



June 2011

FOUNDATION INVESTIGATION AND DESIGN REPORT

**OVERHEAD SIGNS
REHABILITATION OF HIGHWAY 427 NORTHBOUND
COLLECTOR LANES BETWEEN GARDINER EXPRESSWAY
AND HIGHWAY 401, TORONTO, ONTARIO
G.W.P. NO. 2220-03-00**

Submitted to:
URS Canada Inc.
75 Commerce Valley Drive East
Markham, Ontario
L3T 7N9



GEOCRES NO.: 30M11-238

Report Number: 10-1111-0011

Distribution:

3 Copies - Ministry of Transportation, Ontario
1 Copy - MTO Foundations Section
2 Copies - URS Canada Inc.
2 Copies - Golder Associates Ltd.

REPORT





Table of Contents

PART A – FOUNDATION INVESTIGATION REPORT

1.0	INTRODUCTION	1
2.0	SITE DESCRIPTION	2
3.0	EXISTING SUBSURFACE INVESTIGATION DATA	2
4.0	SITE GEOLOGY AND STRATIGRAPHY.....	5
4.1	Regional Geological Conditions	5
4.2	Site Stratigraphy.....	5
4.2.1	Asphalt	5
4.2.2	Fill.....	6
4.2.3	Topsoil.....	6
4.2.4	Surficial Clayey Silt.....	6
4.2.5	Upper Clayey Silt Till	7
4.2.6	Silty Sand to Sandy Silt Till.....	7
4.2.7	Lower Clayey Silt Till	8
4.2.8	Clayey Silt (Residual Soil)	9
4.3	Groundwater Conditions	9
5.0	CLOSURE.....	10

PART B – FOUNDATION DESIGN REPORT

6.0	FOUNDATION ENGINEERING RECOMMENDATIONS	11
6.1	General	11
6.2	Caisson Foundations for Overhead Signs.....	11
6.3	Construction Considerations	13
7.0	CLOSURE	14

REFERENCES

LIST OF TABLES

Table 1	Geotechnical Design Parameters For Overhead Sign Foundations
---------	--



FINAL FOUNDATION REPORT - OVERHEAD SIGNS HIGHWAY 427 NB COLLECTOR REHABILITATION

LIST OF DRAWINGS

Drawing 1	Existing Borehole Locations and Proposed Overhead Sign Locations
Drawing 2	Existing Borehole Locations and Proposed Overhead Sign Locations
Drawing 3	Existing Borehole Locations and Proposed Overhead Sign Locations

LIST OF APPENDICES

List of Symbols and Abbreviations

Appendix A Borehole Records and Laboratory Test Results – GEOCRES No. 30M11-031 and 30M11-033

Records of Boreholes 031-30 and 033-15

Figure A1	Plasticity Chart – Upper Clayey Silt Till
Figure A2	Grain Size Distribution – Sand and Silt to Sandy Silt Till
Figure A3	Grain Size Distribution – Silty Sand Till and Lower Clayey Silt Till
Figure A4	Plasticity Chart – Lower Clayey Silt Till

Appendix B Borehole Records and Laboratory Test Results – GEOCRES No. 30M11-040

Record of Borehole 040-53

Figure B1	Plasticity Chart – Upper Clayey Silt Till
-----------	---

Appendix C Borehole Records and Laboratory Test Results – GEOCRES No. 30M11-042

Records of Boreholes 042-21 and 042-26

Appendix D Borehole Records and Laboratory Test Results – GEOCRES No. 30M11-046

Records of Boreholes 046-5 and 046-17

Figure D1	Plasticity Chart – Upper Clayey Silt Till
-----------	---

Appendix E Borehole Records and Laboratory Test Results – GEOCRES No. 30M11-049

Record of Borehole 049-8

Figure E1	Plasticity Chart – Upper Clayey Silt Till
-----------	---

Appendix F Borehole Records and Laboratory Test Results – GEOCRES No. 30M11-053

Records of Borehole 053-18

Figure F1	Grain Size Distribution – Upper Clayey Silt Till and Sand and Silt to Silty Sand Till
Figure F2	Plasticity Chart – Upper Clayey Silt Till
Figure F3	Plasticity Chart – Clayey Silt (Residual Soil)



FINAL FOUNDATION REPORT - OVERHEAD SIGNS HIGHWAY 427 NB COLLECTOR REHABILITATION

Appendix G Borehole Records and Laboratory Test Results – GEOCRETS No. 30M11-221

Records of Boreholes 221-6, 221-7, 221-14, 221-18, 221-19, 221-20, 221-23, 221-26

Figure G1	Grain Size Distribution – Clayey Silt Fill
Figure G2	Plasticity Chart – Clayey Silt Fill
Figure G3	Grain Size Distribution – Upper Clayey Silt Till
Figure G4	Plasticity Chart – Upper Clayey Silt Till
Figure G5.1	Grain Size Distribution – Silt and Sand Till
Figure G5.2	Grain Size Distribution – Silt and Sand Till
Figure G5.3	Grain Size Distribution – Silt and Sand Till
Figure G5.4	Grain Size Distribution – Sandy Silt Till
Figure G6	Plasticity Chart – Silty Sand to Sandy Silt Till
Figure G7	Plasticity Chart – Lower Clayey Silt Till

Appendix H Non-Standard Special Provisions



**FINAL FOUNDATION REPORT - OVERHEAD SIGNS
HIGHWAY 427 NB COLLECTOR REHABILITATION**

PART A

**FOUNDATION INVESTIGATION REPORT
OVERHEAD SIGNS
REHABILITATION OF HIGHWAY 427 NORTHBOUND COLLECTOR LANES
BETWEEN THE GARDINER EXPRESSWAY AND HIGHWAY 401
TORONTO, ONTARIO
G.W.P. NO. 2220-03-00**



1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by URS Canada Inc. (URS) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services associated with the rehabilitation of the Highway 427 northbound collector lanes between the Gardiner Expressway and Highway 401, in the City of Toronto. As part of the rehabilitation work, 20 new overhead signs will be constructed, of which 19 will require foundation engineering services; the new overhead sign at Station 11+340 will be mounted on an existing retaining wall, and hence does not require foundation engineering services. The overhead signs will be constructed at the following locations (referenced to the stationing along the Highway 427 northbound collector lanes, except where noted for the Rathburn Road off-ramp):

- Highway 427 Northbound Collector Lanes, Station 10+240
- Highway 427 Northbound Express Lanes, Station 10+518
- Highway 427 Northbound Collector Lanes, Station 10+700
- Highway 427 Northbound Express Lanes, Station 10+977
- Highway 427 Northbound Collector Lanes, Station 11+340 (this sign will be mounted on an existing retaining wall, and hence does not require foundation engineering services)
- Highway 427 Northbound Collector Lanes, Station 11+698
- Highway 427 Northbound Express Lanes, Station 12+189
- Highway 427 Northbound Collector Lanes, Station 12+390
- Highway 427 Northbound Express Lanes, Station 12+509
- Highway 427 Northbound Collector Lanes, Station 12+940
- Highway 427 Northbound Collector Lanes, Station 13+243
- Highway 427 Northbound Collector Lanes, Station 13+544
- Rathburn Road Off-Ramp, Station 10+158 (referenced to off-ramp stationing)
- Highway 427 Northbound Collector Lanes, Station 13+900
- Highway 427 Northbound Collector Lanes, Station 14+250
- Highway 427 Northbound Express Lanes, Station 14+318
- Highway 427 Northbound Collector Lanes, Station 15+230
- Highway 427 Northbound Collector Lanes, Station 15+600
- Highway 427 Northbound Collector Lanes, Station 15+905
- Highway 427 Southbound Collector Lanes, Station 16+187

This report presents a summary of the interpreted subsurface conditions throughout the project area based on boreholes advanced by others in the vicinity of the proposed overhead signs. The subsurface information used in this report was obtained from previous Foundation Investigation Reports prepared by others for structures within the Highway 427 corridor, available from MTO Pavement and Foundations Section's GEOCRES database, as referenced in Section 3.0 of this report.

The terms of reference and scope of work for the foundation investigation are outlined in MTO's Request for Proposal for Assignment Number 2008-E-0079, dated May 2008, and in Section 6.8 of URS's *Technical Proposal* for G.W.P. 2220-03-00. The scope of work was revised as outlined in a letter prepared by Golder dated October 12, 2010, which was reviewed and accepted by MTO.



2.0 SITE DESCRIPTION

This project extends along Highway 427 at the western edge of Toronto, from the Gardiner Expressway to Highway 401. The ground surface generally rises from approximately Elevation 125 m near the Gardiner Expressway at the southern project limit, to approximately Elevation 152 m near Highway 401 at the northern project limit. The topography of this area is generally flat, with Highway 427 and/or the local roads constructed on embankments at the grade separation areas.

3.0 EXISTING SUBSURFACE INVESTIGATION DATA

As a part of the Highway 427 reconstruction and widening in the late 1960s and early 1970s, and rehabilitation work beginning in the late 1990s, various subsurface investigations were carried out by or on behalf of the MTO. Golder has reviewed the Foundation Investigation Reports for the Highway 427 corridor that are available in MTO's GEOCRES system, and considers that appropriate subsurface information is available within the Highway 427 corridor between the Gardiner Expressway and Highway 401 to develop a subsurface model for the new overhead sign locations. Those reports that contain borehole information relevant to the proposed overhead sign locations are summarized below:

- **MTO GEOCRES No. 30M11-031 and 30M11-033:** "Foundation Investigation Report for the Proposed Dundas Street and Highway 27 Interchange and Bloor Street Underpass, W.J. 66-F-103, W.P. 275-64-2", by Department of Highways Ontario, dated 1967.
- **MTO GEOCRES No. 30M11-040:** "Foundation Investigation Report for Proposed Retaining Walls at the Dundas Street and Highway 27 Interchange, W.J. 67-F-37, W.P. 275-64-2", by Department of Highways Ontario, dated 1967.
- **MTO GEOCRES No. 30M11-042:** "Proposed Trunk Sewer, West Side of Highway 27, W.J. 67-F-101, W.P. 275-64-2 and 3", by Department of Highways Ontario, dated 1967.
- **MTO GEOCRES No. 30M11-046:** "Foundation Investigation Report for Proposed Retaining Walls at the Site of Highway 401, 27 and Richview Expressway Interchange, W.J. 67-F-68, W.P. 201-62-1", by Department of Highways Ontario, dated 1967.
- **MTO GEOCRES No. 30M11-049:** "Foundation Investigation Report for Contract 8, Highway 27 Improvement, W.J. 67-F-16, W.P. 275-64-3", by Department of Highways Ontario, dated 1967.
- **MTO GEOCRES No. 30M11-053:** "Foundation Investigation Report for the Proposed Highway 401, Highway 27 and Richview Expressway Interchange, Contract 7, W.J. 66-F-102, W.P. 201-62-1", by Department of Highways Ontario, dated 1967.
- **MTO GEOCRES No. 30M11-221:** "Foundation Investigation Report for High Mast Lighting, Highway 427 from Evans Avenue Northerly to Highway 401, W.P. 127/128-85-00," by Strata Engineering Corporation, dated March 1999.



FINAL FOUNDATION REPORT - OVERHEAD SIGNS HIGHWAY 427 NB COLLECTOR REHABILITATION

During Golder's review and compilation of the existing borehole data, a new designation was given to all referenced boreholes to avoid confusion and ambiguity between boreholes from different reports that are numbered similarly. For the purposes of this current Foundation Investigation Report, the boreholes have been re-numbered such that the 30M11-series GEOCREs number precedes the original borehole number. For example, Borehole 15 from GEOCREs Report No. 30M11-221 is referred to throughout this report and on the drawings as Borehole 221-15. The locations of the compiled boreholes extracted from the above-noted reports are shown on Drawings 1 to 3.

The following points are noted regarding determining the locations of the previous boreholes, and assessing the previous boreholes for potential use with respect to the proposed overhead sign locations:

- The borehole locations in the previous Foundation Investigation Reports for the Highway 427 corridor are referenced to a number of coordinate or station systems. Boreholes from GEOCREs 30M11-033, 30M11-046, 30M11-053 and 30M11-221 were referenced to a global datum, and could be converted to the MTM NAD83 coordinate system; the accuracy of these borehole locations is considered to be consistent with the original survey. Boreholes contained in GEOCREs Reports 30M11-031, 30M11-040, 30M11-042 and 30M11-049 were referenced to a project-specific local datum. Golder was not able to find a reference as to how this local coordinate system relates to a global system. For these boreholes, the distances from each borehole to known reference points shown on the original borehole location plan were measured, and then each borehole was plotted on the current base plan, with the relative distance and orientation between borehole locations preserved from the original coordinates. The horizontal accuracy of this method is considered to be within 5 m.
- In general, an existing borehole is located within approximately 100 m of each of the proposed overhead sign locations, except for the proposed overhead sign located at Station 10+158 on the Rathburn Road exit-ramp, where the closest borehole is located approximately 135 m away. Golder has reviewed the topography and subsurface conditions for other boreholes in the general area of this proposed overhead sign location to confirm that the conditions are relatively consistent in the area and therefore applicable to the proposed sign location.
- At two of the proposed overhead sign locations (Stations 10+700 and 10+977), the closest existing boreholes were drilled from original ground surface prior to the construction of the Highway 427 embankment in these areas. The present Highway 427 grade is approximately 6 m higher than the original ground surface, and the existing boreholes do not provide information on the material type and properties of the embankment fill. However, based on a discussion with MTO Foundations on September 17, 2010, it is understood that the Highway 427 embankment was constructed to engineered fill standards and therefore the value of the geotechnical parameters for the fill is considered to meet the minimum soil parameters as defined in the *MTO Sign Support Manual (April 2007)* applicable to standard sign foundation design.

Based on the compiled borehole locations and information, one borehole considered to be representative of the subsurface conditions and in compliance with the Terms of Reference for the current assignment was chosen for each proposed overhead sign location. Presented below are the relevant boreholes as assessed by Golder for each of the proposed overhead sign locations, along with the borehole location (northing and easting



FINAL FOUNDATION REPORT - OVERHEAD SIGNS HIGHWAY 427 NB COLLECTOR REHABILITATION

coordinates) and the ground surface elevation at the time of the borehole investigation and currently as interpreted from topographic maps provided by URS.

Overhead Sign Station (NBL Collector Chainage)	Borehole Designation	MTM NAD83 Coordinates		Depth Drilled (m)	Ground Surface Elevation	
		Northing (m)	Easting (m)		As-drilled Elevation (m)	Current Elevation (m)
10+240	221-6	4,831 226	300,475	14.0	126.9	126.9
10+518	221-7	4,831 511	300,382	13.0	128.6	128.6
10+700	040-53	4,831 733	300,352	5.8	121.9	126.8
10+977	031-30	4,832 030	300,213	9.2	123.6	128.2
11+698	033-15	4,832 687	300,092	13.8	130.1	130.3
12+189	042-21	4,833 094	299,874	9.3	131.2	132.2
12+390	221-14	4,833 245	299,905	6.6	134.2	134.2
12+509	042-26	4,833 424	299,797	8.0	137.1	137.2
12+940	049-8	4,833 959	299,726	12.3	139.2	140.0
13+243	221-18	4,834 108	299,646	8.1	140.9	140.9
13+544	221-19	4,834 486	299,520	6.6	142.9	142.9
10+158 (Rathburn Road Off-Ramp)	221-19	4,834 486	299,520	6.6	142.9	142.9
13+900	221-20	4,834 769	299,419	6.6	144.5	144.5
14+250	221-23	4,835 144	299,278	12.3	146.5	146.5
14+318	221-23	4,835 144	299,278	12.3	146.5	146.5
15+230	221-26	4,836 002	299,006	6.5	146.2	146.2
15+600	046-5	4,836 398	298,940	8.1	146.9	147.4
15+905	046-17	4,836 675	298,882	9.3	148.6	149.9
16+187	053-18	4,836 984	298,854	19.4	152.7	150.4

The procedures used in carrying out the previous investigation are generally similar to current procedures; the boreholes were drilled by truck-mounted drill rigs using continuous flight augers and, in some cases, diamond core drill rigs adapted for soil sampling purposes. Soil sampling was performed at regular intervals of depth using a 50 mm outside diameter split-spoon sampler driven by a manual hammer. The number of hammer blows necessary to drive the split-spoon sampler for 0.3 m of penetration under an impact of 350 ft-lbs (a 140-pound hammer falling 30 inches) was recorded as the Standard Penetration Test "N" value.

The groundwater conditions in the open boreholes were observed either immediately after the drilling operations or a few days thereafter, with the dates noted on the borehole records.

The samples were identified in the field and underwent further visual examination in the laboratory. Classification testing (water content, Atterberg limits and grain size distribution) was carried out on selected samples.



4.0 SITE GEOLOGY AND STRATIGRAPHY

4.1 Regional Geological Conditions

The area north of Dundas Street along Highway 427 is located within the Peel Plain physiographic region, as delineated in *The Physiography of Southern Ontario*. A surficial till sheet, which generally follows the surface topography, is generally present throughout this area. The till is typically comprised of clayey silt to silty clay, with occasional sand to silt zones; it is mapped in this area as the Halton Till. Shallow, localized deposits of loose sand and silt and/or soft clay can overlie this uppermost till sheet, and these represent relatively recent deposits, formed in small glacial meltwater ponds scattered throughout the Peel Plain and concentrated near river valleys, such as the West Don River valley. The recent sand, silt and clay and uppermost till deposits in this area overlie and are interbedded with stratified deposits of sand, silt and clay.

