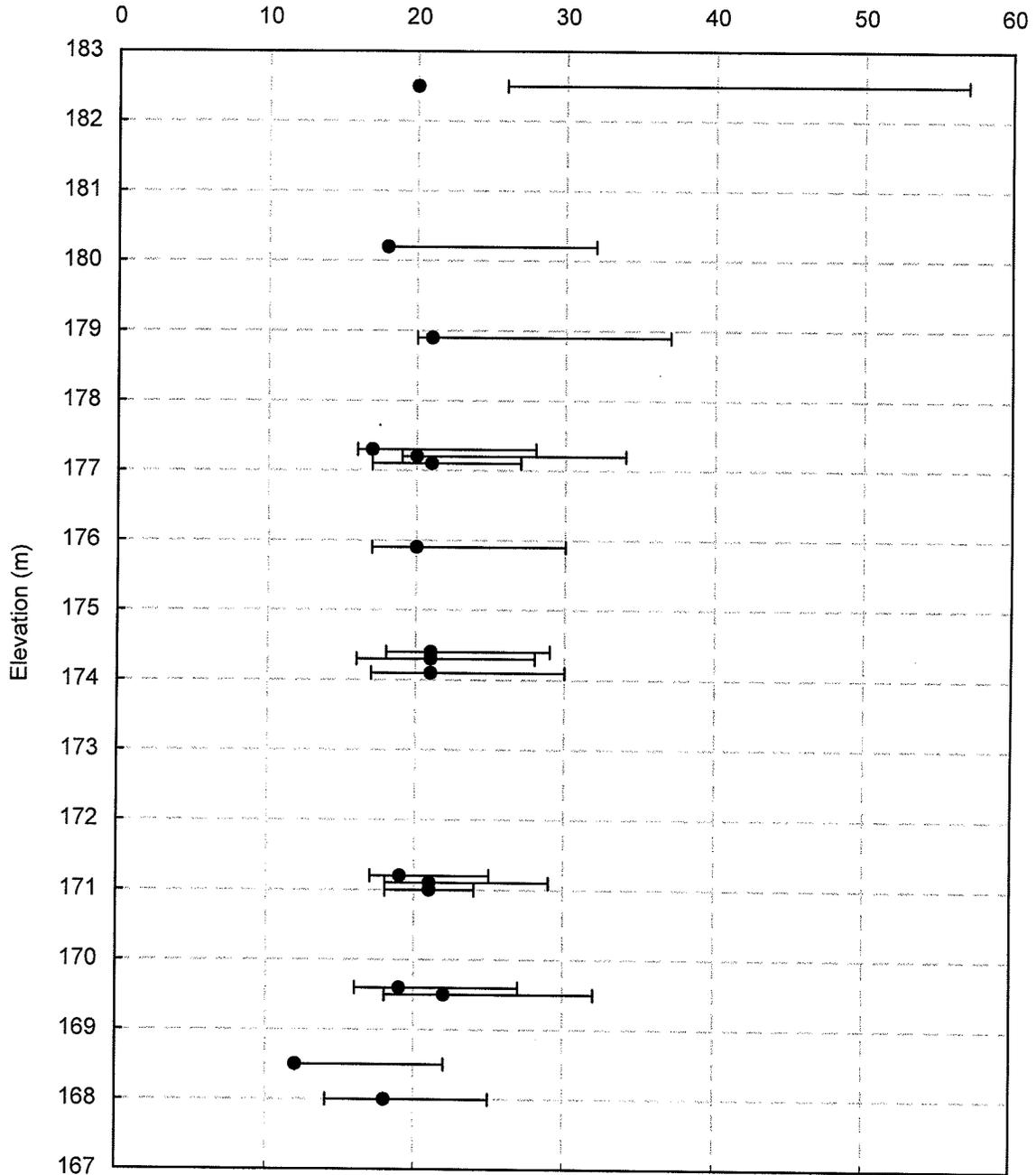
ATTERBERG LIMITS AND WATER CONTENTS

FIGURE B4-11

HWY 406 TWINNING - CULVERT #6

Silty Clay

Atterberg Limits & Water Contents (%)



C:\Documents and Settings\Admin\My Documents\Marc P\Projects 2009\Hwy 406 Expansion\1-09-4135 (Hwy 406 Foundations)\Culverts and Retaining Walls\Culverts\Lab Results\1-09-4135C6 Soil Parameter Estimation.xls

Project No. : 1-09-4135

Date : November, 2010



Terraprobe Inc.

Prepared By : HW

Checked By : RA

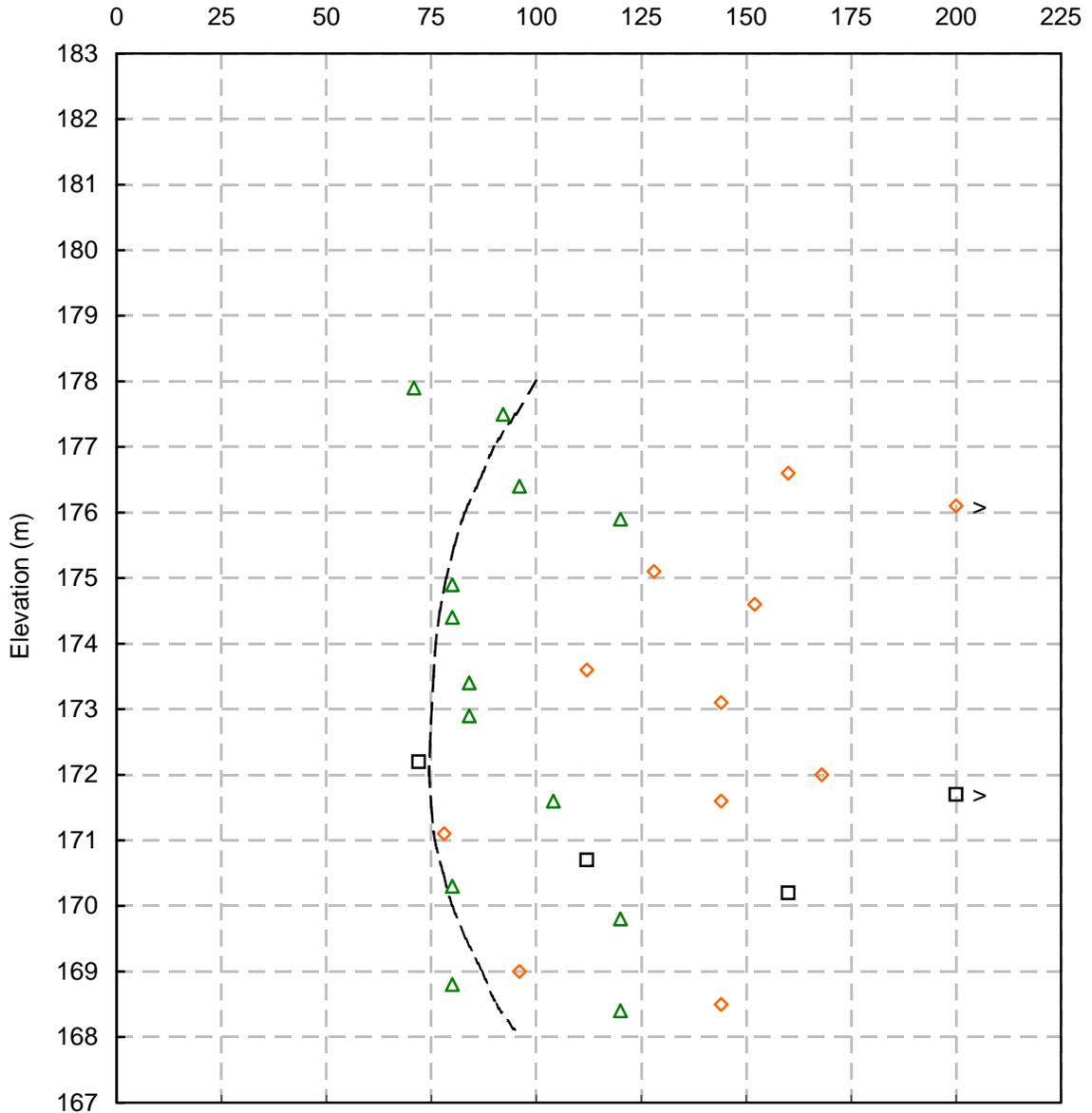
CORRECTED UNDRAINED SHEAR STRENGTH

FIGURE B4-12

HWY 406 TWINNING - CULVERT #6

Silty Clay

Corrected Cu (kPa)



□ C6-1
◇ SEW 10+025 RT
△ WES 10+360 LT

Field Shear Vane Correction	Applied Correction Factors	
Morris & Williams (1994)	0.89 (Elev.>177m)	1.00 (Elev.<177m)
($\mu = 1.18 \text{ EXP}(-0.08 \text{ Ip}) + 0.57$)		

Project No. : 1-09-4135

Date : November, 2010

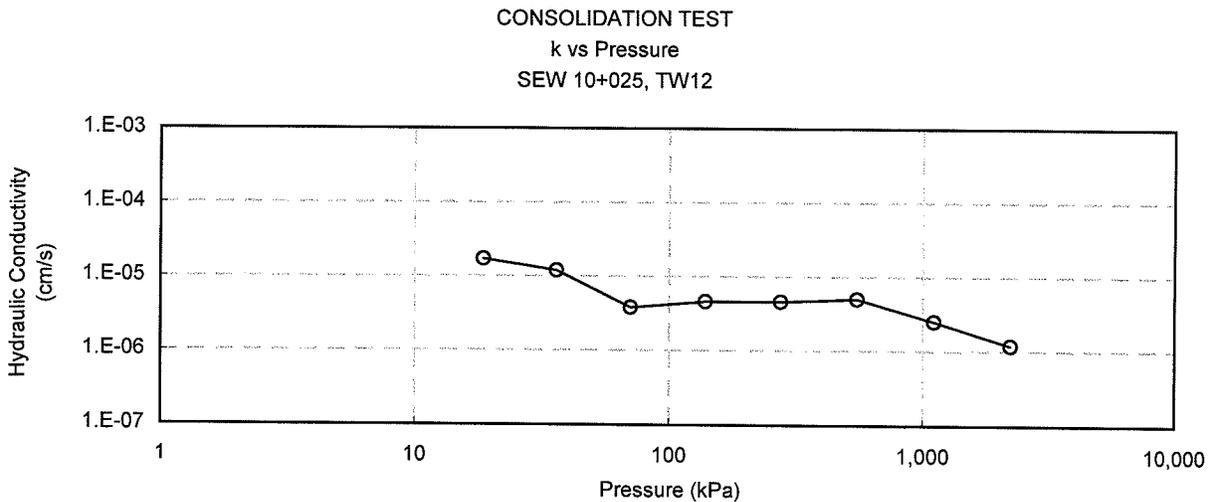
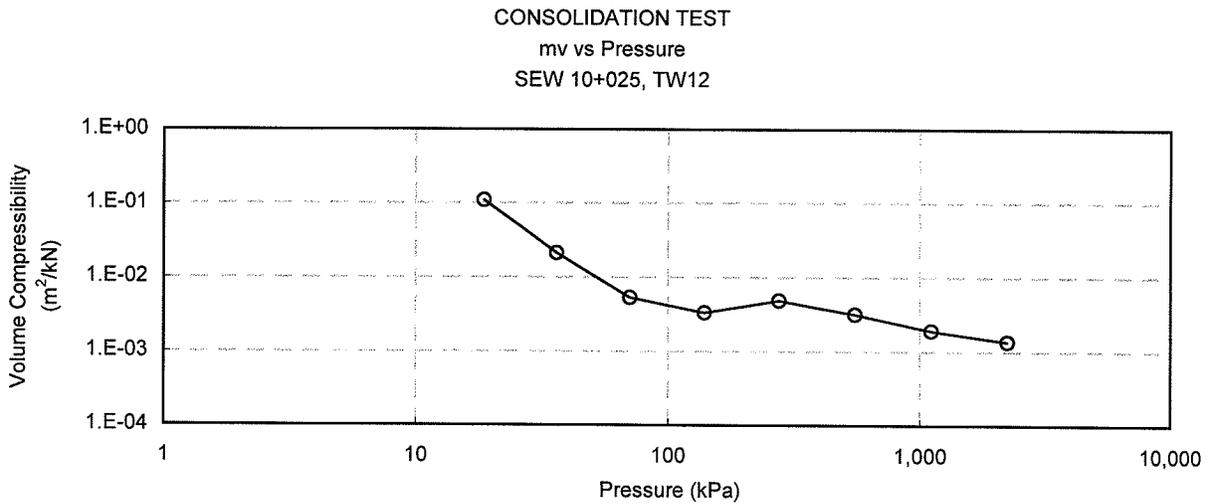
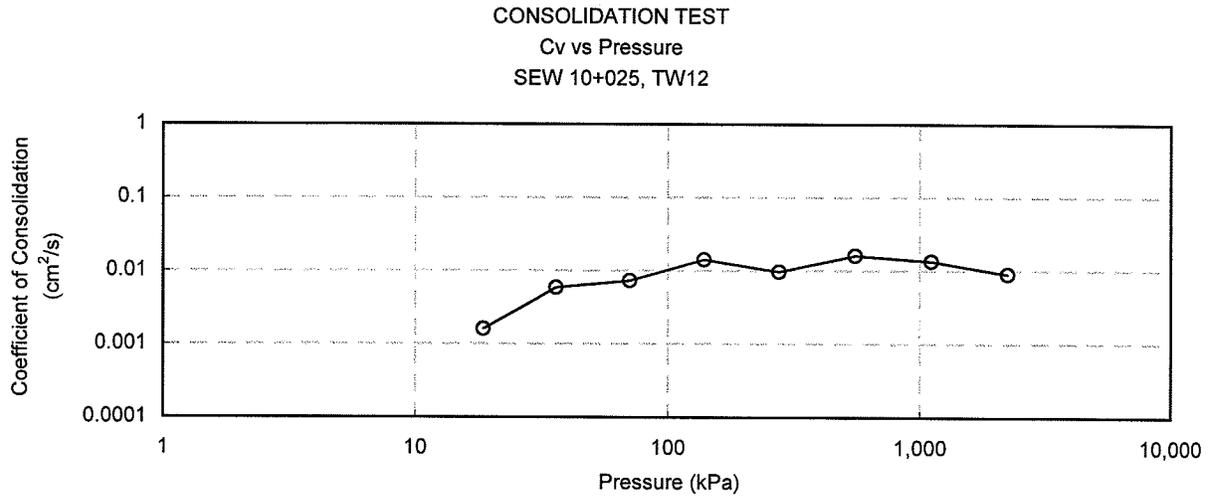


Terraprobe Inc.

Prepared By : HW

Checked By : RA

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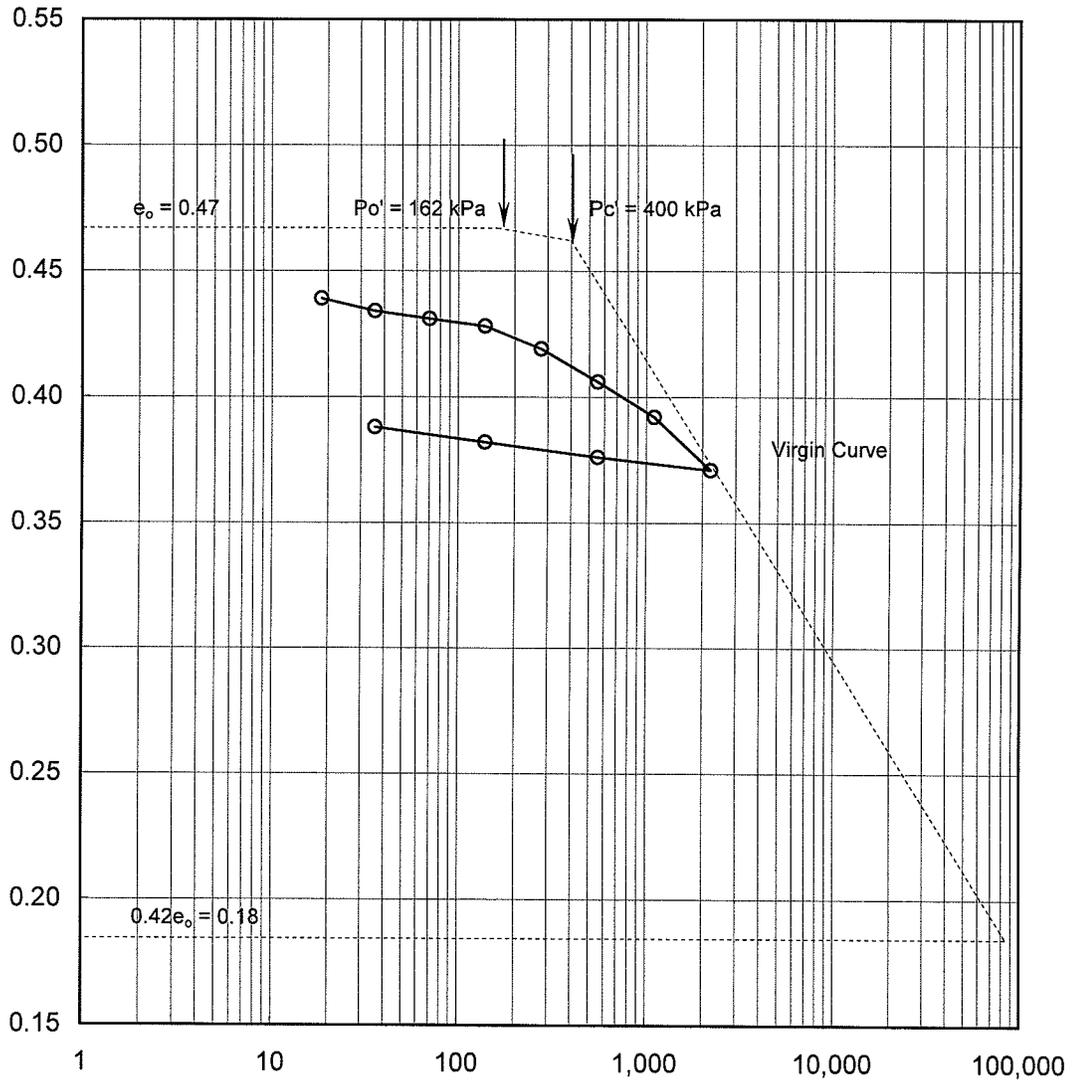
Project No. : 1-09-4135
Date : November 2010



Terraprobe Inc.

Prepared By : HW
Checked By : RA

CONSOLIDATION TEST
e vs Pressure
SEW 10+025, TW12



Soil Type : Silty Clay

$e_0 =$	0.47	$\omega_L =$	25%	$P_{o'} =$	162 kPa
$\omega =$	19%	$\omega_p =$	17%	$P_{c'} =$	400 kPa
$\gamma =$	21.8 kN/m ³	PI =	8%	Cc =	0.119
Gs =	2.73			Cr =	0.013

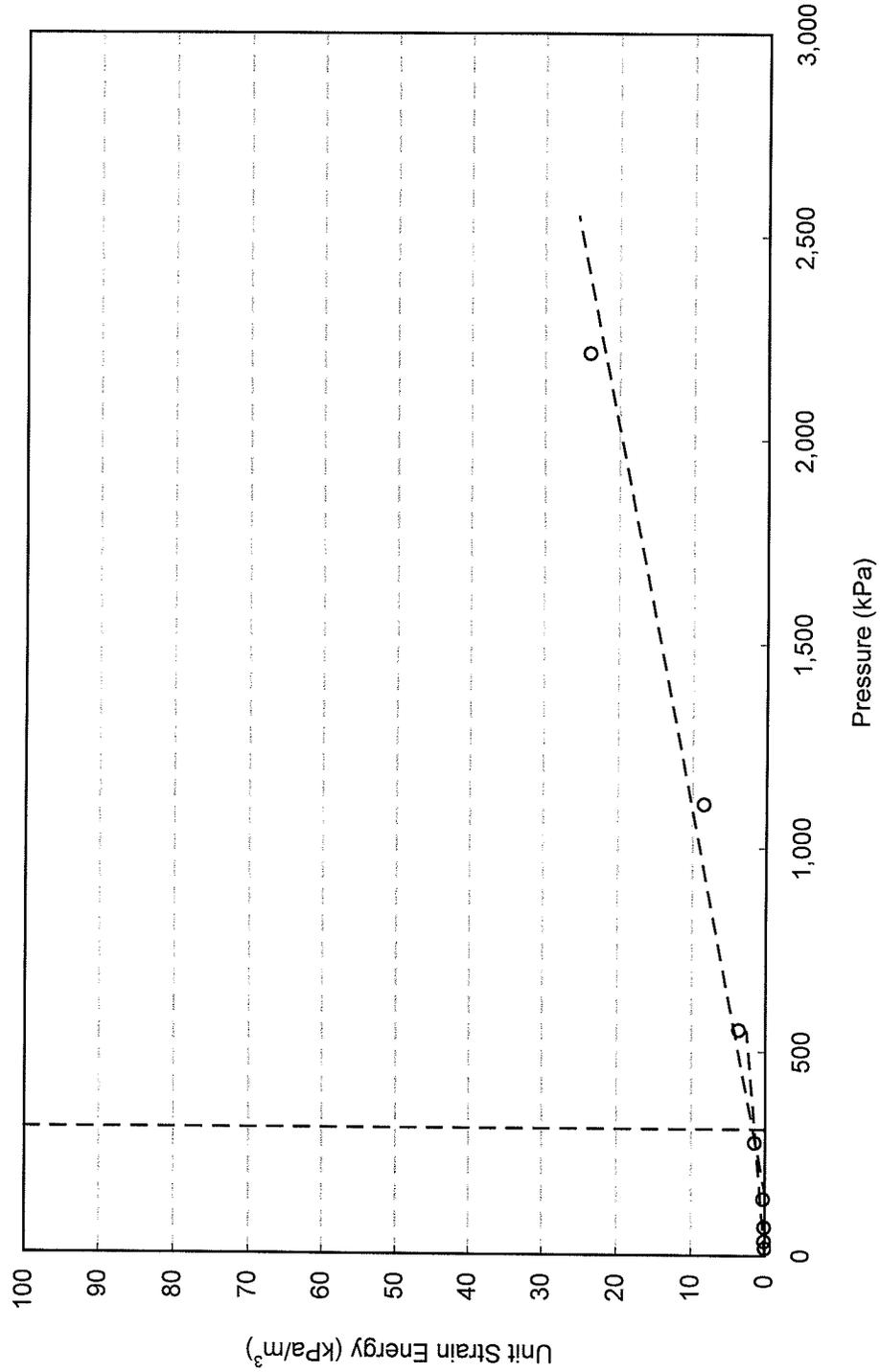
Project No. : 1-09-4135
Date : November 2010



Terraprobe Inc.

Prepared By : HW
Checked By : RA

CONSOLIDATION TEST
Unit Strain Energy vs Pressure
SEW 10+025, TW12



Pc = 310 kPa

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Project No. : 1-09-4135

Date : November 2010

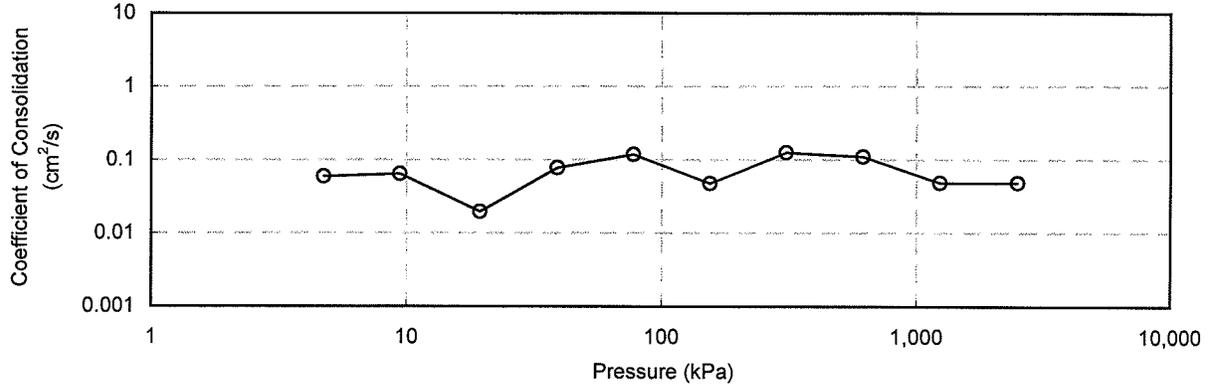


Terraprobe Inc.

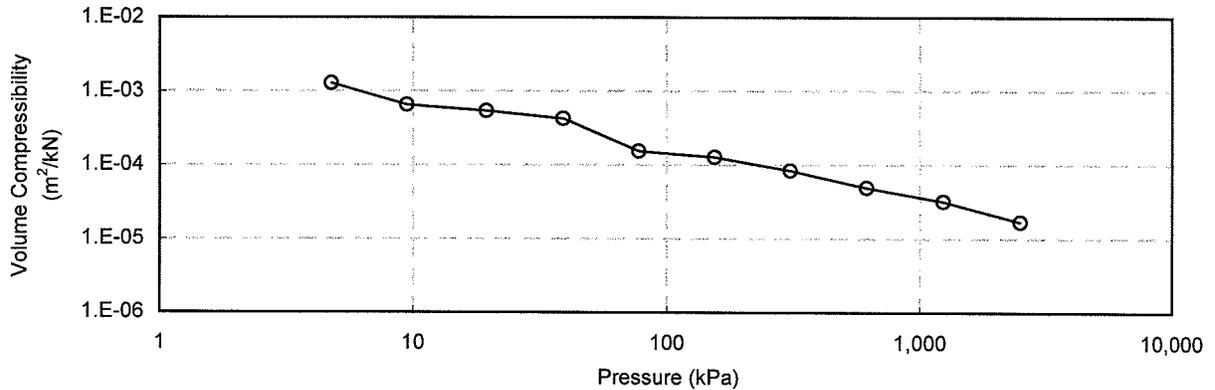
Prepared By : HW

Checked By : RA

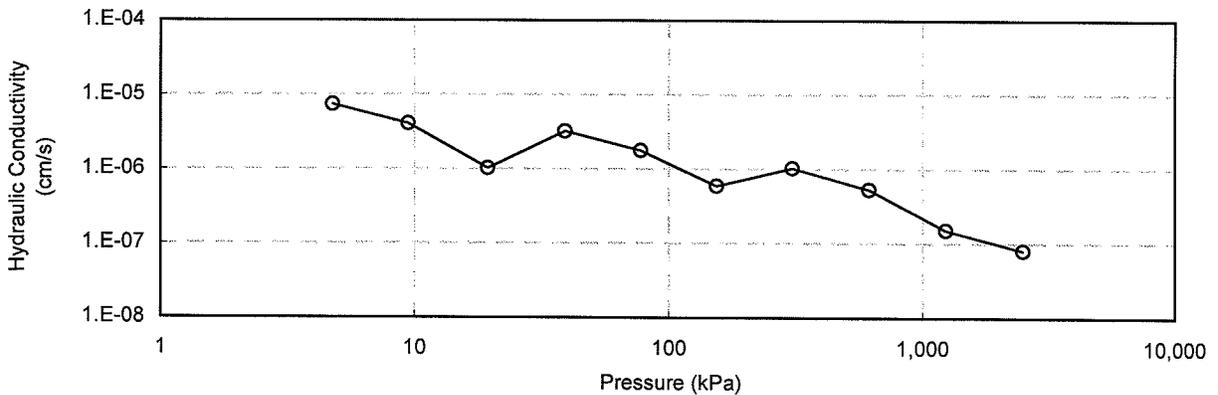
CONSOLIDATION TEST
Cv vs Pressure
WES 10+360 LT, TW11



CONSOLIDATION TEST
mv vs Pressure
WES 10+360 LT, TW11



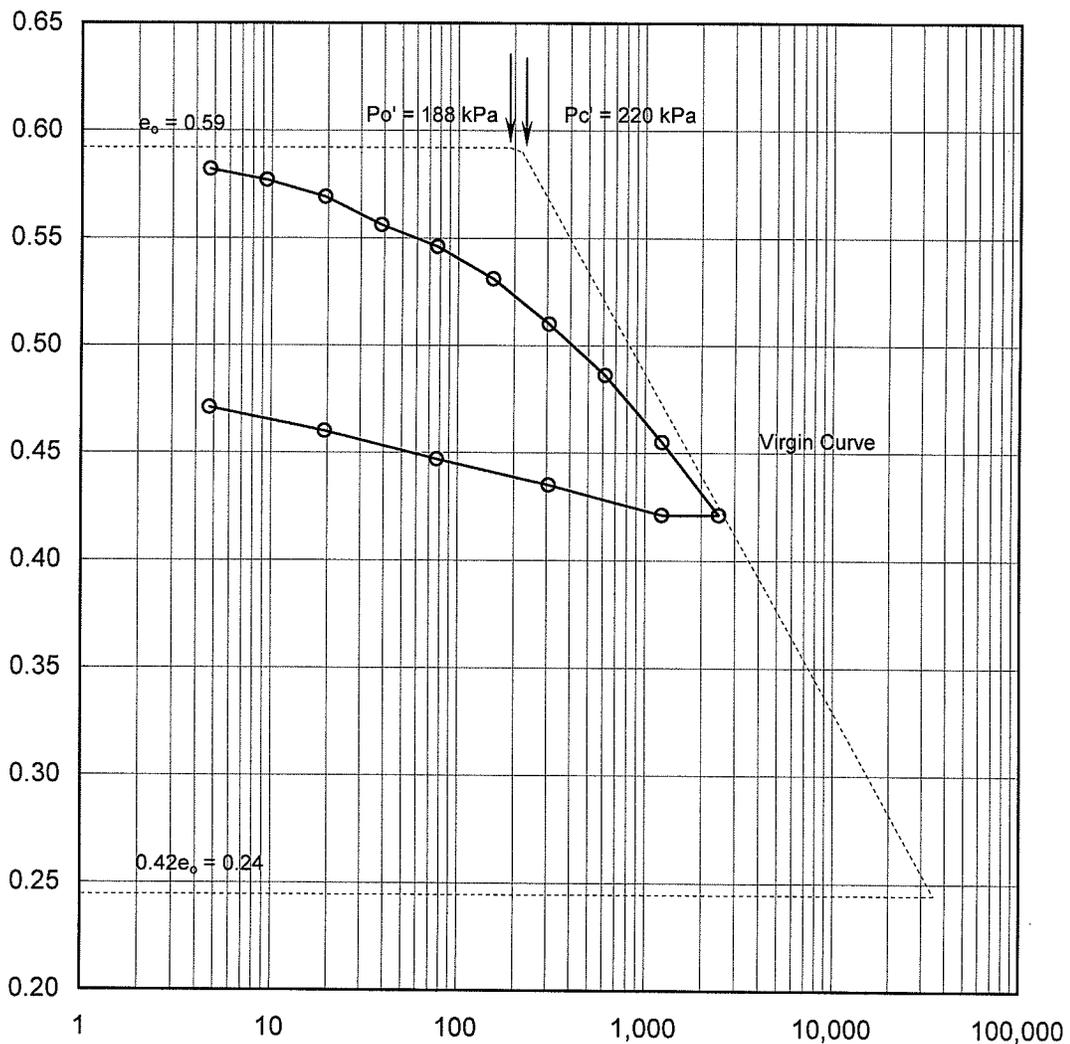
CONSOLIDATION TEST
k vs Pressure
WES 10+360 LT, TW11



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CONSOLIDATION TEST
e vs Pressure
WES 10+360 LT, TW11



Soil Type : Silty Clay

$e_0 =$	0.59	$\omega_L =$	24%	$P_0' =$	188 kPa
$\omega =$	21%	$\omega_p =$	18%	$P_c =$	220 kPa
$\gamma =$	20.5 kN/m ³	PI =	6%	$C_c =$	0.157
$G_s =$	2.75			$C_r =$	0.029

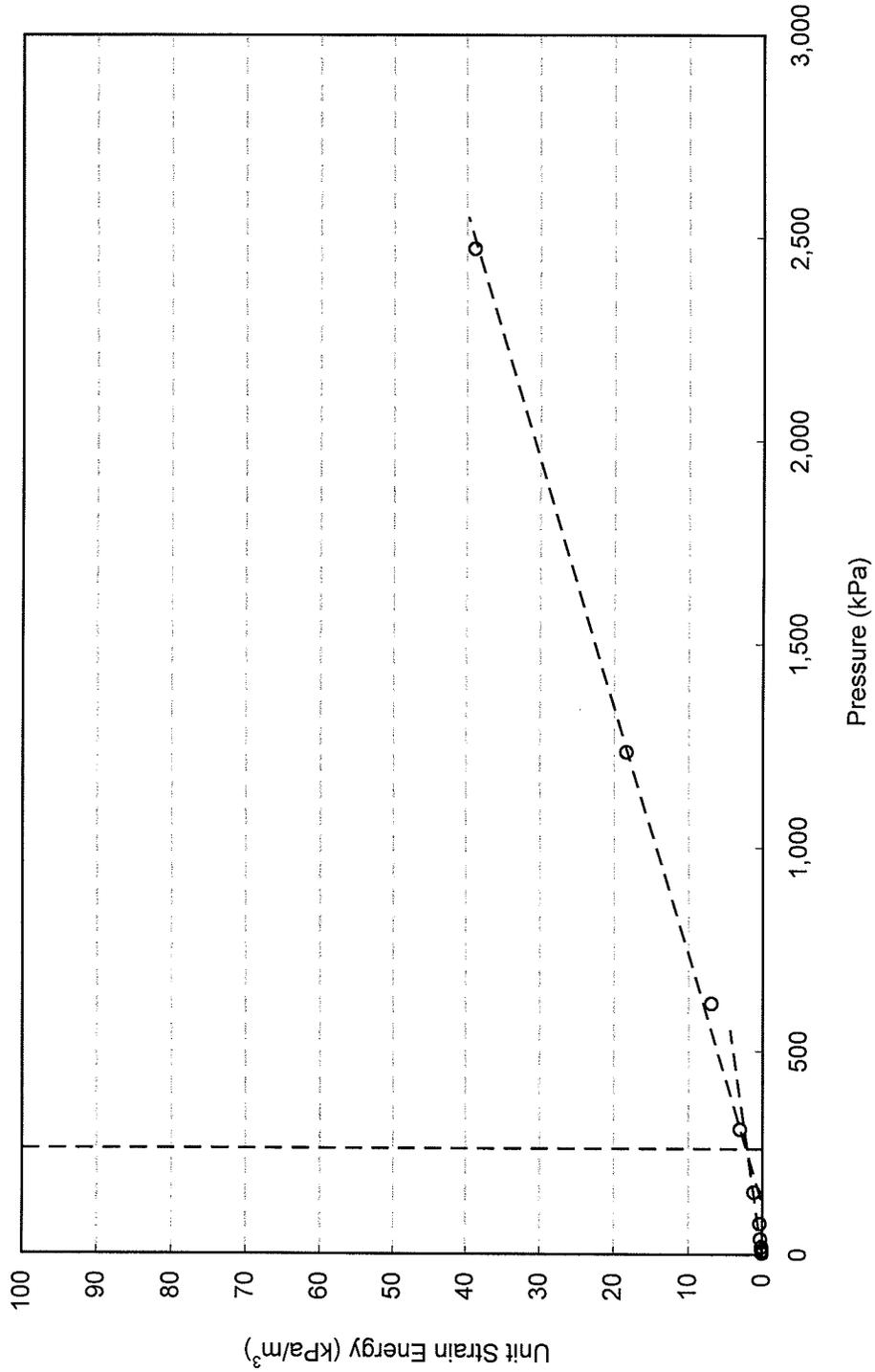
Project No. : 1-09-4135
Date : November 2010



Terraprobe Inc.

Prepared By : HW
Checked By : RA

CONSOLIDATION TEST
 Unit Strain Energy vs Pressure
 WES 10+360 LT, TW11



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Project No. : 1-09-4135

Date : November 2010



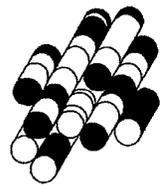
Terraprobe Inc.

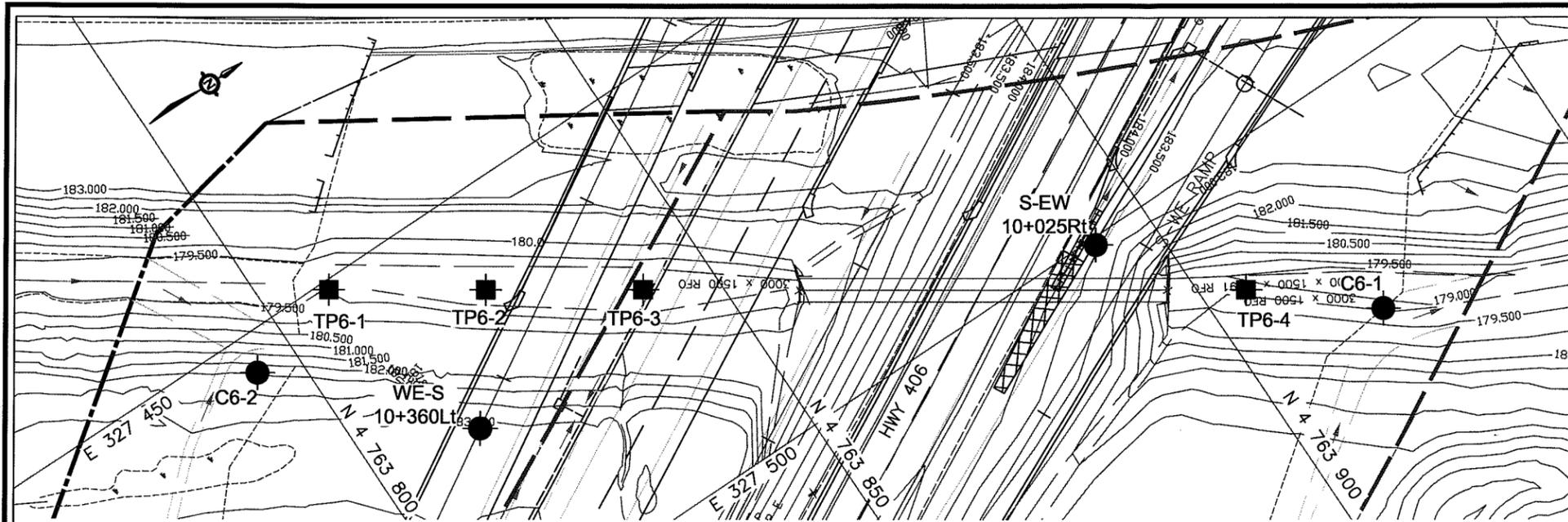
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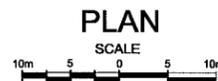
C4

TERRAPROBE INC.





METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETERS
UNLESS OTHERWISE SHOWN

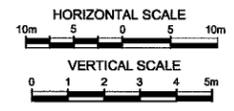
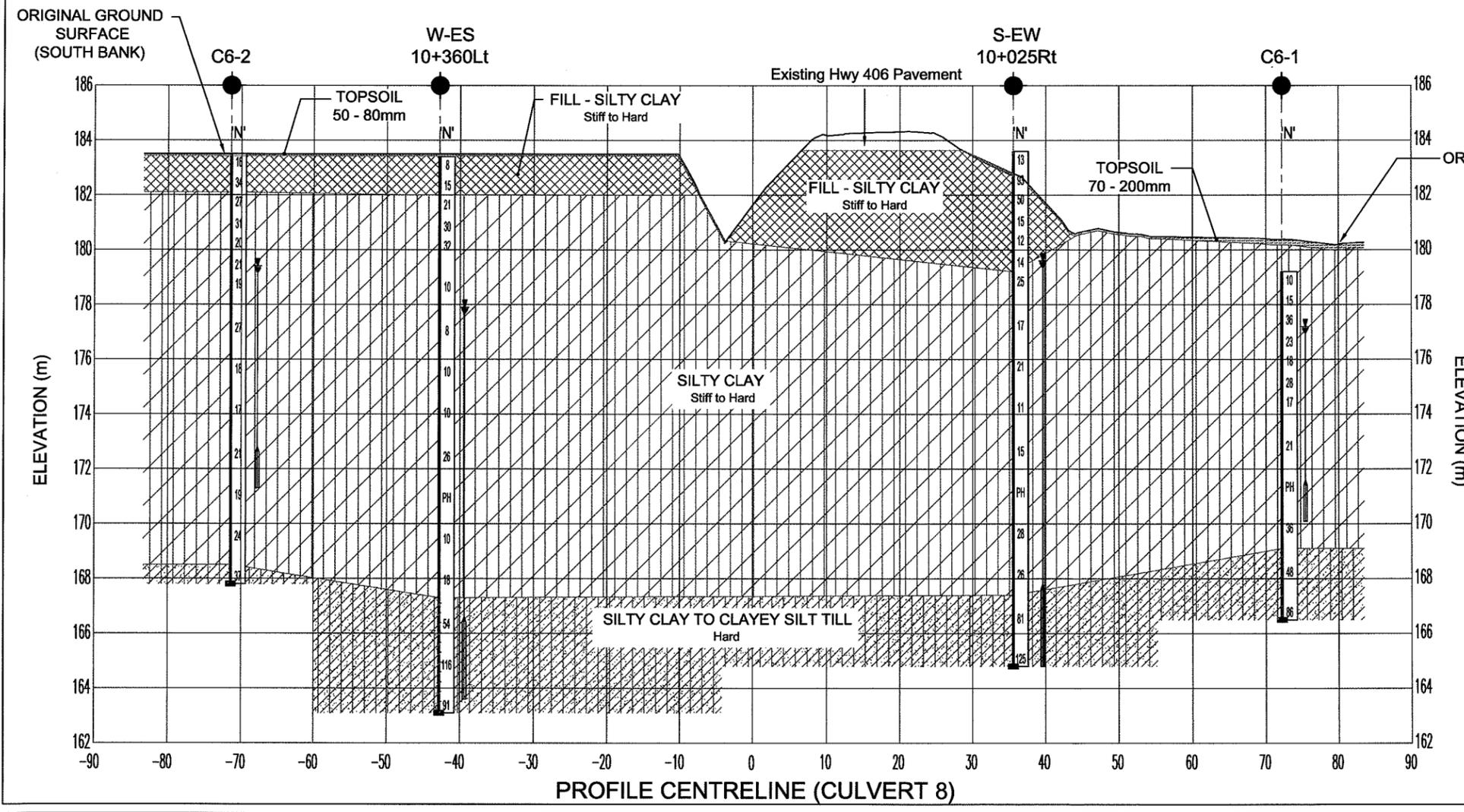
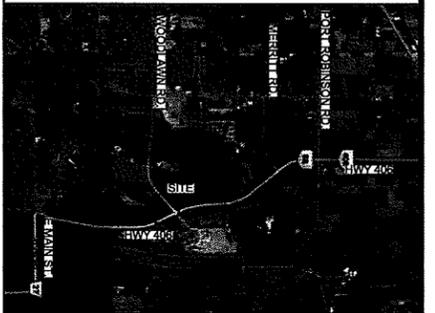


CONT No 2011-2005
WP No 280-99-00

HIGHWAY 406
CULVERT # 8
BOREHOLE LOCATIONS AND SOIL STRATA

IBI GROUP

Terraprobe Inc.
Consulting Geotechnical & Environmental Engineering
Construction Materials Engineering, Inspection & Testing
10 Bram Court - Brampton Ontario L6W 3R6 (905) 796-2650



KEY PLAN

LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test
- ⊙ Bore Hole And Cone
- Test Pits
- 'N' Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60' Cone, 475 J/blow)
- ≡ WL at Time of Investigation
- ≡ WL in Piezometer (SEPT. 2010)
- ⊕ Piezometer
- 90% Rock Quality Designation
- A/R Auger Refusal

No	ELEV.	COORDINATES	
		NORTHING	EASTING
C6-1	179.2	4 763 918.4	327 528.0
C6-2	183.5	4 763 794.6	327 454.9
SEW 10+025Rt	183.6	4 763 892.5	327 500.9
W-ES 10+360Lt	183.4	4 763 814.3	327 476.6

NOTE

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

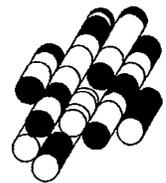
REVISIONS	DATE	BY	DESCRIPTION

DESIGN	CODE	LOAD	DATE
R.A.	CHBDC2008		FEB. 2011

DRAWN	CHK	RA	STRUCT	GEORES
K.C.				30M3-289

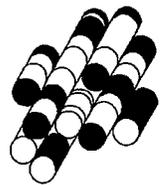
CULVERT #9

TERRAPROBE INC.



A5

TERRAPROBE INC.



RECORD OF BOREHOLE No C7-1

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4763942.5 E:327381.6 ORIGINATED BY PK
 DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 06.29.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			20	40						60	80	100	20
181.0	Ground Surface																
180.9	130mm TOPSOIL																
0.1	SILTY CLAY trace sand, very stiff to hard, brown, damp to moist	1	SS	25													
		2	SS	36								50	0 1 42 57				
		3	SS	48													
		4	SS	67													
		5	SS	71									0 1 71 28				
	stiff to very stiff	6	SS	25													
		7	SS	24													
		8	SS	15									0 3 70 27				
		9	SS	13													
		10	SS	13													
		11	SS	13													
		12	SS	18													
		13	SS	19													
167.0																	
14.0																	

ONTARIO MOT 1-09-4135 CULVERTS2 (KELVIN).GPJ ONTARIO MOT.GDT 09/09/10

Continued Next Page

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

RECORD OF BOREHOLE No C7-1

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4763942.5 E:327381.6 ORIGINATED BY PK
 DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 06.29.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT NUMBER	TYPE	"N" VALUES			20	40	60	80	100						20	40	60
164.0	CLAYEY SILT TO SILTY CLAY sandy, trace gravel, very stiff to hard, brown, damp to moist (GLACIAL TILL)	[Hatched Box]	14	SS	17	[Dotted Box]													
17.0			15	SS	100/ 10cm	[Dotted Box]													
17.0	End of Borehole																		
	No sample recovery at SS7. Sampler redriven and disturbed sample collected.																		
	Resistance to augering at 15.8m and 16.6m.																		
	Borehole was dry (not stabilized) and hole open to full depth on completion.																		
	Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 1.52m slotted screen.																		
	Water Level Readings: Date Depth(m) Elevation(m) July.05.10 5.5 175.5 July.13.10 4.2 176.8 July.19.10 4.1 176.9																		

ONTARIO MOT. 1-09-4135 CULVERTS2 (KELVIN).GPJ ONTARIO MOT.GDT 09/09/10

+³.X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No C7-2

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4763976.6 E:327417.4 ORIGINATED BY PK
 DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 06.28.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20						40
181.5	Ground Surface													
0.1	100mm TOPSOIL		1	SS	11								0 6 57 37	
180.8	FILL - Silty Clay, trace sand, trace organics, stiff, brown, damp to moist		2	SS	32									
0.7	SILTY CLAY trace sand, occasional gravel inclusions, brown, damp to moist		3	SS	29									
			4	SS	52							1 2 72 25		
			5	SS	29									
	very stiff to hard		6	SS	31									
	stiff to very stiff		7	SS	17									
			8	TW	PH						21.0	0 2 72 26		
			9	SS	12							0 3 70 27		
			10	SS	14									
			11	SS	16									
			12	SS	20									
168.3	CLAYEY SILT TO SILTY CLAY sandy, trace gravel, hard, brown, damp to moist (GLACIAL TILL)		13	SS	45							5 25 53 17		
167.3	End of Borehole													

ONTARIO MOT 1-09-4135 CULVERTS2 (KELVIN).GPJ ONTARIO MOT.GDT 09/09/10

Continued Next Page

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No C7-2

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4763976.6 E:327417.4 ORIGINATED BY PK
 DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 06.28.10 CHECKED BY RA

SOIL PROFILE		SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)							
					20	40	60	80	100		10	20	30	kN/m ³	GR SA SI CL		
	No sample recovery at SS10. Sampler redriven and disturbed sample collected. Water level at 7.3m (not stabilized) and hole open to full depth on completion. Consolidation test performed on TW 8. Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 1.52m slotted screen. Water Level Readings: Date Depth(m) Elevation(m) July.05.10 6.4 175.1 July.13.10 2.5 179.0 July.19.10 3.0 178.5 July.28.10 2.8 176.7																

ONTARIO MOT 1-09-4135 CULVERTS2 (KELVIN).GPJ ONTARIO MOT.GDT 09/09/10

+³, X³: Numbers refer to Sensitivity ○³% STRAIN AT FAILURE

RECORD OF BOREHOLE No C7-3

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4764008.4 E:327455.7 ORIGINATED BY PK
 DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 06.25.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			20	40					
182.4	Ground Surface												
0.1	80mm TOPSOIL												
	SILTY CLAY trace sand, brown, damp to moist	1	SS	23									
		2	SS	45									
		3	SS	43									
		4	SS	39									
	very stiff to hard — stiff to very stiff	5	SS	48									
		6	SS	15									0 1 79 20
		7	SS	14									
		8	SS	11									
		9	SS	14									
		10	SS	16									0 2 70 28
		11	SS	22									
		12	SS	20									
169.2	CLAYEY SILT TO SILTY CLAY sandy, trace gravel, hard, brown, damp (GLACIAL TILL)	13	SS	41									4 25 53 18
13.2													

ONTARIO MOT 1-09-4135 CULVERTS2 (KELVIN).GPJ ONTARIO MOT.GDT 09/09/10

Continued Next Page

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No C7-3

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4764008.4 E:327455.7 ORIGINATED BY PK
 DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 06.25.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80					
166.8			14	SS	160/ 20cm	167										
15.6	End of Borehole Borehole was dry (not stabilized) and hole open to full depth on completion.															

ONTARIO MOT 1-09-4135 CULVERTS2 (KELVIN).GPJ ONTARIO MOT.GDT 09/09/10

+³, X³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

RECORD OF BOREHOLE No C7-4

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:476404.4 E:327486.8 ORIGINATED BY PK
 DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 07.07.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			20	40					
182.0	Ground Surface												
181.8	200mm PEAT												
0.2	stiff	1	SS	10									
	SILTY CLAY trace sand, very stiff to hard, brown, damp to moist	2	SS	21									0 1 47 52
		3	SS	32									
		4	SS	29									
		5	SS	18									0 1 56 43
	frequent sandy silt seams	6	SS	34									
		7	SS	37									
		8	SS	18									0 3 69 28
		9	SS	16									
		10	SS	17									
		11	SS	14									
169.7													
12.3	CLAYEY SILT to SILTY CLAY, trace sand, very stiff, brown, damp (GLACIAL TILL)	12	SS	27									0 2 78 20
169.4	End of Borehole												
12.6	No sample recovery in SS8 and SS10. Sampler redriven and disturbed sample collected. Borehole was dry (not stabilized) and hole open to full depth on completion.												

ONTARIO MOT 1-09-4135 CULVERTS2 (KELVIN).GPJ ONTARIO MOT.GDT 09/09/10

Continued Next Page

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

RECORD OF BOREHOLE No C7-4

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4764040.4 E:327486.8 ORIGINATED BY PK
 DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 07.07.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w_p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w_L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE									
					20	40	60	80	100							
	Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 1.52m slotted screen. Water Level Readings: Date Depth(m) Elevation(m) July.12.10 3.6 178.4 July.19.10 2.3 179.7 July.27.10 2.3 179.7															

ONTARIO MOT 1-09-41:35 CULVERTS2 (KELVIN).GPJ ONTARIO MOT.GDT 09/09/10

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

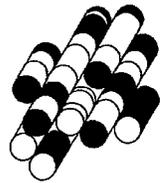
Test Pit Logs
Culvert #7 (Highway 406 Sta. 12+525)

Test Pit# TP 7-1

0	-	230	Dk Br/Blk Amor Peat, Some Rootlets, Moist
230	-	610	Br Si(y) Cl, Tr to Some Org, Tr Rootlets, Moist
610	-	1.22	Br Si(y) Cl, Tr Sa, Damp to Moist

B5

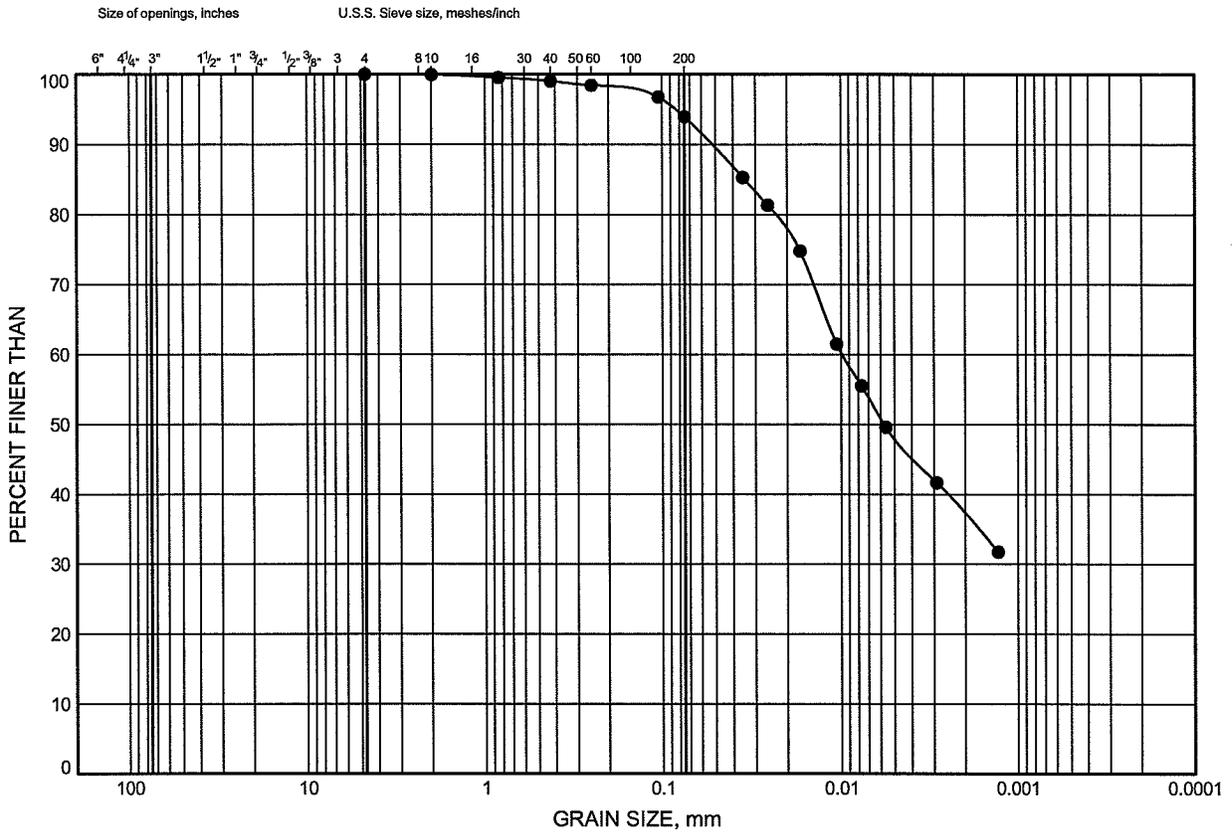
TERRAPROBE INC.



GRAIN SIZE DISTRIBUTION

FIGURE B5-1

FILL - Silty Clay



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C7-2	0.3	181.2

Date November 2010
 Project 1-09-4135

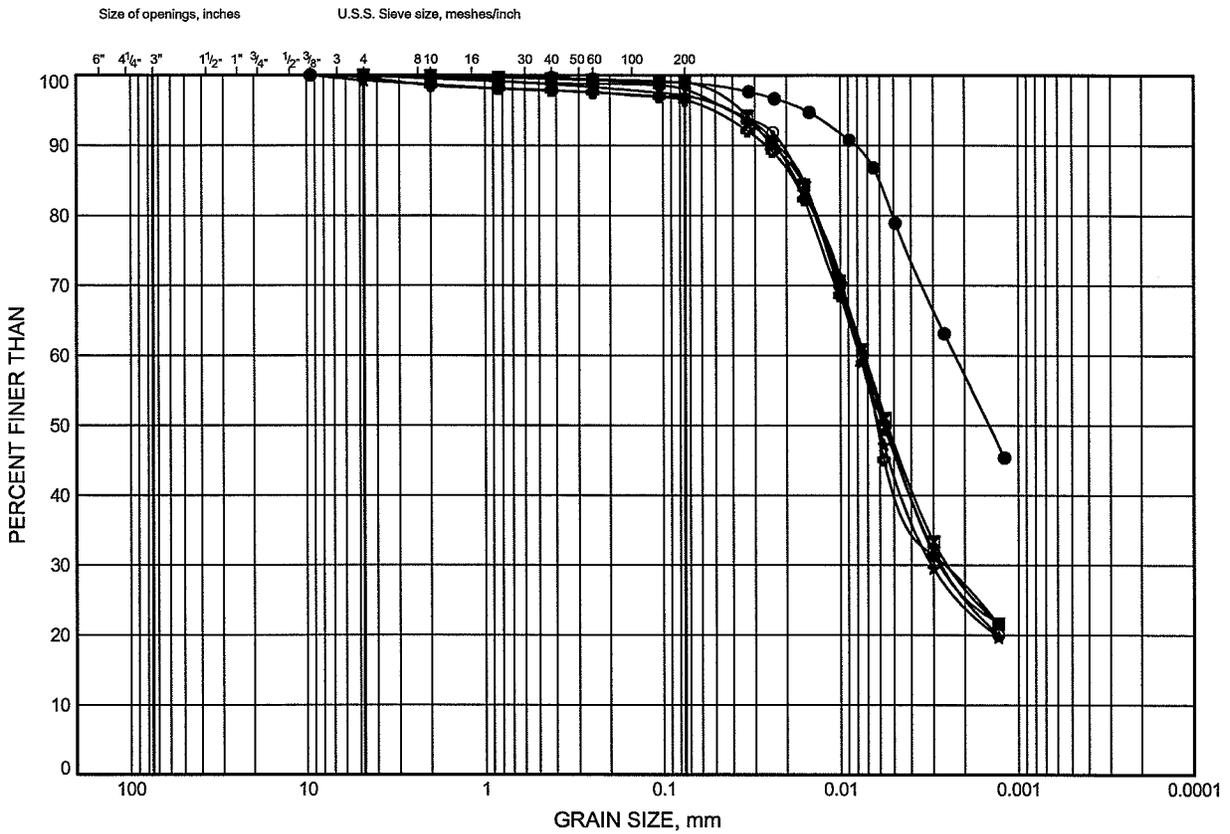


Prep'd K.L.
 Chkd. M.P.

GRAIN SIZE DISTRIBUTION

FIGURE B5-2

SILTY CLAY



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C7-1	1.0	180.0
■	C7-1	3.2	177.8
▲	C7-1	6.3	174.7
★	C7-2	2.5	179.0
⊙	C7-2	6.3	175.2
⊕	C7-2	7.8	173.7

Date November 2010
 Project 1-09-4135

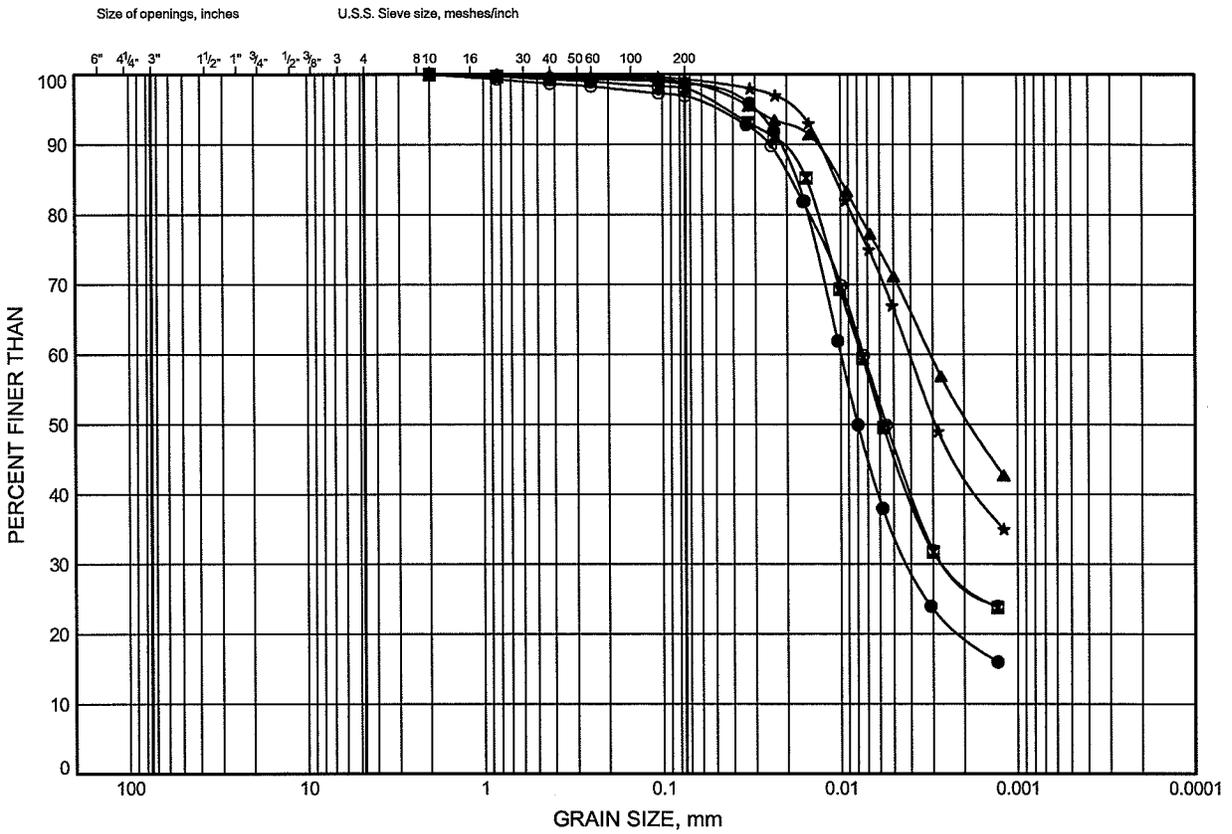


Prep'd K.L.
 Chkd. M.P.

GRAIN SIZE DISTRIBUTION

FIGURE B5-3

SILTY CLAY



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C7-3	4.0	178.4
◻	C7-3	9.3	173.1
▲	C7-4	1.0	181.0
★	C7-4	3.2	178.8
⊙	C7-4	6.3	175.7

GSD 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/09/10

Date November 2010
 Project 1-09-4135

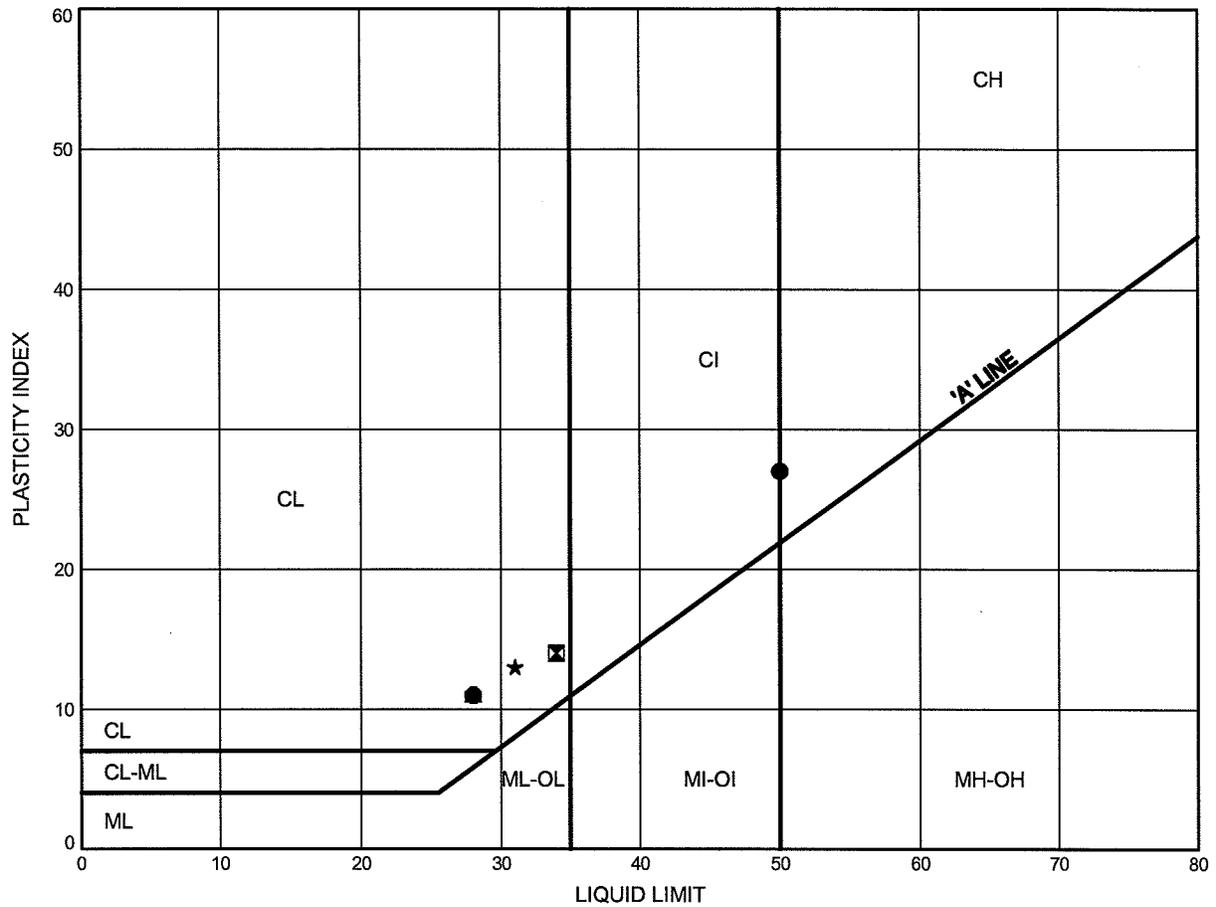


Prep'd K.L.
 Chkd. M.P.

ATTERBERG LIMITS TEST RESULTS

FIGURE B5-4

SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C7-1	1.0	180.0
⊠	C7-1	3.2	177.8
▲	C7-1	6.3	174.7
★	C7-2	2.5	179.0
⊙	C7-2	6.3	175.2
⊕	C7-2	7.8	173.7

ALTR 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/03/10

Date November 2010
 Project 1-09-4135

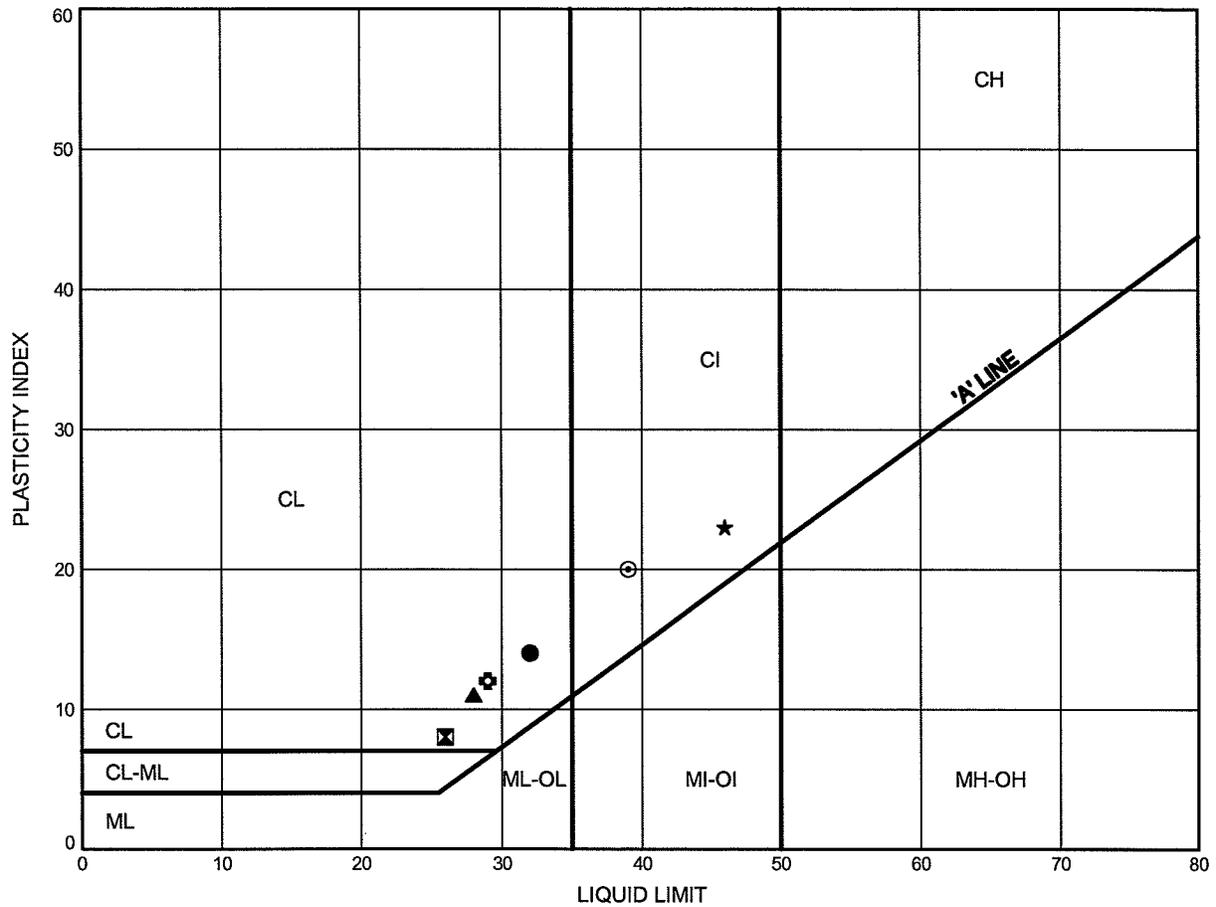


Prep'd K.L.
 Chkd. M.P.

ATTERBERG LIMITS TEST RESULTS

FIGURE B5-5

SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C7-3	1.7	180.7
⊠	C7-3	4.0	178.4
▲	C7-3	9.3	173.1
★	C7-4	1.0	181.0
⊙	C7-4	3.2	178.8
⊕	C7-4	6.3	175.7

ALTR 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/14/10

Date November 2010
 Project 1-09-4135

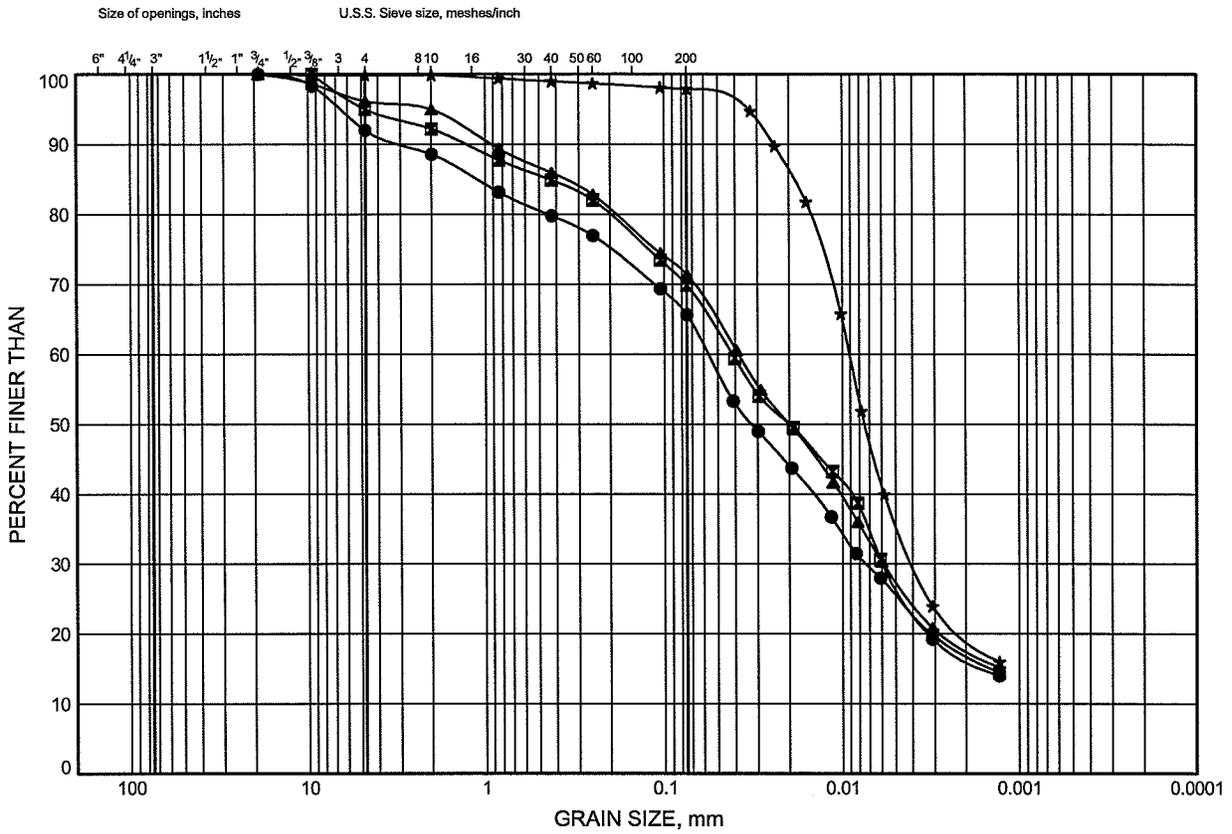


Prep'd K.L.
 Chkd. M.P.

GRAIN SIZE DISTRIBUTION

FIGURE B5-6

CLAYEY SILT TO SILTY CLAY TILL



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C7-1	15.4	165.6
■	C7-2	13.9	167.6
▲	C7-3	13.9	168.5
★	C7-4	12.5	169.5

GSD 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/09/10

Date November 2010
Project 1-09-4135

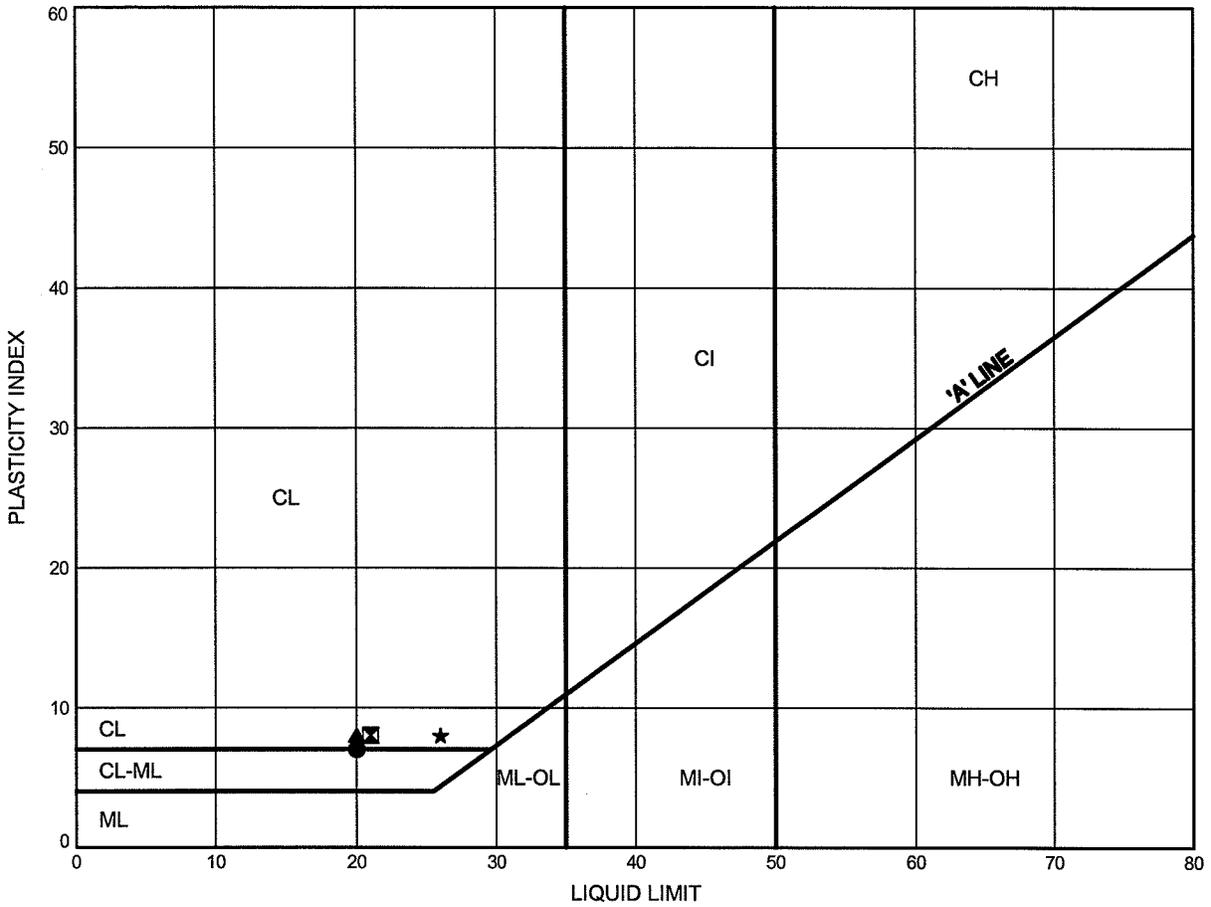


Prep'd K.L.
Chkd. M.P.

ATTERBERG LIMITS TEST RESULTS

FIGURE B5-7

CLAYEY SILT TO SILTY CLAY TILL



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C7-1	15.4	165.6
⊠	C7-2	13.9	167.6
▲	C7-3	13.9	168.5
★	C7-4	12.5	169.5

ALTR 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/09/10

Date November 2010
 Project 1-09-4135



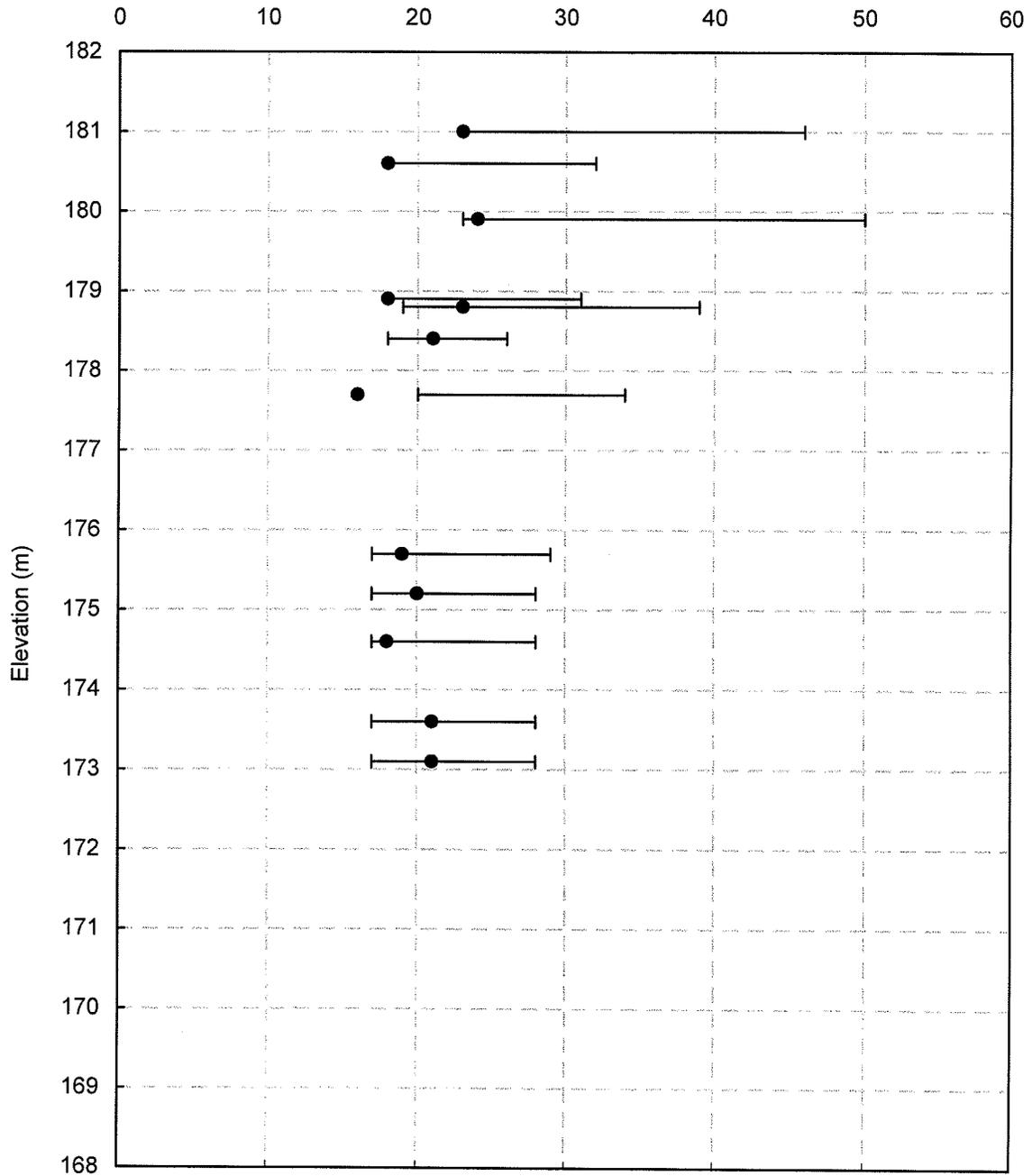
Prep'd K.L.
 Chkd. M.P.

ATTERBERG LIMITS AND WATER CONTENTS

FIGURE B5-8

HWY 406 TWINNING - CULVERT #7
Silty Clay

Atterberg Limits & Water Contents (%)



C:\Documents and Settings\Admin\My Documents\Marc P\Projects 2009\Hwy 406 Expansion\1-09-4135 (Hwy 406 Foundations)\Culverts and Retaining Walls\Culverts\Lab Results\1-09-4135C7 Soil Parameter Estimation.xls

Project No. : 1-09-4135

Date : November, 2010



Terraprobe Inc.

Prepared By : HW

Checked By : RA

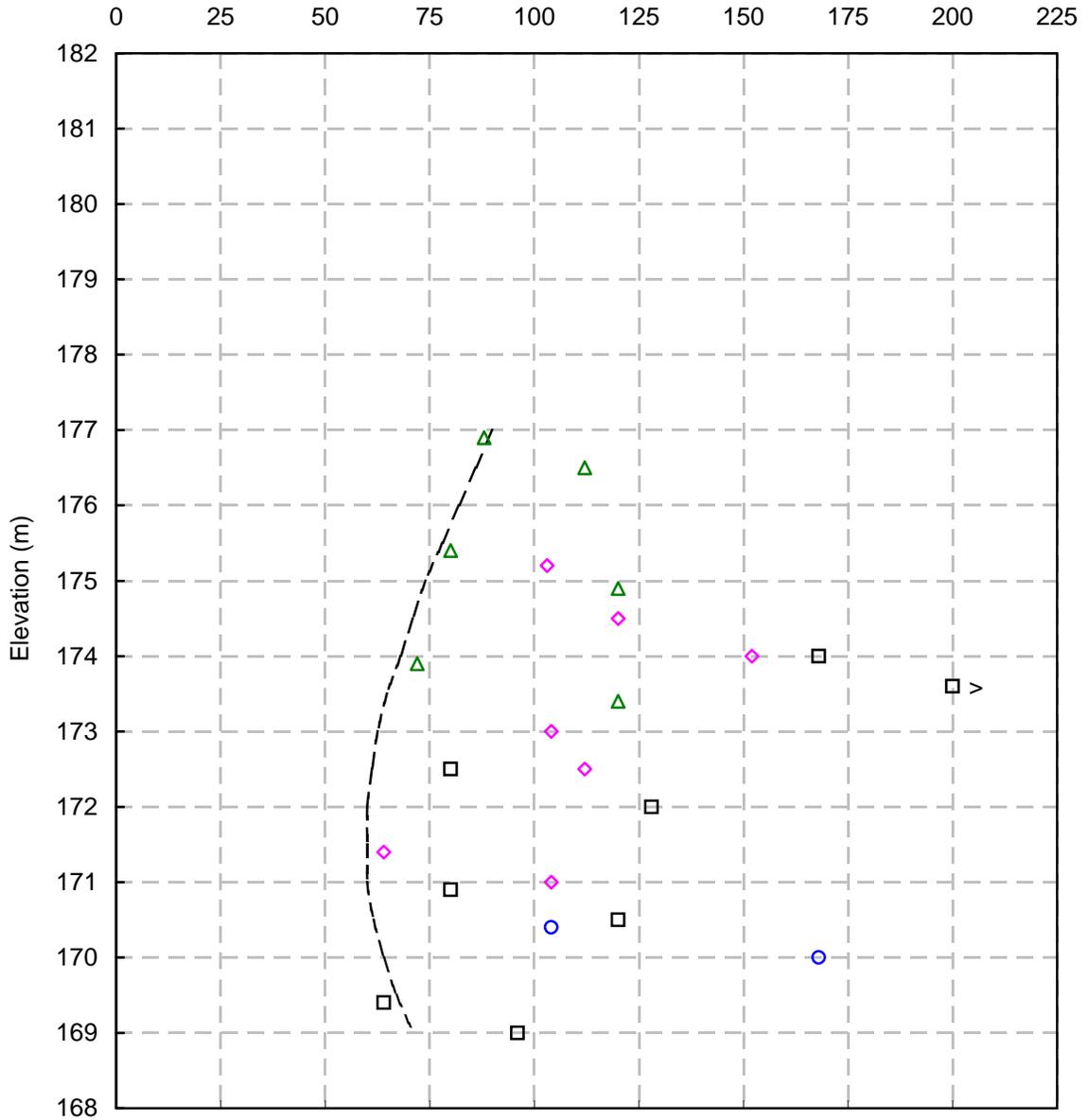
CORRECTED UNDRAINED SHEAR STRENGTH

FIGURE B5-9

HWY 406 TWINNING - CULVERT #7

Silty Clay

Corrected Cu (kPa)



□ C7-1
◇ C7-2
△ C7-3
○ C7-4

Field Shear Vane Correction	Applied Correction Factors	
Morris & Williams (1994)	0.78 (Elev. > 179 m)	1.00 (Elev. < 179 m)
$(\mu = 1.18 \text{ EXP}(-0.08 \text{ Ip}) + 0.57)$		

Project No. : 1-09-4135

Date : November, 2010

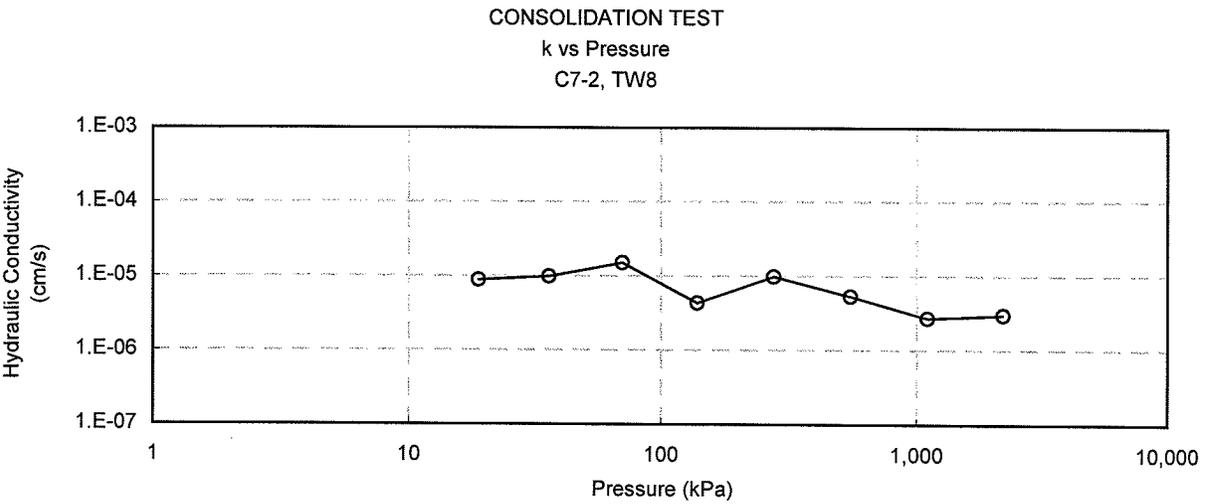
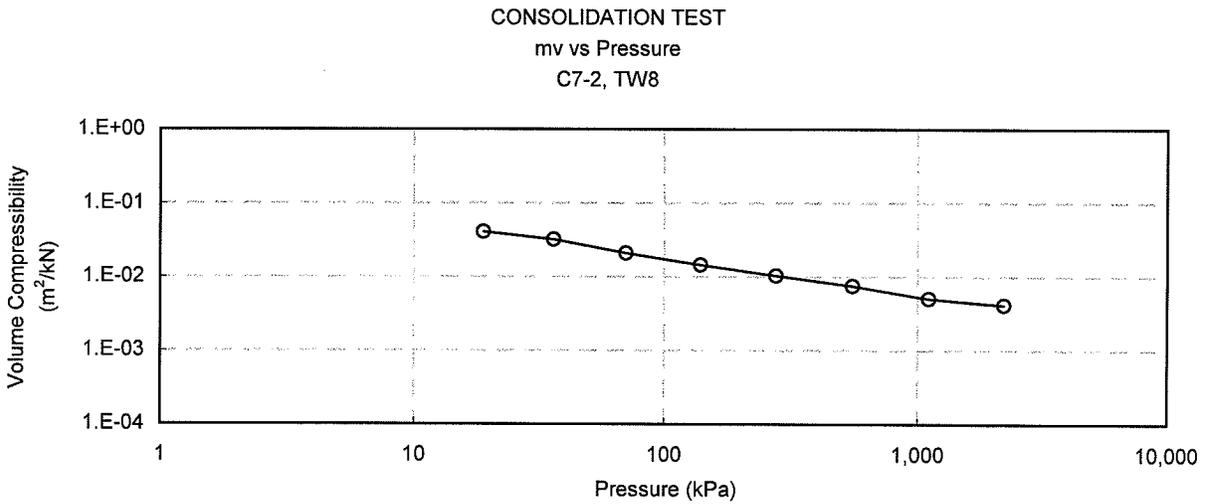
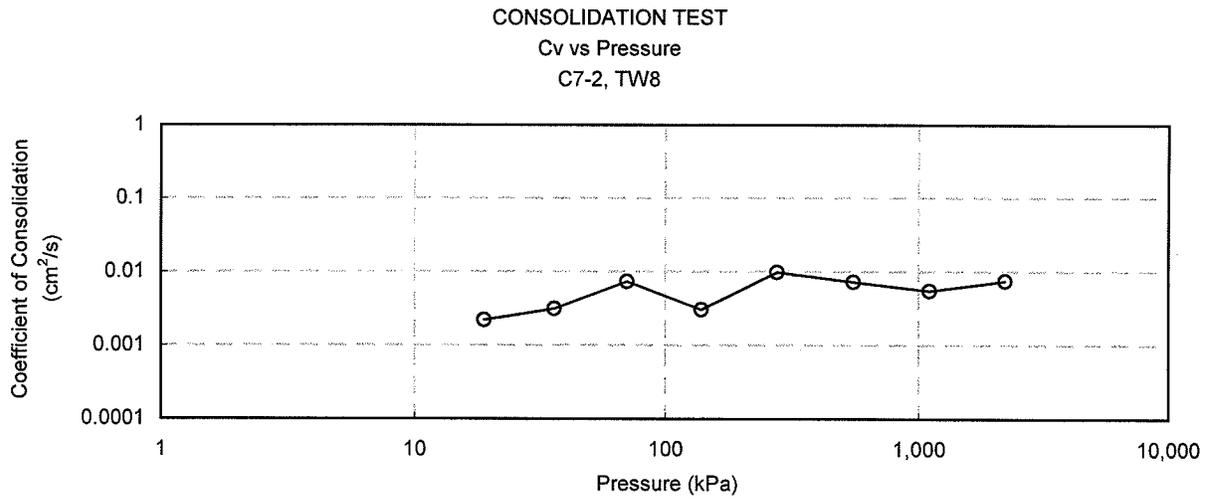


Terraprobe Inc.

Prepared By : HW

Checked By : RA

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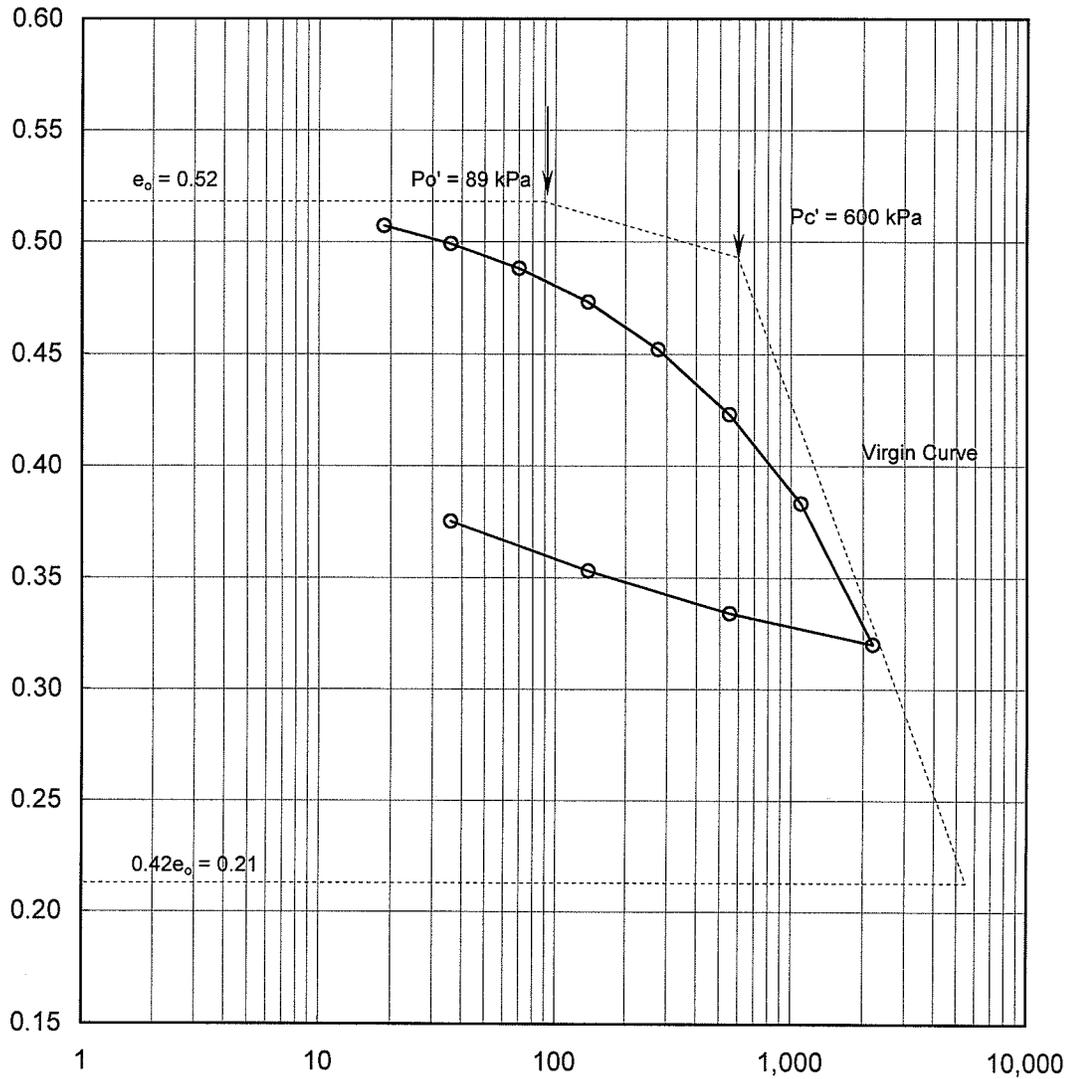
Project No. : 1-09-4135
Date : November 2010



Terraprobe Inc.

Prepared By : HW
Checked By : RA

CONSOLIDATION TEST
e vs Pressure
C7-2, TW8



Soil Type : Silty Clay

e _o =	0.52	ω _L =	28%	P _o ' =	89 kPa
ω =	19%	ω _p =	17%	P _c ' =	600 kPa
γ =	21.0 kN/m ³	PI =	11%	C _c =	0.291
G _s =	2.73			Cr =	0.030

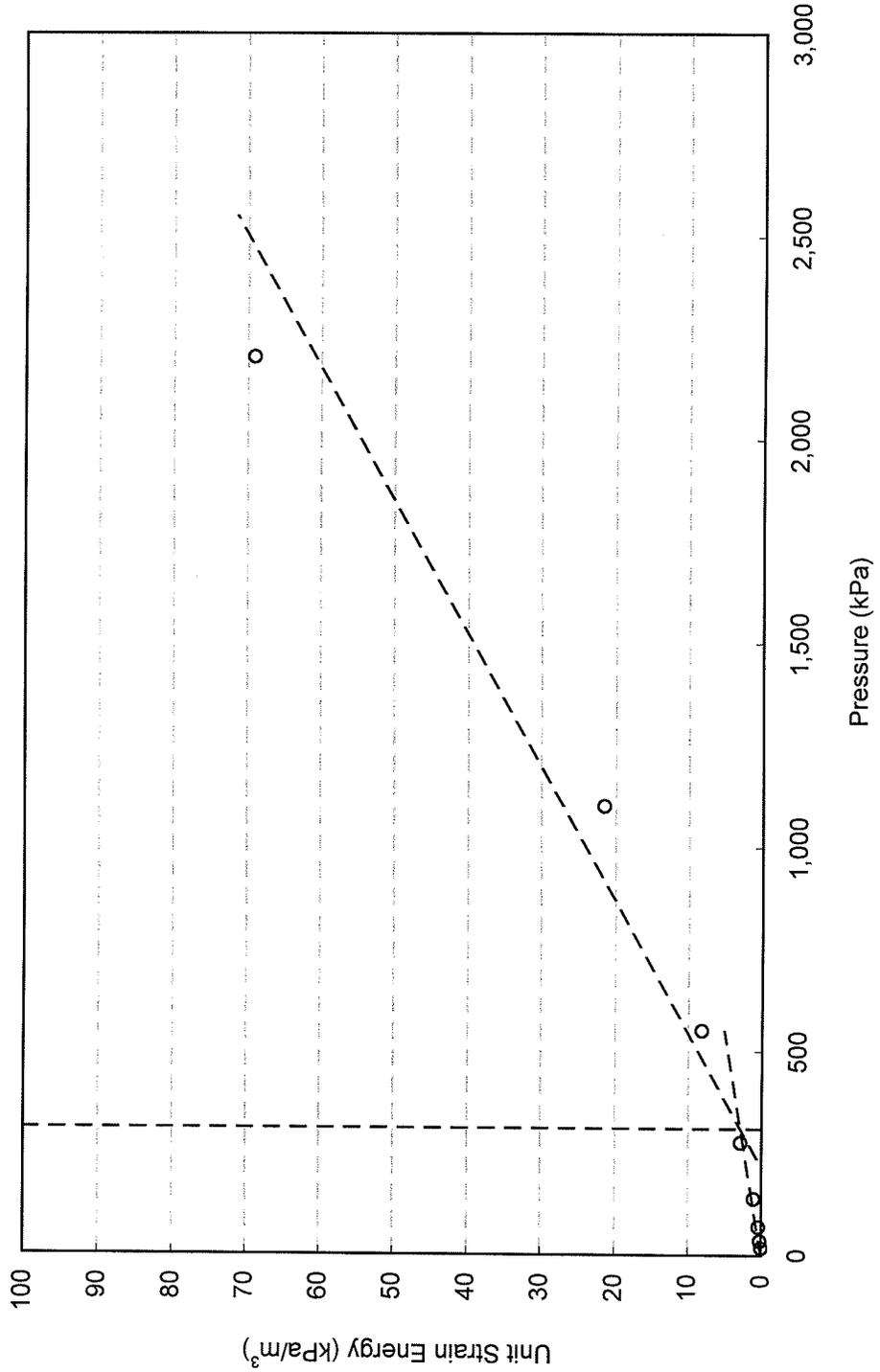
Project No. : 1-09-4135
Date : November 2010



Terraprobe Inc.

Prepared By : HW
Checked By : RA

CONSOLIDATION TEST
Unit Strain Energy vs Pressure
C7-2, TW8



Pc = 310 kPa

C:\Documents and Settings\Admin\My Documents\Marc P\Projects 2009\Hwy 406 Expansion\1-09-4135 (Hwy 406 Foundations)\Culverts and Retaining Walls\Culverts\Lab Results\1-09-4135 Consolidation Results.xls

Project No. : 1-09-4135

Date : November 2010



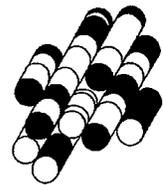
Terraprobe Inc.

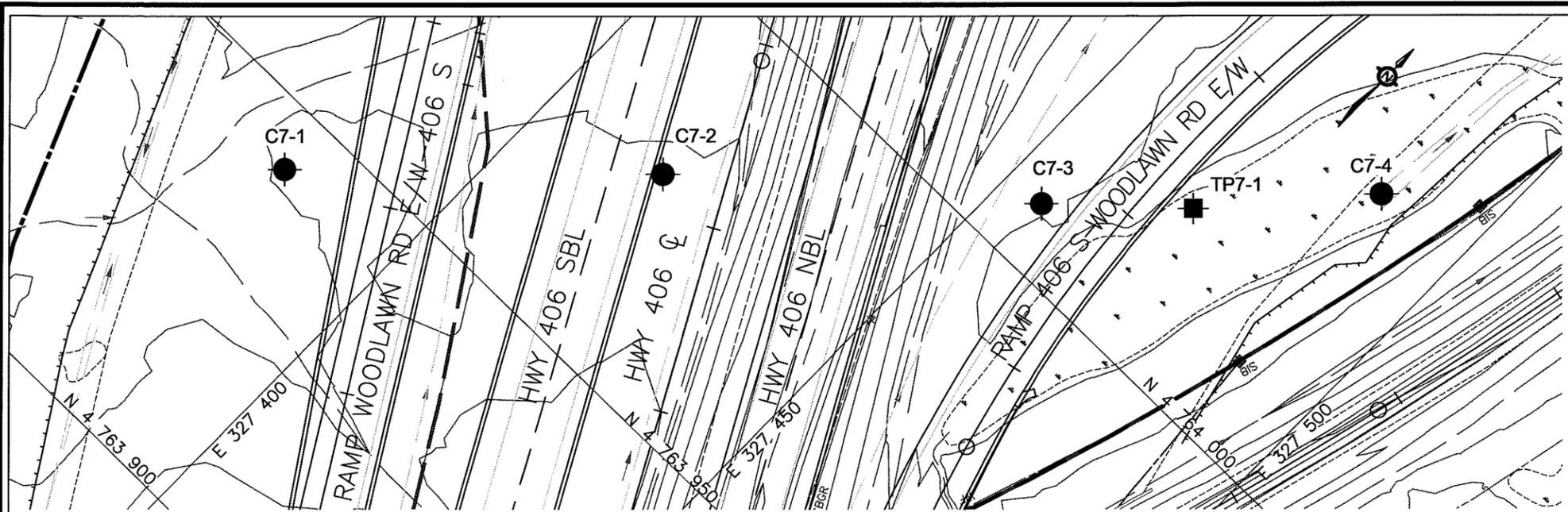
Prepared By : HW

Checked By : RA

C5

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METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETERS
UNLESS OTHERWISE SHOWN

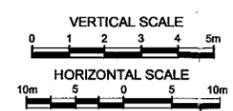
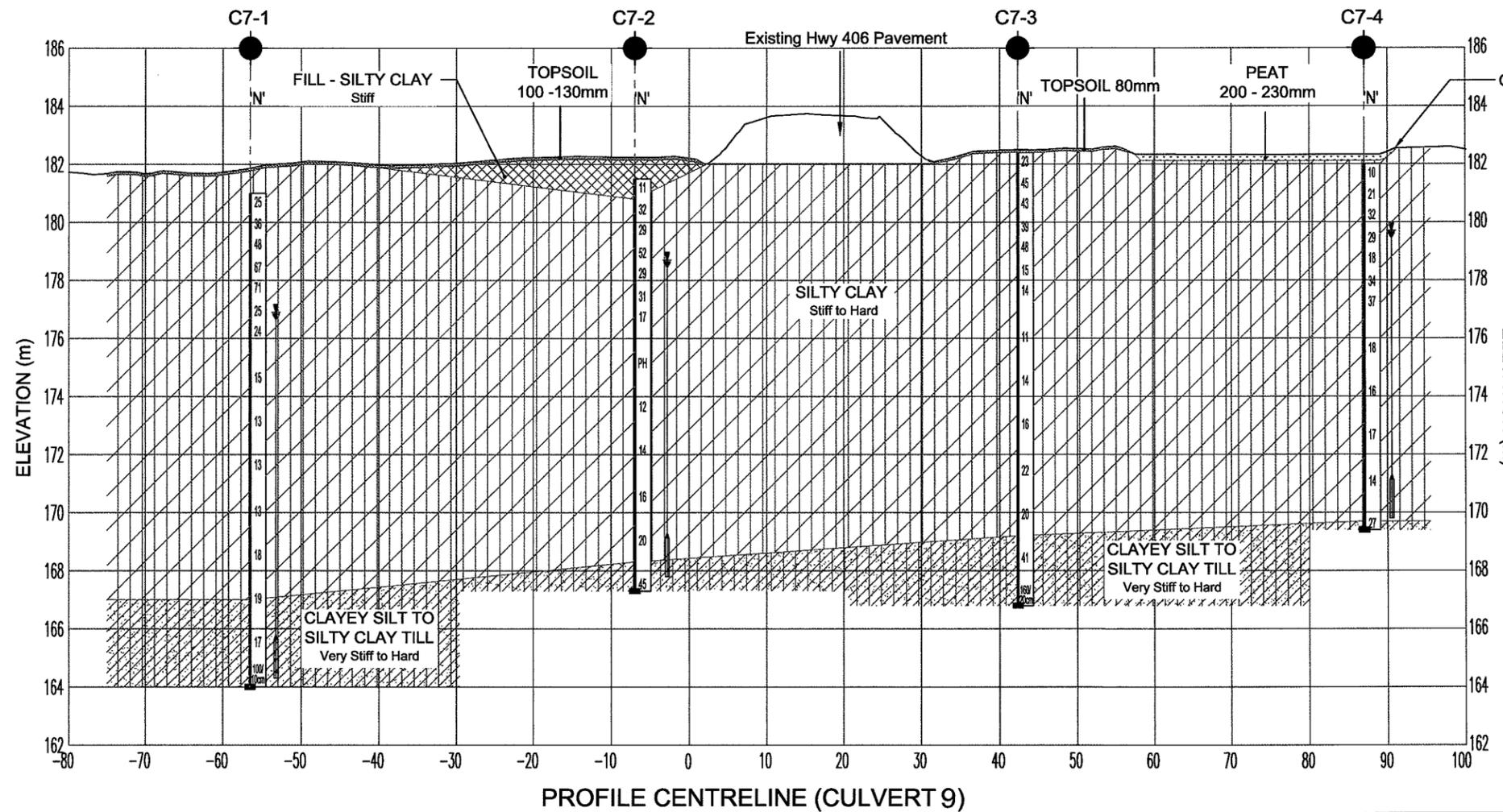
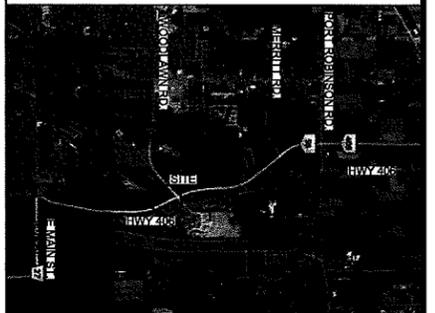


CONT No 2011-2005
WP No 280-99-00

HIGHWAY 406
CULVERT #9

BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
1 OF



KEY PLAN

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test
- Bore Hole And Cone
- Test Pits
- Blows/0.3m (Std Pen Test, 475 J/blow)
- Blows/0.3m (60° Cone, 475 J/blow)
- WL at Time of Investigation
- WL in Piezometer (JULY 2010)
- Piezometer
- 90% Rock Quality Designation
- A/R Auger Refusal

No	ELEV.	COORDINATES	
		NORTHING	EASTING
C7-1	181.0	4 763 942.6	327 381.6
C7-2	181.5	4 763 976.6	327 417.4
C7-3	182.4	4 764 008.4	327 455.7
C7-4	182.0	4 764 040.4	327 486.8

NOTE

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

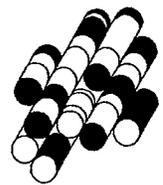
REVISIONS	DATE	BY	DESCRIPTION

DESIGN	R.A.	CODE	CHBDC2006	LOAD	DATE	FEB. 2011
DRAWN	K.C.	CHK	R.A.	STRUCT	GEORES	30M3-269

C:\Users\james\Documents\1-09-4135 HWY 406 CULVERTS\1-09-4135 CULVERTS 7.dwg, KAMAL

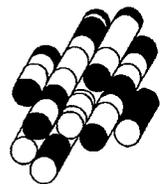
CULVERT #24

TERRAPROBE INC.



A6

TERRAPROBE INC.



RECORD OF BOREHOLE No C9-1

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765568.5 E:326999.7 ORIGINATED BY LY
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 11.18.09 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20						40	60	80	100	10
174.9	Ground Surface																	
0.0	SILTY CLAY trace sand, trace rootlets, occasional sand pockets, firm, brown, moist		1	SS	5													
			2	SS	7								43		0	5	56	39
173.2				3	SS	7												
1.7	SILT - trace clay, loose, brown, wet																	
172.8	SILTY CLAY trace sand, firm to stiff, brown, damp to moist		4	SS	2													
2.1			5	SS	5													
				6	SS	5												
				7	TW	PH												
				8	SS	8												
				9	SS	9												
				10	SS	13												
				11	SS	15												
162.2		End of Borehole																
12.7		Consolidation test performed on TW 7. Borehole was dry (not stabilized) and hole open to full depth on completion.																

ONTARIO MOT 1-09-4135 CULVERTS2 (KELVIN).GPJ ONTARIO MOT.GDT 09/02/10

Continued Next Page

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No C9-1

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765566.5 E:326999.7 ORIGINATED BY LY
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 11.18.09 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
	Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 1.52m slotted screen. Water Level Readings: Date Depth(m) Elevation(m) Nov.30.09 3.0 171.9 Dec.08.09 2.1 172.8 Jan.04.10 0.4 174.5 Jan.11.10 0.6 174.3 Jan.14.10 0.5 174.4															

ONTARIO MOT 1-09-4135 CULVERTS2 (KELVIN).GPJ ONTARIO MOT.GDT 09/02/10

+³, X³: Numbers refer to Sensitivity ○³% STRAIN AT FAILURE

RECORD OF BOREHOLE No C9-2

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765579.6 E:327009.4 ORIGINATED BY LY
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers, D.C.P.T. COMPILED BY DB
 DATUM Geodetic DATE 11.17.09 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
						○ UNCONFINED	+ FIELD VANE						
						● QUICK TRIAXIAL	× LAB VANE						
176.0	Ground Surface												
0.0	SILTY CLAY trace sand, trace rootlets, stiff to very stiff, brown, damp to moist		1	SS	11						52	0 1 43 56	
			2	SS	21								
			3	SS	22								
173.9	SILT trace to some clay, trace sand, compact, brown, moist to wet		4	SS	17								
2.1			5	SS	20							0 3 82 15	
171.9	SILTY CLAY trace sand, trace gravel, firm to stiff, brown, damp to moist		6	SS	3								
4.1			7	SS	9							1 3 72 24	
			8	SS	8								
			9	SS	7								0 1 65 34
			10	SS	9								
			11	SS	13								
162.4	End of Borehole												
13.6													

ONTARIO MOT. 1-09-4135 CULVERTS2 (KELVIN).GPJ_ONTARIO MOT.GDT_09/02/10

Continued Next Page

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No C9-2

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765579.6 E:327009.4 ORIGINATED BY LY
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers, D.C.P.T. COMPILED BY DB
 DATUM Geodetic DATE 11.17.09 CHECKED BY RA

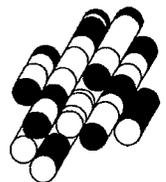
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
158.9															
17.1	End of Dynamic Cone Penetration Test Dynamic Cone Penetration Test performed from 13.6m to 17.1m. Borehole was dry (not stabilized) and hole open to full depth on completion. Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 1.52m slotted screen. Water Level Readings: Date Depth(m) Elevation(m) Nov.30.09 3.9 172.1 Dec.08.09 3.4 172.6 Jan.04.10 1.7 174.3 Jan.11.10 1.7 174.3 Jan.14.10 1.5 174.5														

ONTARIO MOT 1-09-4135 CULVERTS2 (KELVIN).GPJ ONTARIO MOT.GDT 09/02/10

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

B6

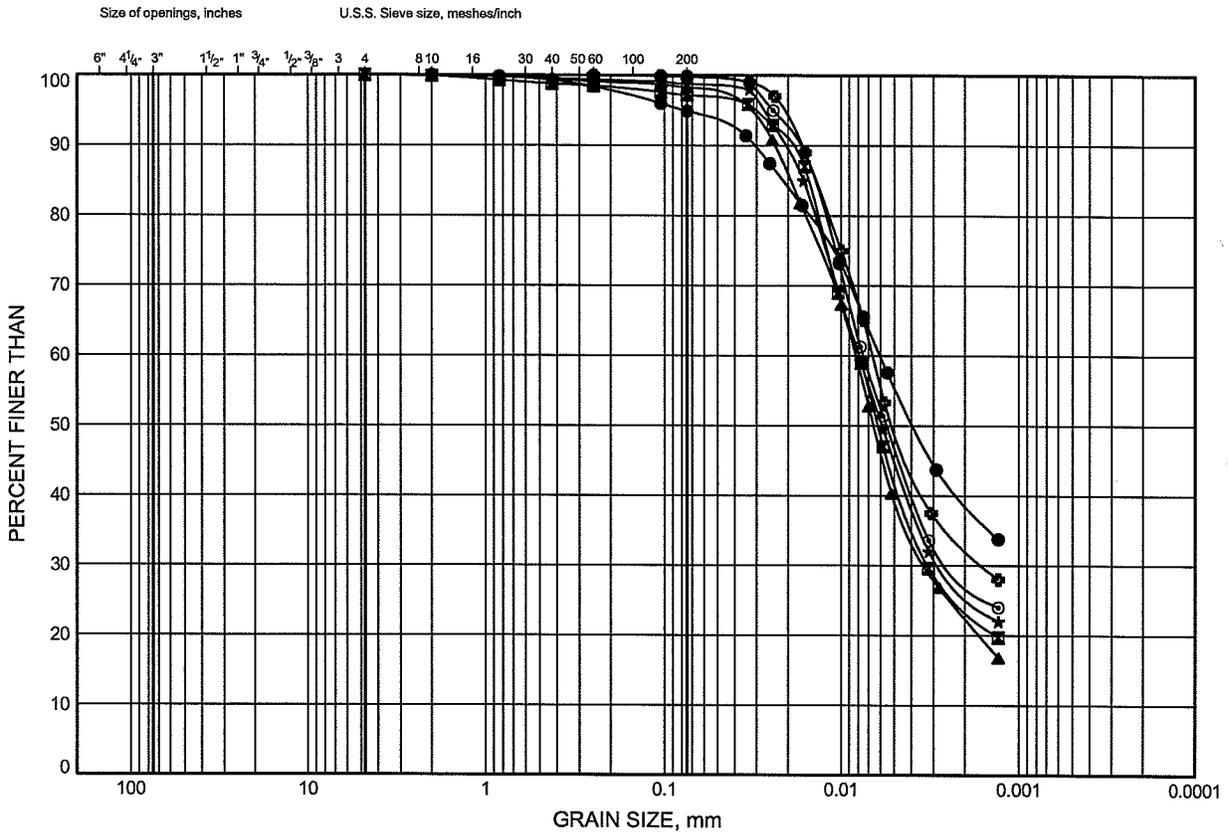
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GRAIN SIZE DISTRIBUTION

FIGURE B6-1

SILTY CLAY



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

SYMBOL BOREHOLE DEPTH (m) ELEVATION (m)

●	C9-1	1.0	173.9
■	C9-1	4.7	170.2
▲	C9-1	6.3	168.6
★	C9-1	7.8	167.1
⊙	C9-1	10.9	164.0
⊕	C9-1	12.4	162.5

GSD 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/03/10

Date November 2010

Project 1-09-4135



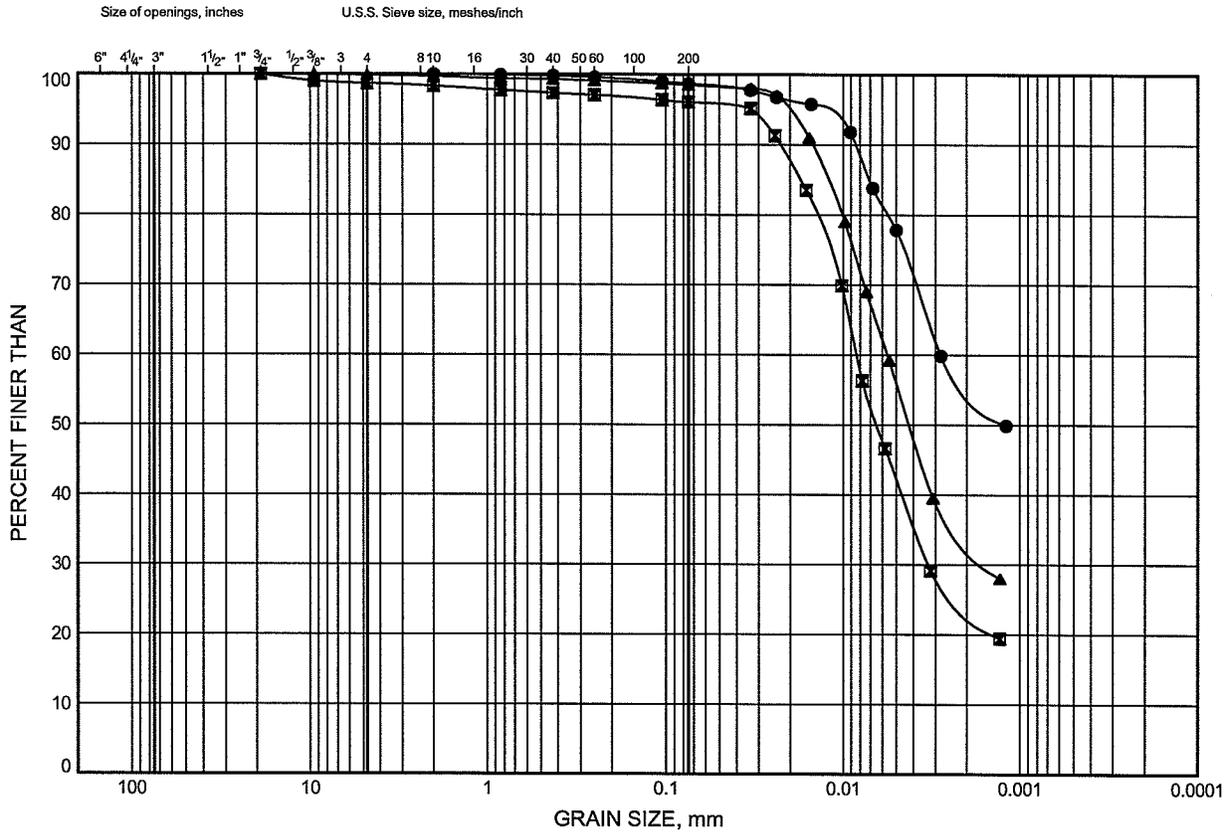
Prep'd K.L.

Chkd. M.P.

GRAIN SIZE DISTRIBUTION

FIGURE B6-2

SILTY CLAY



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C9-2	0.3	175.7
■	C9-2	6.3	169.7
▲	C9-2	9.3	166.7

GSD 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/03/10

Date November 2010
Project 1-09-4135

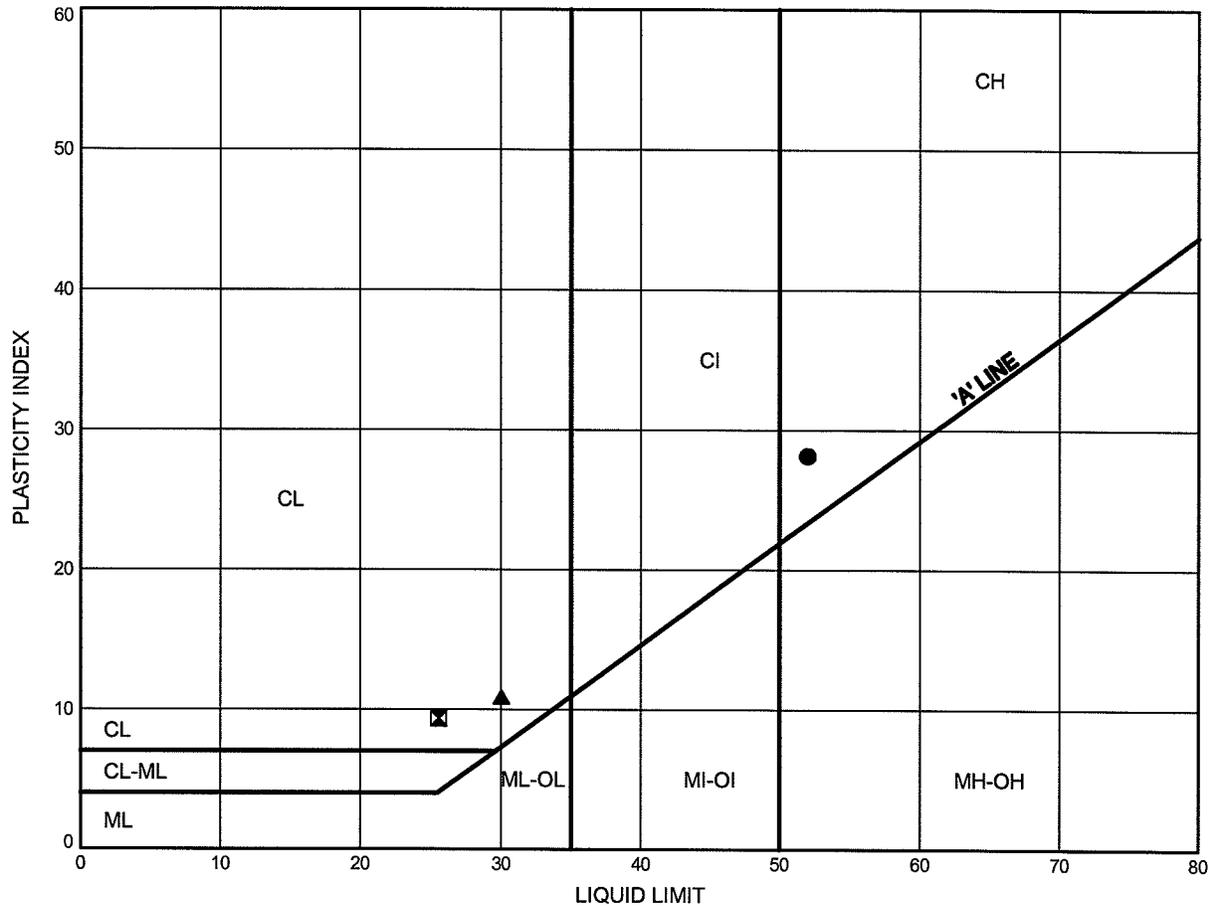


Prep'd K.L.
Chkd. M.P.