The former glacial Lake Iroquois shoreline is located just south of Dundas Street along the Highway 427 corridor, and the near-surface soils in this portion of the study area consist of sands, silts and gravels deposited by the glacial lake, overlying glacial till and/or shale bedrock.

4.2 Site Stratigraphy

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing, where available, are given on the borehole records and laboratory test figures contained in the appendices following the text of this report. The stratigraphic boundaries shown on the borehole records are considered to have been inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

In summary, the soils encountered along the Highway 427 corridor between the Gardiner Expressway and Highway 401 consist of fill underlain by a glacial till deposit that varies in composition from clayey silt, to silty sand to sandy silt; in general, the upper portion of the till deposit consists of clayey silt in many of the boreholes, grading to silty sand to sandy silt, then back to clayey silt with depth. Bedrock was not encountered in any of the boreholes pertinent to the overhead sign locations, although it was encountered in boreholes advanced near the Gardiner Expressway. In that area, bedrock was encountered at a depth of approximately 1 m to 3 m below the existing ground surface.

A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Asphalt

Approximately 100 mm to 200 mm of asphalt was encountered immediately below the highway surface in the boreholes that were advanced as part of the 1999 foundation investigation for high mast light poles (MTO GEOCRES No. 30M11-221, contained in Appendix G).



4.2.2 Fill

Fill was encountered beneath the asphalt or immediately below the ground surface in Boreholes 049-8, 221-6, 221-7, 221-14, 221-18, 221-19, 221-20, 221-23, and 221-26. The fill is generally between 0.3 m and 2.3 m thick; however, in Boreholes 221-6 and 221-7, it is 9.6 m and 12.3 m thick, respectively. Soil sampling in Borehole 221-7 was terminated within the fill layer at a depth of 11.1 m (Elevation 117.5 m), although a dynamic cone penetration test driven below this depth inferred the base of the fill layer to be at Elevation 116.1 m. The remaining boreholes encountered the base of the fill between Elevations 117.1 m and 146.0 m, at depths between 0.5 m and 2.3 m below the pavement surface.

The upper 0.2 m to 1.0 m of fill in the 221-series boreholes consists of crushed gravel or sand and gravel road base/sub-base fill. Below this, in general, the fill consists of clayey silt containing some sand and gravel, in places containing brick fragments, organic inclusions or topsoil. A layer of cohesionless fill, ranging in composition from sandy silt to sand to sand and gravel, was encountered in Boreholes 049-8 (Appendix E) and Boreholes 221-7, 221-18, and 221-20 (Appendix G).

The result of a grain size distribution test carried out on a sample of the clayey silt fill is shown on Figure G1 in Appendix G. Atterberg limits testing on two samples of the clayey silt fill measured plastic limits of 12 and 15 percent, liquid limits of 19 and 27 percent, and plasticity indices of 7 and 12 percent. These test results, which are plotted on a plasticity chart on Figure G2 in Appendix G, confirm that this material is clayey silt of low plasticity.

The measured Standard Penetration Test (SPT) “N” values within the cohesive fill range between 7 and 38 blows per 0.3 m of penetration, suggesting a firm to hard consistency. The measured SPT “N” values within the cohesionless portions of the fill are 5 to 17 blows per 0.3 m of penetration, indicating that this portion of the fill has a loose to compact relative density.

4.2.3 Topsoil

In general, the boreholes advanced during the 1960s investigations encountered native soil at or near the then-ground surface, except Borehole 031-30 where 150 mm of topsoil was encountered immediately below the ground surface.

In Borehole 221-6 advanced through the Highway 427 embankment, a 0.4 m thick layer of topsoil mixed with peat was encountered below the embankment fill at a depth of approximately 9.8 m (Elevation 117.1 m).

4.2.4 Surficial Clayey Silt

A surficial clayey silt deposit was encountered immediately below the ground surface in Borehole 042-26. This stratum is approximately 5.2 m thick, with its base encountered at approximately Elevation 131.9 m.

This deposit is described as consisting of clayey silt containing trace sand and gravel, as well as organic material. The measured SPT “N” values within the deposit range from 9 blows to greater than 100 blows per 0.3 m of penetration, suggesting a stiff to hard consistency.



4.2.5 Upper Clayey Silt Till

An upper deposit of clayey silt till was encountered immediately below the ground surface or below asphalt, fill, topsoil or surficial clayey silt in all boreholes except Borehole 031-30. The upper till deposit is between 2.0 m and 11.3 m thick and the surface of the deposit was encountered at depths from 0 m to 12.5 m below ground surface, between Elevations 116.1 m and 152.7 m (generally rising toward the north). Boreholes 040-53, 046-5, 046-17, 049-8, 221-7 and 221-26 were terminated within this layer, where it was at least 5.9 m to 13.0 m thick. These boreholes were terminated between Elevation 115.6 m and Elevation 138.8 m.

The deposit consists of clayey silt containing varying amounts of sand and gravel, with sand and silt seams or layers noted in Boreholes 221-18, 221-23 and 221-26. In Boreholes 040-53, 046-5 and 049-8, portions of the deposit are identified in the reports and on the borehole records as cohesionless (eg., silt or sand and silt). However, based on the Atterberg limits test results and the current MTO classification system, these portions of the upper till deposit are considered to behave as cohesive materials and have been interpreted to be part of the upper clayey silt till deposit. The deposit was not described as a till on some of the previous borehole records; however, the text of the previous Foundation Investigation Reports refers to these soils as glacial till. Golder has added notes on the original borehole records as contained in the appendices to this report to indicate those deposits that have been interpreted to be glacial till.

The results of grain size distribution tests on three selected samples of the upper cohesive till are shown on Figures F1 and G3 in Appendices F and G. Grain size distribution tests were also completed on two samples from Borehole 049-8; the actual grain size distribution plots were not included in the original Foundation Investigation Report, but the percent passing the clay, silt, sand and gravel sieve sizes are shown on the borehole record in Appendix E and indicate that the material may be described as clayey silt with varying amounts of sand and gravel sizes.

Atterberg limits tests were carried out on 18 samples of the upper till deposit and measured plastic limits between 11 and 17 percent, liquid limits between 17 and 31 percent and plasticity indices between 4 and 14 percent. These test results, which are plotted on plasticity charts on Figure A1, B1, D1, E1, F2 and G4 in the appendices, confirm that this material is a clayey silt of low plasticity.

The measured SPT “N” values within the upper till deposit range from 9 blows to greater than 100 blows per 0.3 m of penetration, but are typically greater than 30 blows per 0.3 m of penetration and typically increase with depth. These results suggest a stiff to hard, but generally hard, consistency.

4.2.6 Silty Sand to Sandy Silt Till

A silty sand to sandy silt till deposit was encountered in Boreholes 031-30, 033-15, 040-53, 042-21, 042-26, 053-18, 221-6, 221-14, 221-18, 221-19, 221-20, and 221-23, generally underlying the upper clayey silt till deposit. The deposit is between 2.3 m and 9.7 m in thickness, with its surface encountered between about Elevation 113.0 m and 142.7 m, and its base (where fully penetrated) encountered between about Elevation 117.5 m and 136.6 m, both generally rising northward. Some of the boreholes were terminated within this deposit.



The deposit varies in composition from silty sand containing some gravel to sandy silt containing trace clay and gravel. Cobbles and/or boulders were encountered in Borehole 033-15 at a depth of 4.5 m (Elevation 125.6 m), and in Borehole 031-30 between depths of 2.1 m and 6.1 m (Elevation 121.5 m and 117.5 m). The results of grain size distribution tests on eleven selected samples are shown on Figures A2, A3, F1, and G5.1 to G5.4 contained in the appendices. Grain size distribution testing was completed on other samples but graphical plots of the distributions were not available in the previous Foundation Investigation Reports; the percentages of clay, silt, sand and gravel are indicated on the borehole records in the appendices. It is noted that this deposit is not labelled as a till on some of the borehole records; however, based on the grain size distribution test results, the text of the original Foundation Investigation Reports, and the glacial history of the area, this deposit has been interpreted as a till; a note has been added to the original borehole records contained in the appendices where applicable.

Atterberg limits tests were carried out on two samples of the silty sand to sandy silt till deposit, and measured plastic limits of 13 and 15 percent, liquid limits of 16 and 18 percent, and plasticity indices of about 3 percent. The test results, which are plotted on a plasticity chart on Figure G6, indicate that this material is essentially non-plastic.

The measured SPT “N” values within the deposit range from 49 blows to greater than 100 blows per 0.3 m of penetration, but are typically greater than 100 blows per 0.3 m of penetration, indicative of a very dense relative density.

4.2.7 Lower Clayey Silt Till

A lower deposit of clayey silt till was encountered below the silty sand to sandy silt till in Boreholes 031-30, 033-15, 221-18 and 221-19. These boreholes encountered the surface of the till deposit at depths between 6.1 m and 12.2 m below ground surface, between Elevation 136.6 m and 117.5 m and were terminated within this deposit, after penetrating it for 0.3 m to 3.1 m.

The lower till deposit consists of clayey silt with sand and trace to some gravel. In Borehole 031-30, a layer of silty sand was encountered within the deposit at a depth of about 9 m and boulders were encountered in Borehole 033-15 at a depth of 13.7 m below ground surface, corresponding to Elevation 116.4 m. The result of a grain size distribution test completed on one selected sample of the lower till is shown on Figure A3 in Appendix A.

Atterberg limits testing was completed on four samples of the deposit and measured plastic limits of 6 to 14 percent, liquid limits of 15 to 23 percent, and plasticity indices of 4 to 12 percent. These test results, which are plotted on a plasticity chart on Figures A4 and G7 in Appendices A and G respectively, indicate that this material is a clayey silt of low plasticity.

The measured SPT “N” values within the deposit ranged from 45 blows to greater than 100 blows per 0.3 m of penetration, but are typically greater than 100 blows per 0.3 m of penetration, suggesting a hard consistency.



4.2.8 Clayey Silt (Residual Soil)

A clayey silt residual soil (transition to shale bedrock) was encountered in Borehole 053-18 underlying the silty sand to sandy silt till at a depth of about 18.3 m (Elevation 134.4 m). The borehole was terminated within the residual soil layer at Elevation 133.4 m, after penetrating it for approximately 1 m.

An Atterberg limits test was carried out on a sample on the residual soil and measured a plastic limit of 19 percent, a liquid limit of 24 percent, and a plasticity index of 5 per cent. The test result, which is plotted on a plasticity chart on Figure F3, indicates that the residual soil is a clayey silt of low plasticity.

The two measured SPT "N" values within the residual soil deposit are greater than 100 blows per 0.3 m of penetration, suggesting a hard consistency.

4.3 Groundwater Conditions

In the boreholes drilled for the foundation investigations in the 1960s, the groundwater level was measured after a minimum period of 24 hours, as noted on the borehole records contained in Appendices A to F. The water level in these boreholes was measured to be between ground surface and 6.9 m below ground surface. In the boreholes drilled for the foundation investigation for the high mast light poles in 1998, the water level was observed immediately upon completion of drilling, as noted on the borehole records in Appendix G. The water level was observed a depth of 6.0 m below ground surface in Borehole 221-19, and Borehole 221-18 was observed to be wet at 8.1 m upon completion of drilling.

The groundwater conditions encountered in the boreholes from the previous investigations are summarized below.

Borehole No.	Depth to Groundwater Level	Groundwater Elevation (m)	Comments
031-30	1.1 m	122.5	Measured 1 week after completion of drilling (January 13, 1967)
033-15	4.6 m	125.6	Measured 1 day after completion of drilling (January 20, 1967)
040-53	2.1 m	119.7	Measured 6 days after completion of drilling (May 8, 1967)
042-21	Ground surface	131.2	Measured at least 1 day after completion of drilling, possibly influenced by rain (October 26, 1967)
042-26	1.7 m	135.4	Measured at least 1 day after completion of drilling (November 1, 1967)
046-5	2.7 m	144.2	Measured at least 1 day after completion of drilling (August 2, 1967)
046-17	6.9 m	141.7	Measured at least 1 day after completion of drilling (July 31, 1967)
049-8	2.3 m	136.9	Measured at least 1 day after completion of drilling (November 15, 1965)
053-18	1.2 m	151.6	Measured 1 day after completion of drilling (December 16, 1966)
221-6	Dry to 14.0 m	-	Measured upon completion of drilling (September 20, 1998)
221-7	Dry to 13.0 m	-	Measured upon completion of drilling (September 20, 1998)
221-14	Dry to 6.6 m	-	Measured upon completion of drilling (September 20, 1998)
221-18	5.6 m	135.3	Seepage measured upon during drilling (September 20, 1998)



FINAL FOUNDATION REPORT - OVERHEAD SIGNS HIGHWAY 427 NB COLLECTOR REHABILITATION

Borehole No.	Depth to Groundwater Level	Groundwater Elevation (m)	Comments
221-19	6.0 m	136.9	Measured upon completion of drilling (September 20, 1998)
221-20	Dry to 6.6 m	-	Measured upon completion of drilling (September 20, 1998)
221-23	Dry to 12.3 m	-	Measured upon completion of drilling (September 20, 1998)
221-26	Dry to 6.5 m	-	Measured upon completion of drilling (September 20, 1998)

The above-noted water level readings may not represent the stabilized groundwater level at the site. Further, the groundwater level will be subject to seasonal variations, and will tend to be higher during wet periods of the year.

5.0 CLOSURE

This Foundation Investigation Report was prepared by Mr. Antony Tomory, EIT, and reviewed by Ms. Lisa Coyne, P.Eng., a geotechnical engineer and Principal with Golder. Mr. Jorge Costa, P.Eng., a Designated MTO Contact for Golder, conducted an independent review of this report.

Antony Tomory, EIT
Geotechnical Engineer in Training

Lisa Coyne, P.Eng.
Geotechnical Engineer, Principal



Jorge M. A. Costa, P. Eng.
Designated MTO Contact, Principal

AT/LCC/JMAC/at/jl

n:\active\2010\1111\10-1111-0011 urs - highway 427 nbl rehab - toronto\5 - reports\final\10-1111-0011 rpt 11jun overhead sign foundations.docx



PART B

**FOUNDATION DESIGN REPORT
OVERHEAD SIGNS**

**REHABILITATION OF HIGHWAY 427 NORTHBOUND COLLECTOR LANES
BETWEEN THE GARDINER EXPRESSWAY AND HIGHWAY 401**

TORONTO, ONTARIO

G.W.P. 2220-03-00



6.0 FOUNDATION ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides foundation design recommendations for the detail design for replacement of 20 overhead signs associated with the rehabilitation of Highway 427, from the Gardiner Expressway to Highway 401 in the City of Toronto. The recommendations are based on interpretation of the factual data obtained from boreholes advanced during previous subsurface investigations carried out by or on behalf of MTO. The discussion and recommendations presented are intended to provide the designers with sufficient information to assess the feasible foundation alternatives and to carry out the design of the structure foundations.

Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project, and for which special provisions or operational constraints may be required in the Contract Documents. Those requiring information on the aspects of construction should make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.\

6.2 Caisson Foundations for Overhead Signs

Caisson foundations for overhead sign supports should be designed in accordance with the requirements in MTO's *Sign Support Manual* (April 2007). The *Sign Support Manual* includes a standard caisson foundation design (Section 4 and Standard Drawings SS118-3, SS118-4 and SS118-5 for Tri-Chord Static Sign Supports), in which the caisson are extended 5 m below the design frost depth. Assuming a frost penetration depth of 1.2 m for the Toronto area, as per Ontario Provincial Standard Drawing (OPSD) 3090.101 (Foundation Frost Depth for Southern Ontario), the standard caisson foundation would have a total length of 6.2 m below grade for this project. The standard design is based on the following minimum soil conditions:

- **Case 1 (Cohesionless Soils):** Sand with a friction angle of 28 degrees surrounding the upper two-thirds of the portion of the caisson foundation below the frost depth, and sand with a friction angle of 30 degrees surrounding the lower third of the portion of the caisson below the design frost depth.
- **Case 2 (Cohesive Soils):** Soft clay with an undrained shear strength of 25 kPa surrounding the upper two-thirds of the portion of the caisson foundation below the frost depth, and "soft" clay with an undrained shear strength of 50 kPa surrounding the lower third of the portion of the caisson below the design frost depth.

The standard foundation design provided in MTO's *Sign Support Manual* does not apply to sites where extensive poor fill materials or materials softer than those of Case 2 are present. For such subsurface conditions, a site-specific design is required.

Based on the review of the available borehole information, the soil conditions at 17 of the 20 proposed overhead sign locations have friction angles and/or undrained shear strengths that exceed the input parameters used in the modelling of the standard caisson foundations and, therefore, the standard caisson foundation design is suitable for these sites. However, "weaker" soils are present at three of the proposed overhead sign locations, and a site-specific foundation design will be required at these locations as summarized below:



FINAL FOUNDATION REPORT - OVERHEAD SIGNS HIGHWAY 427 NB COLLECTOR REHABILITATION

Approximate Location, Overhead Sign Station (Collector Chainage)	Borehole No.	Appendix	Standard Foundation Design	Site-Specific Foundation Design
Station 10+240	221-6	G		✓
Station 10+518	221-7	G	✓	
Station 10+700	040-53	B		✓
Station 10+977	031-30	A		✓
Station 11+698	033-15	A	✓	
Station 12+189	042-21	C	✓	
Station 12+390	221-14	G	✓	
Station 12+509	042-26	C	✓	
Station 12+940	049-8	E	✓	
Station 13+243	221-18	G	✓	
Station 13+544	221-19	G	✓	
Station 10+158 (Rathburn Road Off- Ramp)	221-19	G	✓	
Station 13+900	221-20	G	✓	
Station 14+250	221-23	G	✓	
Station 14+318	221-23	G	✓	
Station 15+230	221-26	G	✓	
Station 15+600	046-5	D	✓	
Station 15+905	046-17	D	✓	
Station 16+187	053-18	F	✓	

The site-specific foundation design for the three overhead sign sites noted above (Stations 10+240, 10+700 and 10+977) should be carried out by the structural designer using the recommendations provided below and the geotechnical parameters provided in Table 1 following the text of this report. The standard design for the remaining sites can be optimized if desired by the structural engineer, based on the parameters provided in Table 1 following the text of this report.