ATTERBERG LIMITS TEST RESULTS

FIGURE B6-4

SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C9-2	0.3	175.7
⊠	C9-2	6.3	169.7
▲	C9-2	9.3	166.7

ALTR 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/03/10

Date November 2010
 Project 1-09-4135

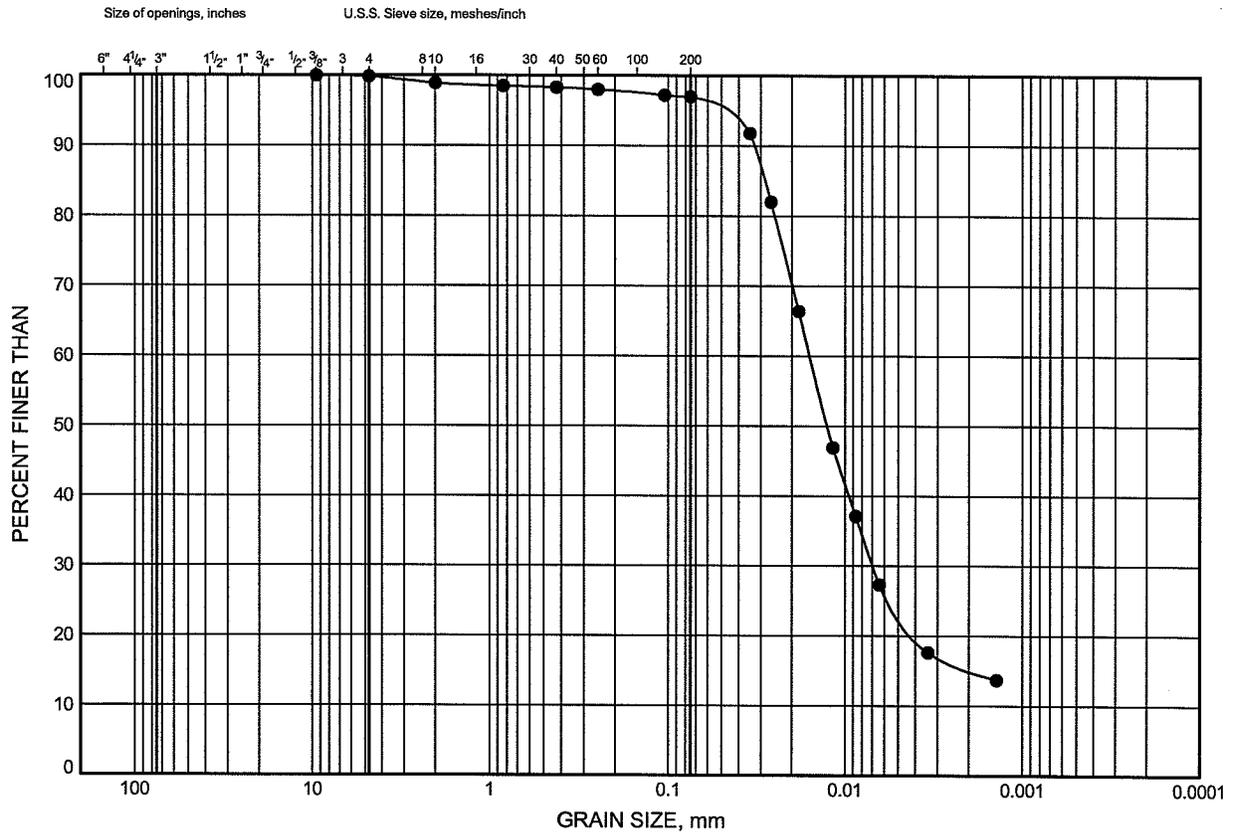


Prep'd K.L.
 Chkd. M.P.

GRAIN SIZE DISTRIBUTION

FIGURE B6-5

SILT

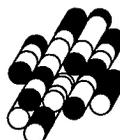


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C9-2	3.2	172.8

GSD 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/03/10

Date November 2010
 Project 1-09-4135



Prep'd K.L.
 Chkd. M.P.

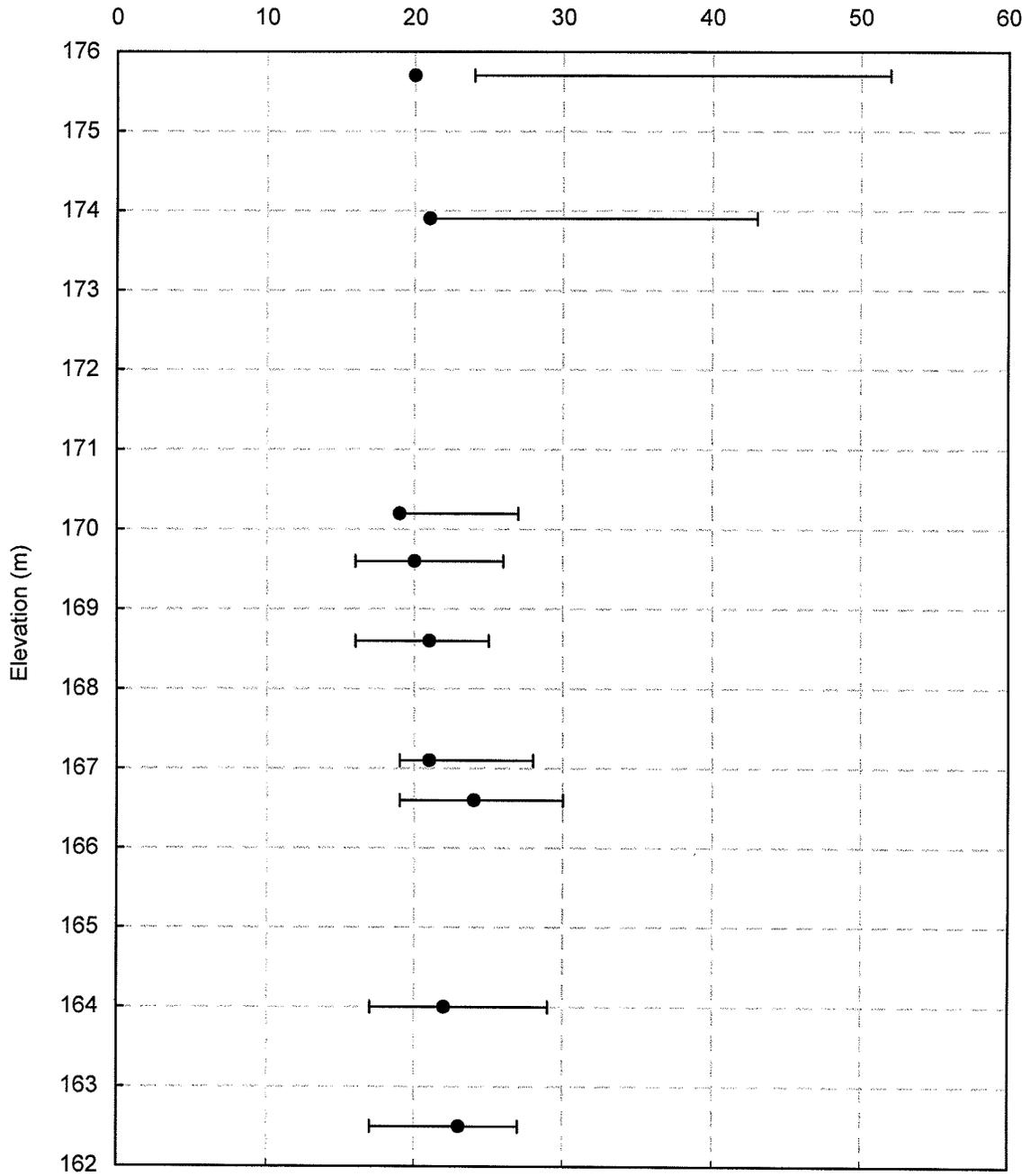
ATTERBERG LIMITS AND WATER CONTENTS

FIGURE B6-6

HWY 406 TWINNING - CULVERT #9

Silty Clay

Atterberg Limits & Water Contents (%)



C:\Documents and Settings\Admin\My Documents\Projects 2009\Hwy 406 Expansion\1-09-4135 (Hwy 406 Foundations)\Culverts and Retaining Walls\Culverts\Lab Results\1-09-4135C9 Soil Parameter Estimation.xls

Project No. : 1-09-4135

Date : November, 2010

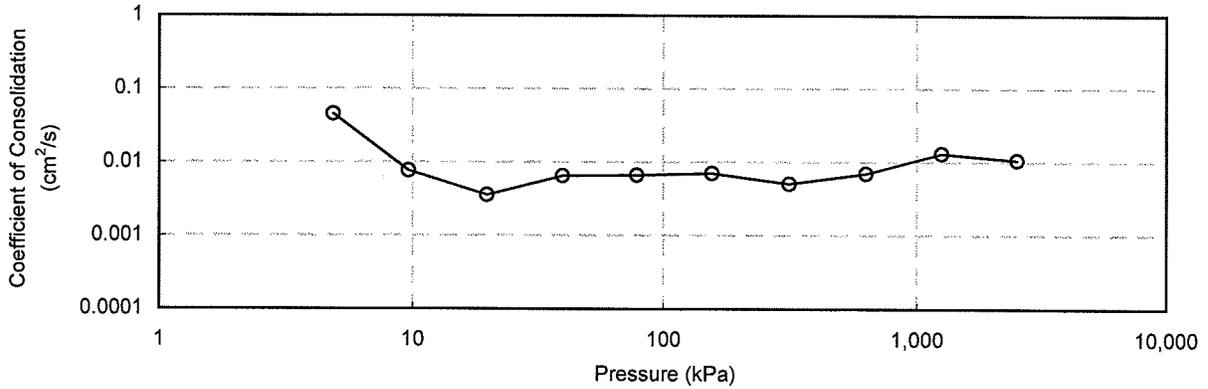


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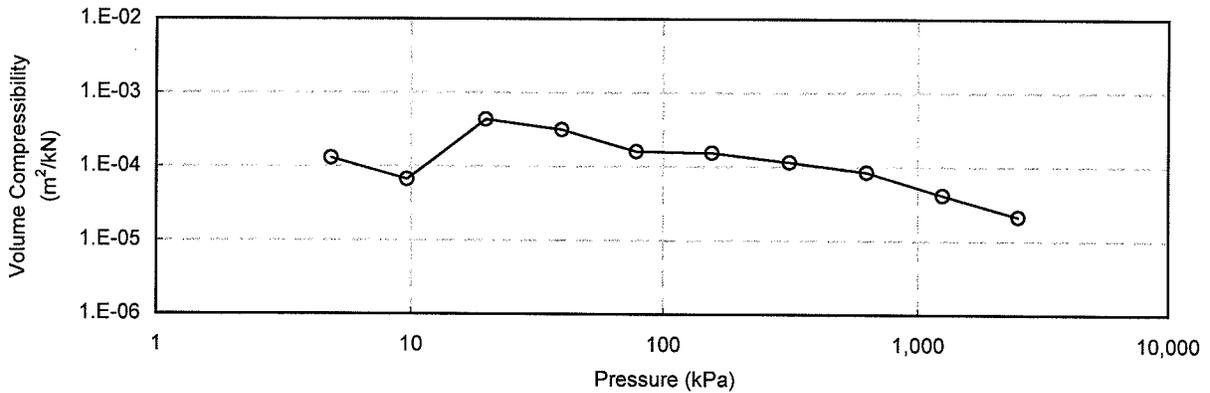
Prepared By : HW

Checked By : RA

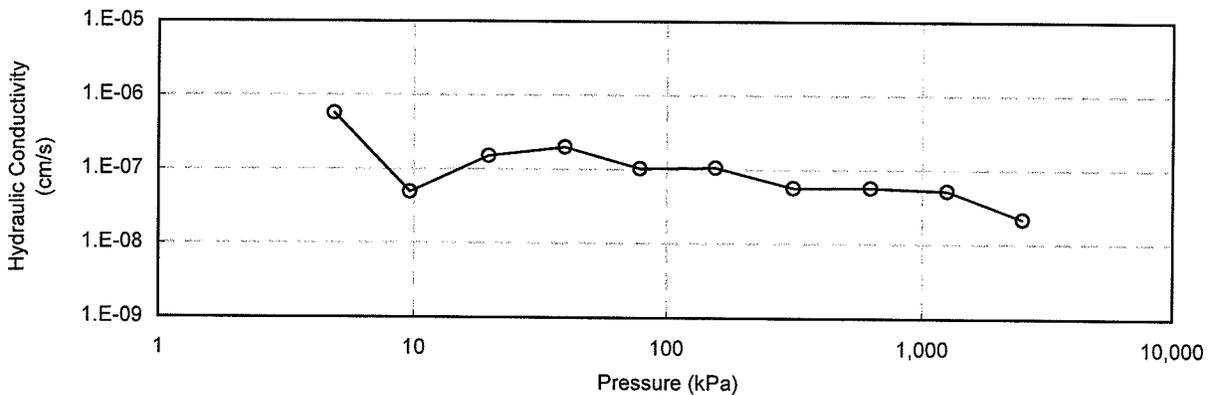
CONSOLIDATION TEST
Cv vs Pressure
C9-1, TW 7



CONSOLIDATION TEST
mv vs Pressure
C9-1, TW 7



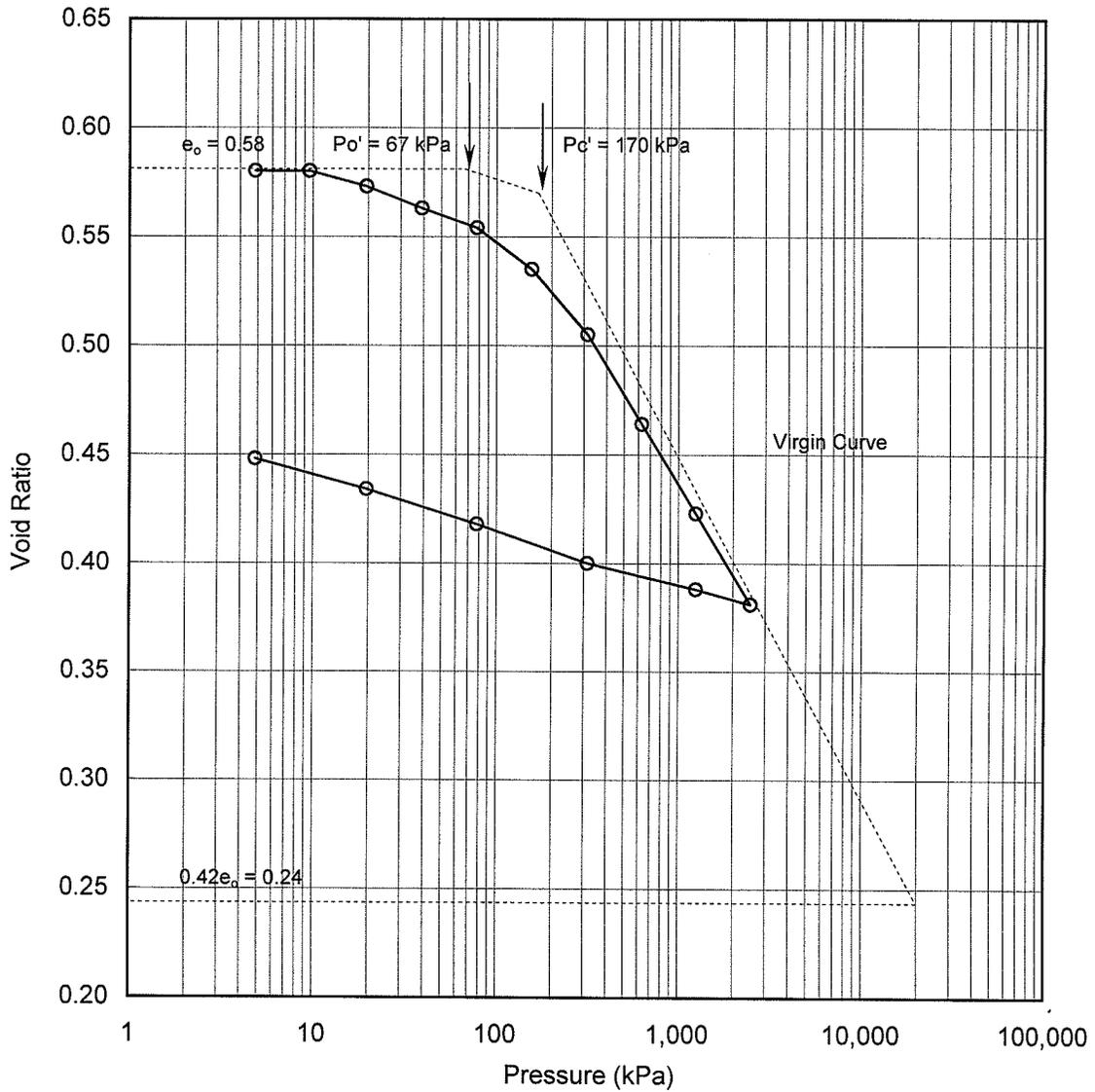
CONSOLIDATION TEST
k vs Pressure
C9-1, TW 7



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CONSOLIDATION TEST
e vs Pressure
C9-1, TW 7



Soil Type : Silty Clay

$e_o =$	0.58	$\omega_L =$	25%	$P_o' =$	67 kPa
$\omega =$	21%	$\omega_p =$	16%	$P_c' =$	170 kPa
$\gamma =$	20.6 kN/m ³	PI =	9%	$C_c =$	0.158
$G_s =$	2.74			$C_r =$	0.027

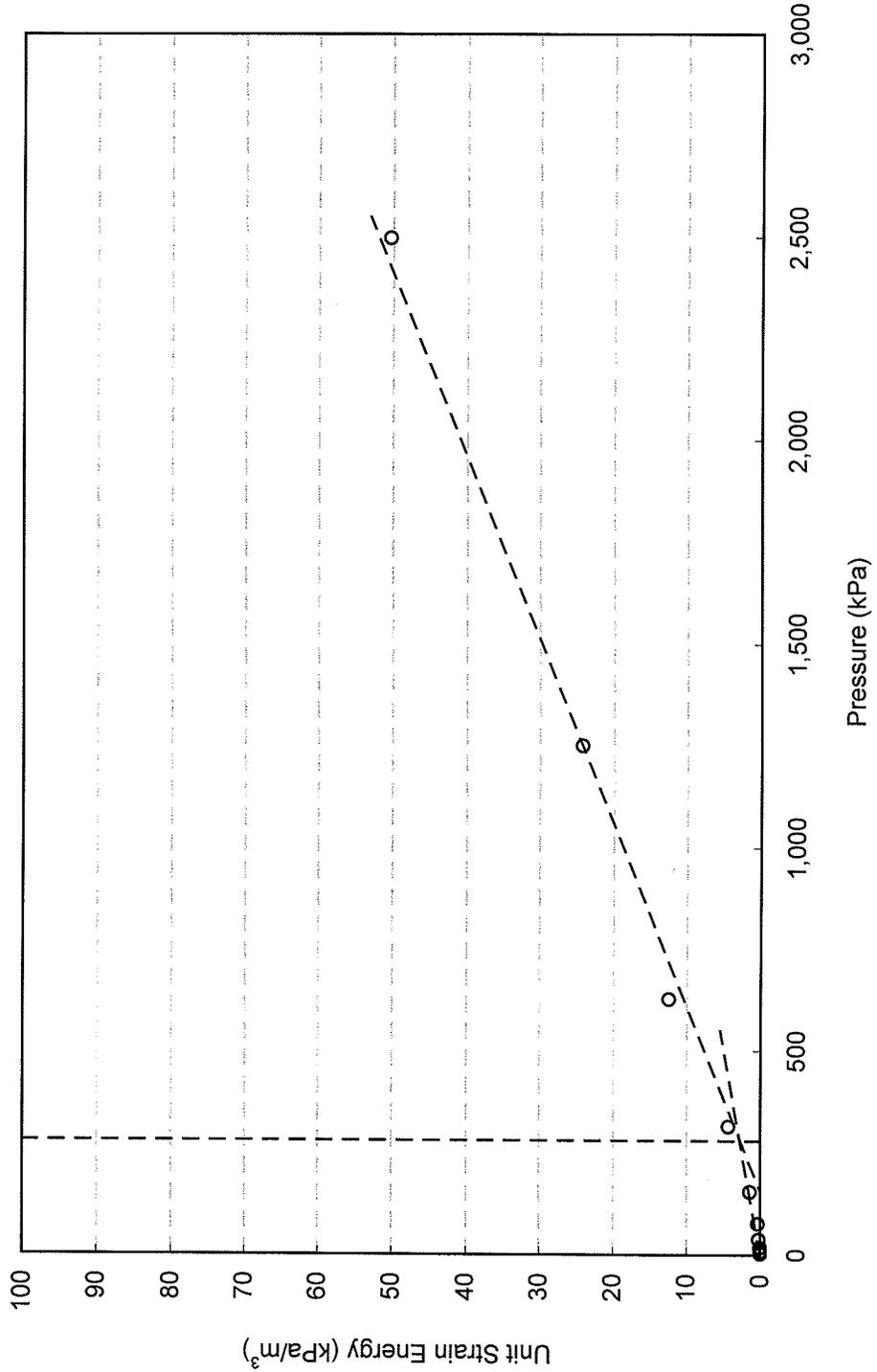
Project No. : 1-09-4135
Date : November 2010



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Prepared By : HW
Checked By : RA

CONSOLIDATION TEST
Unit Strain Energy vs Pressure
C9-1, TW 7



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Project No. : 1-09-4135

Date : November 2010



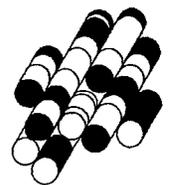
Terraprobe Inc.

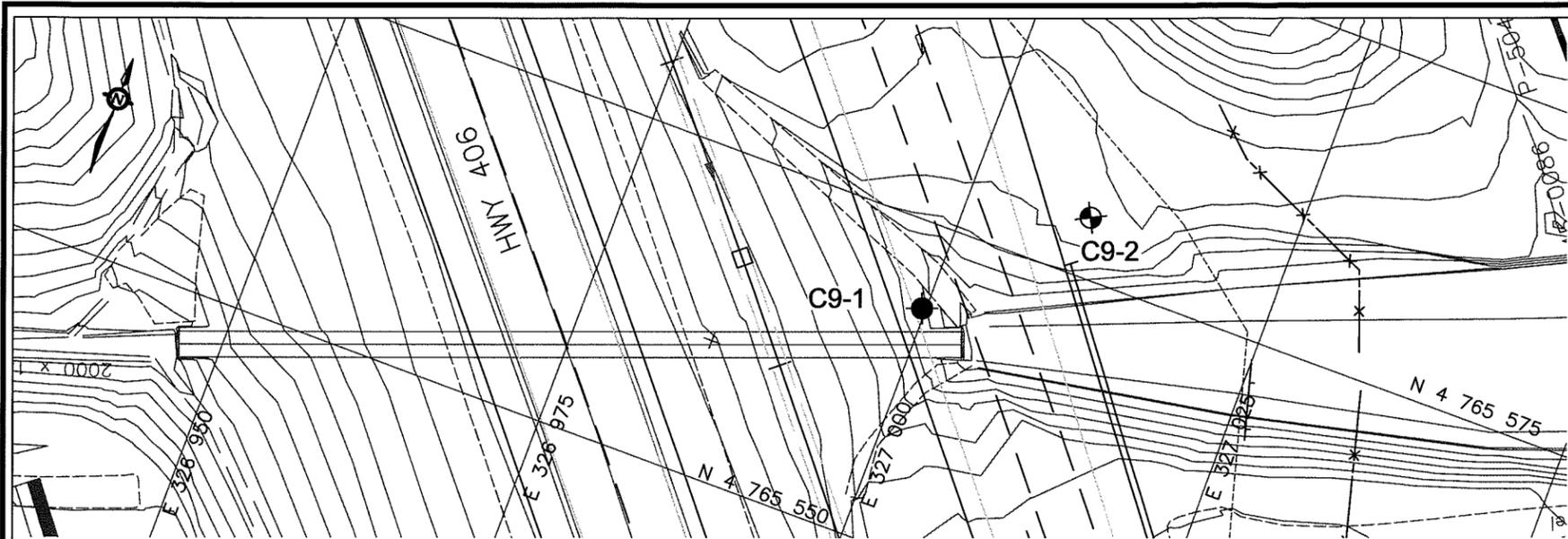
Prepared By : HW

Checked By : RA

C6

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METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETERS
UNLESS OTHERWISE SHOWN

CONT No 2011-2005
WP No 280-99-00

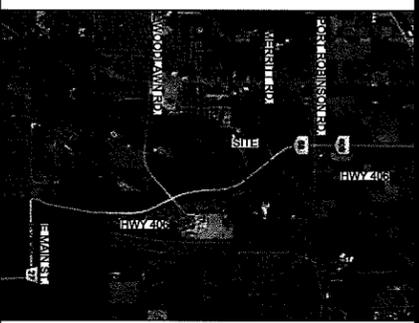


HIGHWAY 406
CULVERT # 24
BOREHOLE LOCATIONS AND SOIL STRATA

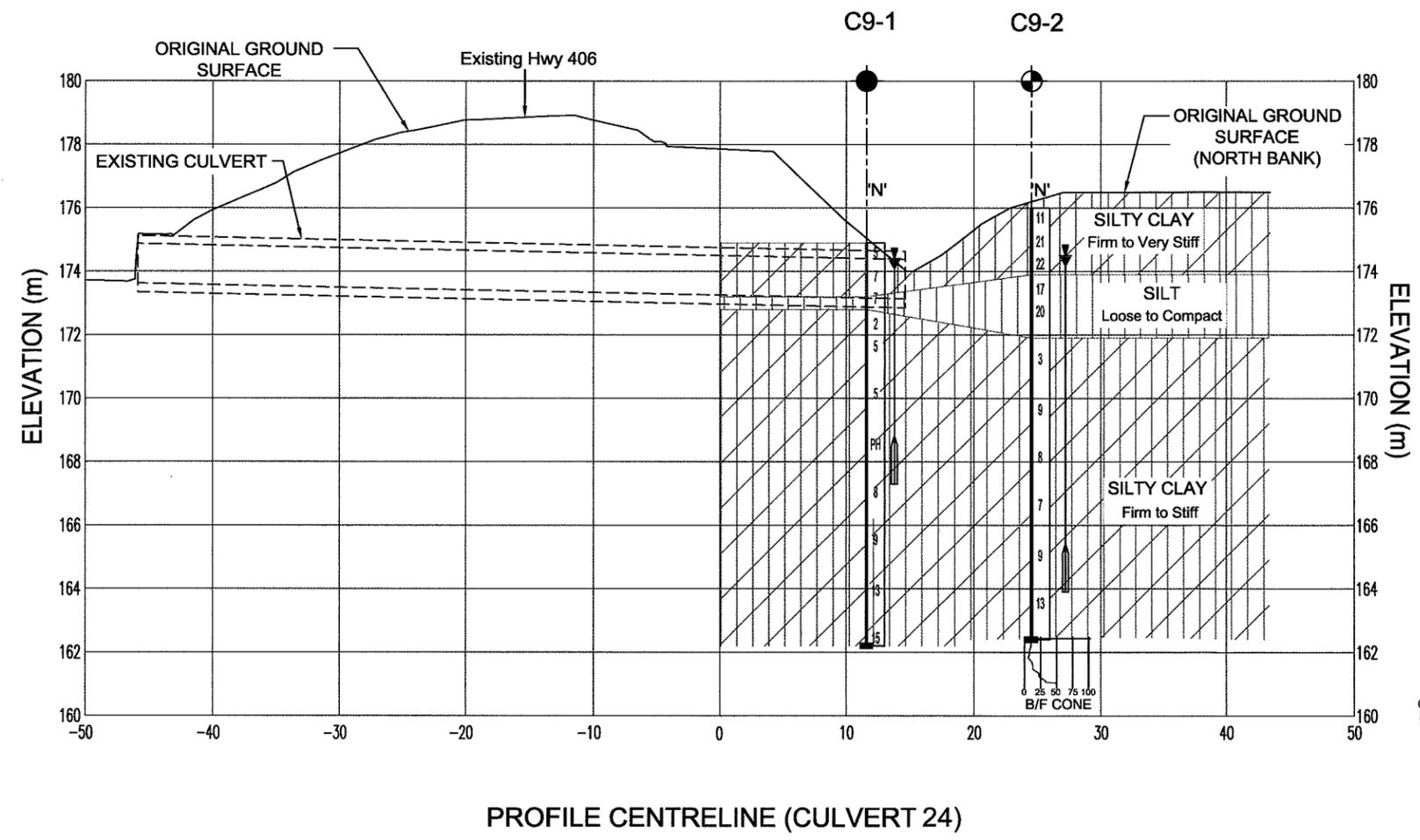
SHEET
1 OF



Terraprobe Inc.
Consulting Geotechnical & Environmental Engineering
Construction Materials Engineering, Inspection & Testing
10 Bram Court - Brampton Ontario L6W 3R6 (905) 796-2650



PLAN
SCALE
5m 2.5 0 2.5 5m



HORIZONTAL SCALE
5m 2.5 0 2.5 5m
VERTICAL SCALE
0 1 2 3 4 5m

KEY PLAN

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test
- Bore Hole And Cone
- Blows/0.3m (Std Pen Test, 475 J/blow)
- Blows/0.3m (60' Cone, 475 J/blow)
- WL at Time of Investigation
- WL in Piezometer (JAN. 2010)
- Piezometer
- 90% Rock Quality Designation
- A/R Auger Refusal

No	ELEV.	COORDINATES	
		NORTHING	EASTING
C9-1	174.9	4 765 568.5	326 999.7
C9-2	176.0	4 765 579.6	327 009.4

NOTE

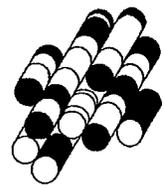
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.
This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

REVISIONS				
DATE	BY	DESCRIPTION		

DESIGN	RA	CODE	CHBDC2006	LOAD	DATE	FEB. 2011
DRAWN	K.C.	CHK	RA	STRUCT	GEOCRIS	30M3-269

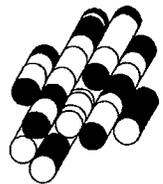
CULVERT #48

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A7

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RECORD OF BOREHOLE No C10-1

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4766880.1 E:326317.5 ORIGINATED BY PK
 DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 07.13.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)								
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			20	40						60	80	100	20	40	60	80	100
177.1	Ground Surface																				
176.9	230mm TOPSOIL																				
0.2	sandy SILTY CLAY trace sand, firm to very stiff, brown, damp to moist	1	SS	7																	
		2	SS	17									42	0 41 30 29							
		3	SS	21																	
		4	SS	22										0 6 56 38							
		5	SS	16																	
		6	SS	10																	
172.7	SILT trace clay, compact, brown, wet	7	SS	11																	
4.4																					
171.5	SILTY CLAY trace sand, firm to stiff, brown, moist	8	SS	6																	
5.6																					
		9	SS	5										0 0 64 36							
		10	TW	PH								20.7	0 1 59 40								
166.6	SILT trace to some clay, very loose to dense, brown, wet	11	SS	2									0 0 89 11								
10.5																					
164.4	End of Borehole Sampler wet at 6.1m. Water level at 7.3m (not stabilized) and hole open to 10.7m on completion. Consolidation test performed on TW 10.	12	SS	37																	
12.7																					

ONTARIO MOT 1-09-4185 CULVERTS2 (KELVIN).GPJ ONTARIO MOT.GDT 09/10/10

Continued Next Page

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No C10-1

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4766880.1 E:326317.5 ORIGINATED BY PK
 DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 07.13.10 CHECKED BY RA

SOIL PROFILE		SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)							
					20	40	60	80	100	10	20	30					
	Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 1.52m slotted screen. Water Level Readings: Date Depth(m) Elevation(m) July.19.10 0.1 177.0 Aug.06.10 0.0 177.1 Aug.13.10 0.0 177.1 Aug.23.10 0.0 177.1																

ONTARIO MOT 1-09-4135 CULVERTS2 (KELVIN).GPJ ONTARIO MOT.GDT 09/10/10

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

RECORD OF BOREHOLE No C10-2

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4766912.0 E:326352.7 ORIGINATED BY BL
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 07.14.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)							
						20	40	60	80	100	20	40	60	80	100	10	20	30	GR	SA	SI	CL		
165.5	SILT trace sand, frequent silty clay seams and partings, very loose, brown, wet	[Hatched]	14	SS	1																			
16.2																								
162.5	SILTY CLAY trace sand, stiff to very stiff, brown, damp to moist	[Hatched]	15	SS	WOH																		0 3 78 19	
19.2																								
162																								
162.5		[Hatched]	16	SS	8																			
19.2																								
160			17	SS	12																		0 7 74 19	
158.3	End of Borehole Sampler wet at 10.7m. Unable to push vane beyond 20.3m. Borehole was dry (not stabilized) and hole open to full depth on completion.	[Hatched]	18	SS	24																			
23.4																								

ONTARIO MOT. 1-09-4135 CULVERTS2 (KELVIN).GPJ ONTARIO MOT.GDT. 09/13/10

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

RECORD OF BOREHOLE No C10-3

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4766953.3 E:326381.6 ORIGINATED BY PK
 DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 07.14.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
						20	40	60	80	100						
						○ UNCONFINED										
						● QUICK TRIAXIAL										
						+ FIELD VANE										
						x LAB VANE										
							20	40	60	80	100	10	20	30		
162.3			14	SS	21											
16.2	SILTY CLAY trace sand, hard, brown, damp to moist															
161.2			15	SS	33											
17.3	End of Borehole Sampler wet at 9.1m. Water level at 8.5m (not stabilized) and hole open to 15.2m on completion. Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 1.52m slotted screen. Water Level Readings: Date Depth(m) Elevation(m) July.20.10 1.5 177.0 July.27.10 1.1 177.4 Aug.06.10 1.1 177.4															

ONTARIO MOT. 1-09-4135 CULVERTS2 (KELVIN).GPJ_ONTARIO MOT.GDT_09/13/10

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Test Pit Logs
Culvert #10 (Highway 406 Sta. 15+723)

Test Pit# TP 10-1

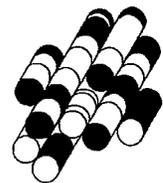
0	-	200	Fill, Br Si, Some Org, Wet
NFP			

Test Pit# TP 10-2

0	-	300	Fill, Br Si, Some Org, Wet
300	-	610	Br Si(y) Cl, Tr Sa, Damp to Moist

B7

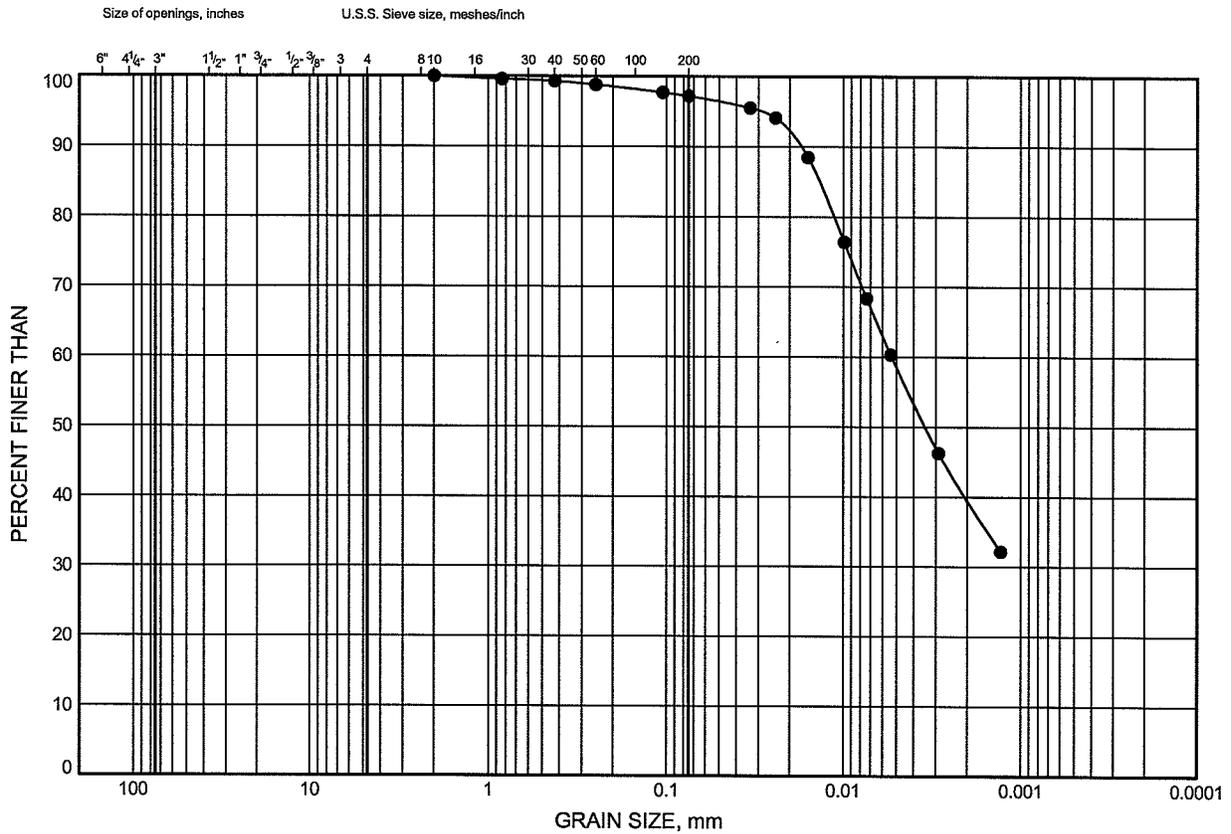
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GRAIN SIZE DISTRIBUTION

FIGURE B7-2

FILL - Silty Clay



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C10-2	3.2	178.5

GSD 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/03/10

Date November 2010
 Project 1-09-4135

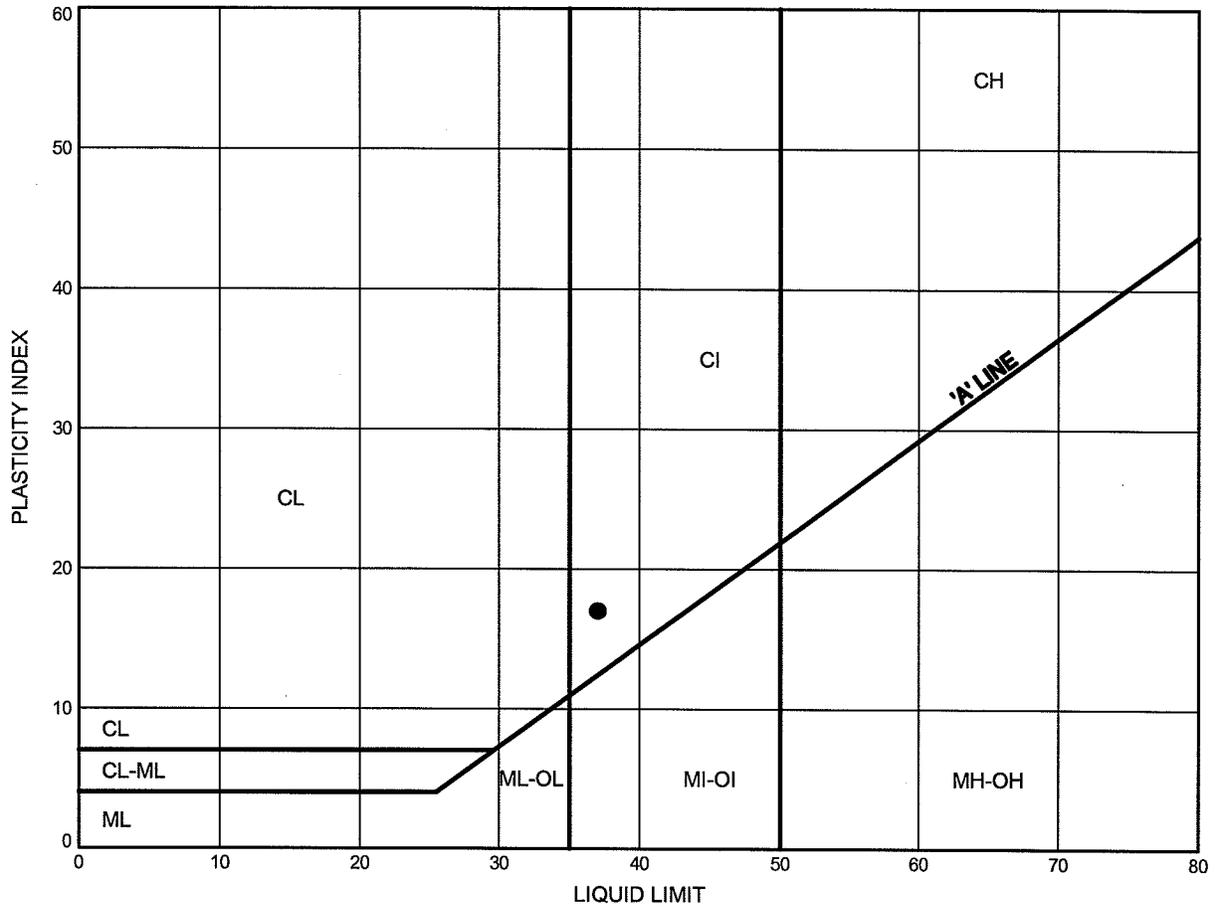


Prep'd K.L.
 Chkd. M.P.

ATTERBERG LIMITS TEST RESULTS

FIGURE B7-3

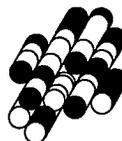
FILL - Silty Clay



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C10-2	3.2	178.5

ALTR 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/03/10

Date November 2010
 Project 1-09-4135

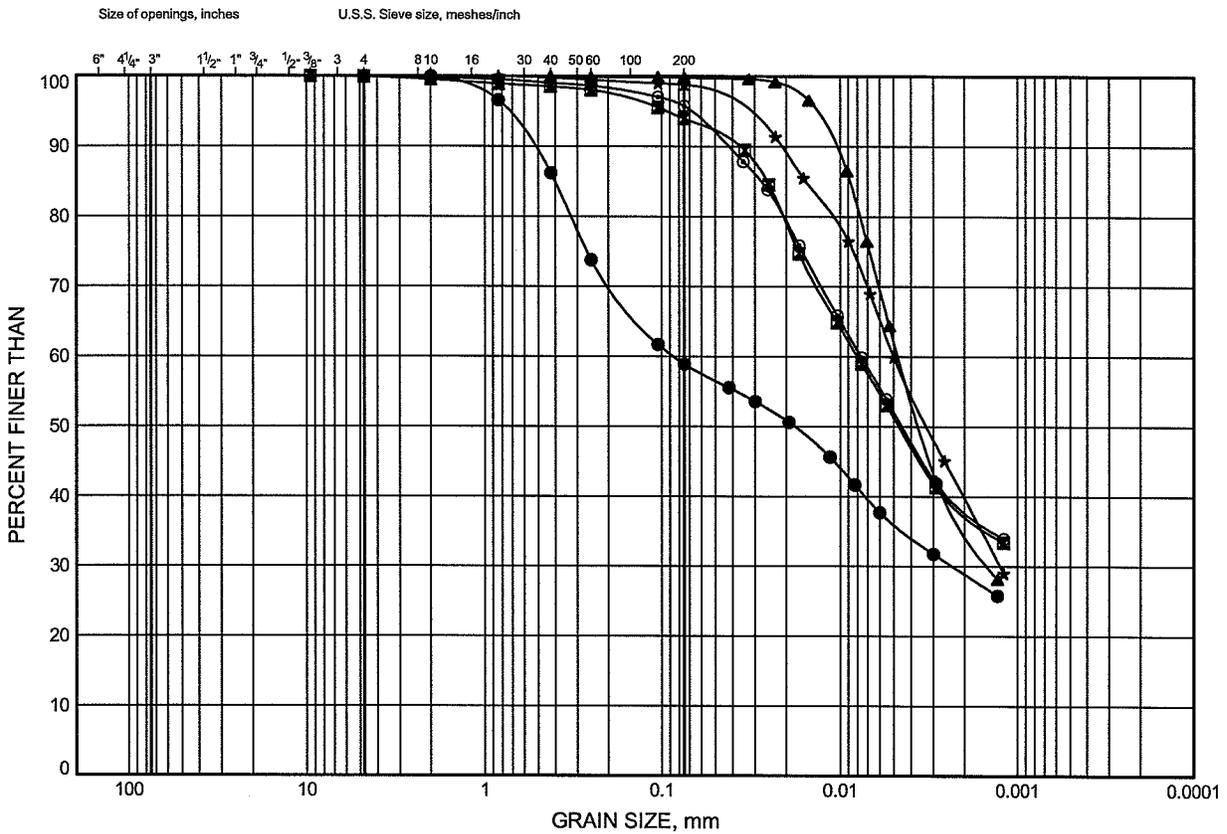


Prep'd K.L.
 Chkd. M.P.

GRAIN SIZE DISTRIBUTION

FIGURE B7-4

SILTY CLAY



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C10-1	1.0	176.1
■	C10-1	2.5	174.6
▲	C10-1	7.8	169.3
★	C10-1	9.3	167.8
⊙	C10-2	9.3	172.4

GSD 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/13/10

Date November 2010
 Project 1-09-4135

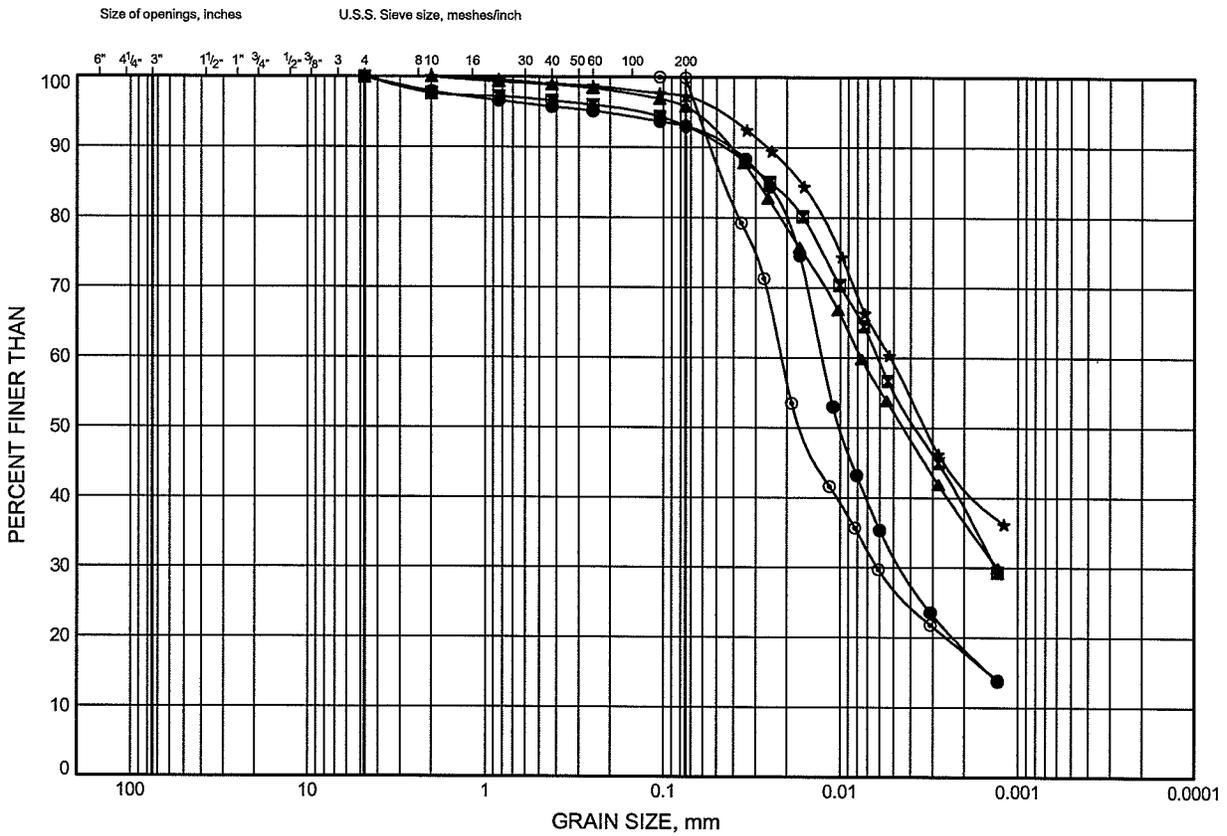


Prep'd K.L.
 Chkd. M.P.

GRAIN SIZE DISTRIBUTION

FIGURE B7-5

SILTY CLAY

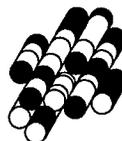


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY FINE GRAINED
	GRAVEL		SAND			

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C10-2	21.5	160.2
■	C10-3	3.2	175.3
▲	C10-3	4.0	174.5
★	C10-3	6.3	172.2
⊙	C10-3	10.9	167.6

GSD 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/13/10

Date November 2010
Project 1-09-4135

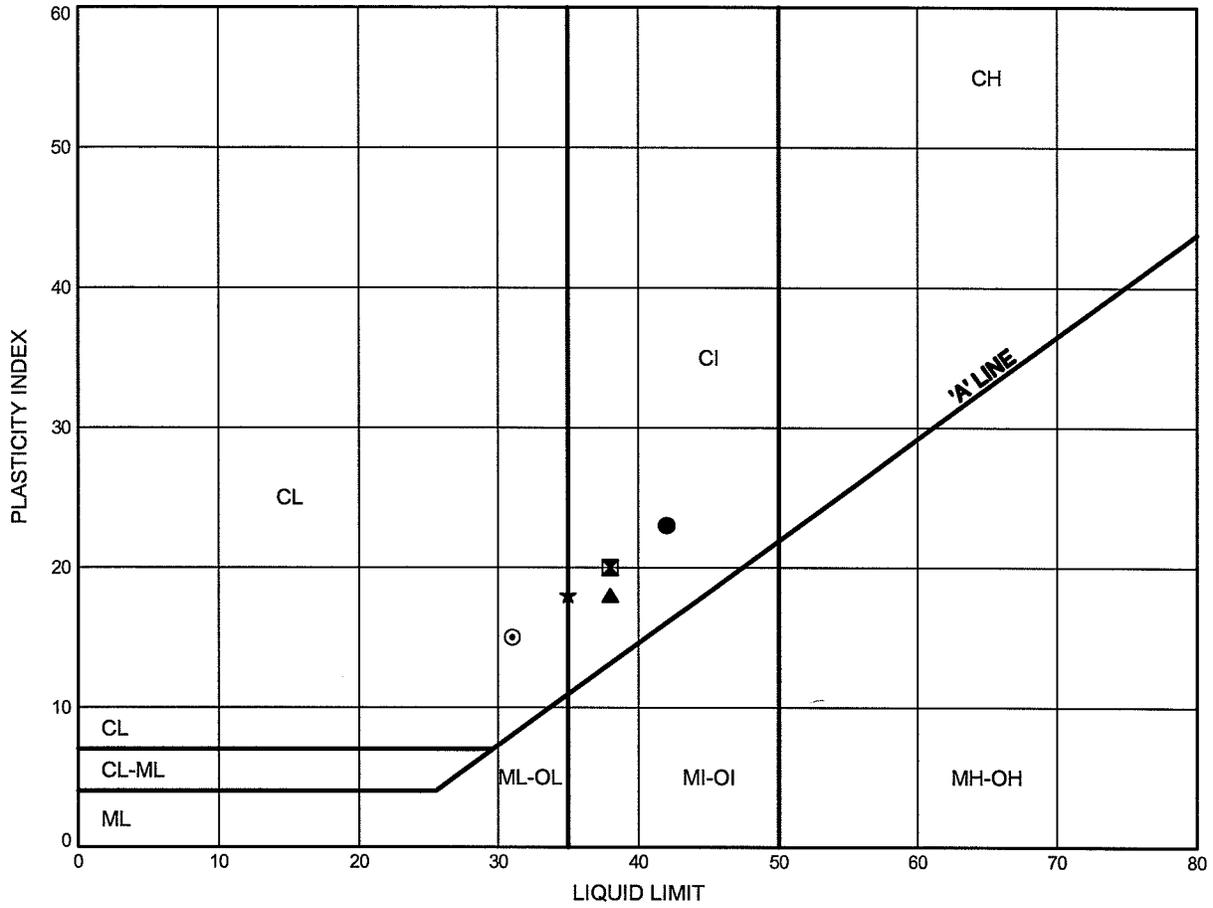


Prep'd K.L.
Chkd. M.P.

ATTERBERG LIMITS TEST RESULTS

FIGURE B7-6

SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C10-1	1.0	176.1
⊠	C10-1	2.5	174.6
▲	C10-1	7.8	169.3
★	C10-1	9.3	167.8
⊙	C10-2	9.3	172.4

ALTR 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/13/10

Date November 2010
 Project 1-09-4135

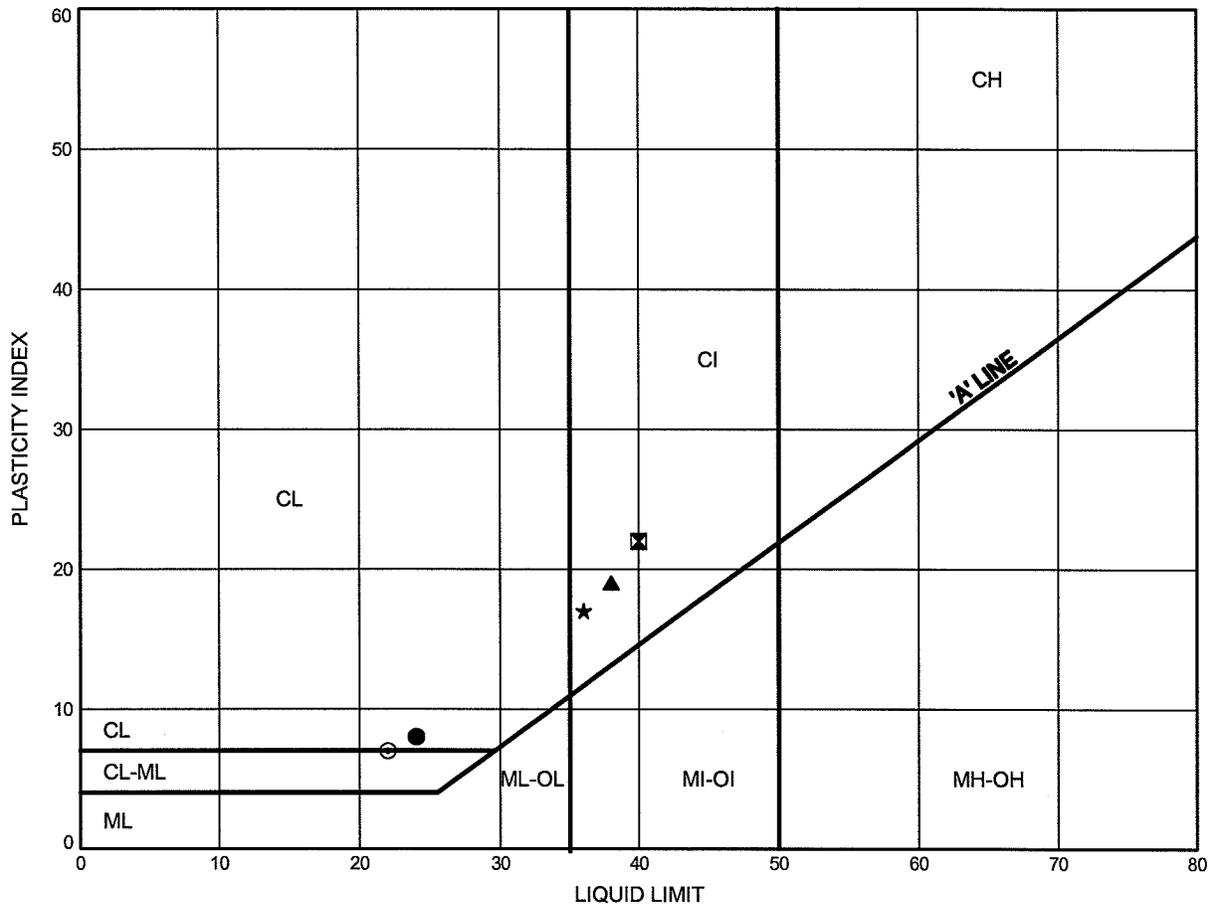


Prep'd K.L.
 Chkd. M.P.

ATTERBERG LIMITS TEST RESULTS

FIGURE B7-7

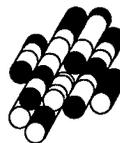
SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C10-2	21.5	160.2
⊠	C10-3	3.2	175.3
▲	C10-3	4.0	174.5
★	C10-3	6.3	172.2
⊙	C10-3	10.9	167.6

ALTR 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/13/10

Date November 2010
 Project 1-09-4135



Prep'd K.L.
 Chkd. M.P.

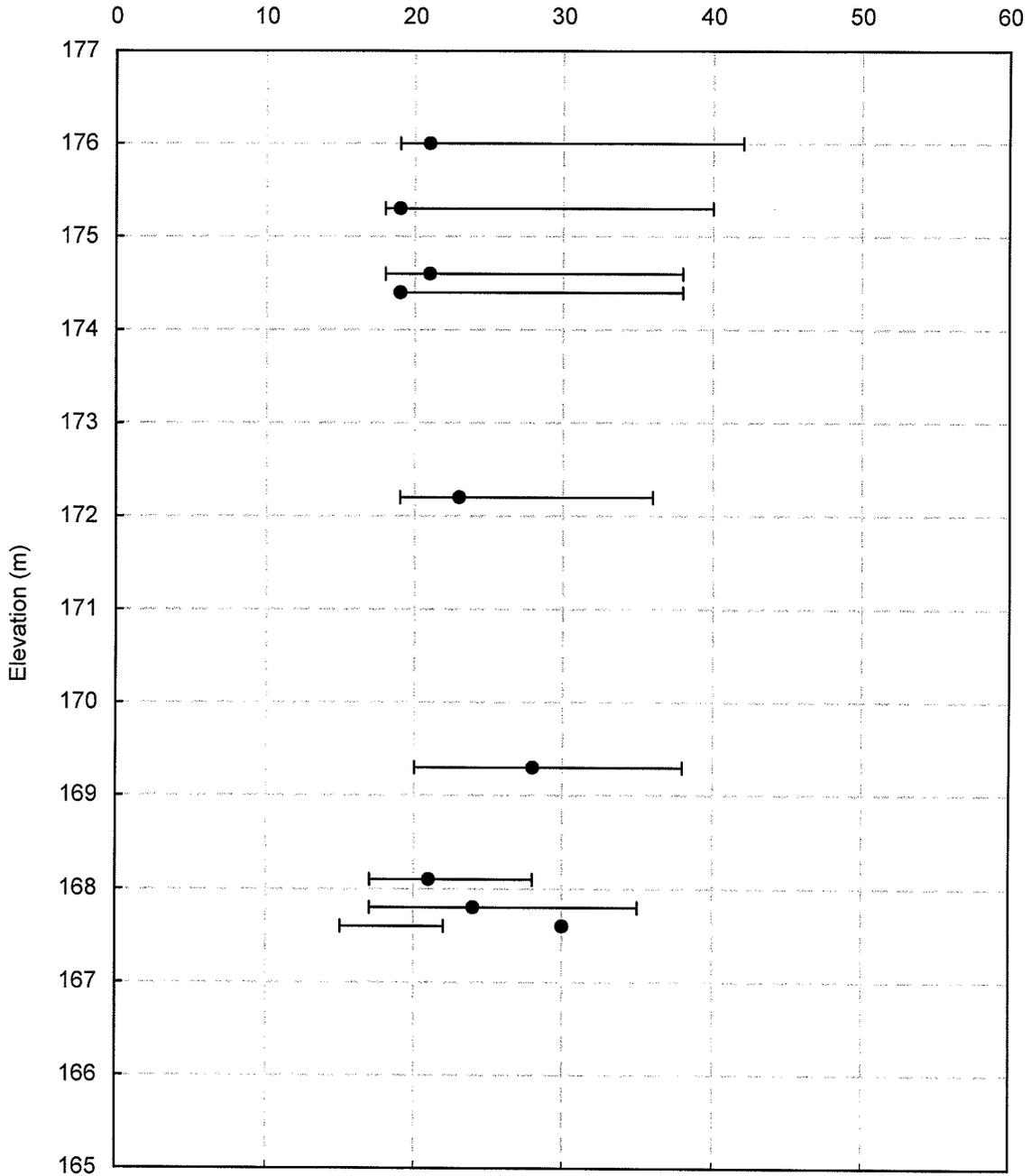
ATTERBERG LIMITS AND WATER CONTENTS

FIGURE B7-9

HWY 406 TWINNING - CULVERT #10

Silty Clay

Atterberg Limits & Water Contents (%)



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Project No. : 1-09-4135

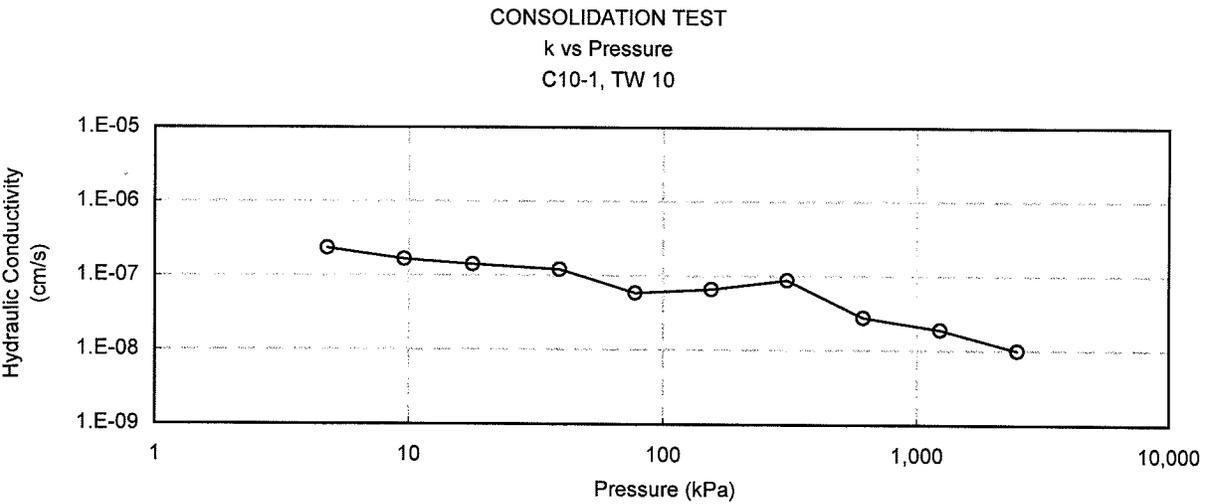
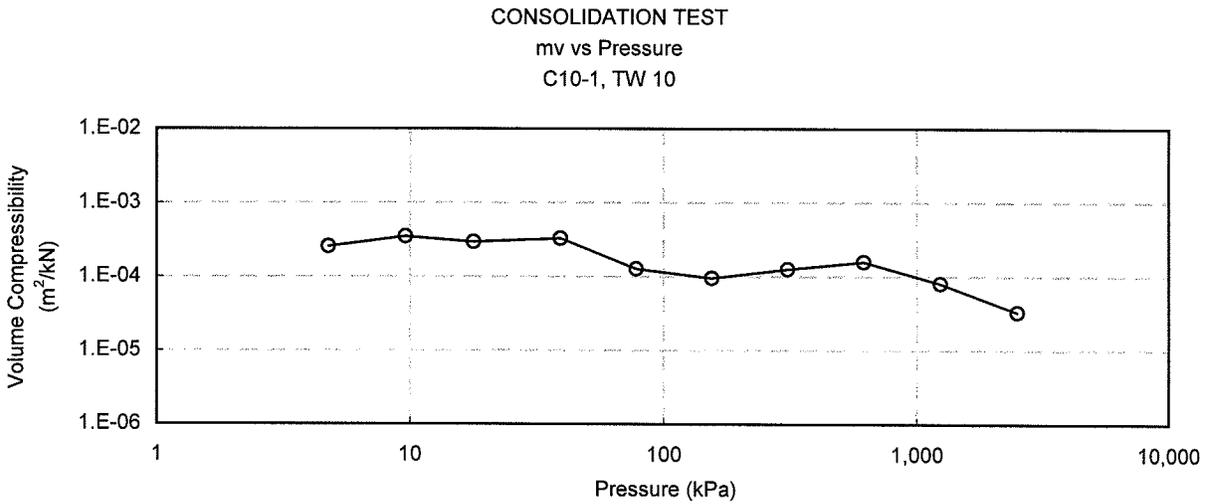
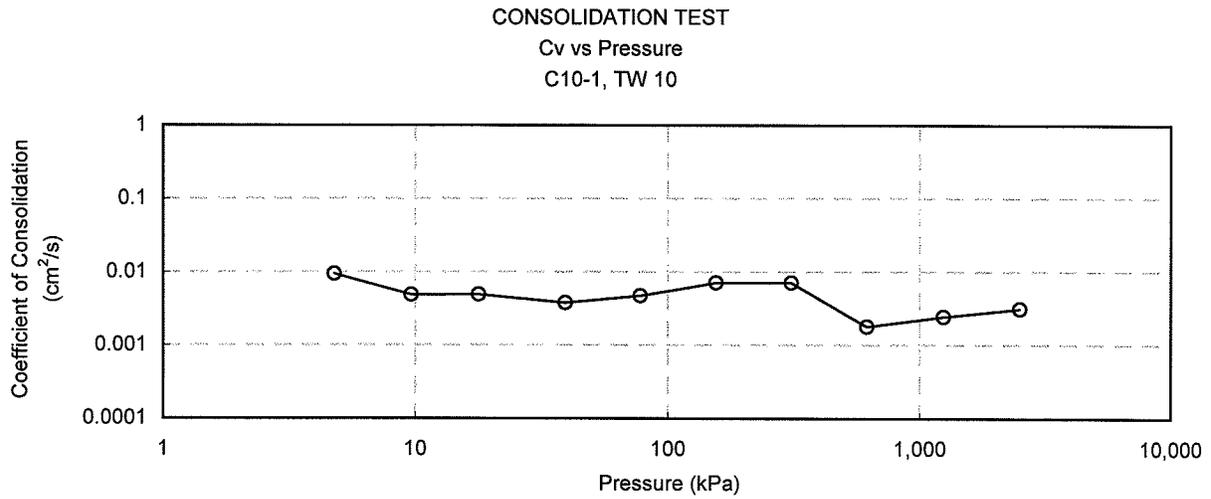
Date : November, 2010



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Prepared By : HW

Checked By : RA



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Project No. : 1-09-4135
Date : November 2010



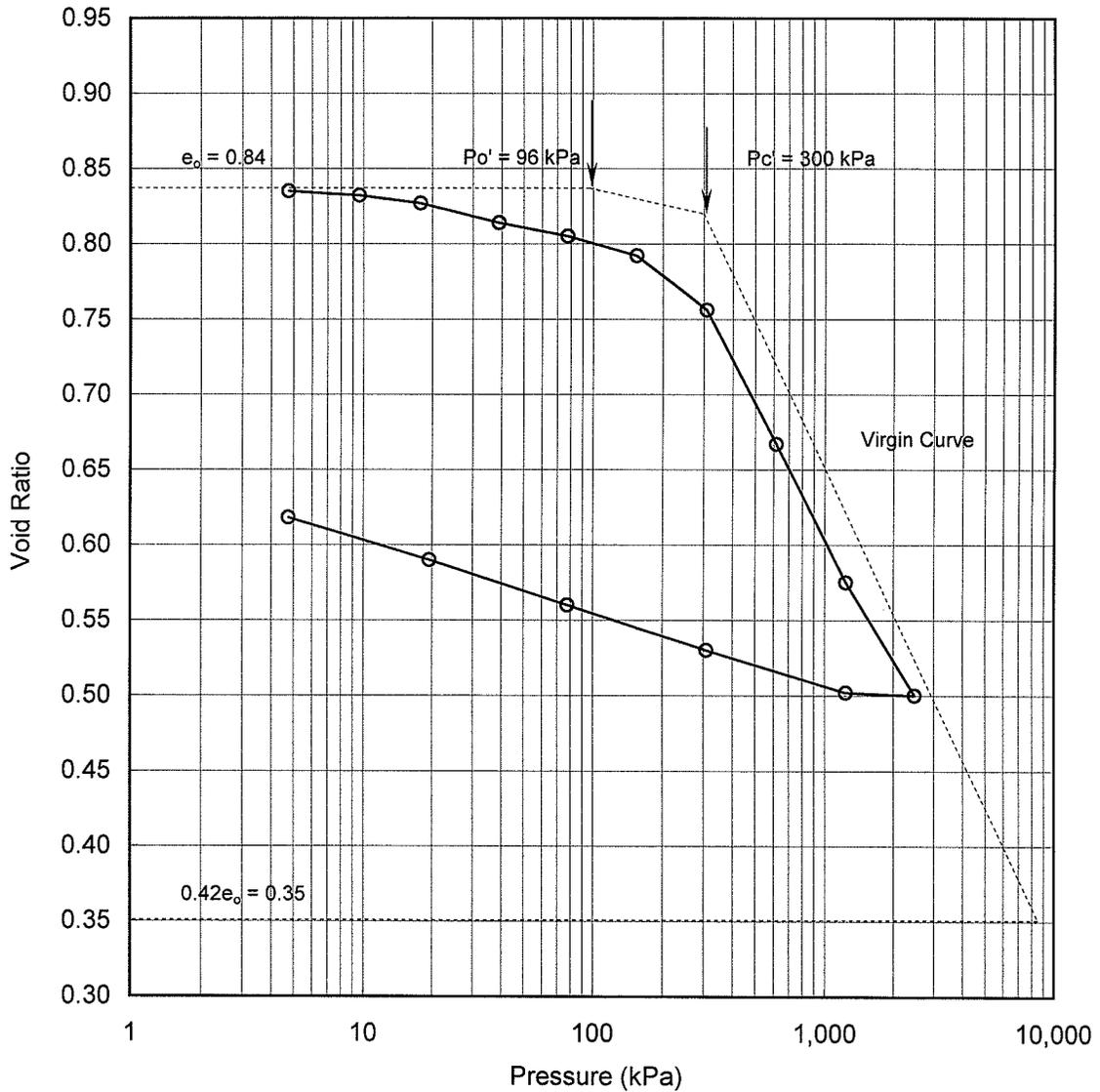
Terraprobe Inc.

Prepared By : HW
Checked By : RA

CONSOLIDATION TEST

e vs Pressure

C10-1, TW 10



Soil Type : Silty Clay

$e_o =$	0.84	$\omega_L =$	35%	$Po' =$	96 kPa
$\omega =$	22%	$\omega_p =$	19%	$Pc' =$	300 kPa
$\gamma =$	20.7 kN/m ³	PI =	17%	$Cc =$	0.323
$G_s =$	2.81			$Cr =$	0.034

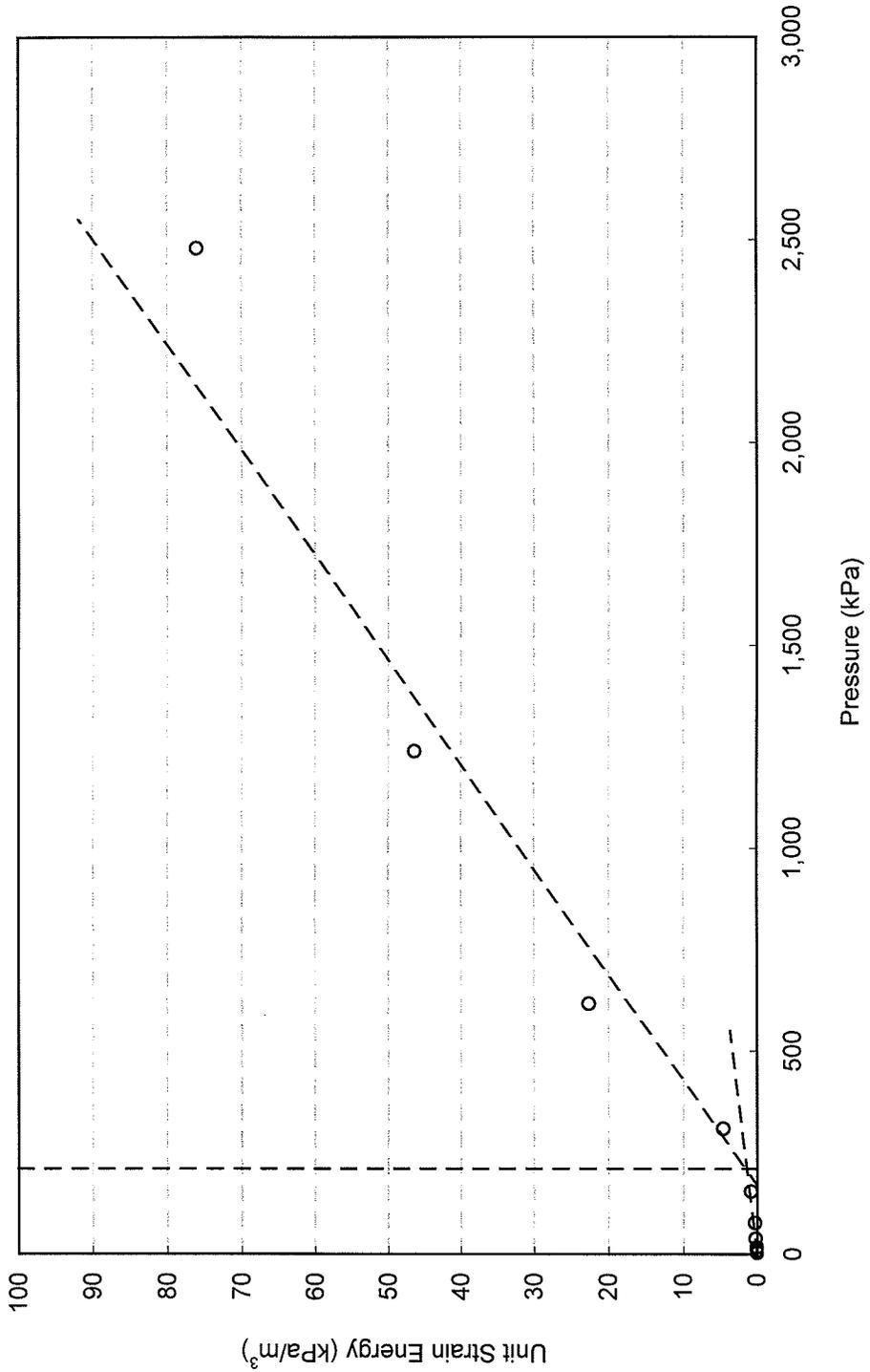
Project No. : 1-09-4135
Date : November 2010



Terraprobe Inc.

Prepared By : HW
Checked By : RA

CONSOLIDATION TEST
Unit Strain Energy vs Pressure
C10-1, TW 10



Pc = 210 kPa

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Project No. : 1-09-4135

Date : November 2010



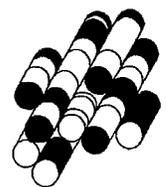
Terraprobe Inc.

Prepared By : HW

Checked By : RA

C7

TERRAPROBE INC.



METRIC
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CONT No 2011-2005
WP No 280-99-00

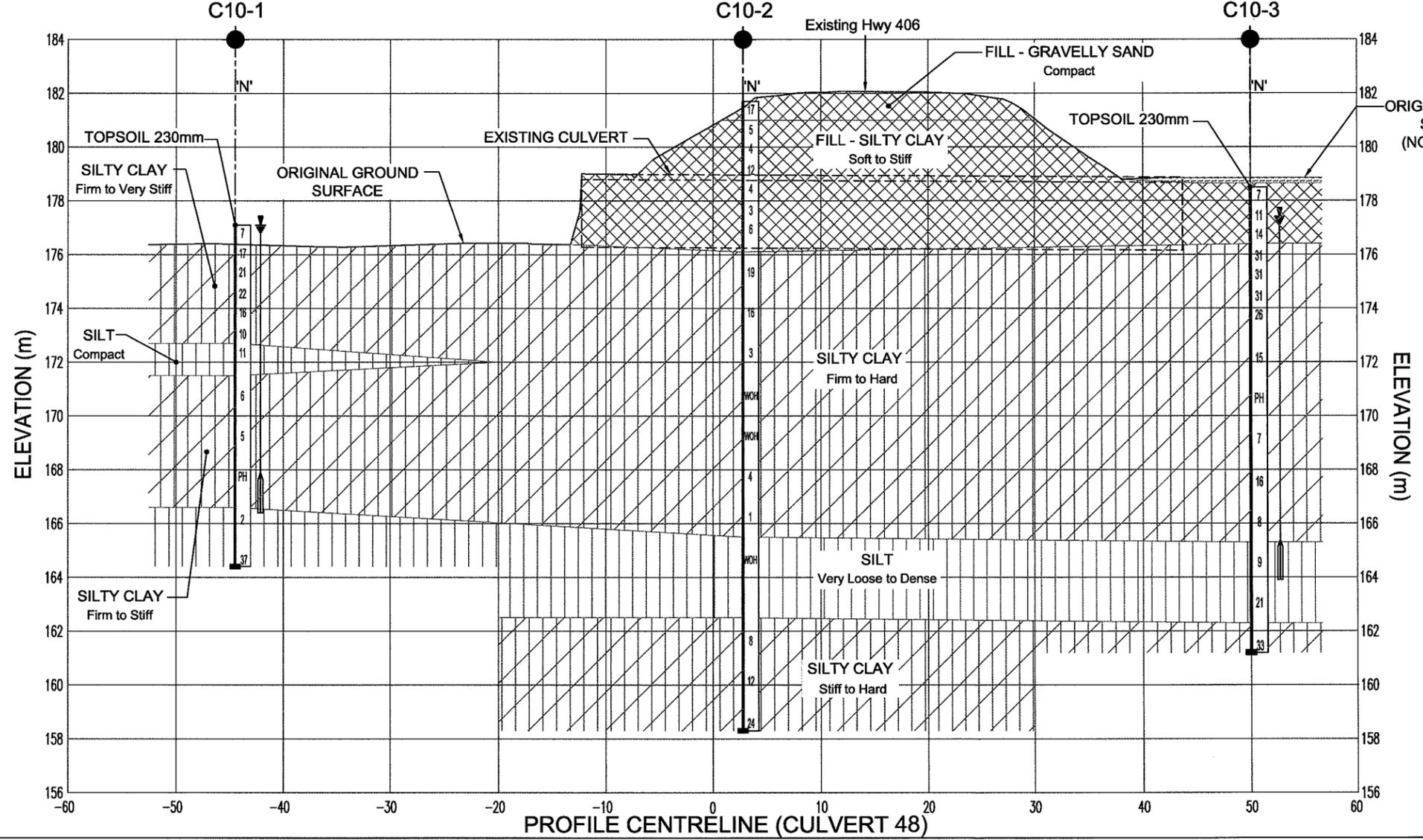
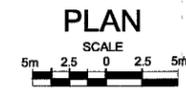
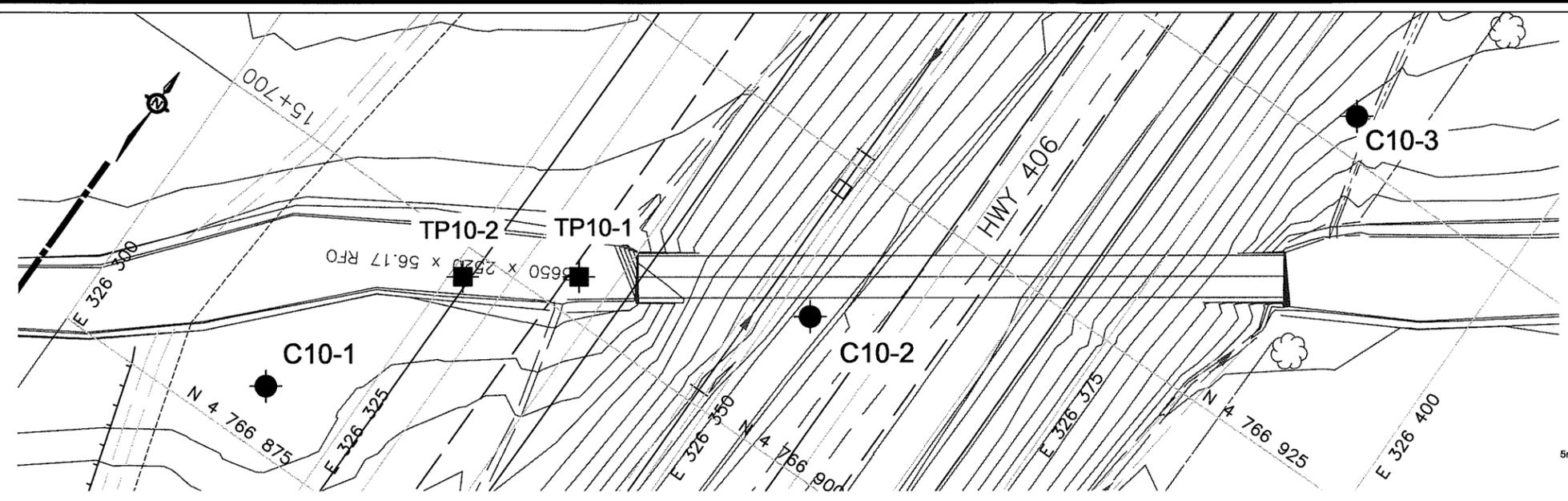


HIGHWAY 406
CULVERT # 48
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
1 OF

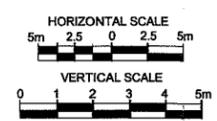


Terraprobe Inc.
Consulting Geotechnical & Environmental Engineering
Construction Materials Engineering, Inspection & Testing
10 Bram Court - Brampton Ontario L6W 3R6 (905) 796-2650



ELEVATION (m)

PROFILE CENTRELINER (CULVERT 48)



KEY PLAN

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test
- Bore Hole And Cone
- Test Pits
- Blows/0.3m (Std Pen Test, 475 J/blow)
- Blows/0.3m (60' Cone, 475 J/blow)
- WL at Time of Investigation
- WL in Piezometer (AUG. 2010)
- Piezometer
- 90% Rock Quality Designation
- Auger Refusal

No	ELEV.	COORDINATES	
		NORTHING	EASTING
C10-1	177.1	4 766 880.1	326 317.5
C10-2	181.7	4 766 912.0	326 352.7
C10-3	178.5	4 766 953.3	326 381.6

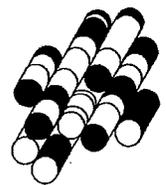
NOTE
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.
This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

REVISIONS	DATE	BY	DESCRIPTION

DESIGN R.A.	CODE CHBDC2006	LOAD	DATE FEB. 2011
DRAWN K.C.	CHK RA	STRUCT	GEORES 30M3-269

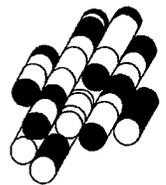
CULVERT #35

TERRAPROBE INC.



A8

TERRAPROBE INC.