The site-specific caisson foundation design may be carried out using the following equations to calculate the unfactored passive lateral earth pressure, P_p (kPa), distributed along the length of the caisson foundation; this earth pressure distribution is triangular with depth:

$$P_p = K_p \gamma d_w \quad \text{above the groundwater table, and}$$

$$P_p = K_p \gamma d_w + K_p \gamma' (d - d_w) \quad \text{below the groundwater table.}$$



where K_p is the passive earth pressure coefficient;
 γ is the bulk unit weight (kN/m^3);
 γ' is the effective unit weight below the groundwater level (kN/m^3);
 d is the depth below the ground surface (m); and
 d_w is the depth to the groundwater level (m).

The stratigraphy and design parameters for the subsurface conditions encountered in the boreholes at the overhead sign locations are given in Table 1 following the text of this report. Since the time of the initial borehole investigations, varying amounts of fill have been placed along some section of the highway. Geotechnical data for the fill is available at some of the overhead sign locations where boreholes have been advanced more recently (i.e., near Boreholes 221-6, 221-7, 221-14, 221-18, 221-19, 221-20, 221-23 and 221-26). At locations where no geotechnical data is available for the fill, soil parameters have been assumed to have the properties of an engineered fill, as it is assumed that the fill was placed in a controlled manner and compacted during the construction of Highway 427. The effective internal friction angle of the fill has been estimated to be between 28° and 30° based on the SPT “N” values and plasticity indices obtained at those boreholes that were advanced through the Highway 427 embankment fill. Therefore, for design, the fill placed to raise the highway grade has been assumed to have an effective internal friction angle of 28° and a unit weight of 20 kN/m^3 .

In the design of the foundations, the passive resistance within the upper 1.2 m below ground surface should be neglected to account for frost action. The unfactored lateral resistance should be calculated assuming an equivalent width equal to three times the caisson diameter. A resistance factor of 0.5 should be applied to the unfactored lateral resistance to obtain the factored lateral geotechnical resistance at Ultimate Limit States (ULS).

Where an undrained shear strength, S_u , is provided for a cohesive soil layer in Table 1, the capacity of the caisson should be checked to determine whether the drained or undrained case will govern. In this case, the lateral resistance for the length of the caisson within the cohesive soil should be calculated assuming an unfactored passive lateral pressure distribution varying from $2 S_u$ at the surface to $9 S_u$ at and below a depth equivalent to three caisson diameters, acting over the actual width of the caisson. A resistance factor of 0.5 should be applied to this calculated lateral resistance in order to obtain the factored lateral geotechnical resistance at ULS.

6.3 Construction Considerations

Water-bearing silty sand to sandy silt till and potentially water-bearing cohesionless soils lenses or interlayers within the cohesive tills are present at this site. “Perched” groundwater may also be encountered at the base of cohesionless fill materials, atop the underlying, less permeable clayey silt till deposit. Wet cohesionless soils should be expected to run or flow into the caisson hole during or after drilling for the foundations. Therefore, temporary or permanent caisson liners are recommended to minimize ground loss during drilling and concrete placement.



FINAL FOUNDATION REPORT - OVERHEAD SIGNS HIGHWAY 427 NB COLLECTOR REHABILITATION

Cobbles and/or boulders were encountered in some of the boreholes drilled near the sign support locations, as noted on the borehole records and discussed in Section 4.2.6 and 4.2.7. Appropriate equipment and procedures will be required to penetrate the cobbles and/or boulders as part of caisson installation for the overhead sign supports.

It is recommended that a Non-Standard Special Provision (NSSP) be included in the Contract Documents to warn the Contractor of the potential presence of wet cohesionless soils and the potential presence of cobbles and boulders within the glacial till deposits, which may affect the installation of the overhead sign caisson foundations at this site. Sample NSSPs to address these conditions are included in Appendix H.

7.0 CLOSURE

This Foundation Design Report was prepared by Mr. Antony Tomory, EIT, and reviewed by Ms. Lisa Coyne, P.Eng., a geotechnical engineer and Principal with Golder. Mr. Jorge Costa, P.Eng., a Designated MTO Contact for Golder, conducted an independent review of this report.

Antony Tomory, EIT
Geotechnical Engineer in Training

Lisa Coyne, P.Eng.
Geotechnical Engineer, Principal

Jorge M. A. Costa, P. Eng.
Designated MTO Contact, Principal
AT/LCC/JMAC/at/jl

n:\active\2010\1111\10-1111-0011 urs - highway 427 nbl rehab - toronto\5 - reports\final\10-1111-0011 rpt 11jun overhead sign foundations.docx



REFERENCES

- Chapman, L.J., and Putnam, D.F., 1984. *The Physiography of Southern Ontario*, 3rd Edition. Ontario Geological Survey, Special Volume 2. Ontario Ministry of Natural Resources.
- Ministry of Transportation, Ontario, 2007. *Sign Support Manual*. Policy, Planning & Standards Division, Engineering Standard Branch, Bridge Office.
- NAVFAC, 1982. *Design Manual DM 7.2: Soil Mechanics, Foundation and Earth Structures*. U.S. Navy. Alexandria, Virginia.

Ontario Provincial Standard Drawings (OPSD)

OPSD 3090.101 Foundation Frost Depths for Southern Ontario



FINAL FOUNDATION REPORT - OVERHEAD SIGNS HIGHWAY 427 NB COLLECTOR REHABILITATION

TABLE 1 - GEOTECHNICAL DESIGN PARAMETERS FOR OVERHEAD SIGN FOUNDATIONS
G.W.P. 2220-03-00

Sign Station	Current G.S. Elevation at Sign Location (m)	Borehole No.	Stratum	Depth ¹ (m)	Elevation (m)	Design Groundwater Elevation (m)	S _u kPa	φ'	γ kN/m ³	γ' kN/m ³	K _p
10+240	126.9	221-6	Asphalt/Sand and gravel fill	0.0 – 0.4	126.9 – 126.5	115	-	-	-	-	-
			Stiff clayey silt fill	0.4 – 9.8	126.5 – 117.1		50	28°	20	-	2.8
			Hard clayey silt till	9.8 – 13.9	117.1 – 113.0		-	35°	22	12	3.7
			Very dense silty sand till	Below 13.9	Below 113.0		-	35°	21	11	3.7
10+518	128.6	221-7	Asphalt/Sand and gravel fill	0.0 – 1.2	128.6 – 127.4	116	-	-	-	-	-
			Stiff to very stiff clayey silt fill	1.2 – 9.4	127.4 – 119.2		-	30°	21	-	3.0
			Loose to compact organic sand fill and probable fill	9.4 – 12.5	119.2 – 116.1		-	26°	18	-	2.6
			Clayey silt till	Below 12.5	Below 116.1		-	35°	22	12	3.7
10+700	126.8	040-53	Engineered fill	0.0 – 4.9	126.8 – 121.9	120	-	28°	20	-	2.8
			Very dense clayey silt till	4.9 – 10.8	121.9 – 116.0		-	35°	22	12	3.7
10+977	128.2	031-30	Engineered fill	0.0 – 4.6	128.2 – 123.6	123	-	28°	20	-	2.8
			Very dense silty sand to sandy silt till	4.6 – 10.7	123.6 – 117.5		-	35°	21	11	3.7
			Hard clayey silt till	Below 10.7	Below 117.5		-	35°	22	12	3.7
11+698	130.3	033-15	Engineered fill	0.0 – 0.2	130.3 – 130.1	126	-	28°	20	-	2.8
			Very stiff to hard clayey silt till	0.2 – 2.6	130.1 – 127.7		-	30°	21	-	3.0
			Very dense sand and silt till / sandy silt till	2.6 – 12.3	127.7 – 118.0		-	35°	21	11	3.7
			Hard clayey silt till	Below 12.3	Below 118.0		-	35°	22	12	3.7
12+189	132.2	042-21	Engineered fill	0.0 – 1.0	132.2 – 131.2	130	-	28°	20	-	2.8
			Hard clayey silt till	1.0 – 6.4	131.2 – 125.8		-	35°	22	12	3.7
			Very dense silty sand till	Below 6.4	Below 125.8		-	35°	21	11	3.7
12+390	134.2	221-14	Asphalt/Sand and gravel fill	0.0 – 0.6	134.2 – 133.6	132	-	-	-	-	-
			Stiff clayey silt fill	0.6 – 1.9	133.6 – 132.3		50	28°	20	-	2.8
			Hard clayey silt till	1.9 – 6.0	132.3 – 128.2		-	35°	22	12	3.7
			Very dense sandy silt to silty sand till	Below 6.0	Below 128.2		-	35°	21	11	3.7
12+509	137.1	042-26	Stiff to hard clayey silt	0.0 – 5.2	137.1 – 131.9	136	-	32°	22	11	3.3
			Hard clayey silt till	5.2 – 6.4	131.9 – 130.7		-	35°	21	11	3.7
			Very dense silty sand till	Below 6.4	Below 130.7		-	35°	21	11	3.7
12+940	140.0	049-8	Engineered fill	0.0 – 0.8	140.0 – 139.2	137	-	28°	20	-	2.8
			Loose to compact fill	0.8 – 3.1	139.2 – 136.9		-	28°	18	8	2.8
			Hard clayey silt till	Below 3.1	Below 136.9		-	35°	22	12	3.7



FINAL FOUNDATION REPORT - OVERHEAD SIGNS HIGHWAY 427 NB COLLECTOR REHABILITATION

Sign Station	Current G.S. Elevation at Sign Location (m)	Borehole No.	Stratum	Depth ¹ (m)	Elevation (m)	Design Groundwater Elevation (m)	S _u kPa	φ'	γ kN/m ³	γ' kN/m ³	K _p
13+243	140.9	221-18	Asphalt/Crushed gravel	0.0 – 0.4	140.9 – 140.5	138	-	-	-	-	-
			Very stiff clayey silt fill/Compact sand and gravel fill	0.4 – 1.5	140.5 – 139.4		-	30°	20	-	3.0
			Very stiff to hard clayey silt till	1.5 – 3.5	139.4 – 137.4		-	32°	20	-	3.3
			Very dense silty sand till	3.5 – 7.8	137.4 – 133.1		-	35°	21	11	3.7
			Hard clayey silt till	Below 7.8	Below 133.1		-	35°	22	12	3.7
13+544 and Rathburn Off-Ramp, 10+158	142.9	221-19	Asphalt/Crushed gravel	0.0 – 0.3	142.9 – 142.6	140	-	-	-	-	-
			Clayey silt fill	0.3 – 1.5	142.6 – 141.4		-	28°	20	-	2.8
			Stiff to hard clayey silt till	1.5 – 4.0	141.4 – 138.9		-	30°	20	10	3.0
			Very dense silty sand till	4.0 – 6.3	138.9 – 136.6		-	35°	21	11	3.7
			Hard clayey silt till	Below 6.3	Below 136.6		-	35°	22	12	3.7
13+900	144.5	221-20	Asphalt/Crushed gravel	0.0 – 0.4	144.5 – 144.1	142	-	-	-	-	-
			Loose sand fill	0.4 – 0.9	144.1 – 143.6		-	28°	20	-	2.8
			Very stiff to hard clayey silt till	0.9 – 6.1	143.6 – 138.4		-	35°	21	11	3.7
			Dense sandy silt till	Below 6.1	Below 138.4		-	35°	21	11	3.7
14+250 and 14+318	146.5	221-23	Asphalt/Crushed gravel	0.0 – 0.4	146.5 – 146.1	143	-	-	-	-	-
			Stiff to hard clayey silt till	0.4 – 11.7	146.1 – 134.8		-	32°	22	12	3.3
			Very dense silty sand till	Below 11.7	Below 134.8		-	35°	21	11	3.7
15+230	146.2	221-26	Asphalt/Crushed gravel	0.0 – 0.3	146.2 – 145.9	143	-	-	-	-	-
			Clayey silt fill	0.3 – 1.2	145.9 – 145.0		-	28°	20	-	2.8
			Hard clayey silt till	Below 1.2	Below 145.0		-	32°	22	12	3.3
15+600	147.4	046-5	Engineered fill	0.0 – 0.5	147.4 – 146.9	145	-	28°	20	-	2.8
			Stiff to hard clayey silt till	0.5 – 8.6	146.9 – 138.8		-	35°	22	12	3.7
15+905	149.9	046-17	Engineered fill	0.0 – 1.3	149.9 – 148.6	146	-	28°	20	-	2.8
			Very stiff to hard clayey silt till	1.3 – 10.6	148.6 – 139.3		-	32°	21	11	3.3
16+187	150.4	053-18	Hard clayey silt till	0.0 – 7.7	150.4 – 142.7	150	-	35°	21	11	3.7
			Very dense sandy silt to silty sand till	7.7 – 16.0	142.7 - 134.4		-	35°	21	11	3.7
			Hard clayey silt	Below 16.0	Below 134.4		-	35°	22	12	3.7

Prepared By: AT
Reviewed By: LCC



FINAL FOUNDATION REPORT - OVERHEAD SIGNS HIGHWAY 427 NB COLLECTOR REHABILITATION

NOTES:

1. Depths are given at the borehole location relative to present (2011) estimated ground surface; the ground surface elevation at the borehole location should be compared to the ground surface elevation at the actual sign support location, and the depths of the soil strata adjusted accordingly.
2. Design parameters:
 - s_u = undrained shear strength (kPa);
 - ϕ' = effective friction angle (degrees);
 - γ = bulk unit weight (kN/m³);
 - γ' = effective unit weight below the groundwater level (kN/m³); and
 - K_p = passive earth pressure coefficient.
3. Although the passive resistance in the upper 1.2 m is neglected to account for frost action, S_u , ϕ' and K_p parameters are given for the soil, and should be neglected for the asphalt/crushed granular layer, in the event that the ground surface elevation varies significantly between the borehole and sign support locations.

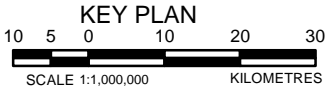
G:\Projects\2010\10-1111-0011_427Rehab\GIS\MXDs\Reporting\Dwg1ExistingBoreholeLocations.mxd



CONT No. G.W.P. No. 220-03-00	
HIGHWAY 427 REHABILITATION EXISTING BOREHOLE LOCATIONS AND PROPOSED OVERHEAD SIGN LOCATIONS	SHEET

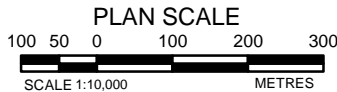


Golder Associates Ltd.
Mississauga, Ontario, Canada



NOTES:

1. Sign at station 11+340 will be located on existing retaining wall.



LEGEND
Existing Borehole Location
Overhead Sign Location (and Approximate Location by Reference to Station)

NOTES
The complete Foundation Investigation and Design Report for the project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE
Base Data - MNR NRVIS, obtained 2004, CANMAP v2006.4 Imagery - Bing Maps © 2009 Microsoft Corporation and its data suppliers Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queens Printer 2008 Projection: Transverse Mercator Datum: NAD 83 Coordinate System: MTM Zone 10

NO.	DATE	BY	REVISION

Geocres No. 30M11-238	PROJECT NO. 10-1111-0011	DIST.
HWY. 427		
SUBM'D. AT	CHKD. AT	DATE: 2/8/2011
DRAWN: ME	CHKD. JMAC	APPD.
		DWG. 1

G:\Projects\2010\10-1111-0011_427Rehab\GIS\MXDs\Reporting\DWG2\ExistingBoreholeLocations.mxd



CONT No.
G.W.P. No. 220-03-00

HIGHWAY 427 REHABILITATION
EXISTING BOREHOLE LOCATIONS
AND PROPOSED OVERHEAD
SIGN LOCATIONS

SHEET

Golder Associates Ltd.
Mississauga, Ontario, Canada

KEY PLAN

10 5 0 10 20 30

SCALE 1:1,000,000 KILOMETRES

NOTES:

1. Sign at Station 11+340 will be located on existing retaining wall.

PLAN SCALE

100 50 0 100 200 300

SCALE 1:10,000 METRES

LEGEND

Existing Borehole Location

Overhead Sign Location (and Approximate Location by Reference to Station)

NOTES

The complete Foundation Investigation and Design Report for the project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base Data - MNR NRVIS, obtained 2004, CANMAP v2006.4
Imagery - Bing Maps © 2009 Microsoft Corporation and its data suppliers
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: MTM Zone 10

NO.	DATE	BY	REVISION

Geocres No. 30M11-238

HWY. 427

PROJECT NO. 10-1111-0011

DIST.

SUBM'D. AT

CHKD. LCC

DATE: 2/8/2011

SITE:

DRAWN: ME

CHKD. JMAC

APPD.