RECORD OF BOREHOLE No C11-1

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4766756.7 E:326046.4 ORIGINATED BY PK
 DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 07.08.10 - 07.09.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)													
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)												
						20	40	60	80	100	20	40	60	80	100	10	20	30	GR	SA	SI	CL							
160.8	SILT trace sand, trace gravel, frequent silty clay seams and partings, loose to compact, brown, wet		14	SS	9																		1	5	77	17			
17.1	CLAYEY SILT trace sand, very stiff to hard, brown, damp to moist		15	SS	16																								
159.1			16	SS	55																					0	1	83	16
18.8	End of Borehole Sampler wet at 3.8m. No sample recovery at SS3. Disturbed sample collected. No sample recovery at SS7. Sampler redriven and disturbed sample collected. Borehole was dry (not stabilized) and hole open to full depth on completion. Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 1.52m slotted screen. Water Level Readings: Date Depth(m) Elevation(m) July.12.10 4.5 173.4 July.19.10 4.4 173.5																												

ONTARIO MOT 1-09-4135 CULVERTS2 (KELVIN).GPJ ONTARIO MOT.GDT 09/10/10

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

RECORD OF BOREHOLE No C11-2

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4766773.0 E:326047.9 ORIGINATED BY AW
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 07.16.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80						100	20	40	60	80	100	10	20
179.0	Ground Surface																							
0.1	110mm ASPHALT																							
178.5	410mm FILL - Gravelly Sand, some silt, very dense, brown, damp		1	SS	83																			26 58 (16)
0.5	FILL - Silty Clay, sandy, gravelly, trace organics, firm, brown, damp to moist		2	SS	5																			28 21 25 26
			3	SS	6																			
176.9	SILTY CLAY trace sand, firm to stiff, brown, damp to moist		4	SS	13																			
2.1			5	SS	11																			0 3 51 46
			6	SS	12																			
			7	SS	5																			
			8	SS	6																			
			9	SS	3																			0 1 53 46
			10	SS	WOH																			
			11	SS	WOH																			0 0 62 38
			12	SS	WOH																			0 0 63 37
			13	SS	1																			
164.3																								
14.7																								

ONTARIO MOT 1-09-4135 CULVERTS2 (KELVIN) GPJ ONTARIO MOT.GDT. 09/10/10

Continued Next Page

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No C11-2

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4766773.0 E:326047.9 ORIGINATED BY AW
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 07.16.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa							
						20	40	60	80	100					
160.1	SILT trace to some clay, very loose to loose, brown, wet		14	SS	WOH										
						163									
			15	SS	5										
						162									
						161									
			16	SS	6										
18.9	CLAYEY SILT trace sand, stiff to hard, brown, damp to moist					160									
			17	SS	21										
						159									
						158									
			18	SS	8										
						157									
						156									
155.6	End of Borehole		19	SS	43										
23.4	Sampler wet at 12.2m. Wet cave at 14.3m on completion.														

ONTARIO MOT 1-09-4135 CULVERTS2 (KELVIN).GPJ ONTARIO MOT.GDT 09/10/10

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

RECORD OF BOREHOLE No C11-3

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4766795.7 E:326063.9 ORIGINATED BY PK
 DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 07.09.10 - 07.12.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			20	40						60	80	100	20
179.1	Ground Surface																
179.0	150mm TOPSOIL																
0.2	FILL - Silty Clay, occasional cobbles, hard, brown, damp	1	SS	100/23cm													
178.4																	
0.7	SILTY CLAY trace sand, very stiff to hard, brown, damp to moist	2	SS	38													
		3	SS	39													
		4	SS	55								42	0 1 49 50				
		5	SS	30													
		6	SS	34													
		7	SS	34									0 2 61 37				
		8	SS	23													
		9	SS	19									0 3 56 41				
		10	SS	9													
	firm to stiff																
		11	TW	PH								20.8	0 1 68 31				
		12	SS	6									0 0 63 37				
		13	SS	6													

ONTARIO MOT. 1-09-4135 CULVERTS2 (KELVIN).GPJ ONTARIO MOT.GDT 09/10/10

Continued Next Page

+3, X3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No C11-3

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4766795.7 E:326063.9 ORIGINATED BY PK
 DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 07.09.10 - 07.12.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)															
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa																							
						20	40	60	80	100																					
163.6 15.5	SILT trace clay, loose, brown, wet		14	SS	5											July 09 July 12															
162.1 17.0	CLAYEY SILT trace sand, trace gravel, firm to hard, brown, damp to moist		15	SS	6																										
			16	SS	11																										
158.8 20.3	End of Borehole		17	SS	59											0 0 86 14															
<p>Consolidation test performed on TW 11.</p> <p>Water level at 17.4m (not stabilized) and hole open to 13.7m on completion.</p> <p>SS1 - Sampler bouncing, probably on a cobble.</p> <p>Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 1.52m slotted screen.</p> <p>Water Level Readings:</p> <table border="1"> <tr> <th>Date</th> <th>Depth(m)</th> <th>Elevation(m)</th> </tr> <tr> <td>July.19.10</td> <td>5.1</td> <td>174.0</td> </tr> <tr> <td>July.26.10</td> <td>3.5</td> <td>175.6</td> </tr> <tr> <td>Aug.06.10</td> <td>2.0</td> <td>177.1</td> </tr> <tr> <td>Aug.13.10</td> <td>1.9</td> <td>177.2</td> </tr> </table>																	Date	Depth(m)	Elevation(m)	July.19.10	5.1	174.0	July.26.10	3.5	175.6	Aug.06.10	2.0	177.1	Aug.13.10	1.9	177.2
Date	Depth(m)	Elevation(m)																													
July.19.10	5.1	174.0																													
July.26.10	3.5	175.6																													
Aug.06.10	2.0	177.1																													
Aug.13.10	1.9	177.2																													

ONTARIO MOT 1-09-4135 CULVERTS2 (KELVIN).GPJ ONTARIO MOT.GDT 09/10/10

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

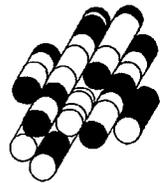
Test Pit Logs
Culvert #11 (Port Robinson Road Sta. 9+710)

Test Pit# TP 11-1

0	-	180	Fill, Br Si(y) Sa, Some Org, Some Rootlets, Wet
180	-	300	Br Si(y) Cl, Tr Sa, Damp to Moist

B8

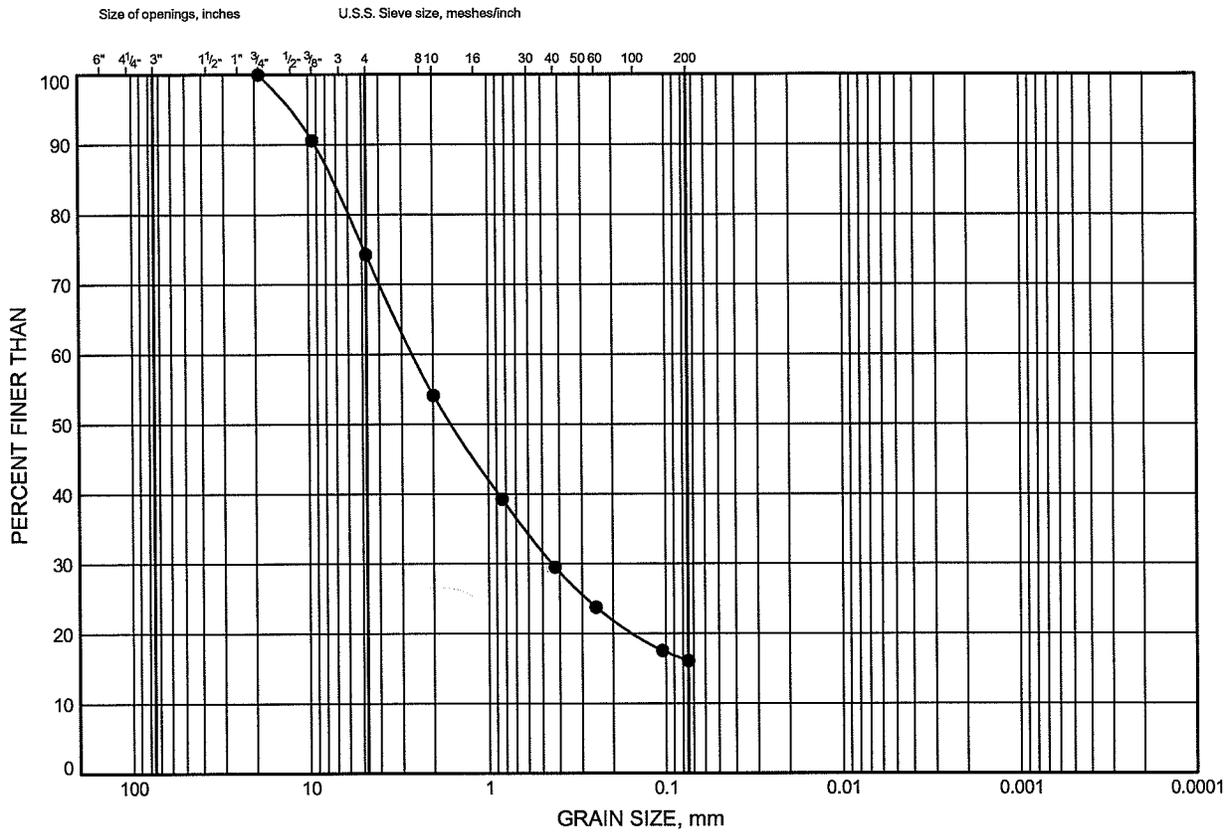
TERRAPROBE INC.



GRAIN SIZE DISTRIBUTION

FIGURE B8-1

FILL - Gravelly Sand



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C11-2	0.3	178.7

Date November 2010
 Project 1-09-4135

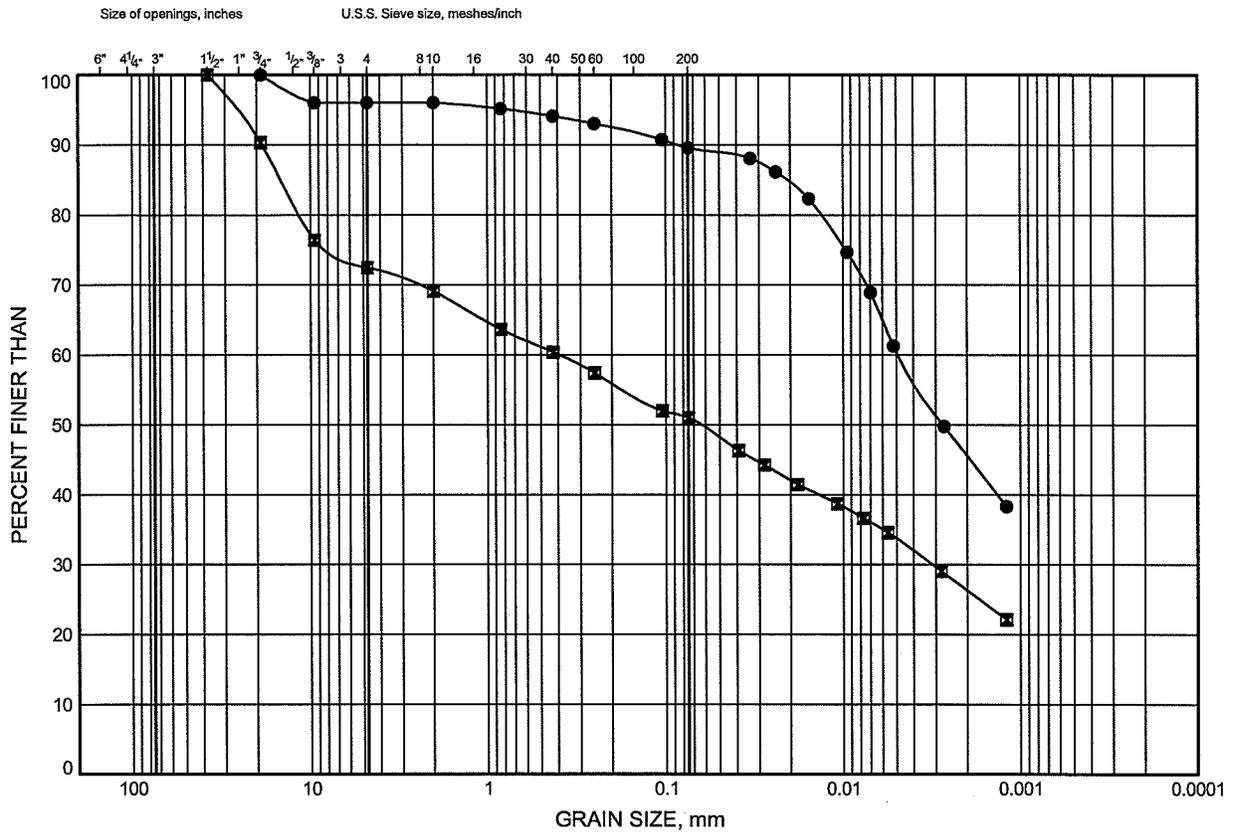


Prep'd K.L.
 Chkd. M.P.

GRAIN SIZE DISTRIBUTION

FIGURE B8-2

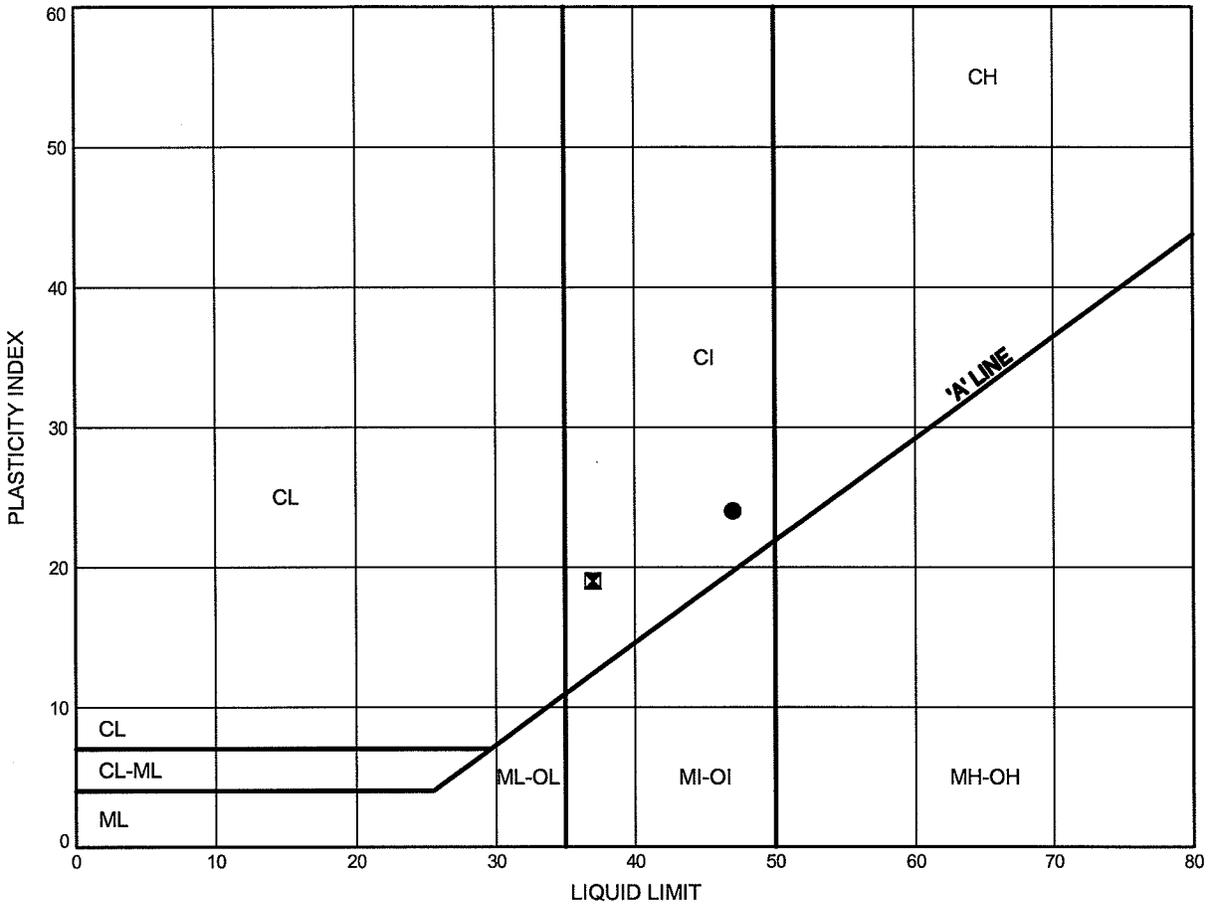
FILL - Silty Clay



ATTERBERG LIMITS TEST RESULTS

FIGURE B8-3

FILL - Silty Clay



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C11-1	0.3	177.6
⊠	C11-2	1.0	178.0

ALTR 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/07/10

Date November 2010
 Project 1-09-4135

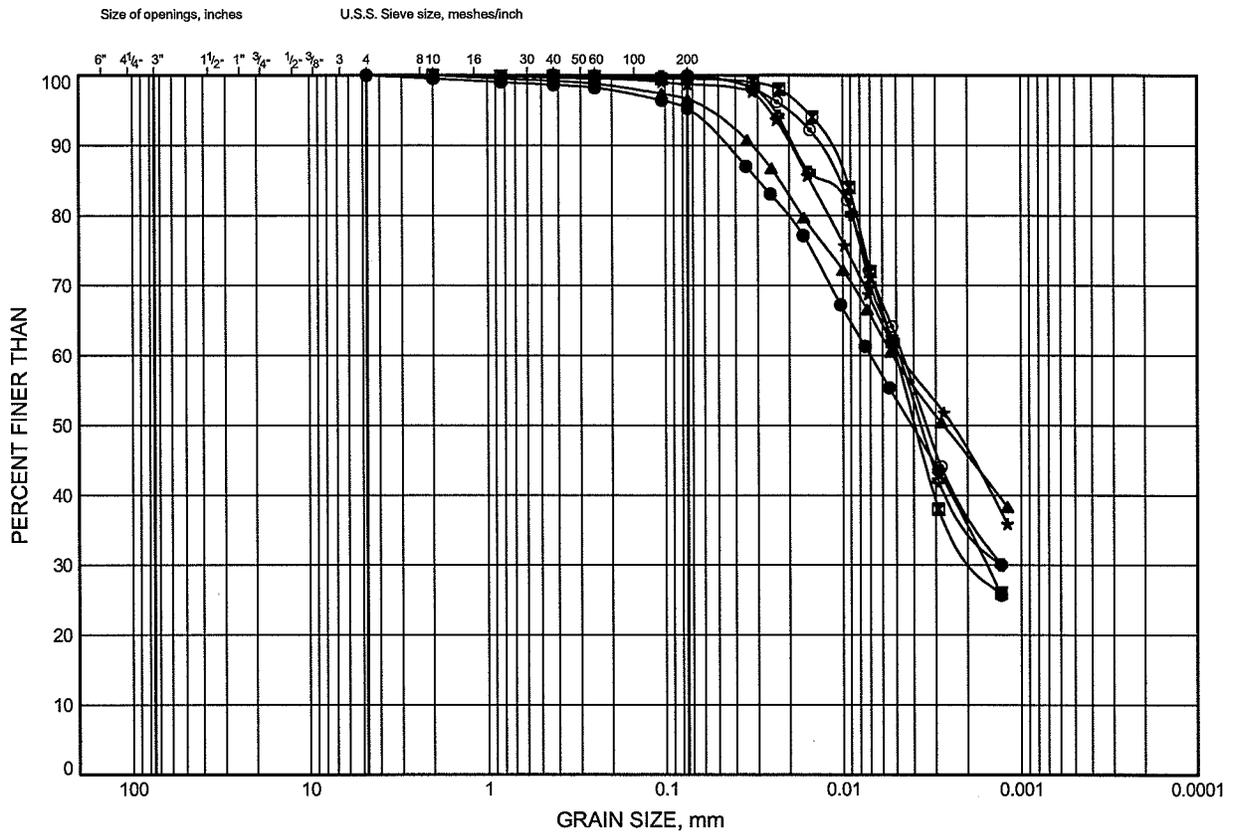


Prep'd K.L.
 Chkd. M.P.

GRAIN SIZE DISTRIBUTION

FIGURE B8-4

SILTY CLAY



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C11-1	4.0	173.9
■	C11-1	9.3	168.6
▲	C11-2	3.2	175.8
★	C11-2	7.8	171.2
⊙	C11-2	10.9	168.1
⊕	C11-2	12.4	166.6

GSD 1-09-4135_CULVERTS2 (KELVIN).GPJ 09/03/10

Date November 2010
Project 1-09-4135

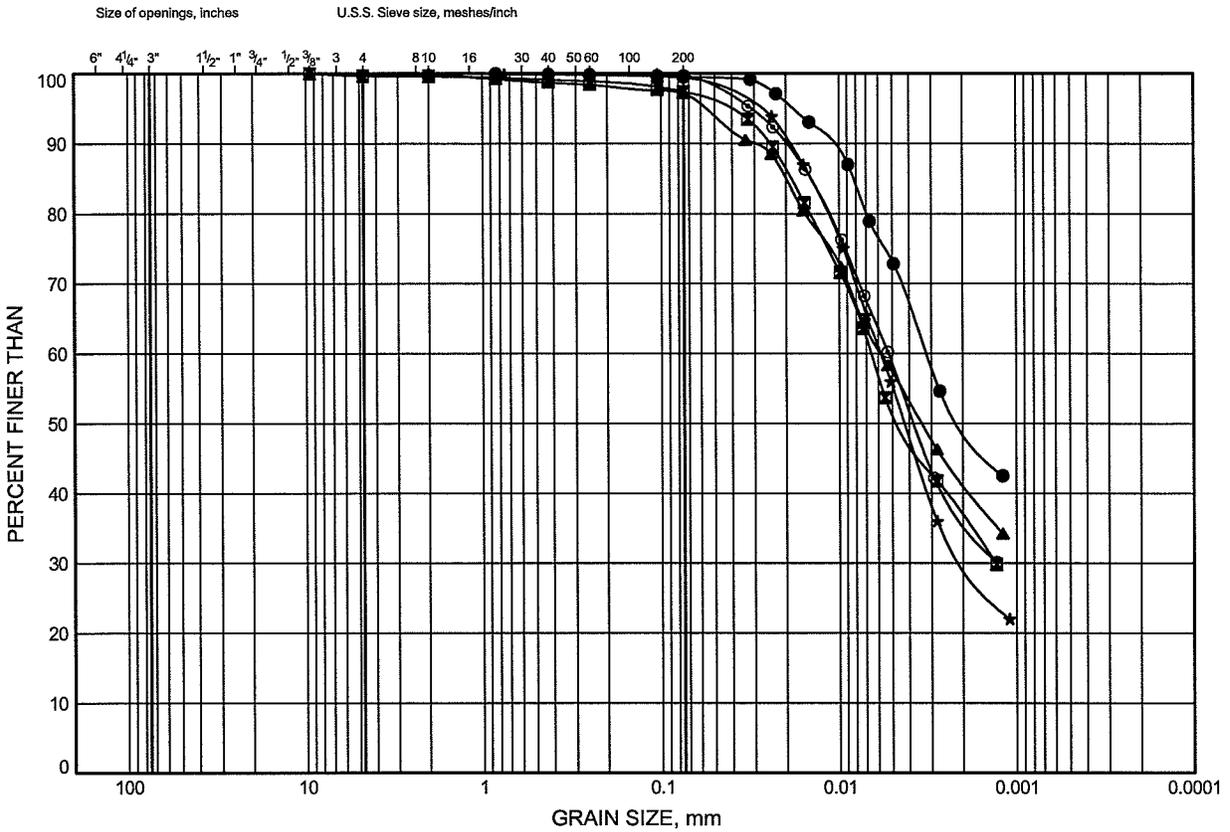


Prep'd K.L.
Chkd. M.P.

GRAIN SIZE DISTRIBUTION

FIGURE B8-5

SILTY CLAY



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C11-3	2.5	176.6
■	C11-3	4.7	174.4
▲	C11-3	7.8	171.3
★	C11-3	10.9	168.2
⊙	C11-3	12.4	166.7

GSD 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/03/10

Date November 2010
 Project 1-09-4135

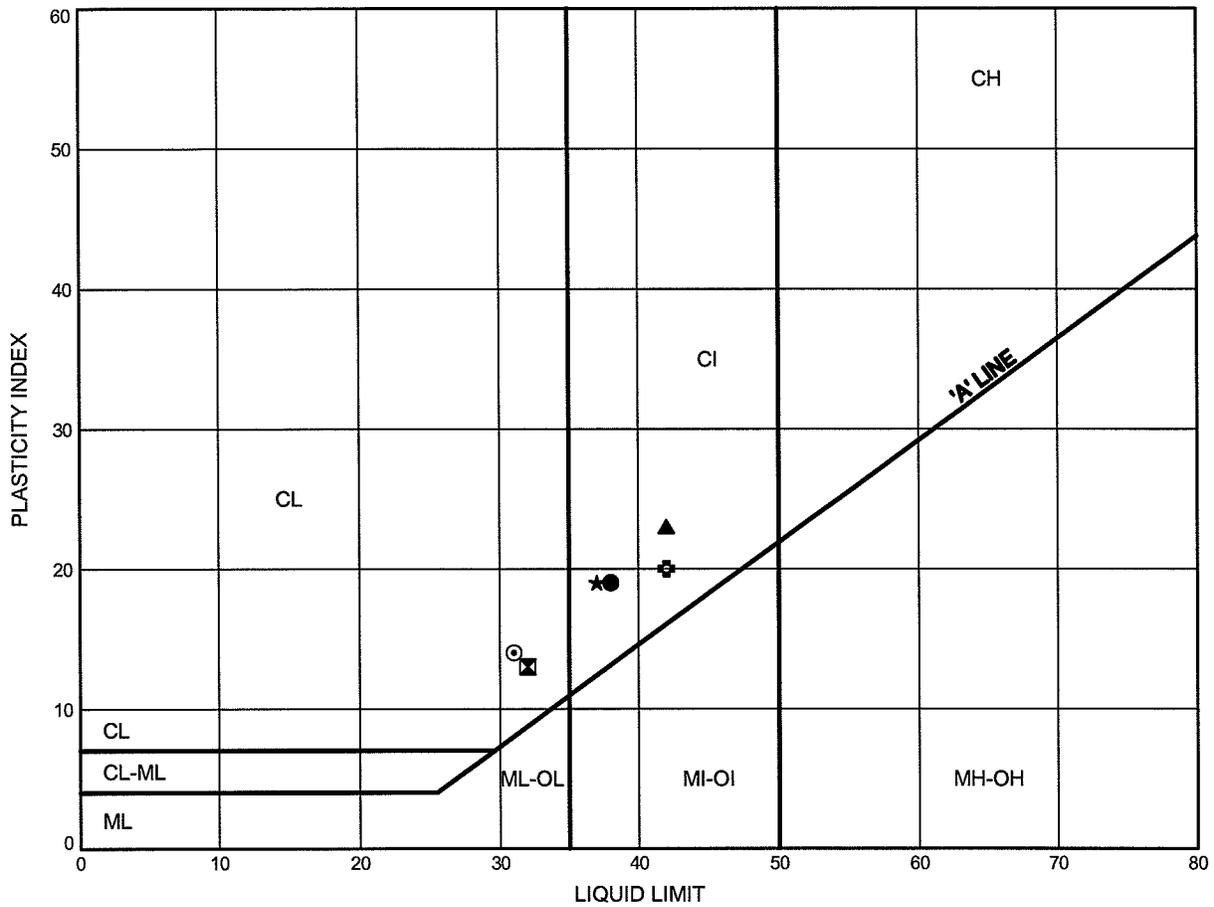


Prep'd K.L.
 Chkd. M.P.

ATTERBERG LIMITS TEST RESULTS

FIGURE B8-6

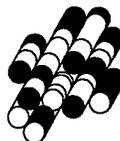
SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C11-1	4.0	173.9
⊠	C11-1	9.3	168.6
▲	C11-2	3.2	175.8
★	C11-2	7.8	171.2
⊙	C11-2	12.4	166.6
⊕	C11-3	2.5	176.6

ALTR 1-09-4135 CULVERTS2 (KELVIN).GPJ 08/03/10

Date November 2010
 Project 1-09-4135

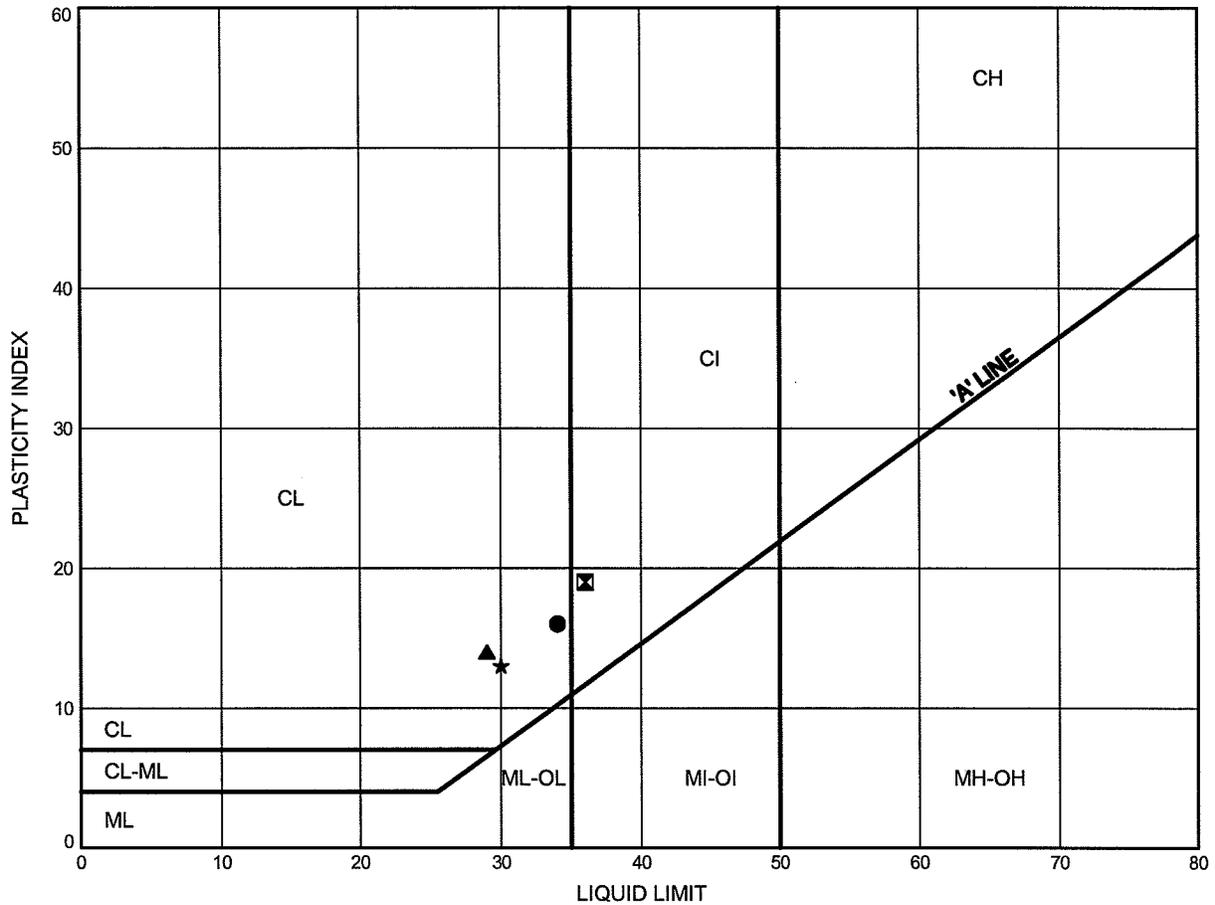


Prep'd K.L.
 Chkd. M.P.

ATTERBERG LIMITS TEST RESULTS

FIGURE B8-7

SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C11-3	4.7	174.4
⊠	C11-3	7.8	171.3
▲	C11-3	10.9	168.2
★	C11-3	12.4	166.7

ALTR 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/03/10

Date November 2010
 Project 1-09-4135

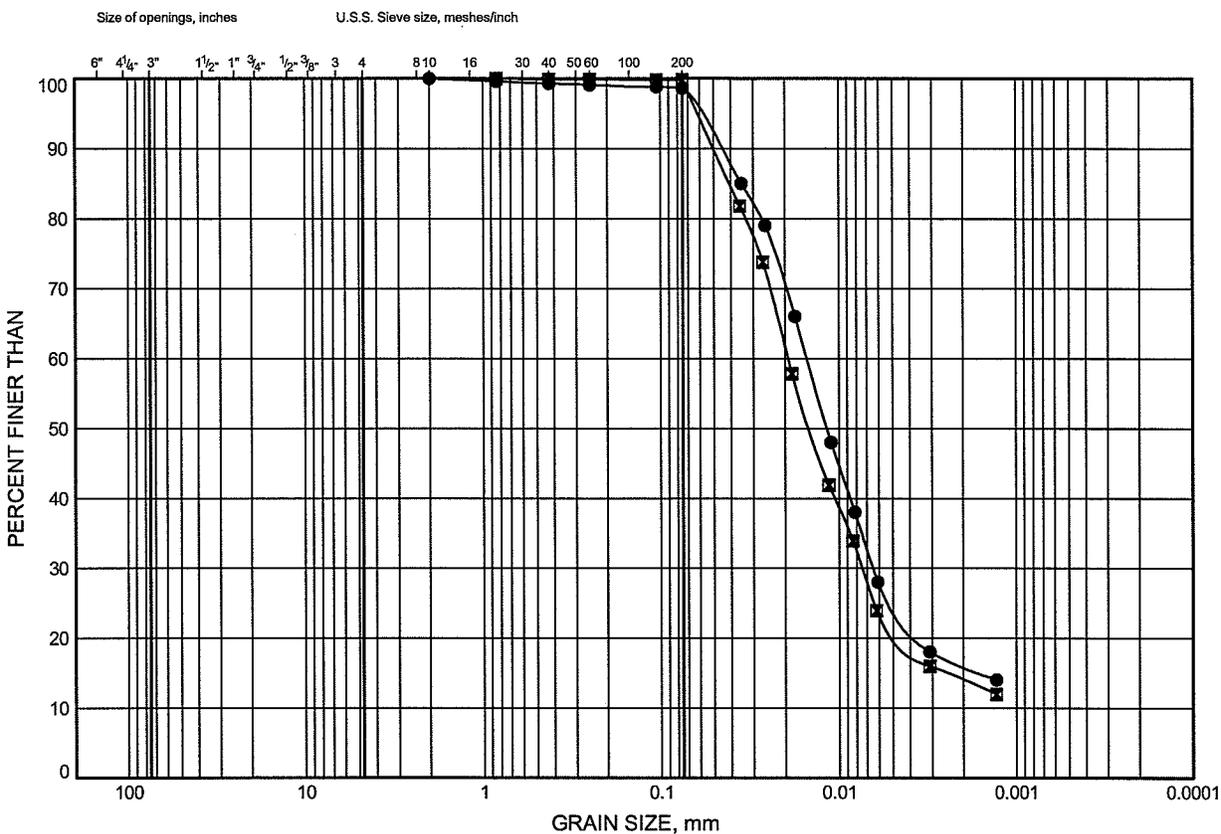


Prep'd K.L.
 Chkd. M.P.

GRAIN SIZE DISTRIBUTION

FIGURE B8-9

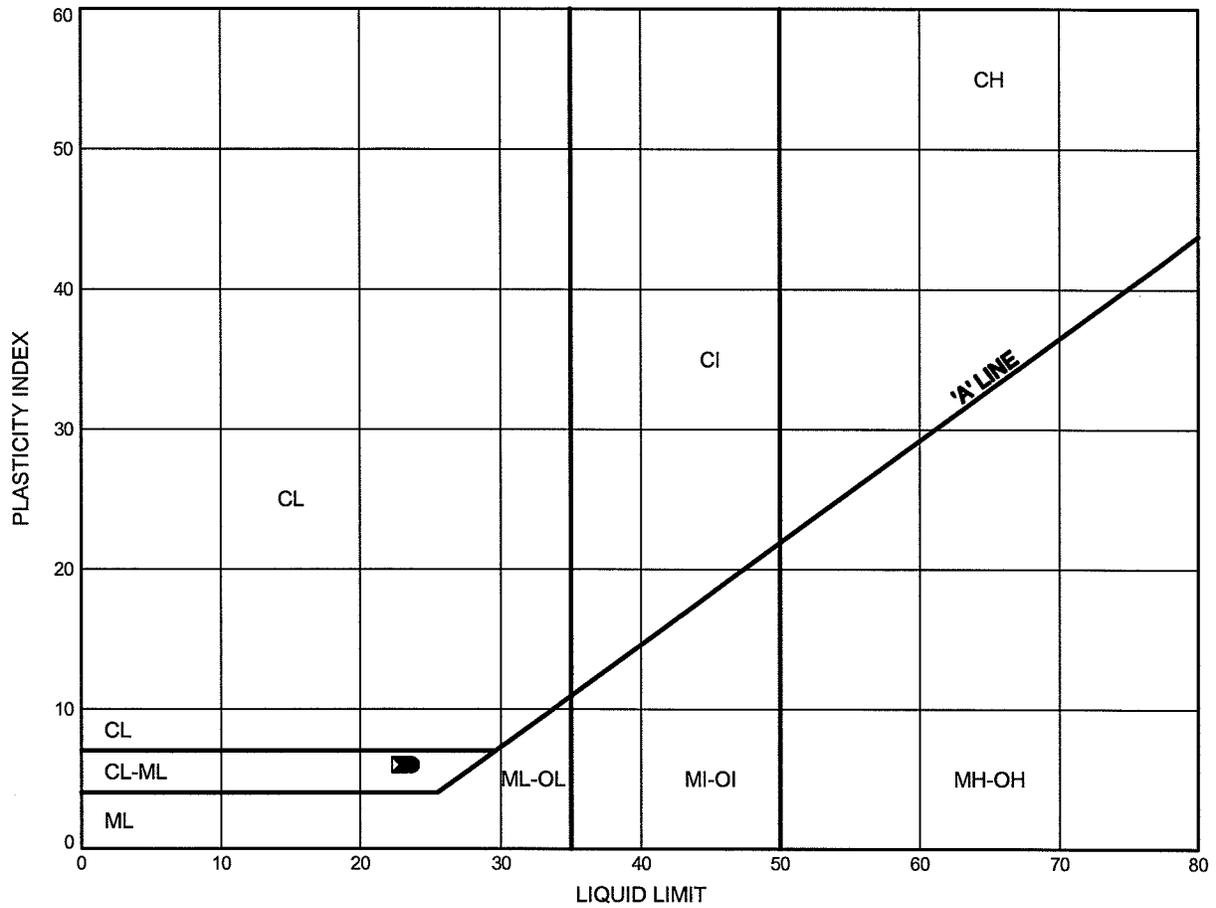
CLAYEY SILT



ATTERBERG LIMITS TEST RESULTS

FIGURE B8-10

CLAYEY SILT



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C11-1	18.5	159.4
⊠	C11-3	20.0	159.1

ALTR 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/03/10

Date November 2010
 Project 1-09-4135



Prep'd K.L.
 Chkd. M.P.