DWG. 2

G:\Projects\2010\10-1111-0011_427Rehab\GIS\MXDs\Reporting\DWG3ExistingBoreholeLocations.mxd



CONT No.
G.W.P. No. 220-03-00

HIGHWAY 427 REHABILITATION
EXISTING BOREHOLE LOCATIONS
AND PROPOSED OVERHEAD
SIGN LOCATIONS

SHEET

Golder Associates Ltd.
Mississauga, Ontario, Canada

KEY PLAN

10 5 0 10 20 30

SCALE 1:1,000,000 KILOMETRES

100 50 0 100 200 300

SCALE 1:10,000 METRES

PLAN SCALE

Existing Borehole Location

Overhead Sign Location (and Approximate Location by Reference to Station)

NOTES

The complete Foundation Investigation and Design Report for the project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base Data - MNR NRVIS, obtained 2004, CANMAP v2006.4
Imagery - Bing Maps © 2009 Microsoft Corporation and its data suppliers
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: MTM Zone 10

NO.	DATE	BY	REVISION

Geocres No. 30M11-238

HWY. 427

PROJECT NO. 10-1111-0011

DIST.

SUBM'D. AT

CHKD. LCC

DATE: 2/8/2011

SITE:

DRAWN: ME

CHKD. JMAC

APPD.

DWG. 3



LIST OF SYMBOLS

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

I. GENERAL

π	3.1416
$\ln x$,	natural logarithm of x
\log_{10}	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety
V	volume
W	weight

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
ν	poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - \mu$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
μ	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_a	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

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

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

Notes: 1 $\tau = c' + \sigma' \tan \phi'$
2 shear strength = (compressive strength)/2



LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d :

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

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

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Cohesionless Soils

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

(b) Cohesive Soils Consistency

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

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO ₄	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

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

V. MINOR SOIL CONSTITUENTS

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



APPENDIX A

Borehole Records and Laboratory Test Results – GEOCRES NO. 30M11-031 and 30M11-033

031-30

GEOTECHNICAL DATA SHEET FOR BOREHOLE 3.0.

OUR REFERENCE NO. 8-12-13
Your Ref. No. W.J. 66-F-103

CLIENT: D. H. O.

PROJECT: FROM N. OF C. R. O'HEAD TO N. OF BLOOR ST.

LOCATION: 183,750 N. 207,350 E.

DATUM ELEVATION: G.S.C.

METHOD OF BORING: AUGERING

DIAMETER OF BOREHOLE: 3 1/2"

DATE: DEC. 29, 1966. JAN. 4, 1967.

W.P. 275-64-2

ENCLOSURE NO.

Elevation (m)	ELEVATION ft	DEPTH ft	STRATIFICATION DESCRIPTION	SYMBOL	SAMPLES		PENETRATION RESISTANCE blows per ft					CONSISTENCY water content %				REMARKS
					NUMBER	TYPE	2.0	4.0	6.0	8.0	10.0	W _p	W	W _L		
123.6	405.5	0	GROUND SURFACE													
			6" TOPSOIL													
			SILTY SAND with some Gravel and trace of Clay (glacial till)		1	S.S. 100/4									28 40 26 6	
			Very Dense		2	S.S. 100/4									W.L. 402.0 ft. JAN. 13, 1967.	
	400	5													16 44 33 7	
121.5	398.5	7	cobbles													
			SANDY SILT with some Clay (glacial till)		3	S.S. 100/2										
	395	10	Very Dense		4	S.S. 100/3										
	390	15	cobbles													
117.5	385.5	20	CLAYEY SILT (glacial till)		5	S.S. 100/2									W.L. 384.0 ft. JAN. 5, 1967.	
	385		Hard		6	S.S. 100/3										
	380	25														
114.4	375	30	SILTY SAND with some Clay and trace of Gravel		7	S.S. 100/3									5 50 28 17	
	375	30.3	Very Dense													
			END OF BOREHOLE at 30.3 ft.													
	370	35														
															GR SA SI CL — per cent —	

Note:

1. Based on Atterberg limits test results, Golder has interpreted Sample 3 to be "clayey silt till" of low plasticity, suggesting this deposit varies from "sandy silt till" to "clayey silt till".

033-15

GEOTECHNICAL DATA SHEET FOR BOREHOLE . . 15 . .

OUR REFERENCE NO. 6 - 12 - 13
Your Ref. No. W.J. 68 - F - 103

CLIENT: D. H. O.

PROJECT: FROM N. OF C.P.R. O'HEAD TO N. OF BLOOR ST.

LOCATION: 185,905 N. ; 206,955 E.

DATUM ELEVATION: G. S. C.

METHOD OF BORING: AUGERING

DIAMETER OF BORING: 3 1/2"

DATE: JAN. 19, 1967

W.P. 275 - 64 - 2

ENCLOSURE NO.

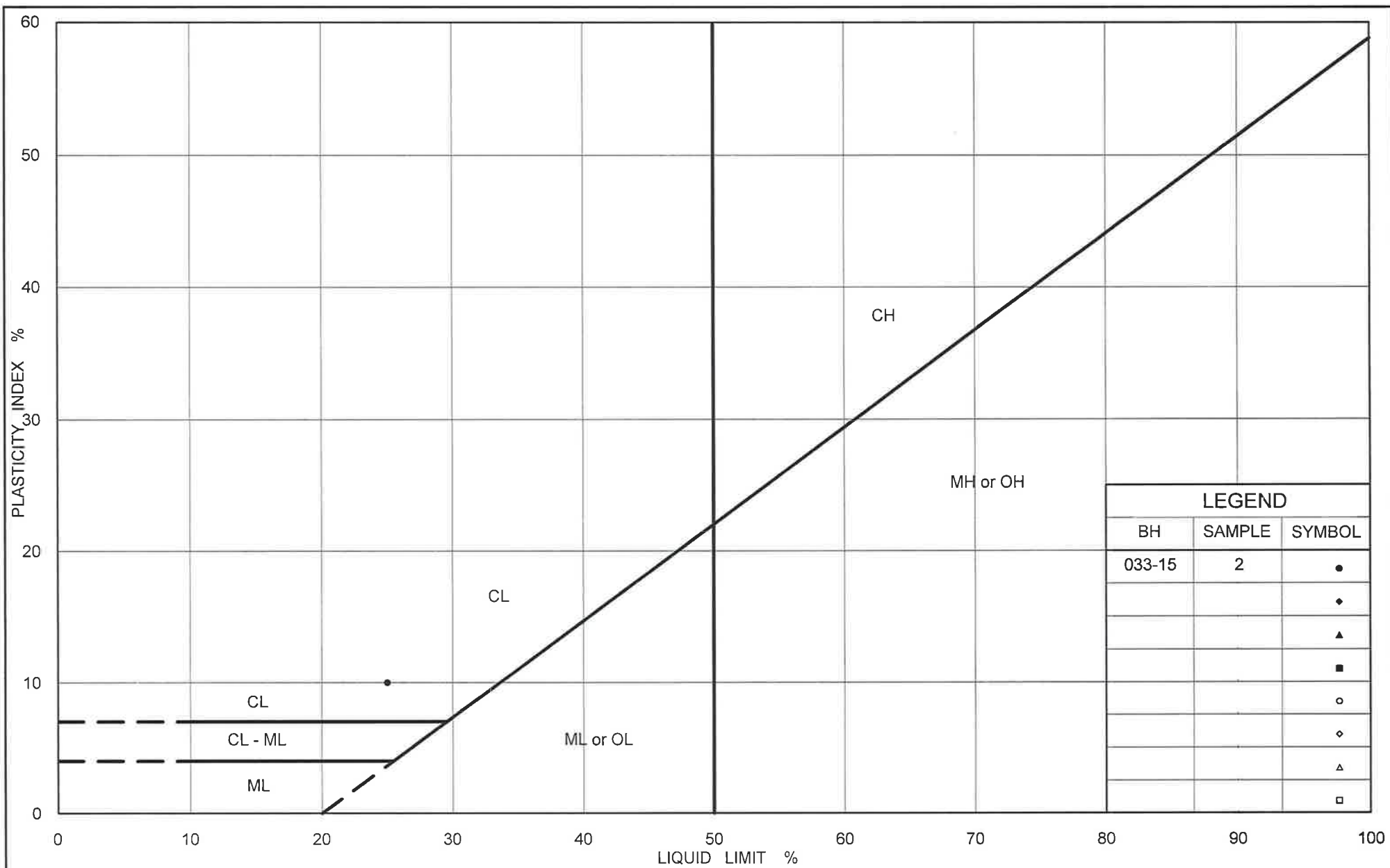
ELEVATION (m)	DEPTH (ft)	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLES			PENETRATION RESISTANCE					CONSISTENCY				REMARKS
				NUMBER	TYPE	28 Days Adjustment to Sample	20	40	60	80	100	WP	W	WL		
130.1	0	GROUND SURFACE														
127.7	5	CLAYEY SILT with sand and trace of gravel. V. Stiff Hard (Weathered Till) Mottled Brown		1	S.S.	10										
	10	SAND and SILT with some gravel and a trace of clay		2	S.S.	32										
	15	Boulders Brown Grey (Glacial Till) Very Dense		3	S.S.	100/5									12 40 40 8	
	20			4	S.S.	100/4									W.L. El. 412.0' JAN. 20, 1967	
	25	SANDY SILT with trace of clay and gravel (Glacial Till) Very Dense		5	S.S.	110									0 32 64 4	
	30			6	S.S.	100/6										
	35			7	S.S.	100/4									9 40 44 7	
	40			8	S.S.	100/4										
	45	CLAYEY SILT with sand (Glacial Till) Hard Boulder		9	S.S.	100/2										
	50	END OF BOREHOLE													GR SA SI CL — per cent —	