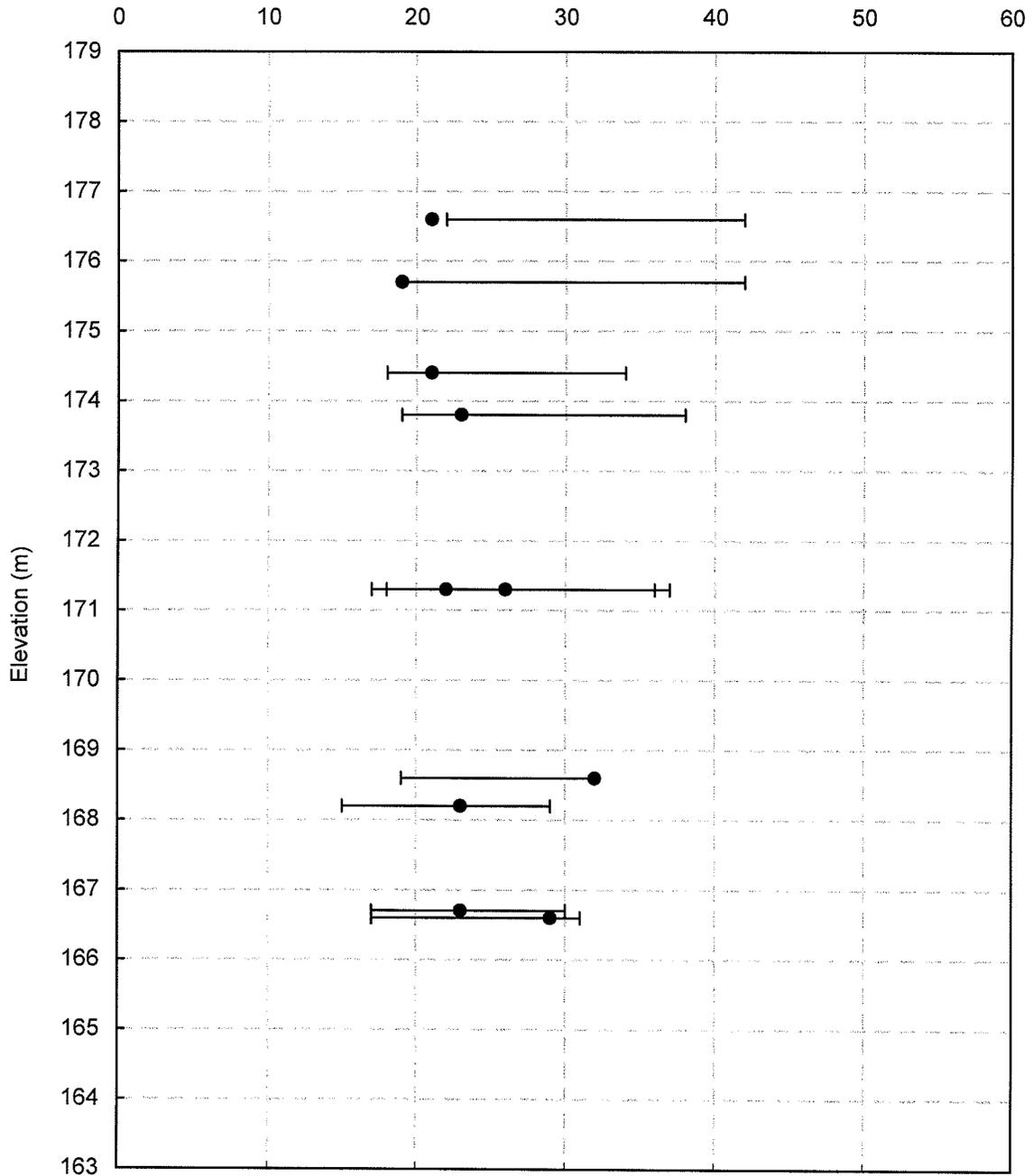
ATTERBERG LIMITS AND WATER CONTENTS

FIGURE B8-11

HWY 406 TWINNING - CULVERT #11

Silty Clay

Atterberg Limits & Water Contents (%)



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Project No. : 1-09-4135

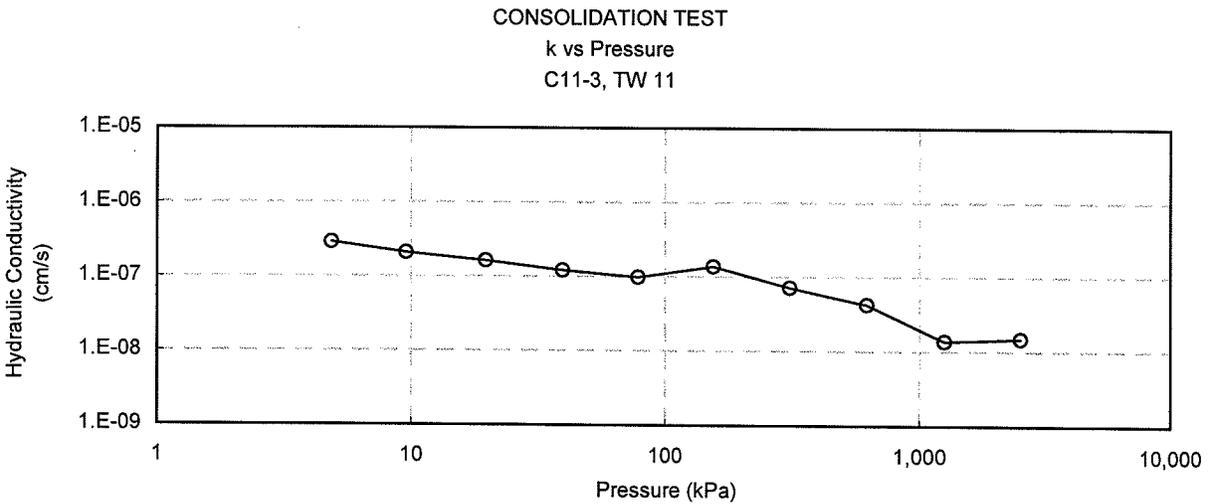
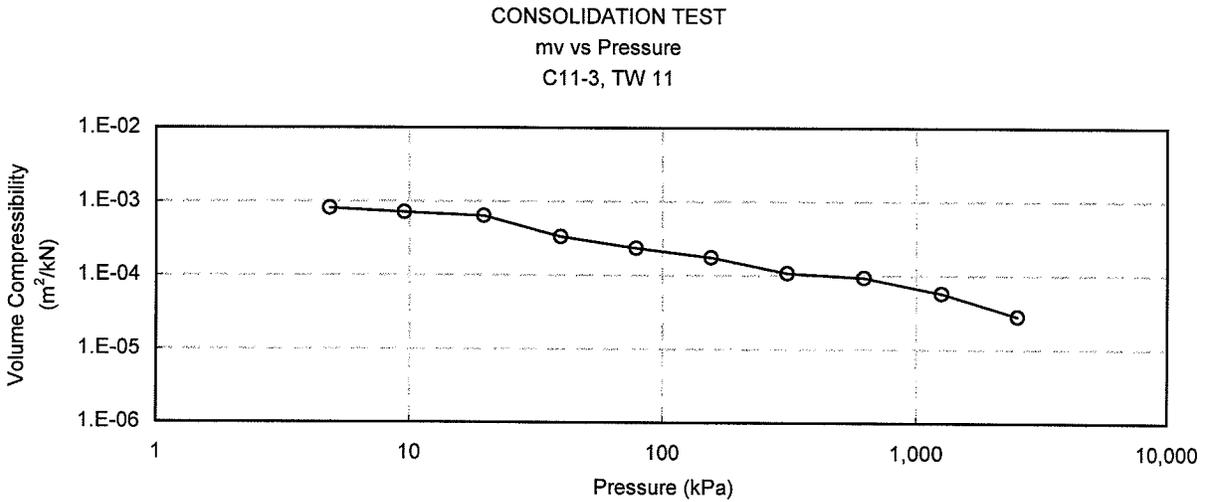
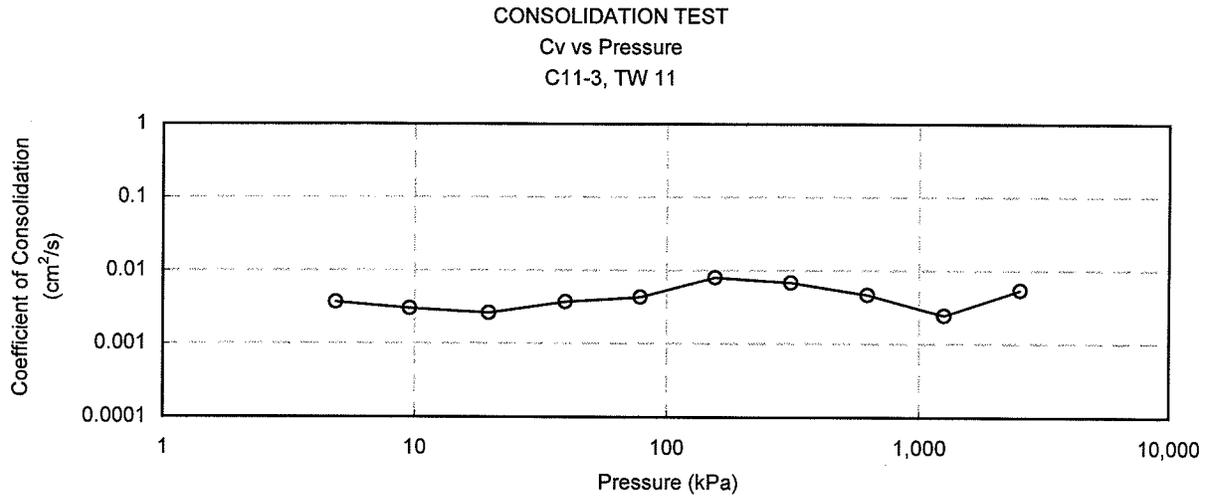
Date : November, 2010



Terraprobe Inc.

Prepared By : HW

Checked By : RA



C:\Documents and Settings\Admin\My Documents\Marc P\Projects 2009\Hwy 406 Expansion\1-09-4135 (Hwy 406 Foundations)\Culverts and Retaining Walls\Culverts\Lab Results\1-09-4135 Consolidation Results.xls

Project No. : 1-09-4135
Date : November 2010



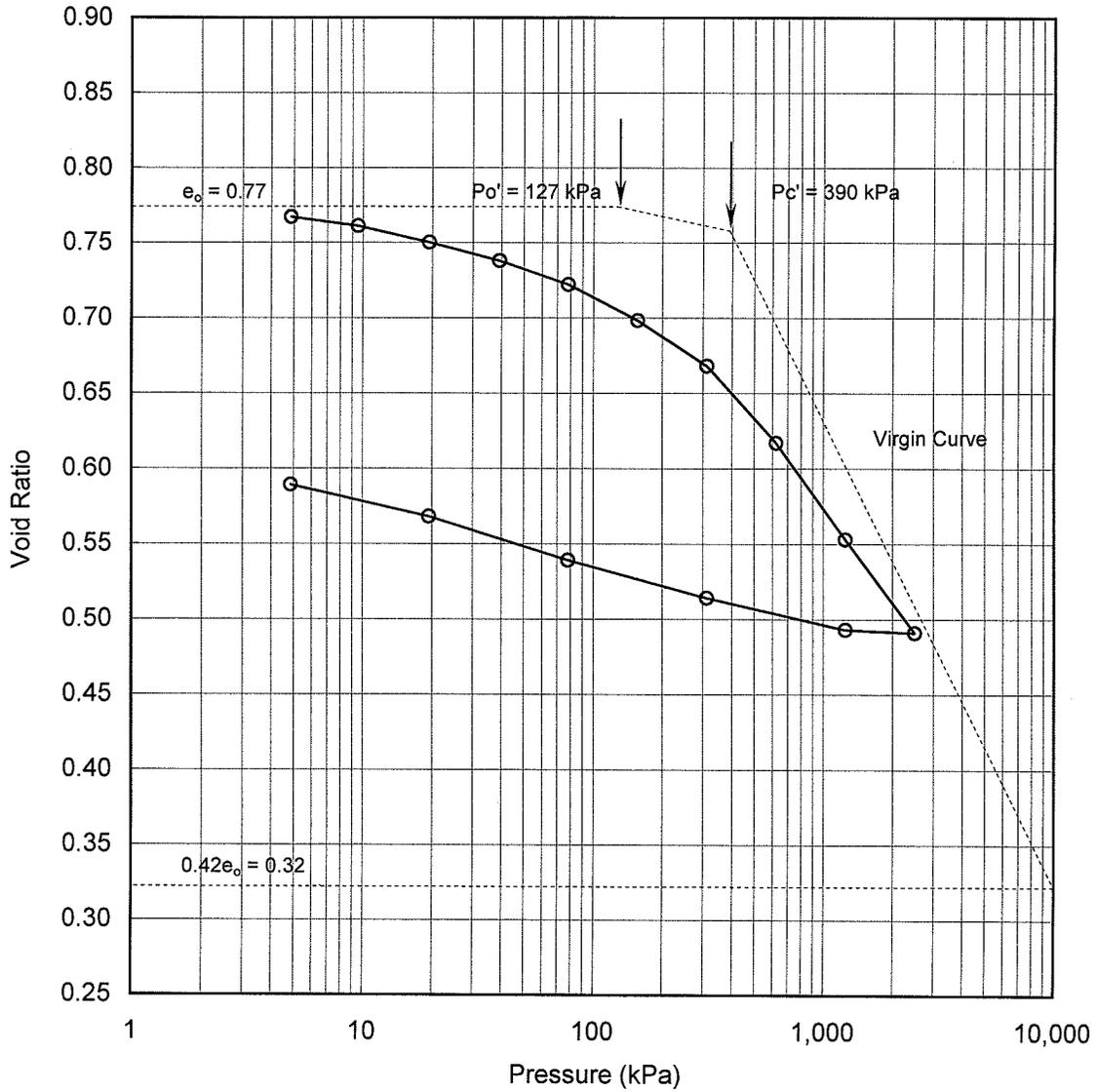
Terraprobe Inc.

Prepared By : HW
Checked By : RA

CONSOLIDATION TEST

e vs Pressure

C11-3, TW 11



Soil Type : Silty Clay

$e_o =$	0.77	$\omega_L =$	29%	$P_{o'} =$	127 kPa
$\omega =$	22%	$\omega_p =$	14%	$P_{c'} =$	390 kPa
$\gamma =$	20.8 kN/m ³	PI =	14%	Cc =	0.309
Gs =	2.76			Cr =	0.033

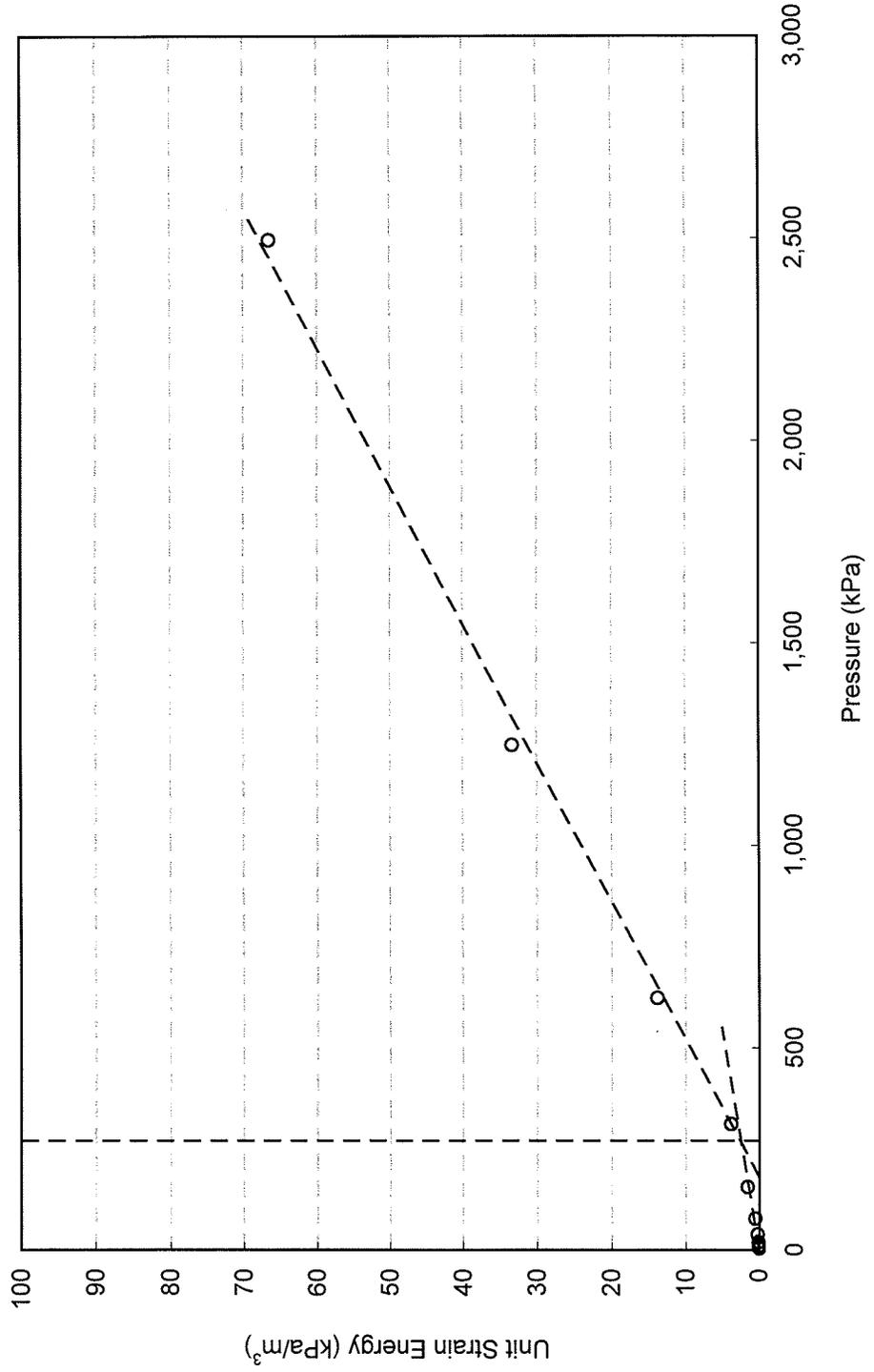
Project No. : 1-09-4135
Date : November 2010



Terraprobe Inc.

Prepared By : HW
Checked By : RA

CONSOLIDATION TEST
Unit Strain Energy vs Pressure
C11-3, TW 11



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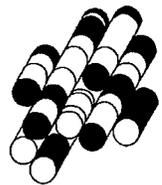
Project No. : 1-09-4135
Date : November 2010



Prepared By : HW
Checked By : RA

C8

TERRAPROBE INC.



METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETERS
UNLESS OTHERWISE SHOWN

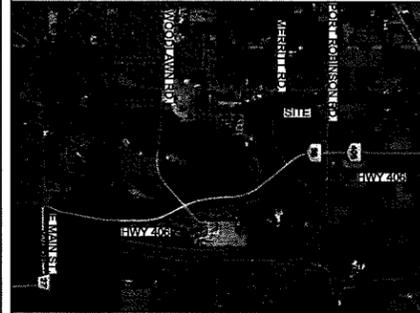
CONT No 2011-2005
WP No 280-99-00

HIGHWAY 406
CULVERT #35
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
1 OF

IBI GROUP

Terraprobe Inc.
Consulting Geotechnical & Environmental Engineering
Construction Materials Engineering, Inspection & Testing
10 Bram Court - Brampton Ontario L6W 3R6 (905) 796-2650



KEY PLAN

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test
- Bore Hole And Cone
- Test Pit
- 'N' Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60' Cone, 475 J/blow)
- WL at Time of Investigation
- WL in Piezometer (AUG. 2010)
- Piezometer
- 90% Rock Quality Designation
- A/R Auger Refusal

No	ELEV.	COORDINATES	
		NORTHING	EASTING
C11-1	177.9	4 766 756.7	326 046.4
C11-2	179.0	4 766 773.0	326 047.9
C11-3	179.1	4 766 795.7	326 063.9

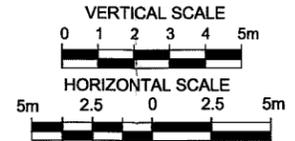
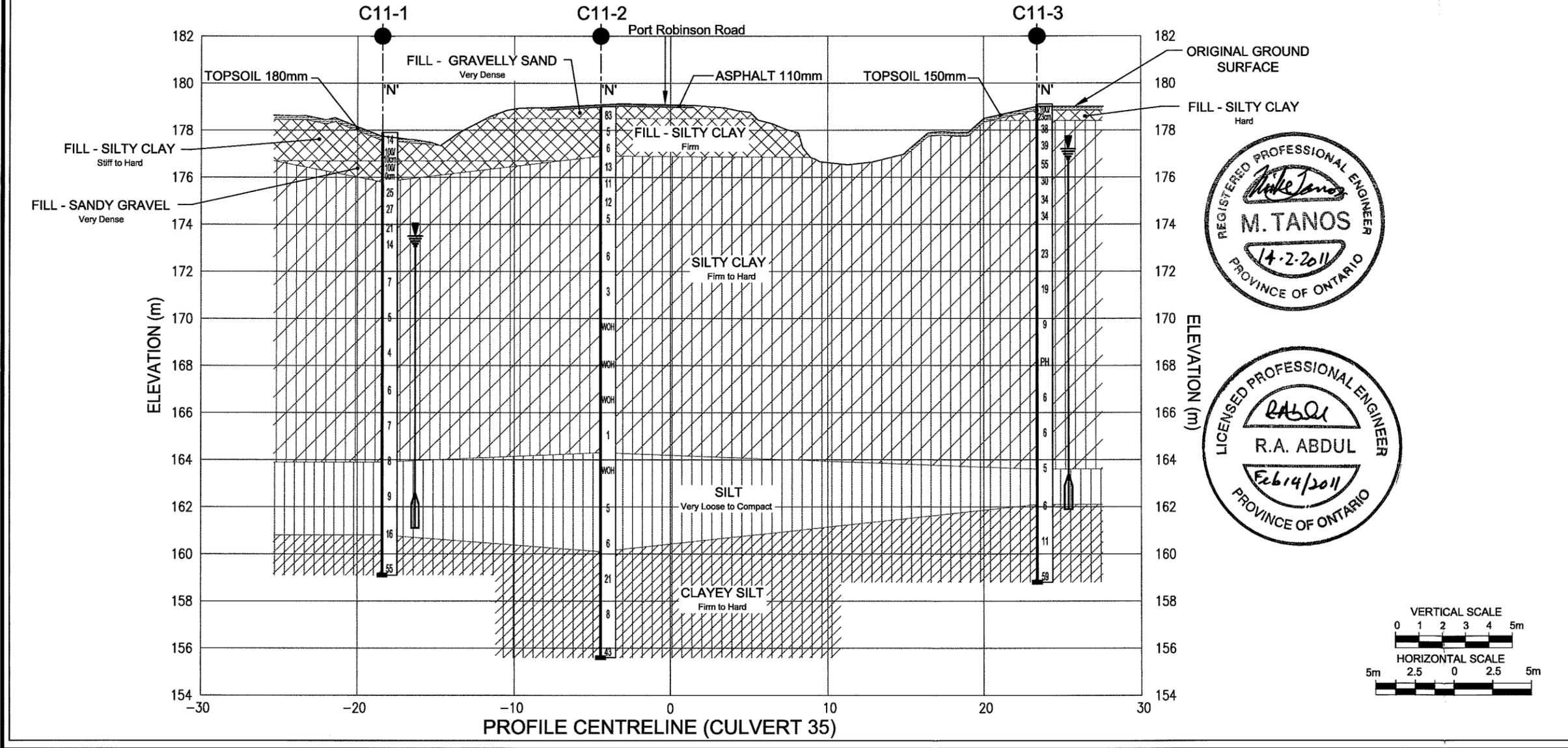
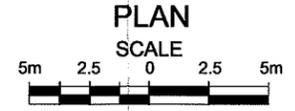
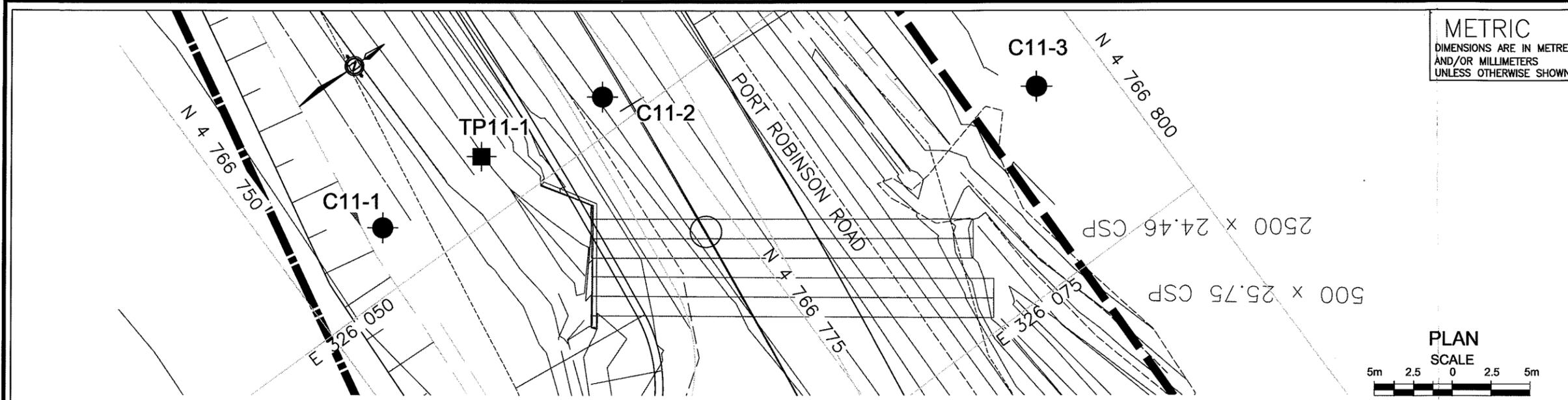
NOTE

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

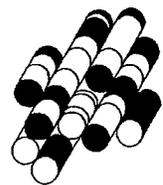
REVISIONS	DATE	BY	DESCRIPTION

DESIGN	RA	CODE	CHBDC2006	LOAD	DATE	FEB. 2011
DRAWN	K.C.	CHK	RA	STRUCT	GEOCRES	30M3-269



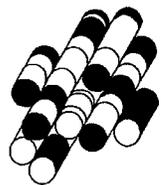
CULVERT #49

TERRAPROBE INC.



A9

TERRAPROBE INC.



RECORD OF BOREHOLE No C12-1

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4767228.9 E:326354.3 ORIGINATED BY BL
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers, D.C.P.T. COMPILED BY DB
 DATUM Geodetic DATE 06.25.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
181.3	Ground Surface												
181.2	130mm ASPHALT												
181.0	180mm FILL - Sandy Gravel, grey, damp		1	AS	-								
0.3													
	FILL - Silty Clay, some sand, gravelly, trace organics, soft to firm, brown, damp to moist		2	SS	6								28 16 28 28
			3	SS	3								
179.2													
2.1	SILTY CLAY trace sand, firm to very stiff, brown, damp to moist		4	SS	12								
			5	SS	22								0 0 57 43
			6	SS	16								
			7	SS	12								
			8	SS	6								0 4 60 36
			9	TW	PH								
			10	SS	2								
			11	SS	1								0 1 19 80
			12	SS	WOH								
			13	SS	6								0 1 77 22

ONTARIO MOT 1-09-4135_CULVERTS2 (KELVIN).GPJ ONTARIO MOT.GDT 09/10/10

Continued Next Page

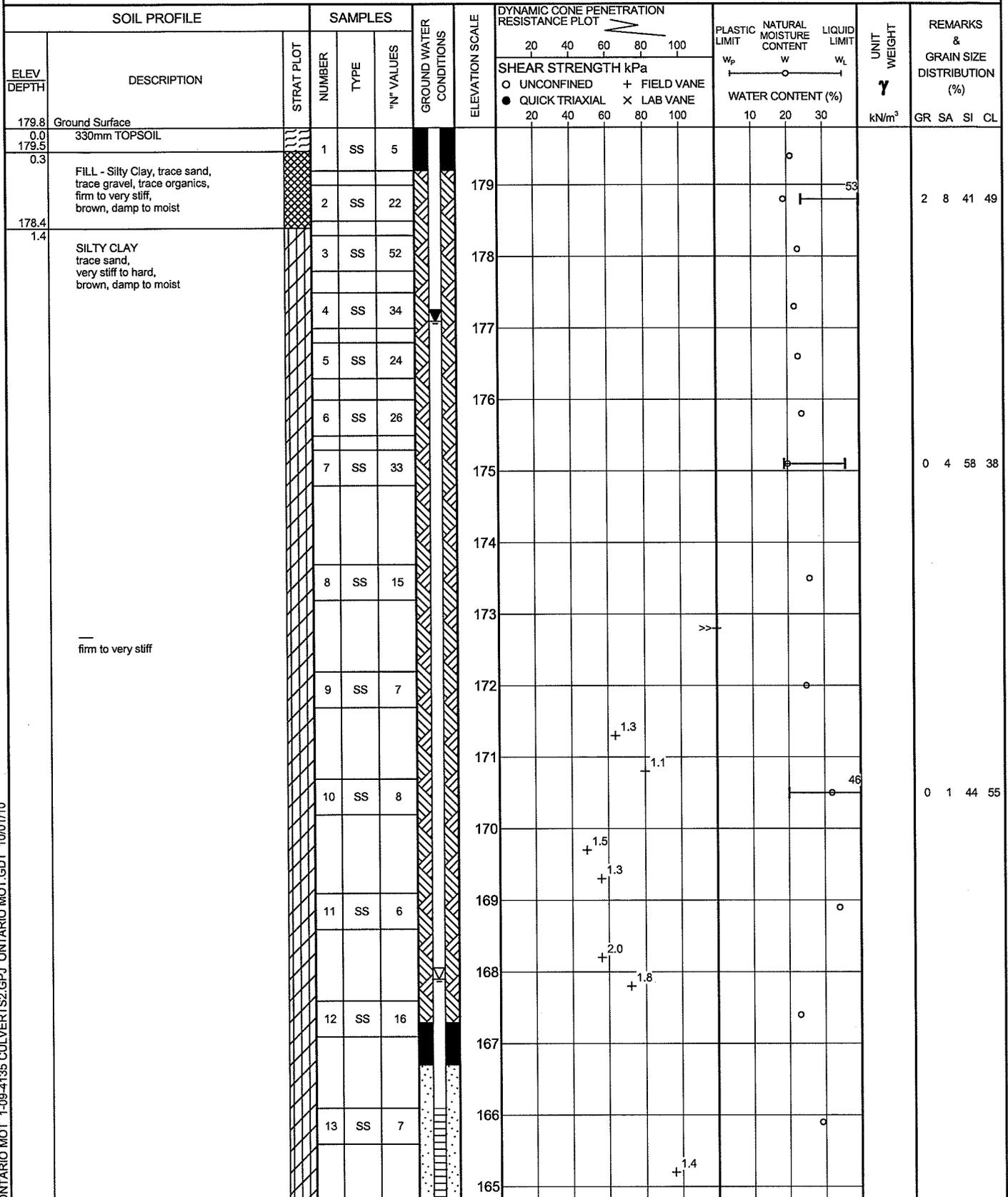
+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No C12-2

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4767226.6 E:326344.2 ORIGINATED BY PK
 DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 07.15.10 CHECKED BY RA



Continued Next Page

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

RECORD OF BOREHOLE No C12-2

2 OF 2

METRIC

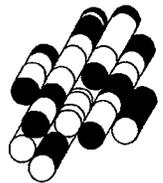
W.P. 280-99-00 LOCATION Coords: N:4767226.6 E:326344.2 ORIGINATED BY PK
 DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 07.15.10 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80						100
164.6 15.2	SILT trace sand, occasional silty clay seams and partings, loose to compact, brown, wet		14	SS	16												
			15	SS	8												
162.0 17.8	SILTY CLAY trace sand, very stiff, brown, damp to moist		16	SS	24												
			17	SS	29												
159.5 20.3	End of Borehole Sampler wet at 9.1m. Water level at 11.9m (not stabilized) and hole open to 15.2m on completion. Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 1.52m slotted screen. Water Level Readings: Date Depth(m) Elevation(m) July.20.10 4.5 175.3 July.26.10 3.7 176.1 Aug.06.10 2.7 177.1 Aug.13.10 2.7 177.1																

ONTARIO MOT 1-09-4135 CULVERTS2.GPJ ONTARIO MOT.GDT 10/01/10

B9

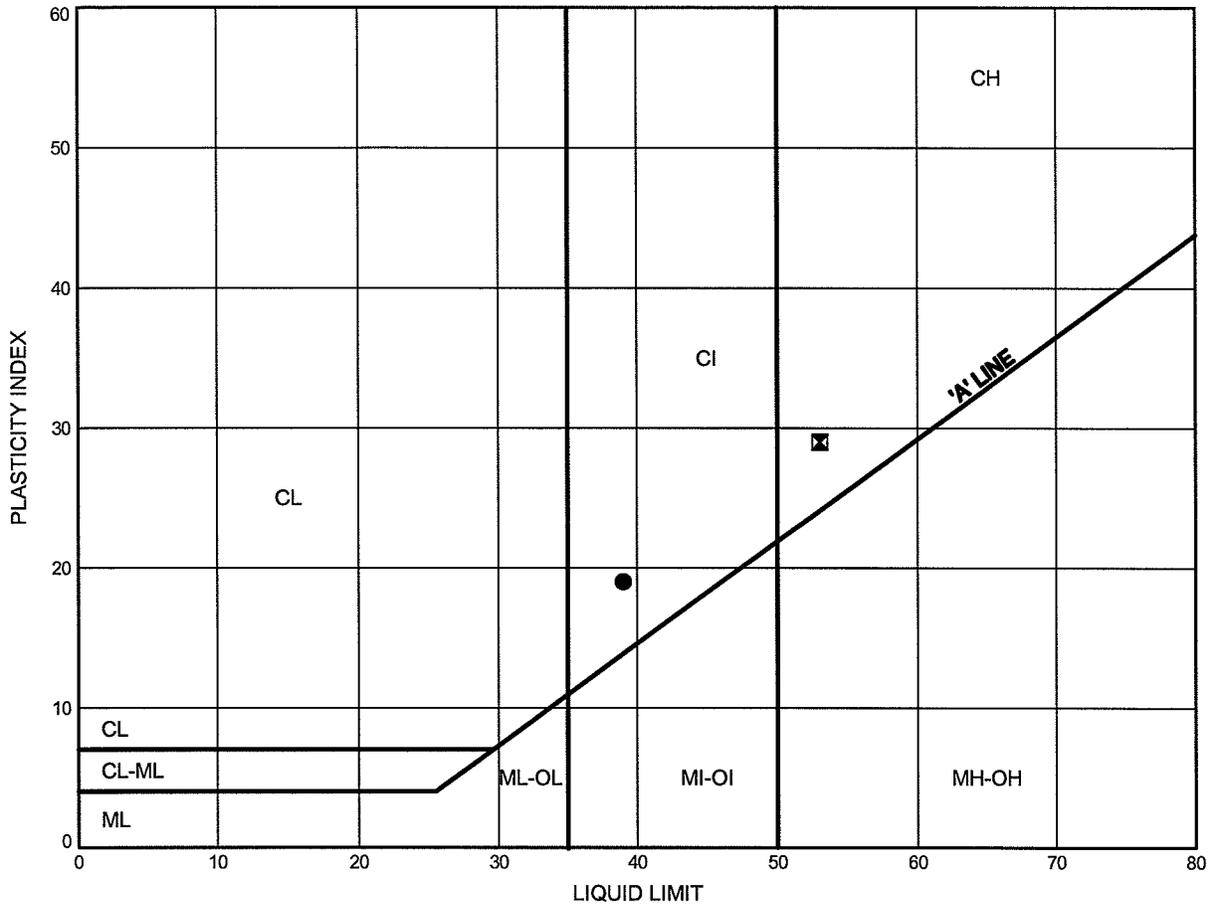
TERRAPROBE INC.



ATTERBERG LIMITS TEST RESULTS

FIGURE B9-2

FILL - Silty Clay



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C12-1	1.0	180.3
⊠	C12-2	1.0	178.8

ALTR 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/03/10

Date November 2010
 Project 1-09-4135

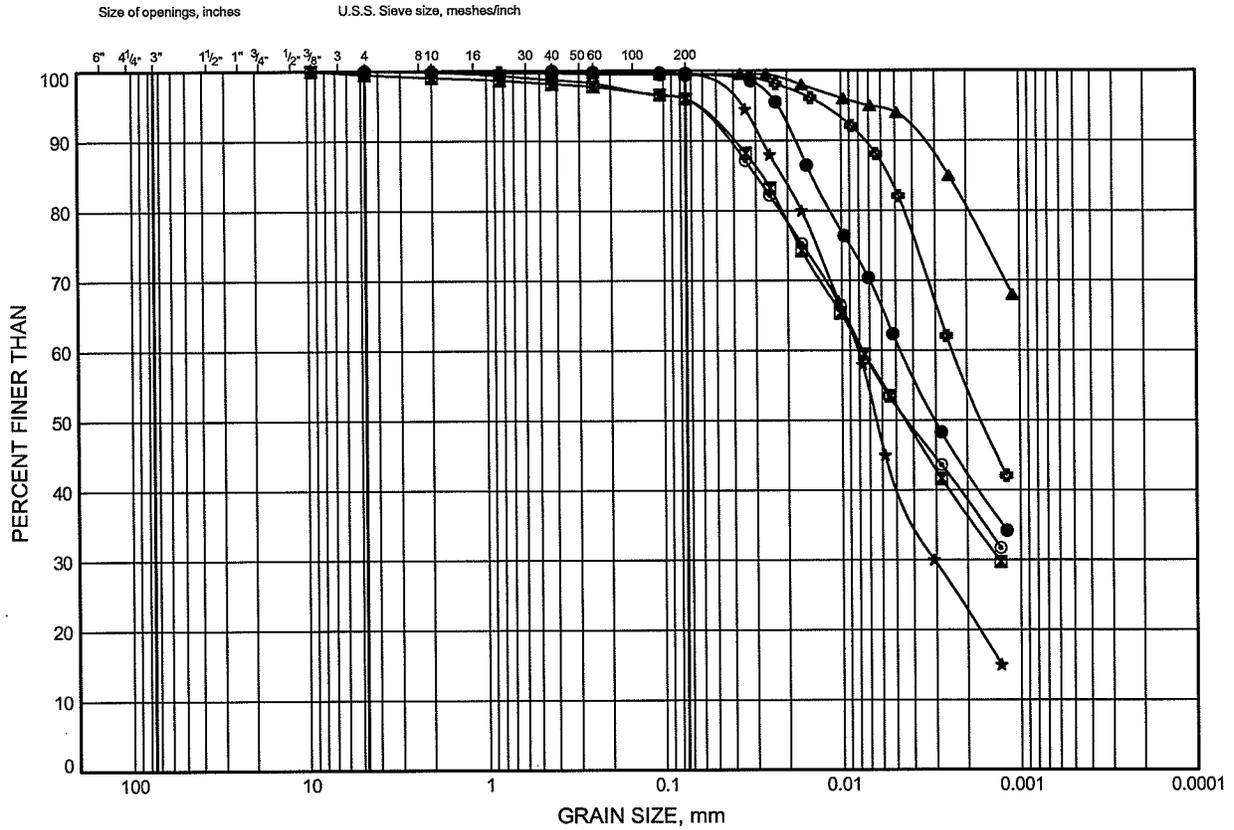


Prep'd K.L.
 Chkd. M.P.

GRAIN SIZE DISTRIBUTION

FIGURE B9-3

SILTY CLAY



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C12-1	3.2	178.1
■	C12-1	6.3	175.0
▲	C12-1	10.9	170.4
★	C12-1	13.9	167.4
⊙	C12-2	4.7	175.1
⊕	C12-2	9.3	170.5

GSD 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/07/10

Date November 2010
Project 1-09-4135

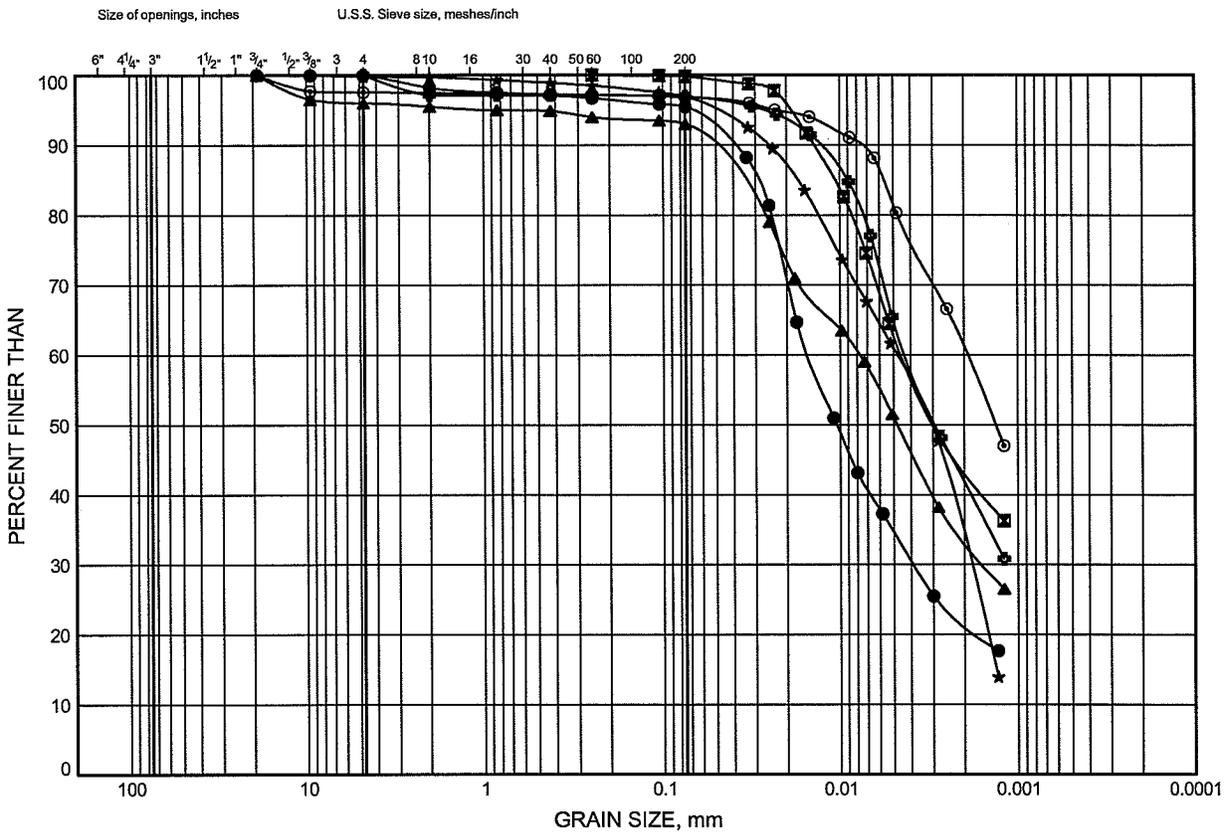


Prep'd K.L.
Chkd. M.P.