Date: June 2011

Project No: 10-1111-0011

Prepared By: SB Reviewed By: LCC





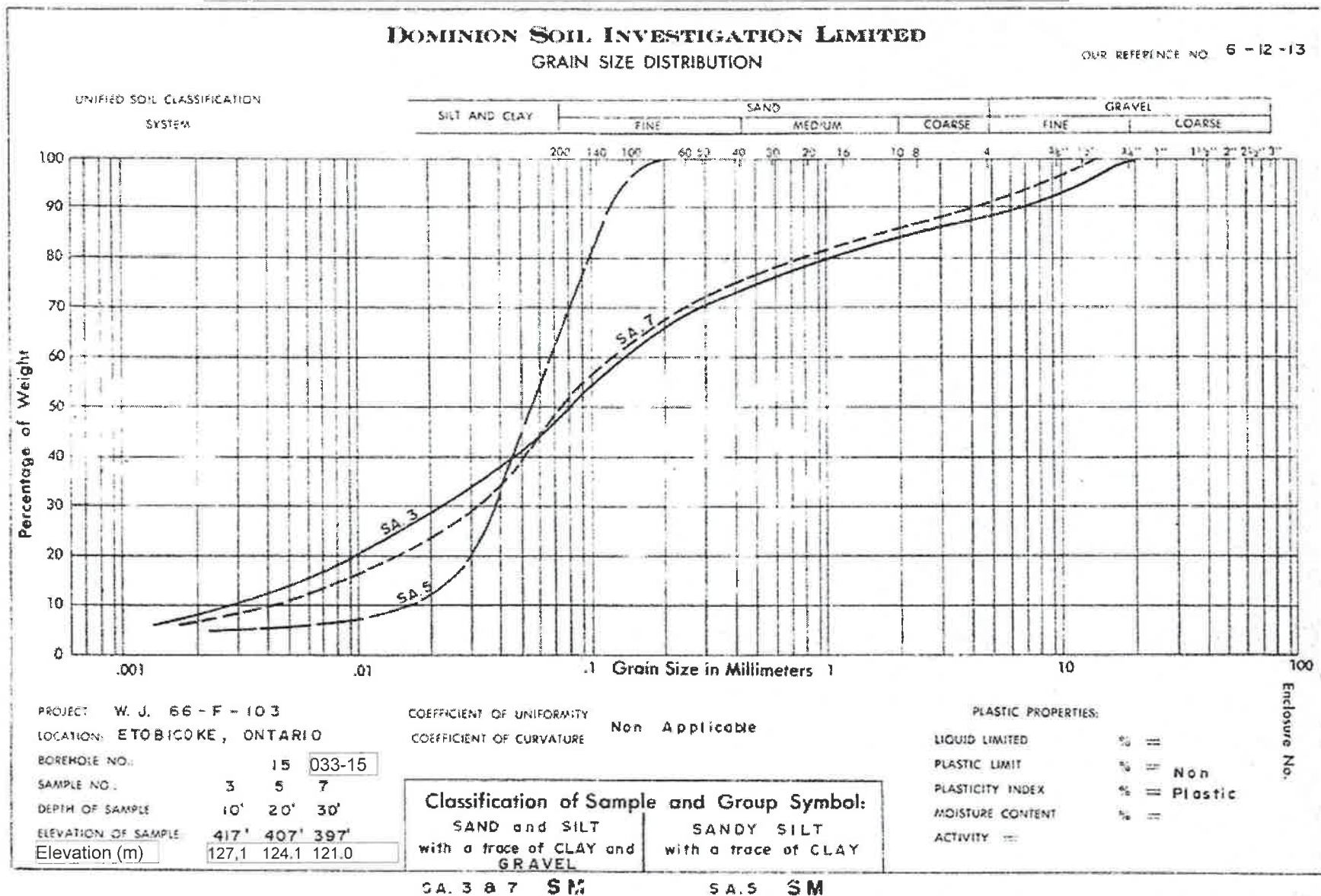
PLASTICITY CHART Upper Clayey Silt Till

Figure No. A1

Project No. 10-1111-0011

Checked By: LCC *llc*

Figure A2 – Grain Size Distribution– Sand and Silt to Sandy Silt Till



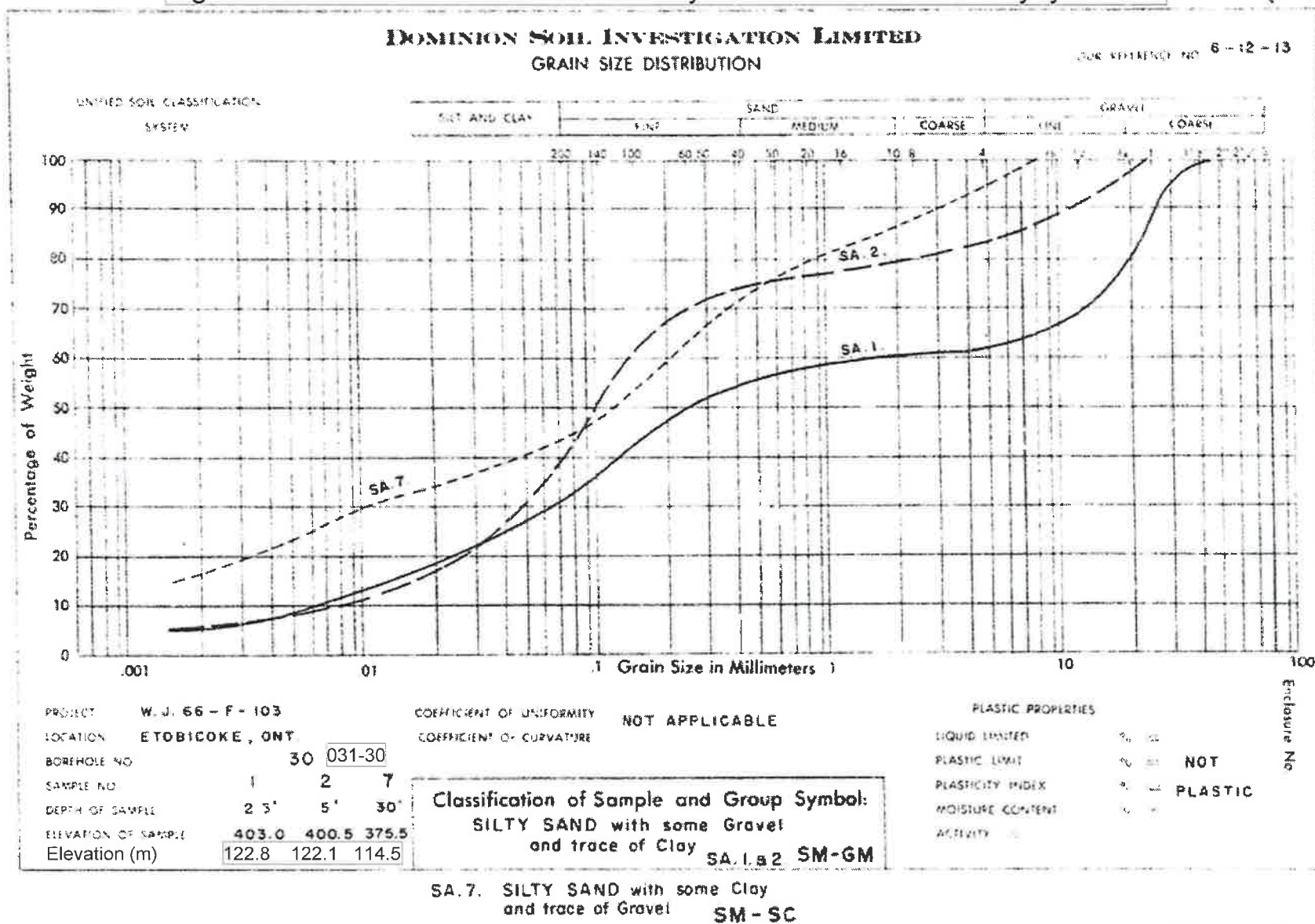
Date: June 2011

Project No: 10-1111-0011

Prepared By: SB Reviewed By: LCC *ll*



Figure A3 – Grain Size Distribution – Silty Sand Till and Lower Clayey Silt Till

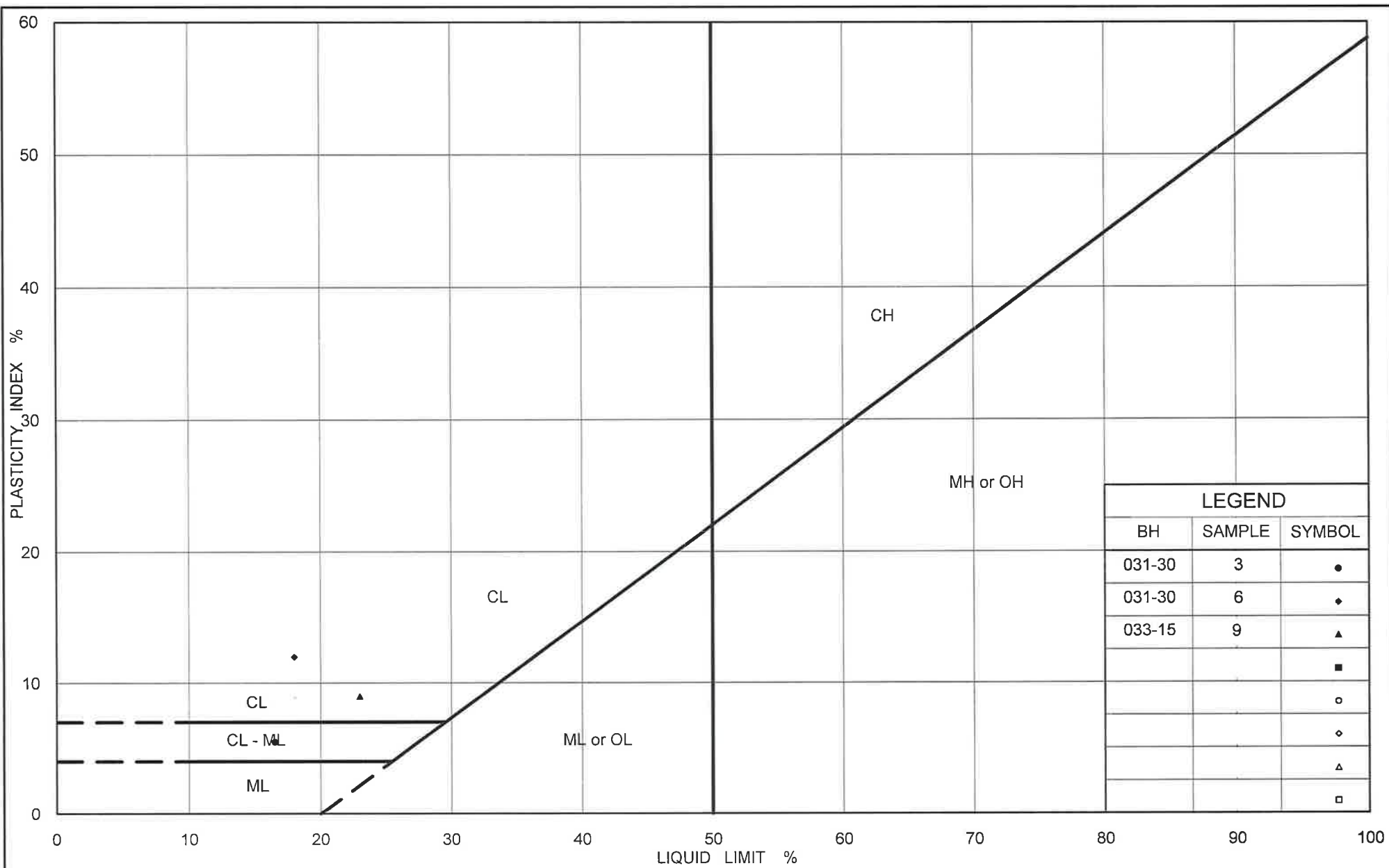


Date: June 2011

Project No: 10-1111-0011

Prepared By: SB Reviewed By: LCC *llc*





PLASTICITY CHART Lower Clayey Silt Till

Figure No. A4

Project No. 10-1111-0011

Checked By: LCC *[signature]*



APPENDIX B

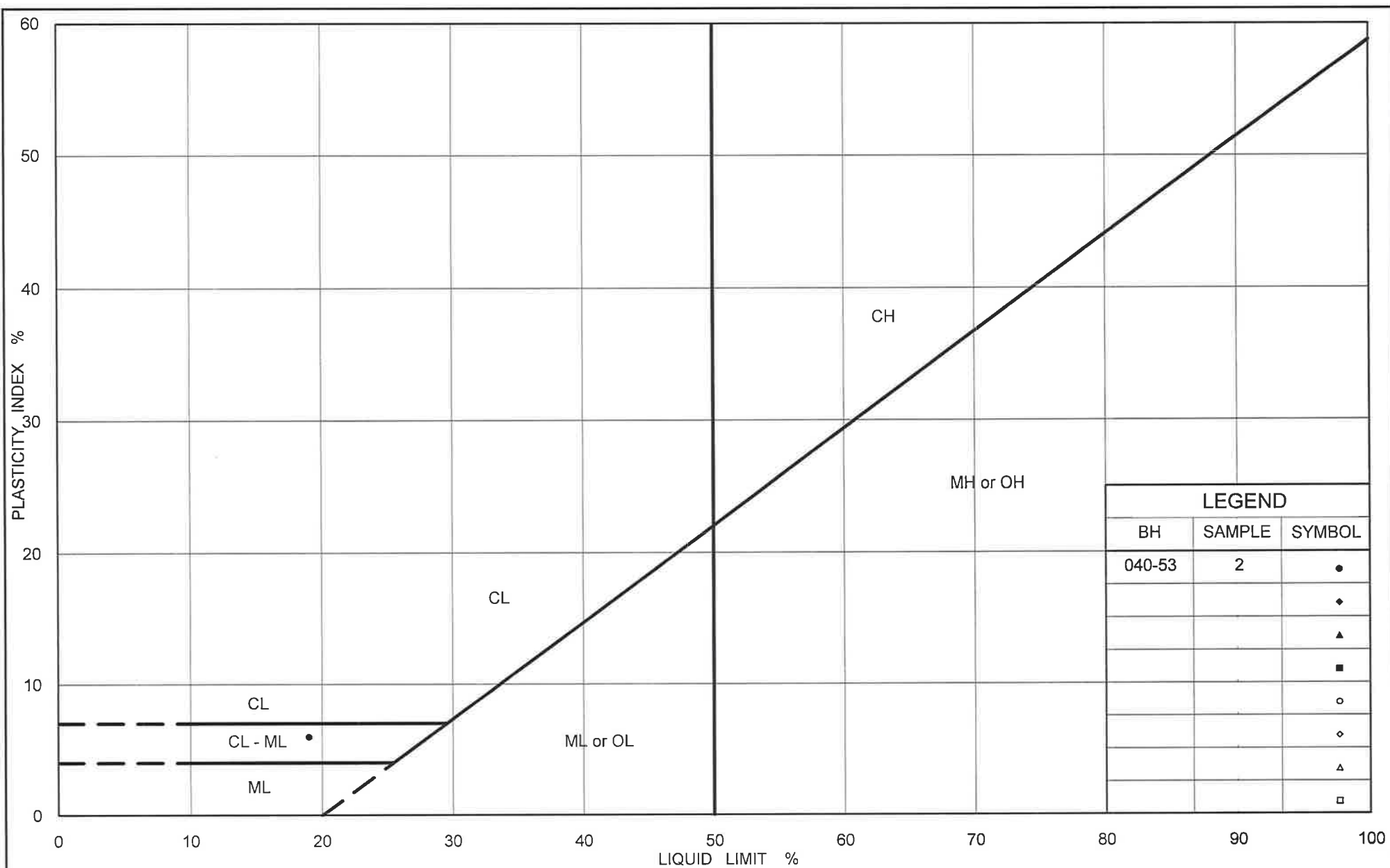
Borehole Records and Laboratory Test Results – GEOCRES NO. 30M11-040

DEPARTMENT OF HIGHWAYS - ONTARIO			RECORD OF BOREHOLE NO. 53				FOUNDATION SECTION		
MATERIALS & TESTING DIVISION			JOB 47-P-37 LOCATION Hwy. 27, 182,775 N; 207,805 E.				ORIGINATED BY AP		
W.P. 275-66-2			BORING DATE May 2, 1967				COMPILED BY AP		
DATUM Geodetic			BOREHOLE TYPE Bombardier Flight Auger				CHECKED BY		
SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — WL		BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	PLASTIC LIMIT — WP		
121.9	399.8	GROUND LEVEL							
	0.0	Silt to sandy silt, traces of gravel.							
			1	SS	71				
			2	SS	100/4"				
		Very dense.							
			3	SS	100/7 1/2"				
			4	SS	100/6"				
116.0	380.7	End of Borehole							
	19.1								

Note:

1. Based on Atterberg limits test results, Golder has interpreted Sample 2 as a "clayey silt" of low plasticity. The grain size distribution test result for Sample 4 contains only 2% clay-size particles. Therefore, this deposit is considered to vary from "silt" to "sandy silt" to "clayey silt".

2. According to the subsurface description in the original report, this deposit is likely a glacial till. Golder has therefore interpreted this deposit as a till.



PLASTICITY CHART Upper Clayey Silt Till

Figure No. B1

Project No. 10-1111-0011

Checked By: LCC *[Signature]*



APPENDIX C

Borehole Records and Laboratory Test Results – GEOCRES NO. 30M11-042

DEPARTMENT OF HIGHWAYS - ONTARIO			RECORD OF BOREHOLE NO. 21				FOUNDATION SECTION					
MATERIALS & TESTING DIVISION			JOB <u>67-R-101</u> LOCATION <u>Co-ord. 187,242 N; 206,232 E.</u>				ORIGINATED BY <u>SN</u>					
W.P. <u>275-64-2 & 3</u>			BORING DATE <u>Oct. 25, 1967</u>				COMPILED BY <u>AKB</u>					
DATUM <u>Geodetic</u>			BOREHOLE TYPE <u>Auger</u>				CHECKED BY <u>AKB</u>					
Elevation (m)	SOIL PROFILE		SAMPLES			DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT		LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W			SULK DENSITY P.C.F.	REMARKS WL at ground
	ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	WATER CONTENT % 10 20 30				
131.2	130.3	Ground Level										
	0.0	Clayey silt with sand and gravel. Hard. Brown		1	SS	52						
				2	SS	43						
128.3	120.8	Clayey silt to silt. Hard. Grey		3	SS	100/4"	120					
	9.5			4	SS	100/4"						
				5	SS	100/3"						
125.8	112.8	Silty sand, some gravel. Very dense. Grey		6	SS	100/4"	110					
	18.0			7	SS	100/3"						
121.9	109.8			8	SS	100/5"	100					
	30.5	End of Borehole										

Note:

1. According to the subsurface description in the original report the "clayey silt with sand and gravel", "clayey silt to silt" and "silty sand" deposits are likely a glacial till. Golder has therefore interpreted these layers as till deposits.

DEPARTMENT OF HIGHWAYS - ONTARIO										RECORD OF BOREHOLE NO. 26										FOUNDATION SECTION	
MATERIALS & TESTING DIVISION																					
JOB 67-F-101										LOCATION Co-ords. 188,325 N; 205,987 E.										ORIGINATED BY HS	
W.P. 275-64-2 & 3										BORING DATE Nov. 1, 1967										COMPILED BY AKB	
DATUM Geodetic										BOREHOLE TYPE Auger										CHECKED BY	
Elevation (m)	SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE			LIQUID LIMIT — WL			BULK DENSITY	REMARKS							
	ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	BLOWS / FOOT	SHEAR STRENGTH P.S.F.	PLASTIC LIMIT — WP	WATER CONTENT — W	WATER CONTENT %			P.C.F.						
137.1	142.7	Ground Level																			
	0.0	Clayey silt, traces of sand & gravel, some organics.		1	SS	12															
		Stiff to hard.		2	SS	63	1440														
		Brown		3	SS	177/11"															
131.9	132.7			4	SS	15															
130.7	129.7	Clayey silt with sand & gravel. Hard. Grey		5	SS	72	1430														
	21.0	Silty sand with gravel		6	SS	100/6"															
129.1	123.4	Very dense.		7	SS	100/4"															
	26.3	End of Borehole					1420														

Note:

1. According to the subsurface description in the original report the "clayey silt with sand and gravel" and the "silty sand with gravel" deposits are likely a glacial till. Golder has therefore interpreted these layers as till deposits.



APPENDIX D

Borehole Records and Laboratory Test Results – GEOCRES NO. 30M11-046

046-5

DEPARTMENT OF HIGHWAYS - ONTARIO				RECORD OF BOREHOLE NO. 5				FOUNDATION SECTION			
MATERIALS & TESTING DIVISION											
JOB 67-F-68				LOCATION Co-ord. 866,737 N.; 980,711 E.				ORIGINATED BY BRQ			
W.P. 201-62-1				BORING DATE August 2, 1967				COMPILED BY BRQ			
DATUM Geodetic				BOREHOLE TYPE Penn Drill				CHECKED BY <i>ll</i>			
Elevation (m)	SOIL PROFILE		SAMPLES			DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — WL		BULK DENSITY	REMARKS
	ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	BLOWS / FOOT	PLASTIC LIMIT — WP		
146.9	482.0	Ground Level							WATER CONTENT — W		
	0.0	Clayey silt with sand, traces of gravel some organics.		1	SS	12	480		Wp	Wl	
				2	SS	9					
		Stiff to hard.		3	SS	29	470				
				4	SS	70					
				5	SS	160/10"					
140.8	462.0			6	SS	100/5"	460				
	20.0	Silt to sandy silt, traces of clay and gravel. Very dense.									
138.8	455.5			7	SS	138					
	26.5	End of Borehole									

Note:

1. Based on Atterberg limits test results, Golder has interpreted the "silt to sandy silt" layer as a "clayey silt with sand".

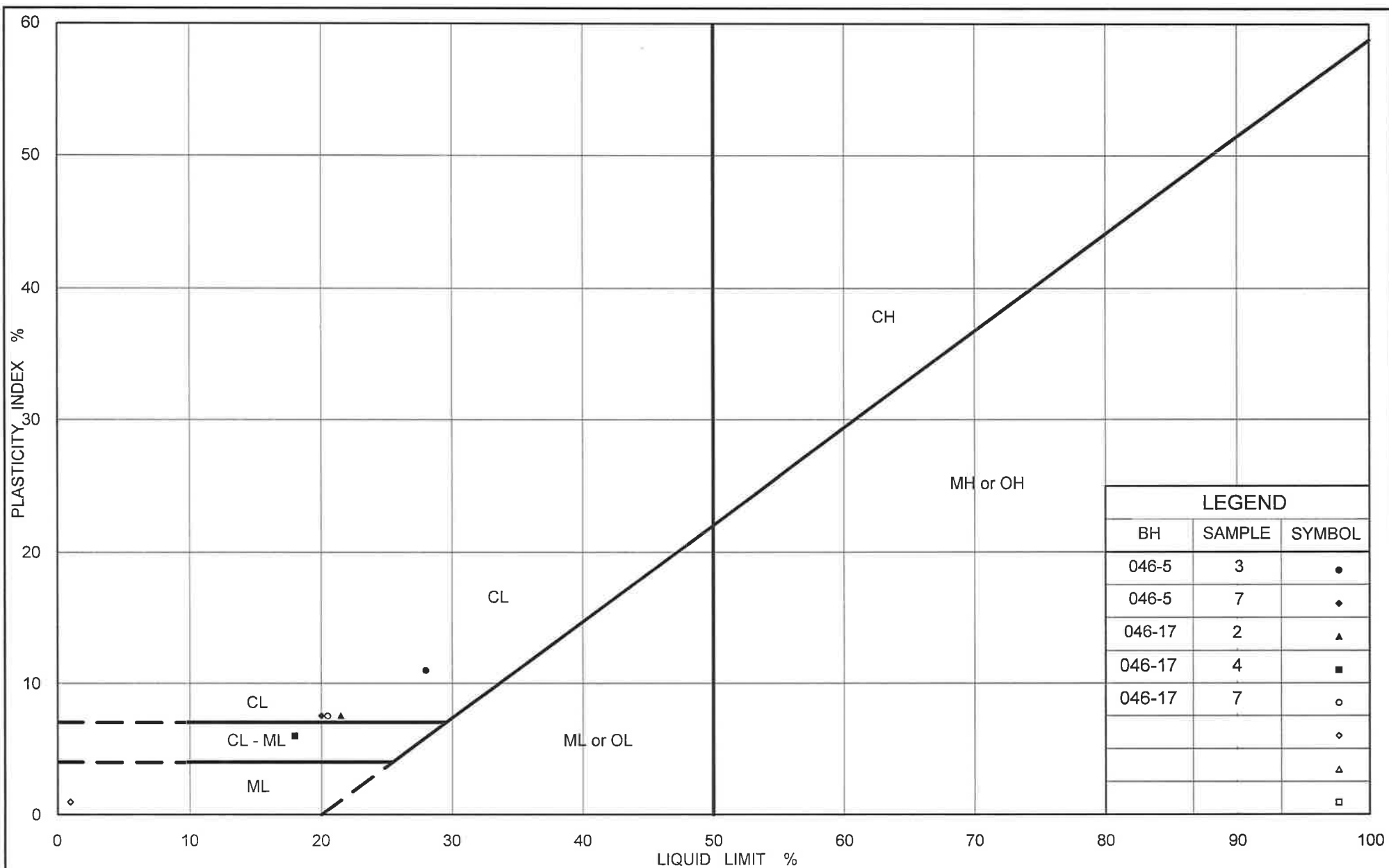
2. According to the subsurface description in the original report, these deposits are likely a glacial till. Golder has therefore interpreted the deposits as a till.

046-17

DEPARTMENT OF HIGHWAYS - ONTARIO			RECORD OF BOREHOLE NO. 17				FOUNDATION SECTION					
MATERIALS & TESTING DIVISION												
JOB <u>67-F-68</u>			LOCATION <u>Co-ord. 867,625 N.; 980,523 E.</u>				ORIGINATED BY <u>BRG</u>					
W.P. <u>201-62-1</u>			BORING DATE <u>July 31, 1967</u>				COMPILED BY <u>BRG</u>					
DATUM <u>Geodetic</u>			BOREHOLE TYPE <u>Penn Drill</u>				CHECKED BY <u>RL</u>					
Elevation (m)	SOIL PROFILE		SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT <u>WL</u>		BULK DENSITY	REMARKS
	ELEV. DEPTH	DESCRIPTION	STRAT. PLAT	NUMBER	TYPE		BLOWS / FOOT	BLOWS / FOOT	SHEAR STRENGTH P.S.F.	PLASTIC LIMIT <u>WP</u>		
148.6	487.5	Ground Level										
	0.0	Clayey silt with sand traces of gravel. Brown Grey Very stiff to hard.		1	SS	41	480					
				2	SS	52						
145.7				3	SS	22						
				4	SS	28						
				5	SS	34						
				6	SS	33						
				7	SS	39						
				8	SS	100/5"						
139.3	457.0											
	30.5	End of Borehole										

Note:

1. According to the subsurface description in the original report the "clayey silt with sand" deposit is likely a glacial till. Golder has therefore interpreted the "clayey silt" as a till.



PLASTICITY CHART Upper Clayey Silt Till

Figure No. D1

Project No. 10-1111-0011

Checked By: LCC *lee*



APPENDIX E

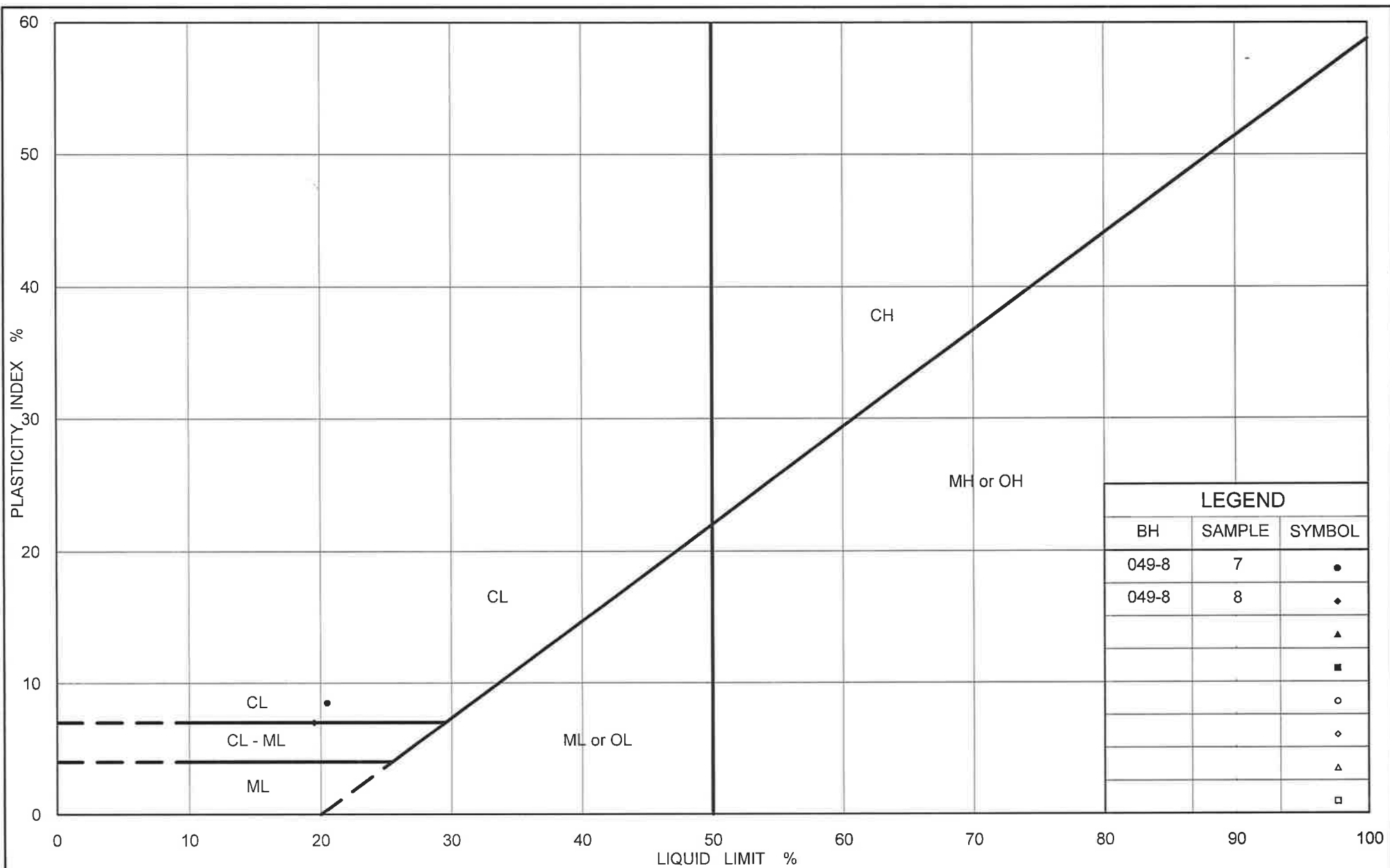
Borehole Records and Laboratory Test Results – GEOCRES NO. 30M11-049

DEPARTMENT OF HIGHWAYS - ONTARIO			RECORD OF BOREHOLE NO. 8			FOUNDATION SECTION			
MATERIALS & TESTING DIVISION			JOB 67-F-16			LOCATION Co-ords. 190,080 N; 205,752 E.			
W.P. 262-65			BORING DATE Nov. 15, 1965			ORIGINATED BY P.Mc.			
DATUM			BOREHOLE TYPE			COMPILED BY AKB			
CHECKED BY									
SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — WL		BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	PLASTIC LIMIT — WP	WATER CONTENT — W		
139.2	456.7	Ground Level							
	0.0	Sandy silt to sand.	1	SS	5				
		Traces of Gravel.	2	SS	9				
136.9		Compact (Fill)	3	SS	61				
		Sandy silt with gravel.	4	SS	75.5"				
			5	SS	75.7"				
		Very dense.	6	SS	111.8"				
			7	SS	110.4"				
			8	SS	100.6"				
			9	SS	130.6"				
126.9	416.2	End of Borehole							
	410.5								

Note:

1. Based on the grain size distribution and Atterberg limits test results, Golder has interpreted the "sandy silt with gravel" as "clayey silt with sand and gravel".

2. According to the subsurface description in the original report, the "sandy silt with gravel" is a glacial till. Golder has therefore interpreted the "sandy silt with gravel" as a "clayey silt till".



PLASTICITY CHART Upper Clayey Silt Till

Figure No. E1

Project No. 10-1111-0011

Checked By: LCC *lee*



APPENDIX F

Borehole Records and Laboratory Test Results – GEOCRES NO. 30M11-053

053-18

21) C.E.C. 4 + 13, 1966

W. F. 201-62-1

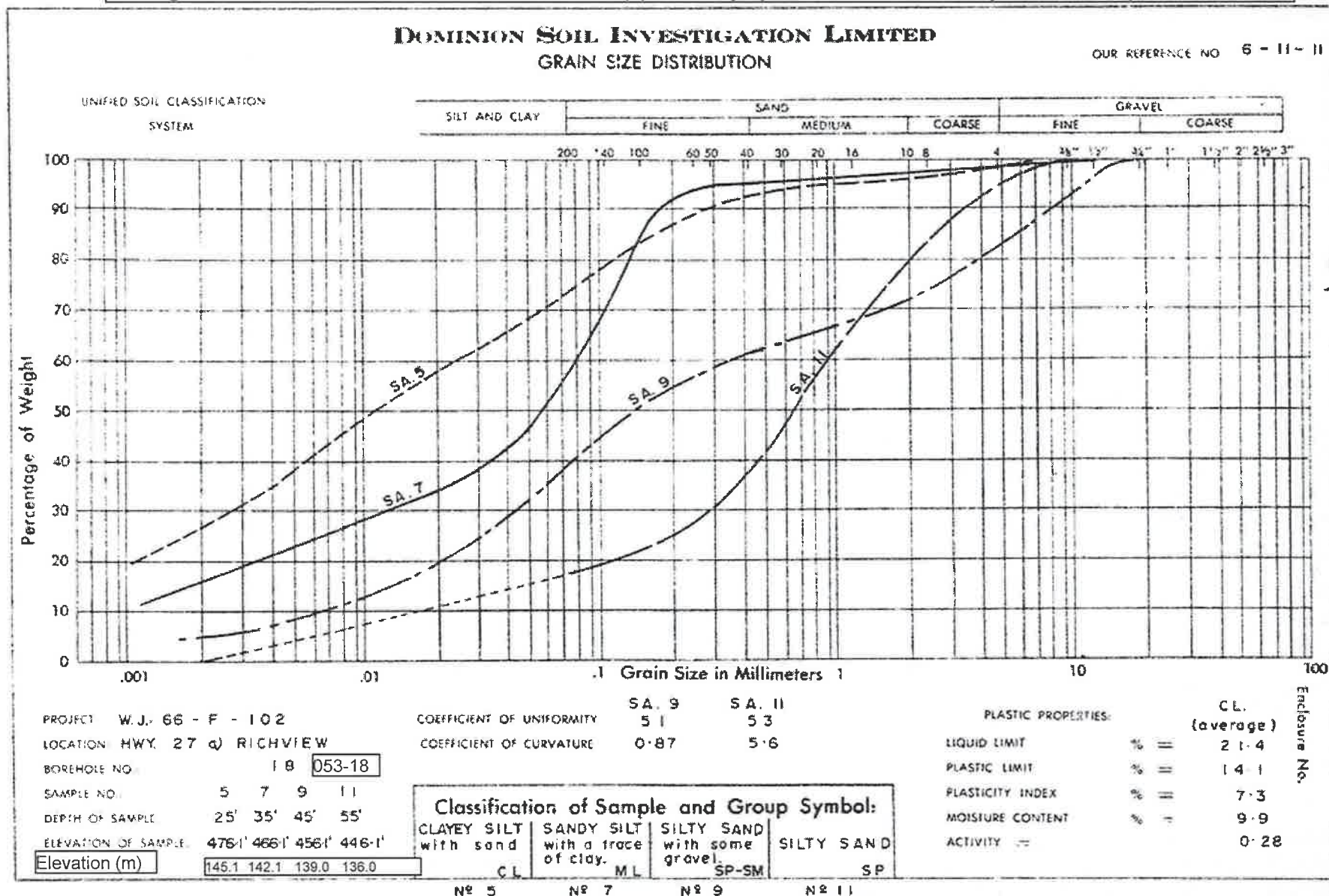
133.4

Note



**Golder
Associates**

Figure F1 - Grain Size Distribution – Upper Clayey Silt Till and Sandy Silt to Silty Sand Till

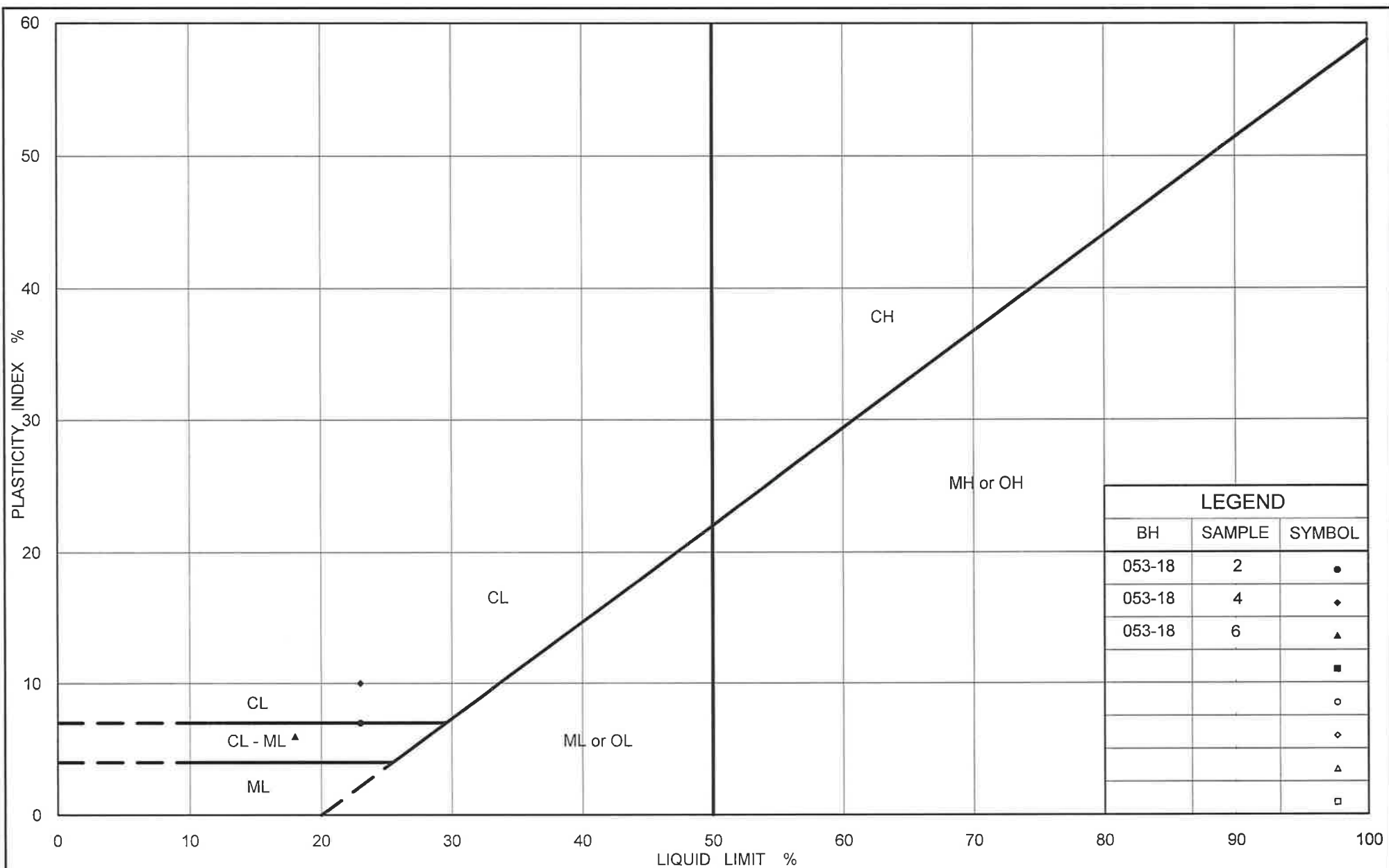


Date: June 2011

Project No: 10-1111-0011

Prepared By: SB Reviewed By: LCC *llc*





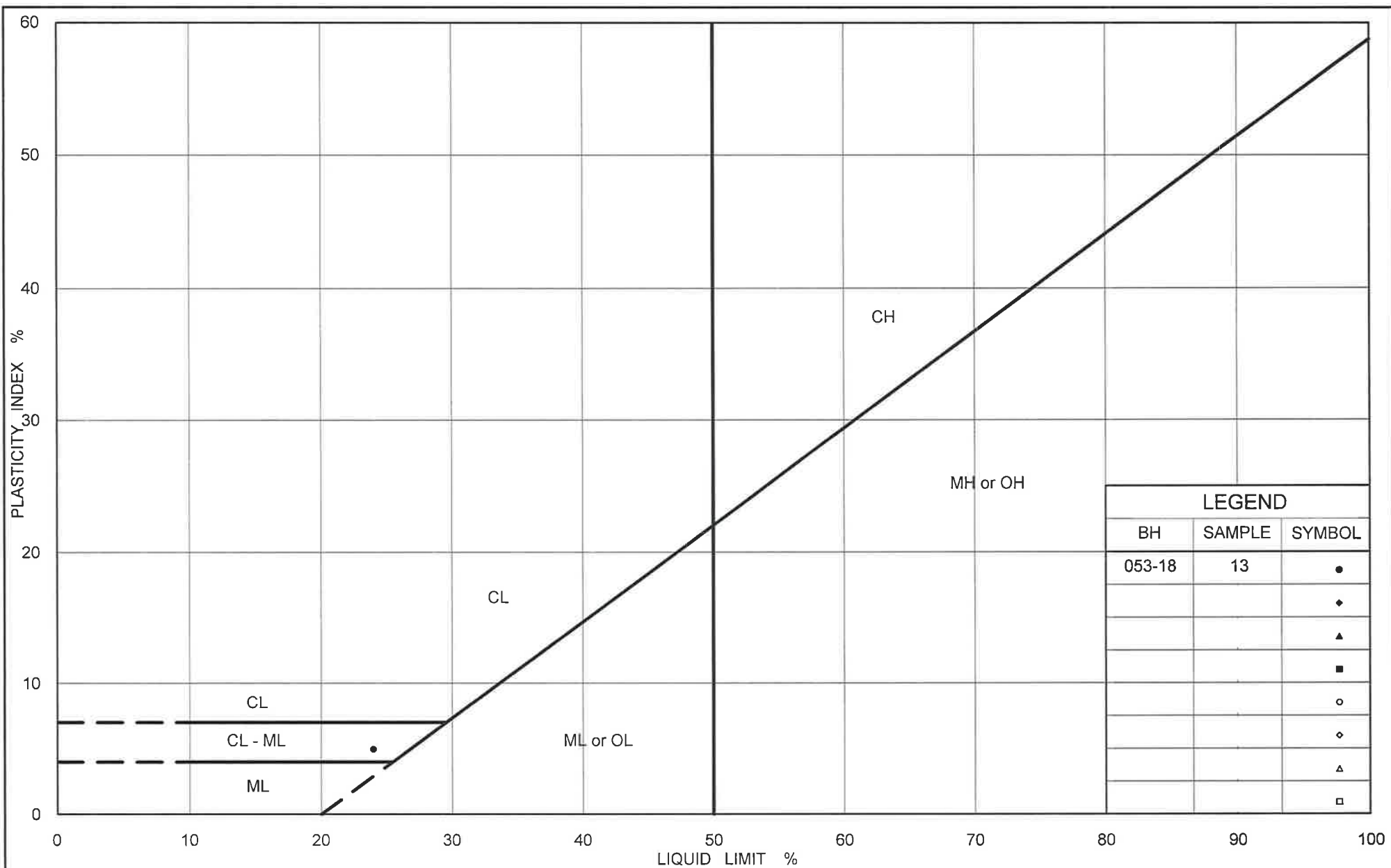
PLASTICITY CHART

Upper Clayey Silt Till

Figure No. F2

Project No. 10-1111-0011

Checked By: LCC *ll*



PLASTICITY CHART Clayey Silt (Residual Soil)

Figure No. F3

Project No. 10-1111-0011

Checked By: LCC *llc*



APPENDIX G

Borehole Records and Laboratory Test Results – GEOCRES NO. 30M11-221

RECORD OF BOREHOLE No 6 221-6 METRIC													
W P 127/128-85-00		LOCATION Sta. 10+200 2.9 m Rt. CL Med. N: 4 831 226; E: 300 675				ORIGINATED BY G.L.							
DIST G.R. HWY 427		BOREHOLE TYPE Solid Stem Auger, Truck				COMPILED BY G.P.							
DATUM Geodetic		DATE 1998 09 20				CHECKED BY C.M.							
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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100					
126.4	Paved Shoulder												
0.0	175 mm Asphalt												
	250 mm Sand & Gravel												
	Hard		1	SS	39								
	Fill		2	SS	13								
	Brown clayey silt some sand, gravel		3	SS	9								
	Stiff		4	SS	13								
			5	SS	10								
			6	SS	13								
			7	SS	8								
117.1	400 mm Topsoil, mixed w/ peat												
9.8	Brown Clayey Silt with sand, some gravel (Glacial Till)		8	SS	31								
	Hard		9	SS	75								
	grey												
111.0	Grey Silty Sand		10	SS	50/1								
13.9	End of Borehole												
112.0	* Borehole dry upon completion												
14.0													

Note: 1. Based on grain size distribution test results, Golder has interpreted the "silty sand" deposit as a till.