GRAIN SIZE DISTRIBUTION

FIGURE B9-4

SILTY CLAY



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C12-2	20.0	159.8
⊠	C12-3	2.5	177.3
▲	C12-3	4.7	175.1
★	C12-3	6.3	173.5
⊙	C12-3	9.3	170.5
⊕	C12-3	10.9	168.9

GSD 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/10/10

Date November 2010
Project 1-09-4135

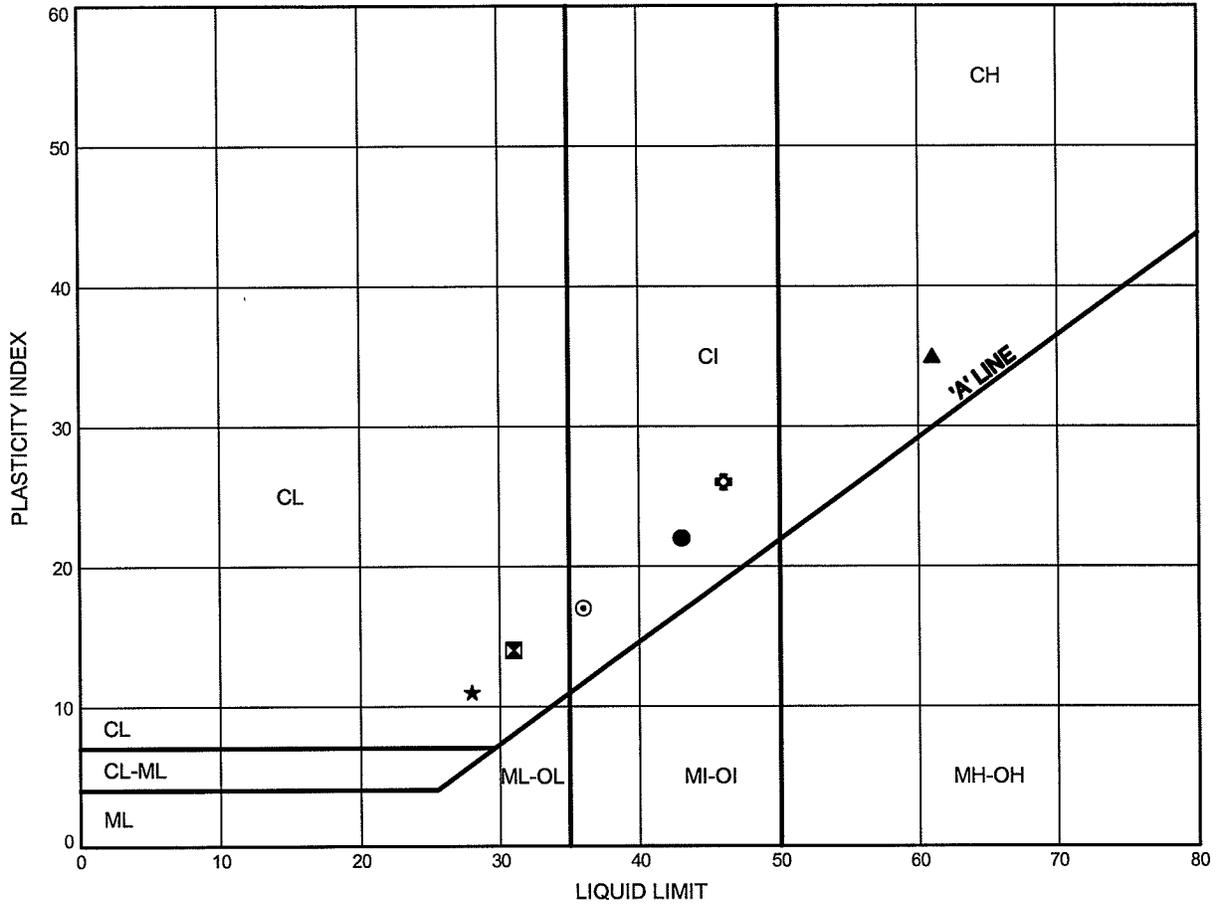


Prep'd K.L.
Chkd. M.P.

ATTERBERG LIMITS TEST RESULTS

FIGURE B9-5

SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C12-1	3.2	178.1
⊠	C12-1	6.3	175.0
▲	C12-1	10.9	170.4
★	C12-1	13.9	167.4
⊙	C12-2	4.7	175.1
⊕	C12-2	9.3	170.5

ALTR 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/03/10

Date November 2010
 Project 1-09-4135

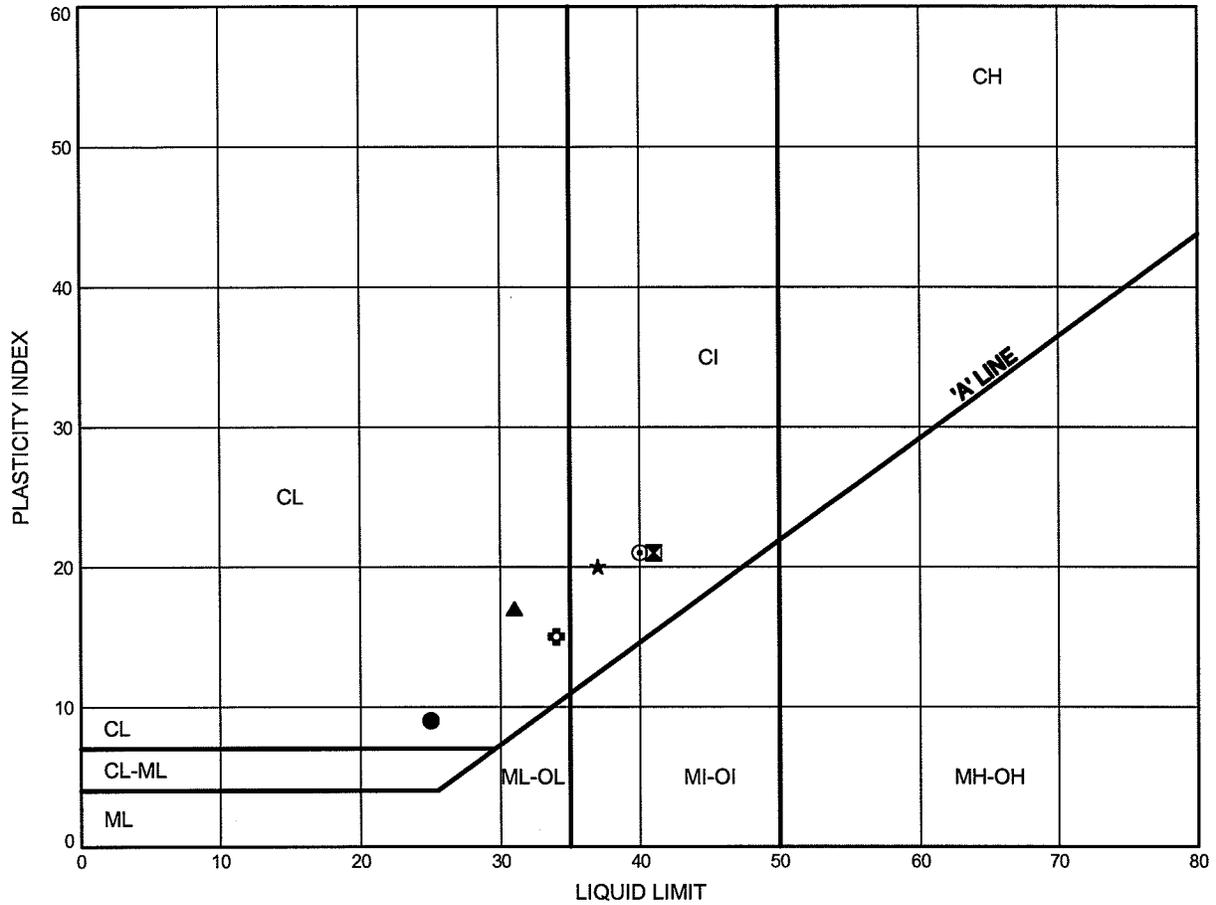


Prep'd K.L.
 Chkd. M.P.

ATTERBERG LIMITS TEST RESULTS

FIGURE B9-6

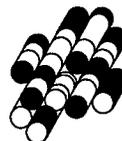
SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C12-2	20.0	159.8
⊠	C12-3	2.5	177.3
▲	C12-3	4.7	175.1
★	C12-3	6.3	173.5
⊙	C12-3	9.3	170.5
⊕	C12-3	10.9	168.9

ALTR 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/10/10

Date November 2010
 Project 1-09-4135

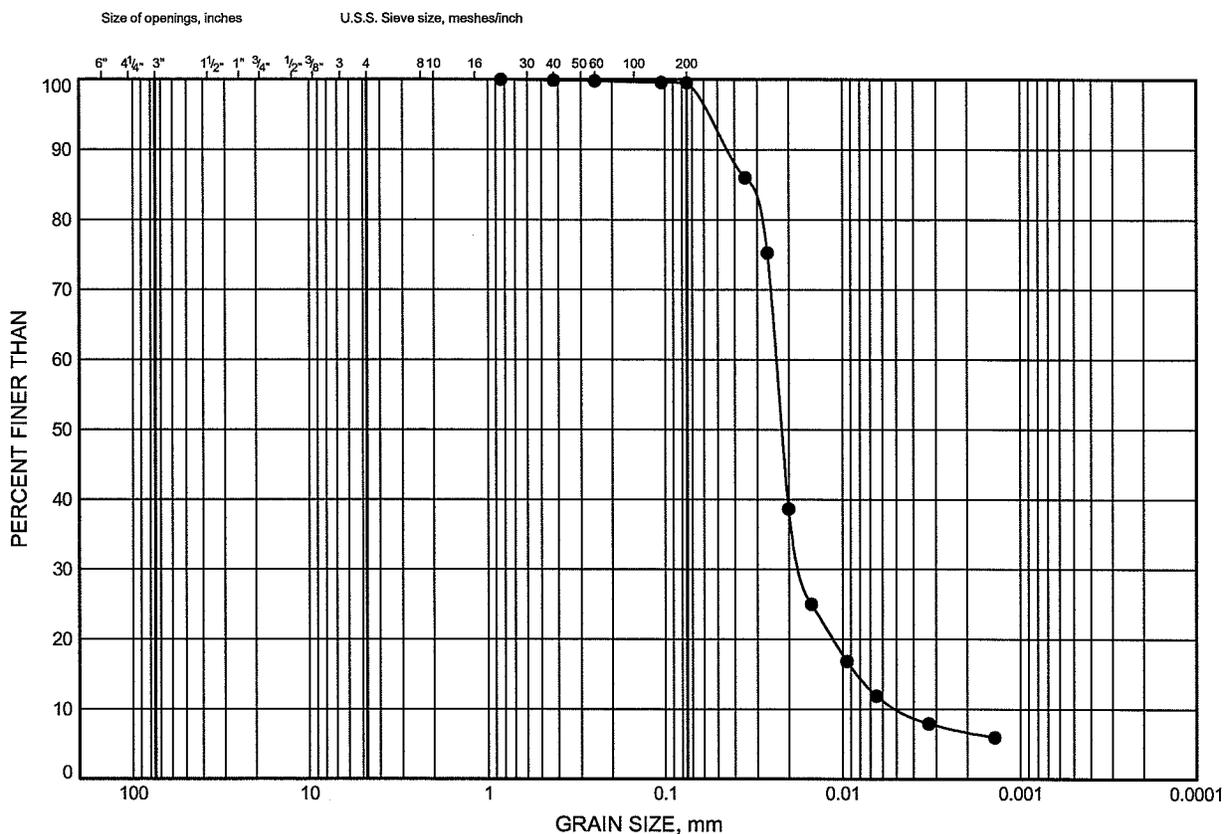


Prep'd K.L.
 Chkd. M.P.

GRAIN SIZE DISTRIBUTION

FIGURE B9-7

SILT



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C12-2	17.0	162.8

GSD 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/07/10

Date November 2010
 Project 1-09-4135

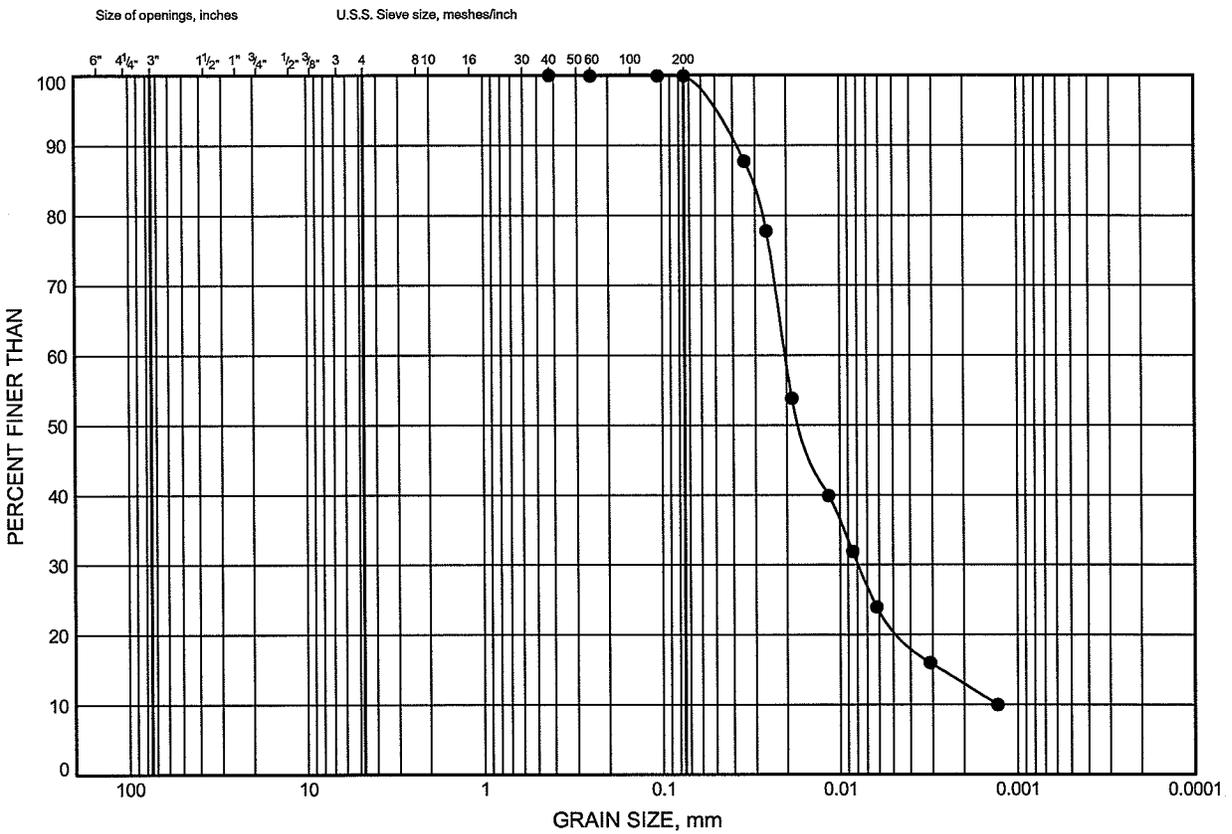


Prep'd K.L.
 Chkd. M.P.

GRAIN SIZE DISTRIBUTION

FIGURE B9-8

CLAYEY SILT



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C12-3	12.4	167.4

GSD 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/03/10

Date November 2010
Project 1-09-4135

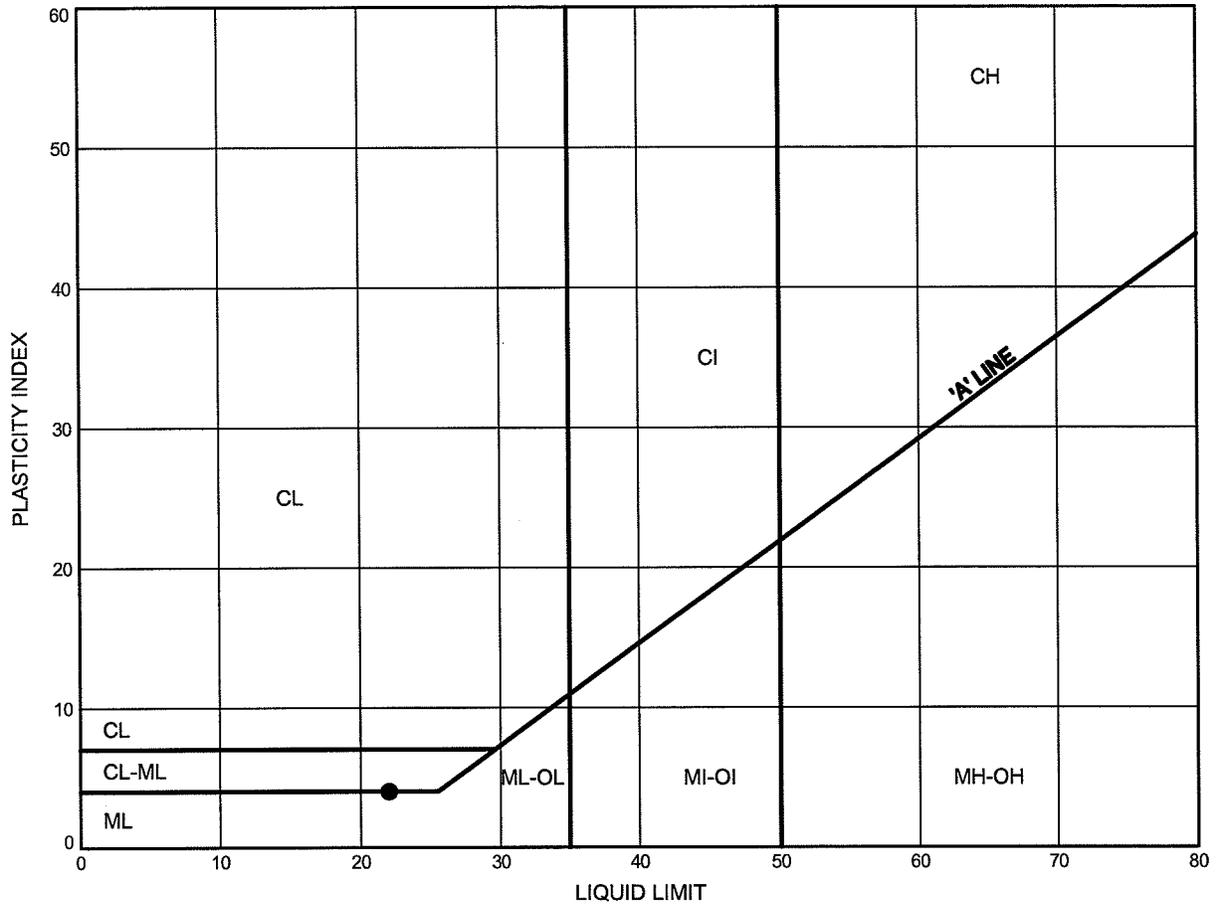


Prep'd K.L.
Chkd. M.P.

ATTERBERG LIMITS TEST RESULTS

FIGURE B9-9

CLAYEY SILT



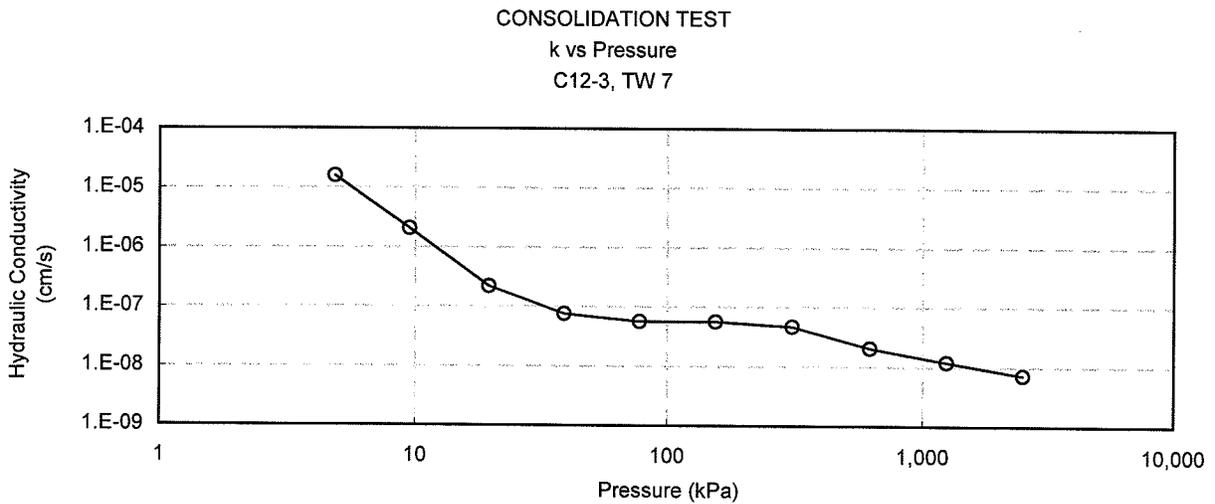
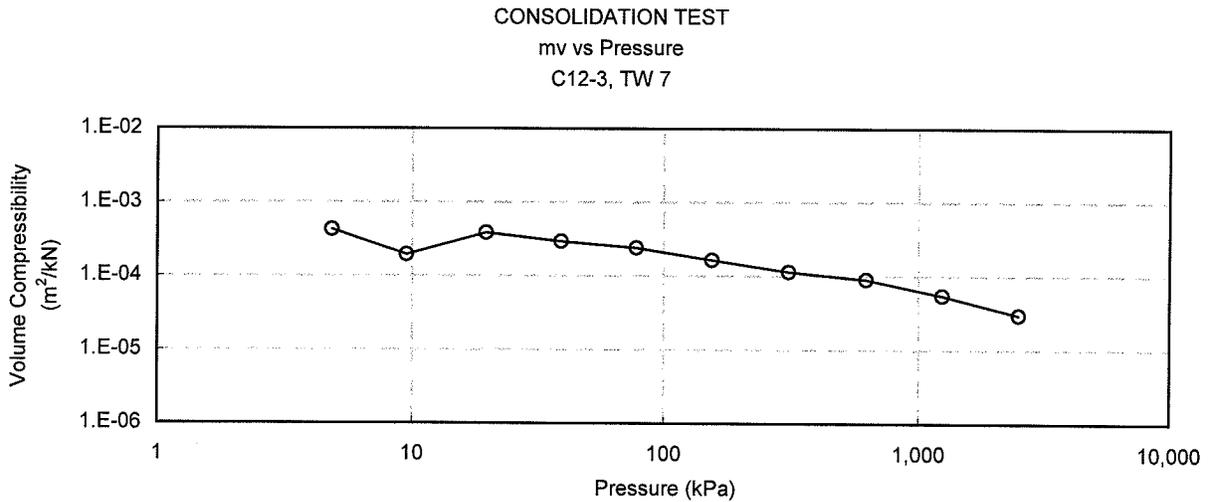
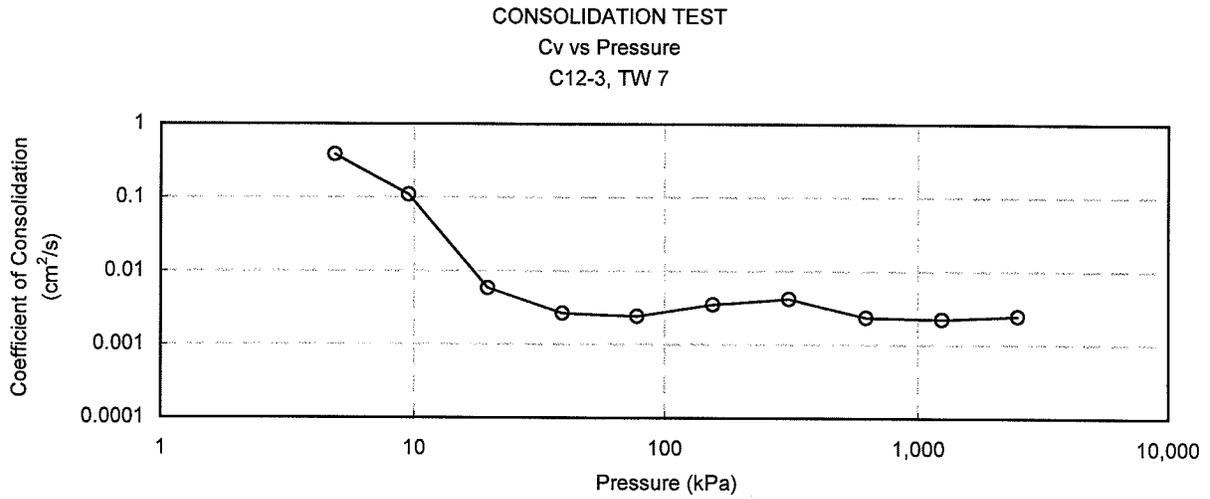
SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	C12-3	12.4	167.4

ALTR 1-09-4135 CULVERTS2 (KELVIN).GPJ 09/07/10

Date November 2010
 Project 1-09-4135



Prep'd K.L.
 Chkd. M.P.



C:\Documents and Settings\Admin\My Documents\Marc P\Projects 2009\Hwy 406 Expansion\1-09-4135 (Hwy 406 Foundations)\Culverts and Retaining Walls\Culverts\Lab Results\1-09-4135 Consolidation Results.xls

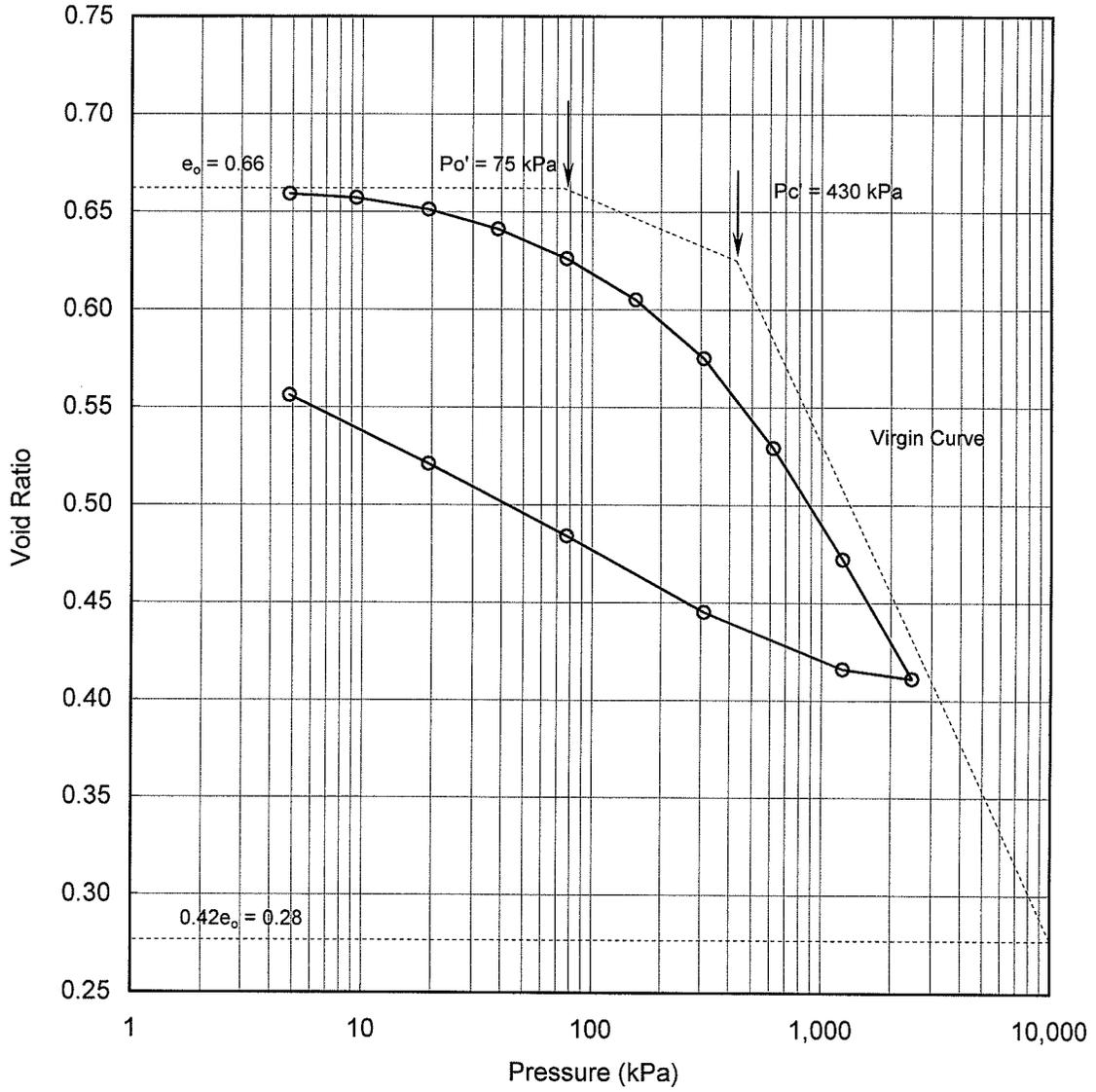
Project No. : 1-09-4135
Date : November 2010



Terraprobe Inc.

Prepared By : HW
Checked By : RA

CONSOLIDATION TEST
e vs Pressure
C12-3, TW 7



Soil Type : Silty Clay

$e_0 =$	0.66	$\omega_L =$	31%	$P_{o'} =$	75 kPa
$\omega =$	21%	$\omega_p =$	17%	$P_c =$	430 kPa
$\gamma =$	21.1 kN/m ³	PI =	14%	$C_c =$	0.255
$G_s =$	2.78			$C_r =$	0.049

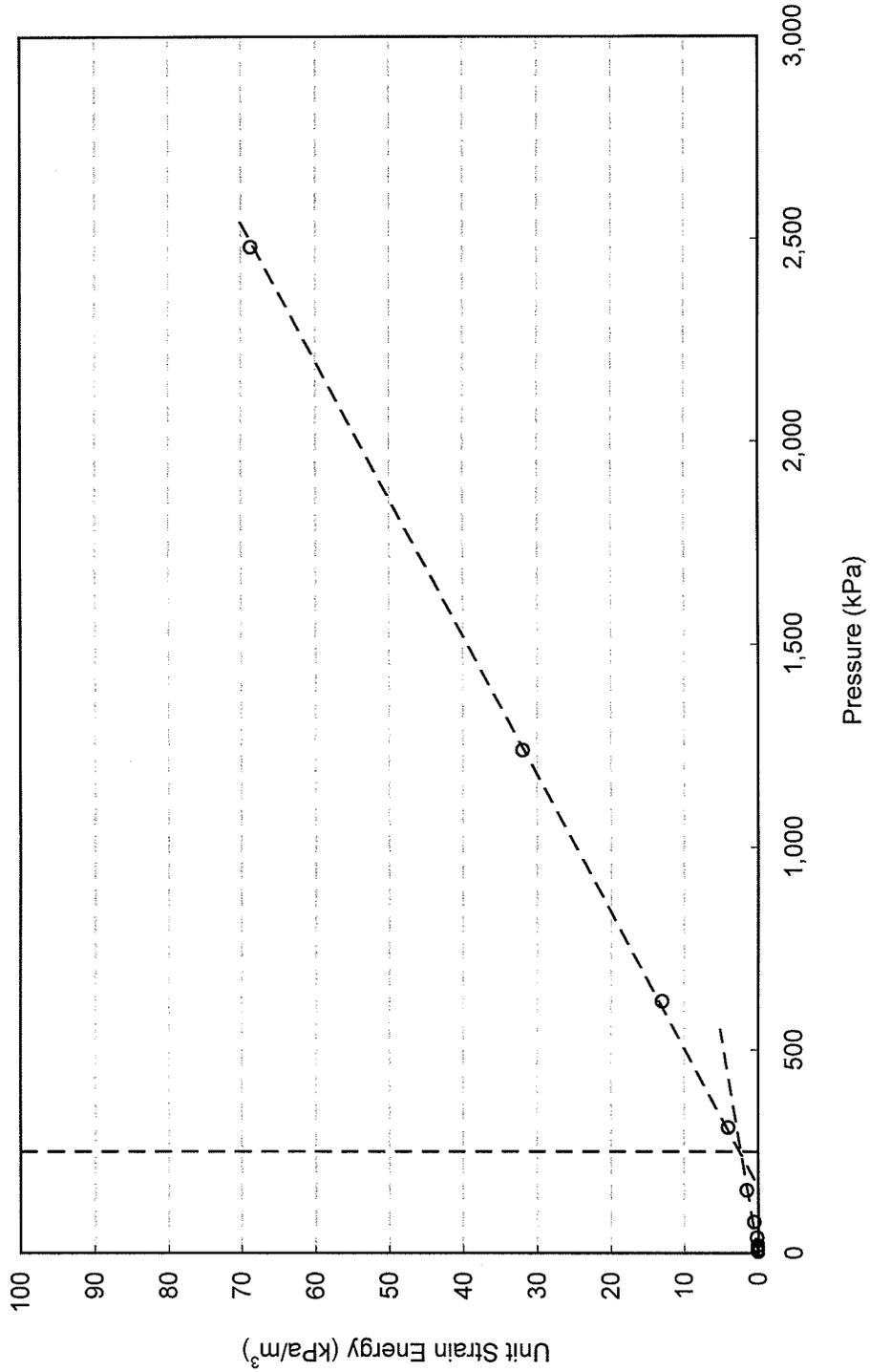
Project No. : 1-09-4135
Date : November 2010



Terraprobe Inc.

Prepared By : HW
Checked By : RA

CONSOLIDATION TEST
Unit Strain Energy vs Pressure
C12-3, TW 7



C:\Documents and Settings\Admin\My Documents\Marc P\Projects 2009\Hwy 406 Expansion\1-09-4135 (Hwy 406 Foundations)\Culverts and Retaining Walls\Culverts\Lab Results\1-09-4135 Consolidation Results.xls

Project No. : 1-09-4135

Date : November 2010



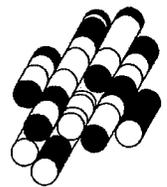
Terraprobe Inc.

Prepared By : HW

Checked By : RA

C9

TERRAPROBE INC.



METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETERS
UNLESS OTHERWISE SHOWN

CONT No 2011-2005
WP No 280-99-00

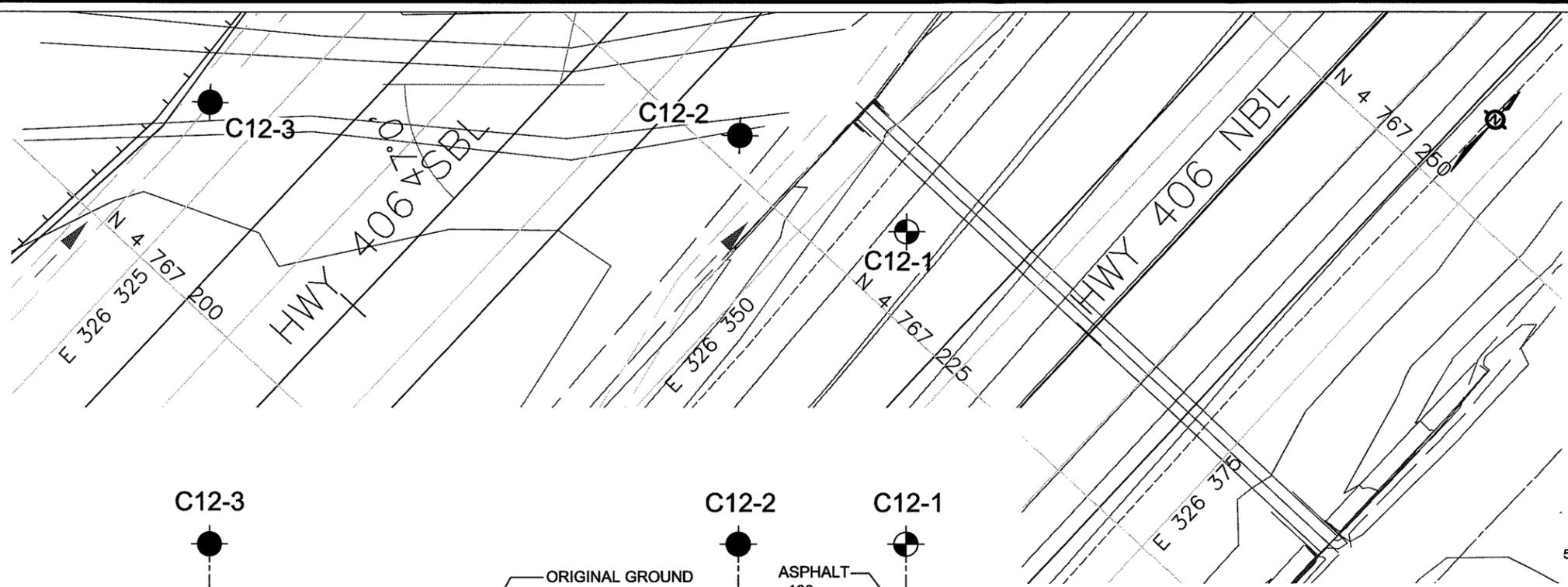


HIGHWAY 406
CULVERT # 49
BOREHOLE LOCATIONS AND SOIL STRATA

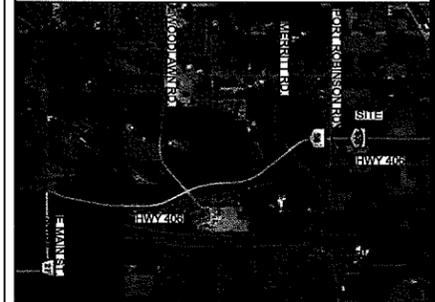
SHEET
1 OF



Terraprobe Inc.
Consulting Geotechnical & Environmental Engineering
Construction Materials Engineering, Inspection & Testing
10 Bram Court - Brampton Ontario L6W 3R6 (905) 796-2650



PLAN
SCALE
5m 2.5 0 2.5 5m



KEY PLAN

LEGEND

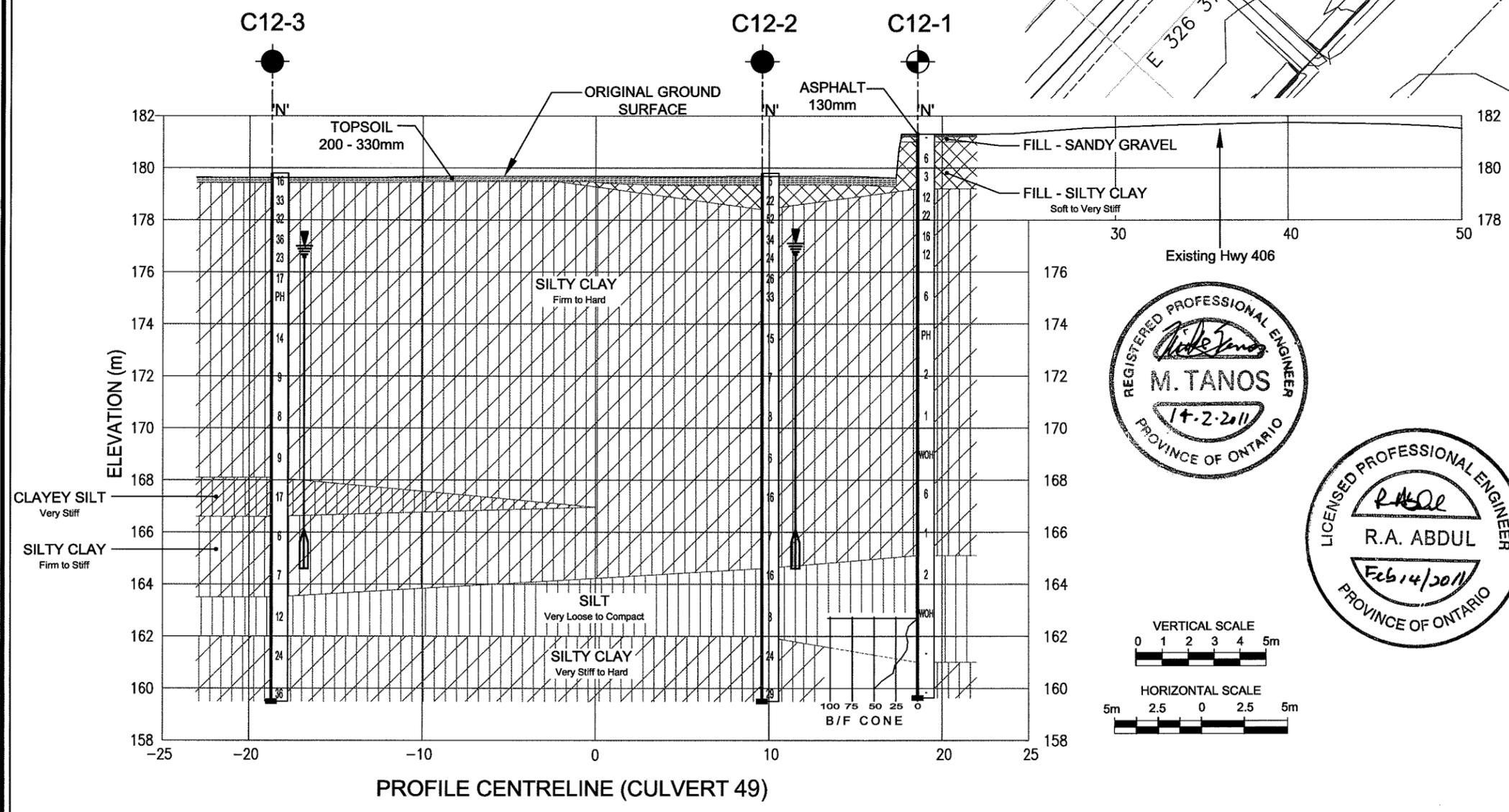
- Bore Hole
- ⊕ Dynamic Cone Penetration Test
- ⊙ Bore Hole And Cone
- 'N' Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60' Cone, 475 J/blow)
- ≡ WL at Time of Investigation
- ⊕ WL in Piezometer (AUG. 2010)
- ⊕ Piezometer
- 90% Rock Quality Designation
- A/R Auger Refusal

No	ELEV.	COORDINATES	
		NORTHING	EASTING
C12-1	181.3	4 767 228.9	326 354.3
C12-2	179.8	4 767 226.6	326 344.2
C12-3	179.8	4 767 208.6	326 322.1

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

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	R.A.	CODE	CHBDC2006
DRAWN	K.C.	CHK	RA
		STRUCT	

DATE FEB. 2011
GEOCRE3 30M3-269



VERTICAL SCALE
0 1 2 3 4 5m
HORIZONTAL SCALE
5m 2.5 0 2.5 5m

C:\Users\jwerner\Documents\1-09-4135 HWY 406 CULVERTS UPDATES\1-09-4135 CULVERTS 11.dwg, KAMAL