Date: June 2011
Project No: 10-1111-0011

Prepared By: SB Reviewed By: LCC



RECORD OF BOREHOLE No 7 221-7										METRIC			
W P 127/128-85-00		LOCATION Sta. 10+500 1.6 m Rp. Cr Med. N: 4 831 511; E: 300 382						ORIGINATED BY C.M.					
DIST C.R. MWY 427		BOREHOLE TYPE Solid Stem Auger, Truck						COMPILED BY G.P.					
DATUM Geodetic		DATE 1998 09 20						CHECKED BY G.L.					
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					
128.6 0.0	Paved Shoulder 200 mm Asphalt												
127.4 1.2	Brown Sand and Gravel												
	Fill		1	SS	31								
	Brown to Grey clayey silt		2	SS	19								
	Stiff - Very Stiff		3	SS	17							21.7	
	occasional pieces of brick, egg shells, organic inclusions		4	SS	7								
	Random shale fragments throughout		5	SS	25								
119.2 9.4	mixed with topsoil		6	SS	17								
	Black Organic Sand		7	SS	7								
117.5 11.1	End of Borehole Start Dynamic Cone penetration test Probable Fill												
116.1 12.5													
115.6	Probable Clayey Silt												
13.0	End of Cone Test Probable Glacial Till												
	* Borehole dry upon completion												

Date: June 2011
Project No: 10-1111-0011

Prepared By: SB Reviewed By: LCC



RECORD OF BOREHOLE No 14 221-14 METRIC												
W P <u>127/128-85-00</u>		LOCATION <u>Sta. 12+300 1.9 m Rt. CL Med.</u>				N: <u>4 833 245</u>		ORIGINATED BY <u>G.M.</u>				
DIST <u>C.R. HWY 427</u>		BOREHOLE TYPE <u>Solid Stem Auger, Truck</u>				E: <u>299 905</u>		COMPILED BY <u>G.P.</u>				
DATUM <u>Geodetic</u>		DATE <u>1998 09 20</u>						CHECKED BY <u>G.L.</u>				
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	'N' VALUES	20 40 60 80 100	Wp	W		
134.2	Paved Shoulder											
0.0	100 mm Asphalt											
133.6	Crushed Gravel											
0.6	Sand and Gravel											
	Fill		1	SS	9							3 40 37 20
	Brown clayey silt											
132.3	Stiff		2	SS	18						22.8	
1.9	brown stiff											
	Gray Clayey Silt, some sand, occ. gravel (Glacial Till)		3	SS	50/8 cm							
	Hard		4	SS	80/20 cm							
128.2	Gray Sandy Silt - Silty Sand (Glacial Till) V. Dense		5	SS	100						21.3	
6.0												
127.6	End of Borehole											
6.6	* Borehole dry upon completion											

Date: June 2011
Project No: 10-1111-0011

Prepared By: SB Reviewed By: LCC *ll*



RECORD OF BOREHOLE No 18 221-18 METRIC																
W.P. 1277128-85-00		LOCATION Spa. 13+200 2.8 m Rt. Cl. Med.				N: 4 834 108		ORIGINATED BY G.L.								
DIST C.R. Hwy 427		BOREHOLE TYPE Solid Stem Auger, Truck				E: 299 646		COMPILED BY G.P.								
DATUM Geodetic		DATE 1998 09 20						CHECKED BY C.M.								
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE			'N' VALUES	20	40	60	80	100	W _p	W		
140.9	Paved Shoulder															
0.0	175 mm Asphalt															
	250 mm Crushed Gravel															
	Fill - brown clayey silt mixed with topsoil very stiff		1	SS	26											
139.4	Brown sand & gravel															
1.5	Brown Clayey Silt fissured (Glacial Till) occ. sand layers		2	SS	25											
	V. Stiff - Hard		3	SS	35											
137.4	Brown Silty Sand, trace gravel and clay (Glacial Till)		4	SS	50/10	cm										
3.5	Very Dense		5	SS	50/9	cm										
133.1	Grey Clayey Silt (Glacial Till) Hard		6	SS	85											
132.8																
8.1	End of Borehole															
	* Borehole wet upon completion - seepage between 5.6 and 7.8 m.															

Date: June 2011
Project No: 10-1111-0011

Prepared By: SB Reviewed By: LCC



RECORD OF BOREHOLE No 19 221-19 METRIC																
W P 127/128-85-00			LOCATION Sta. 13+600 2.0 m Rt. CL Med.			N: 4 834 486			ORIGINATED BY G.L.							
DIST C.R. HWY 427			BOREHOLE TYPE Solid Stem Auger, Truck			E: 299 520			COMPILED BY G.P.							
DATUM Geodetic			DATE 1998 09 20						CHECKED BY G.H.							
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
142.9 0.0	Paved Shoulder 188 mm Asphalt 188 mm Crushed Gravel Fill Brown clayey silt	X														
141.4 1.5	Stiff - v. Stiff Brown Clayey Silt to Silt (Glacial Till)	X	1	SS	17											
140.3 2.6	Hard	X	2	SS	54											
138.9 4.0	Grey Silty Sand (Glacial Till) Very Dense	X	3	SS	80/12											6 50 34 10
136.6 136.3	Grey Clayey Silt (Glacial Till) Hard	X	4	SS	45											21.9
6.6	End of Borehole															
<p>* Water level on 1998 09 20 (not stabilized)</p> <p>Note:</p> <p>1. Based on Atterberg limits test results, Golder has interpreted Sample 2 to be non-plastic and therefore classified with the underlying "silty sand till".</p>																

Date: June 2011
Project No: 10-1111-0011

Prepared By: SB Reviewed By: LCC



RECORD OF BOREHOLE No 20 221-20 METRIC																
W P 127/128-85-00		LOCATION Sta. 13+900 2.3 m Rt. CL Med.			N: 4 834 769		ORIGINATED BY G.L.									
DIST C.R. HWY 427		BOREHOLE TYPE Solid Stem Auger, Truck			E: 299 419		COMPILED BY G.P.									
DATUM Geodetic		DATE 1998 09 20			CHECKED BY C.H.											
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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80					
144.5	Paved Shoulder															
0.0	175 mm Asphalt															
	263 mm Crushed Gravel															
143.6	Brown fine sand															
0.9	Loose															
	Brown Clayey Silt fissured (Glacial Till)		1	SS	11											
	V. Stiff - Hard		2	SS	45											
			3	SS	48											
	grey		4	SS	50											
138.4	Sandy Silt															
6.1	Dense		5	SS	49											
137.9	Brown Grey															
6.6	End of Borehole															
	* Borehole dry upon completion															
	Notes:															
	1. Based on Atterberg limits test results, Golder has interpreted Sample 4 as a "sandy silt till"															
	2. Golder has interpreted Sample 5 as a "sandy silt till".															

Date: June 2011
Project No: 10-1111-0011

Prepared By: SB Reviewed By: LCC



RECORD OF BOREHOLE No 23 221-23										METRIC			
W P 127/128-85-00		LOCATION Sta. 14+300 2.4 m Rt. CL Med.				N: 4 835 144		ORIGINATED BY G.L.					
DIST C.R. HWY 427		BOREHOLE TYPE Solid Stem Auger, Truck				E: 299 278		COMPILED BY G.P.					
DATUM Geodetic		DATE 1998 09 20						CHECKED BY C.H.					
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100	W _p	W	W _L		
146.5	Paved Shoulder												
Q.0	175 mm Asphalt												
	288 mm Crushed Gravel												
	Brown Clayey Silt, fissured (Glacial Till)		1	SS	19								
			2	SS	53								
	Stiff to Hard												
			3	SS	58								
	grey												
			4	SS	25								
	Stiff - V. Stiff												
			5	SS	18								
			6	SS	12								3 42 43 12
	with wet sand seams												
			7	SS	16								
	hard												
			8	SS	93/28 cm							22.6	
134.8	Grey Silty Sand (Glacial Till) Very Dense												
11.7													
134.2			9	SS	61/15 cm								
12.3	End of Borehole												
	* Borehole dry upon completion												

Date: June 2011
Project No: 10-1111-0011

Prepared By: SB Reviewed By: LCC



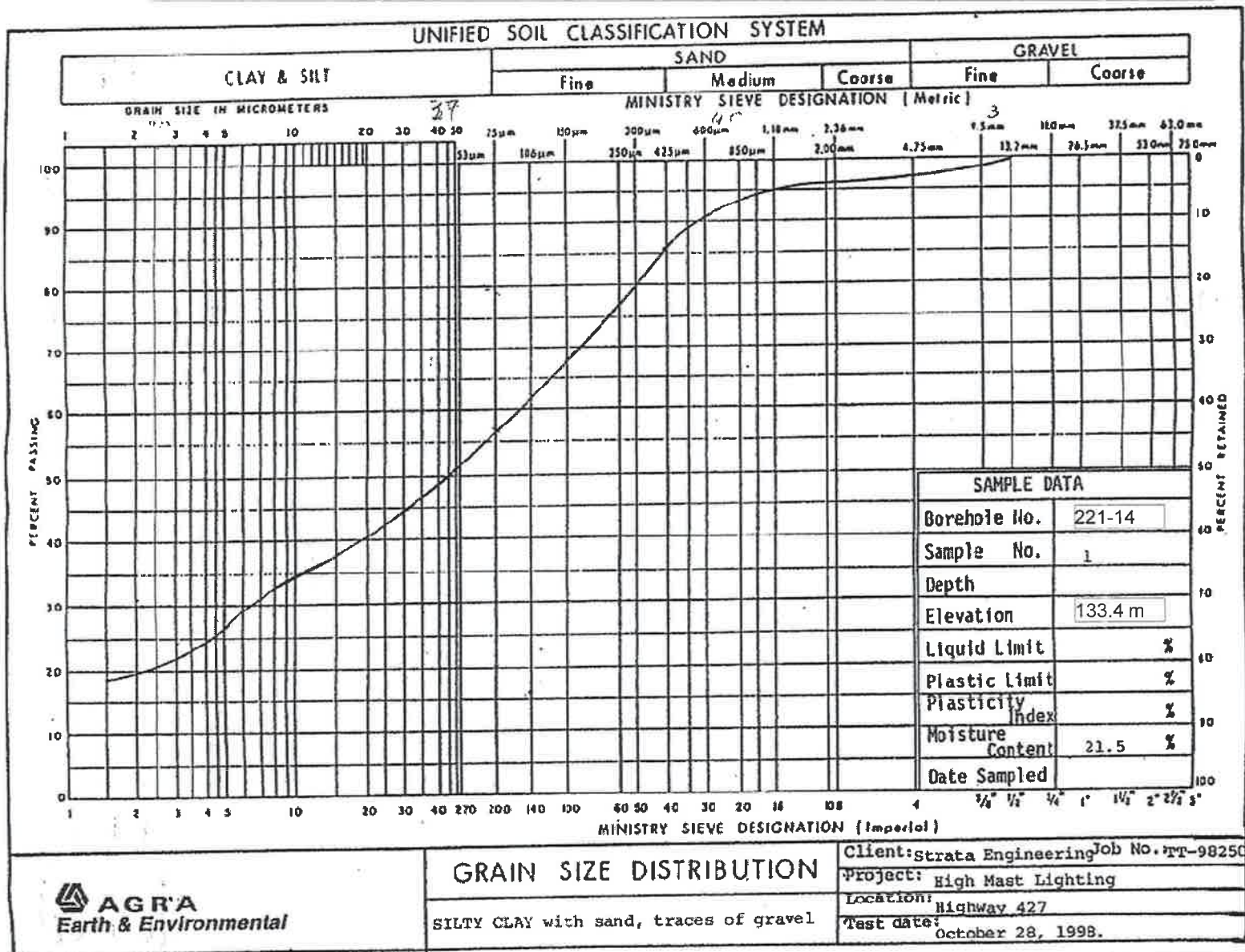
RECORD OF BOREHOLE No 26 221-26 METRIC													
W P <u>127/128-85-00</u>		LOCATION <u>Sta. 15+200 2.0 m Rt. Cl Med.</u>			N: <u>4 836 002</u>		ORIGINATED BY <u>C.H.</u>						
DIST <u>G.R. HWY 427</u>		BOREHOLE TYPE <u>Solid Stem Auger, Truck</u>			E: <u>299 006</u>		COMPILED BY <u>G.P.</u>						
DATUM <u>Geodetic</u>		DATE <u>1998 09 20</u>					CHECKED BY <u>G.L.</u>						
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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			VALUES	20					
146.2	Paved Shoulder												GR SA SI CL
0.0	150 mm Asphalt					146							
	150 mm Crushed Gravel												
145.0	Fill - clayey silt mixed with topsoil												
1.2													
	Brown		1	SS	45								
	Clayey Silt (Glacial Till)					144							
			2	SS	49								
	Hard												
						142							
	occasional silt and fine sand seams		3	SS	27							23.2	
	grey												
139.7			4	SS	60/27	140						22.9	
6.5	End of Borehole												
	* Borehole dry upon completion												

Date: June 2011
Project No: 10-1111-0011

Prepared By: SB Reviewed By: LCC



Figure G1 – Grain Size Distribution– Clayey Silt Fill

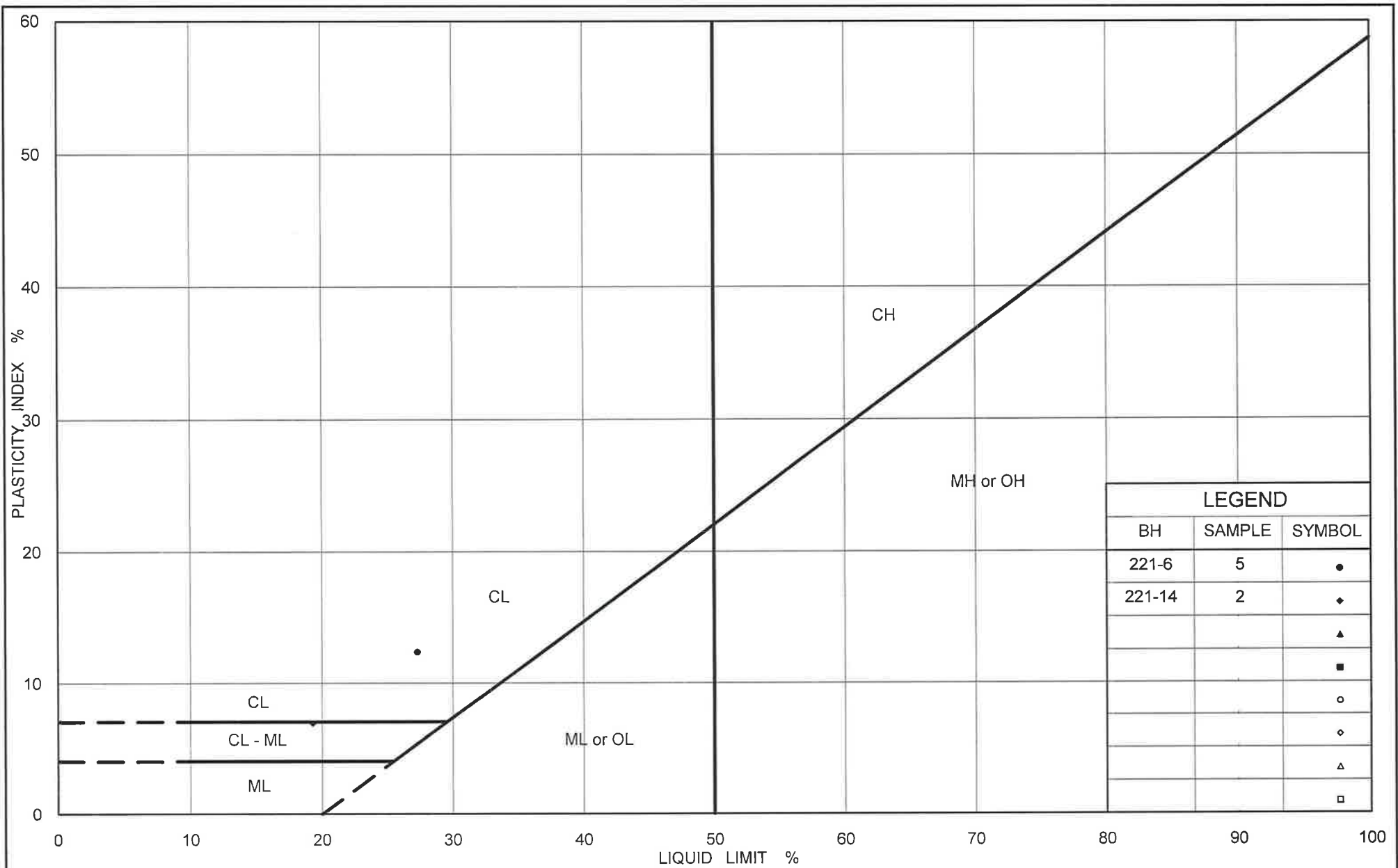


Date: June 2011

Project No: 10-1111-0011

Prepared By: SB Reviewed By: LCC *ll*





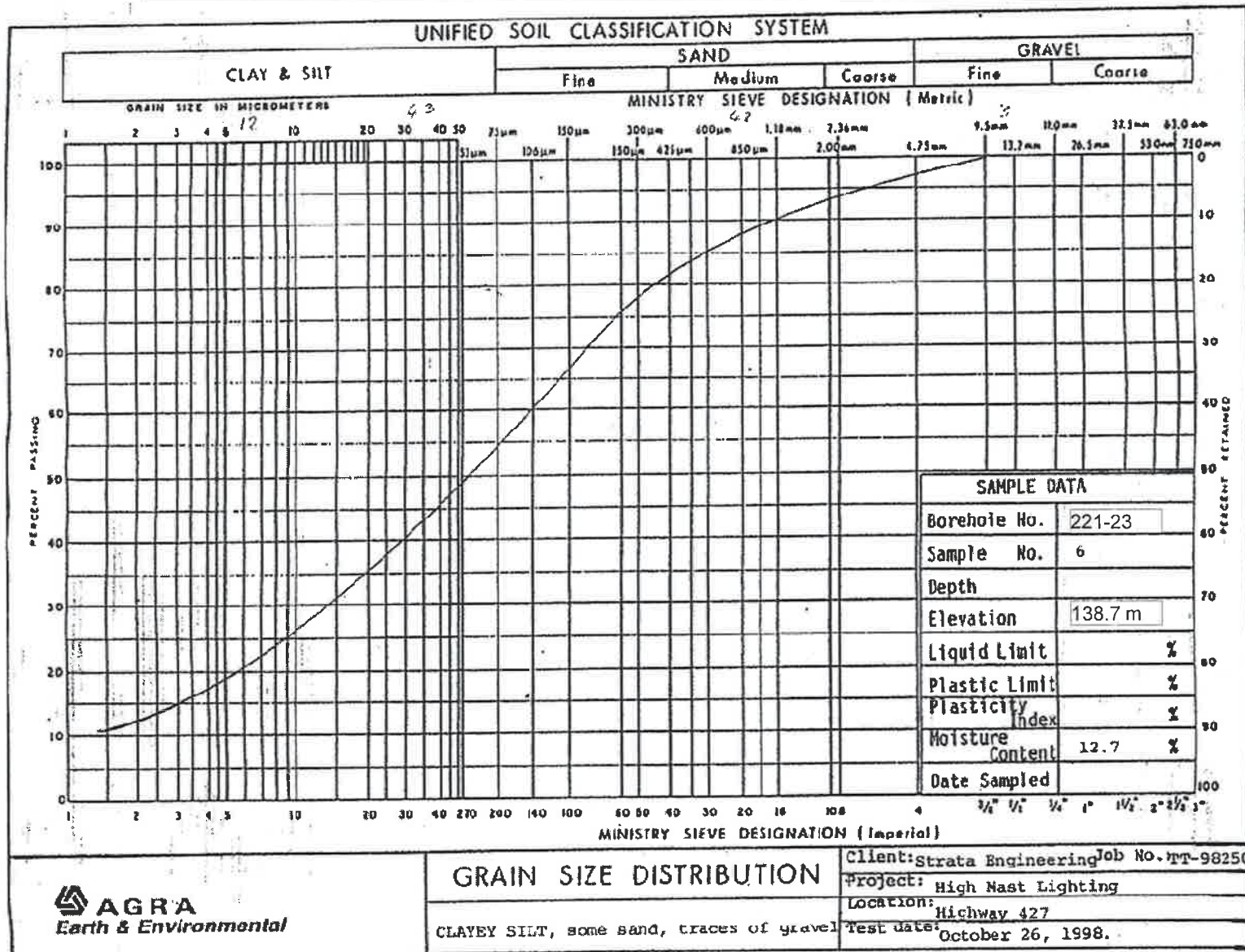
PLASTICITY CHART Clayey Silt Fill

Figure No. G2

Project No. 10-1111-0011

Checked By: LCC *ll*

Figure G3 – Grain Size Distribution Test Results – Upper Clayey Silt Till

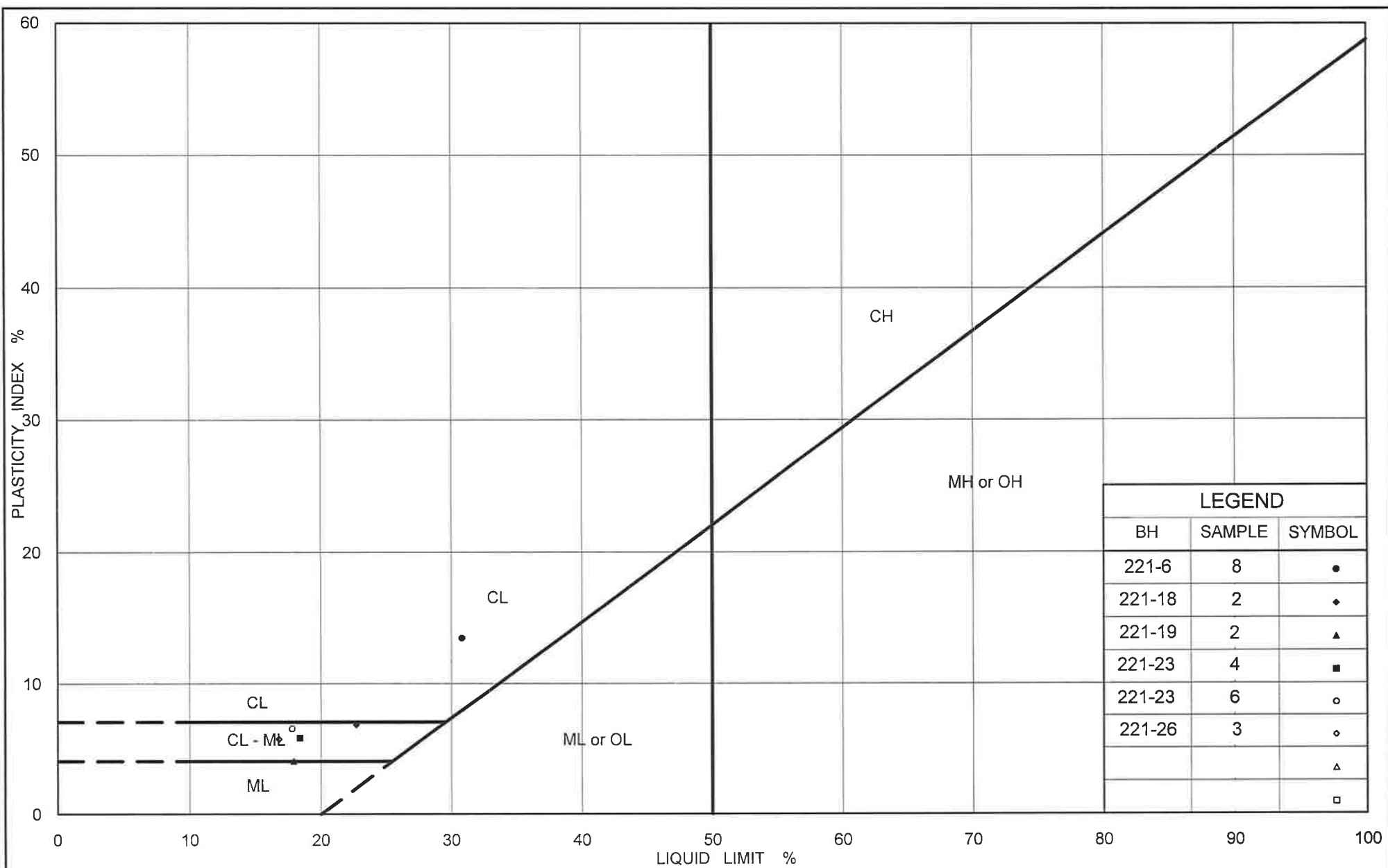


Date: June 2011

Project No: 10-1111-0011

Prepared By: SB Reviewed By: LCC *llc*





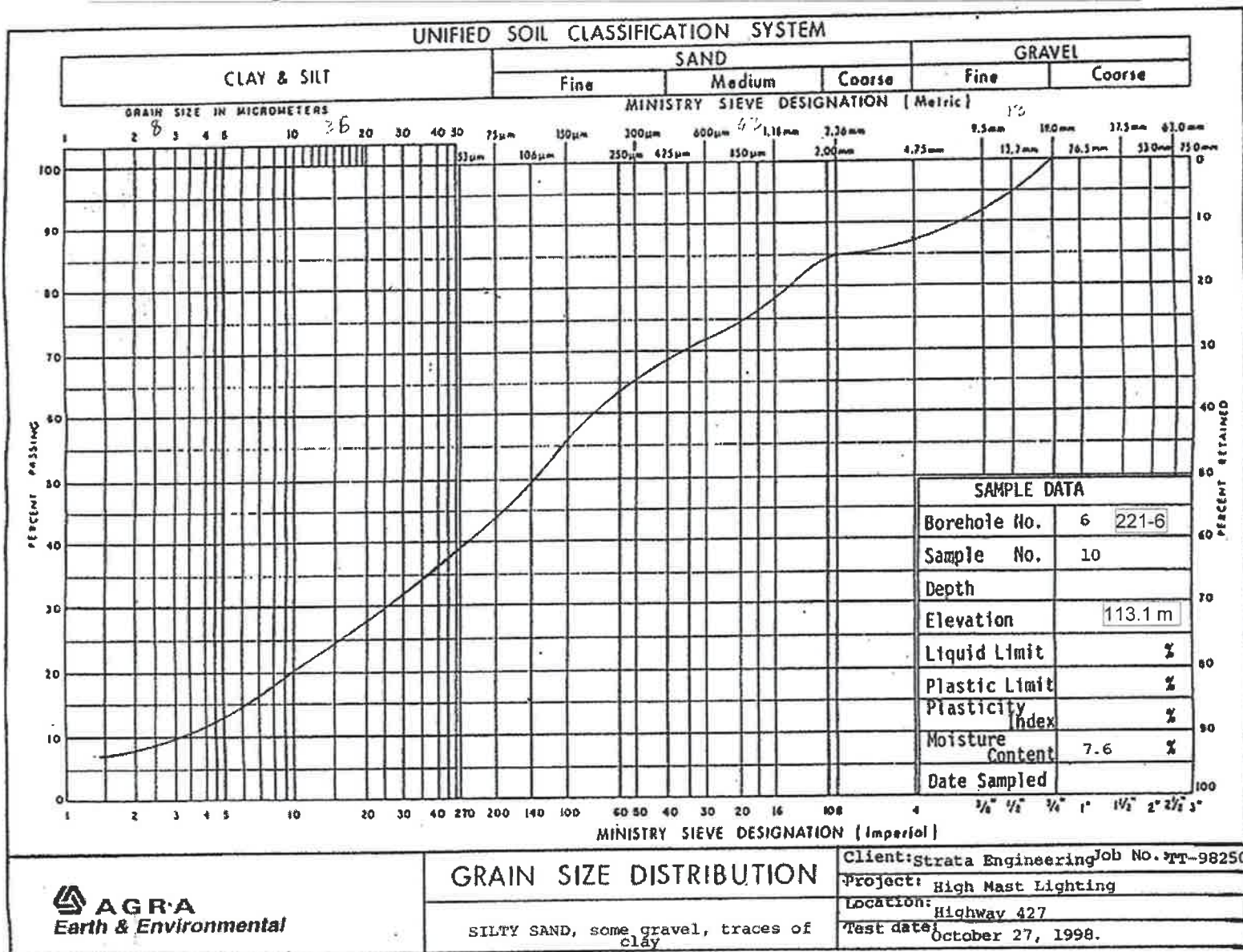
PLASTICITY CHART Upper Clayey Silt Till

Figure No. G4

Project No. 10-1111-0011

Checked By: LCC *[Signature]*

Figure G5.1 – Grain Size Distribution – Silt and Sand Till



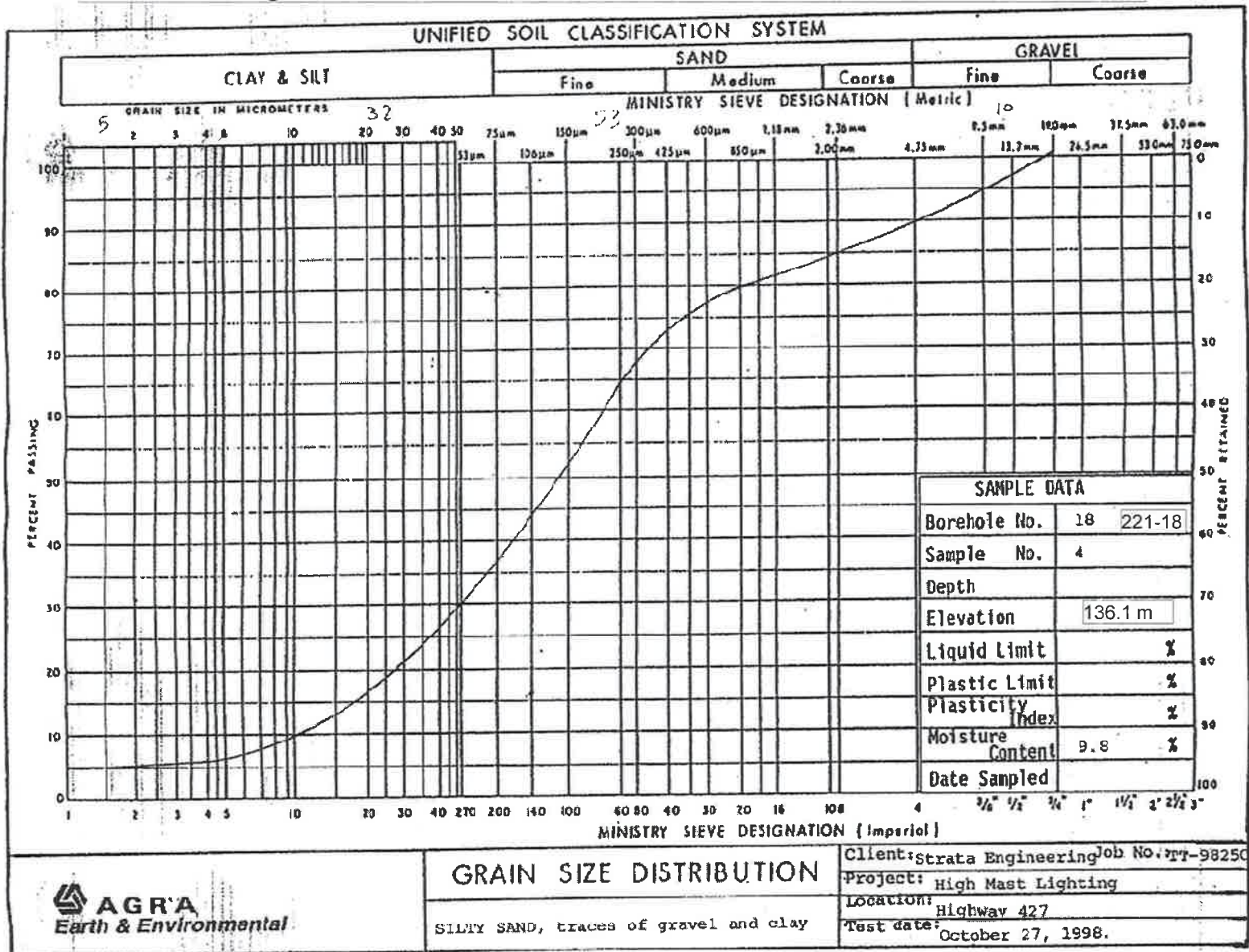
Date: June 2011

Project No: 10-1111-0011

Prepared By: SB Reviewed By: LCC *ll*



Figure G5.2 – Grain Size Distribution – Silt and Sand Till



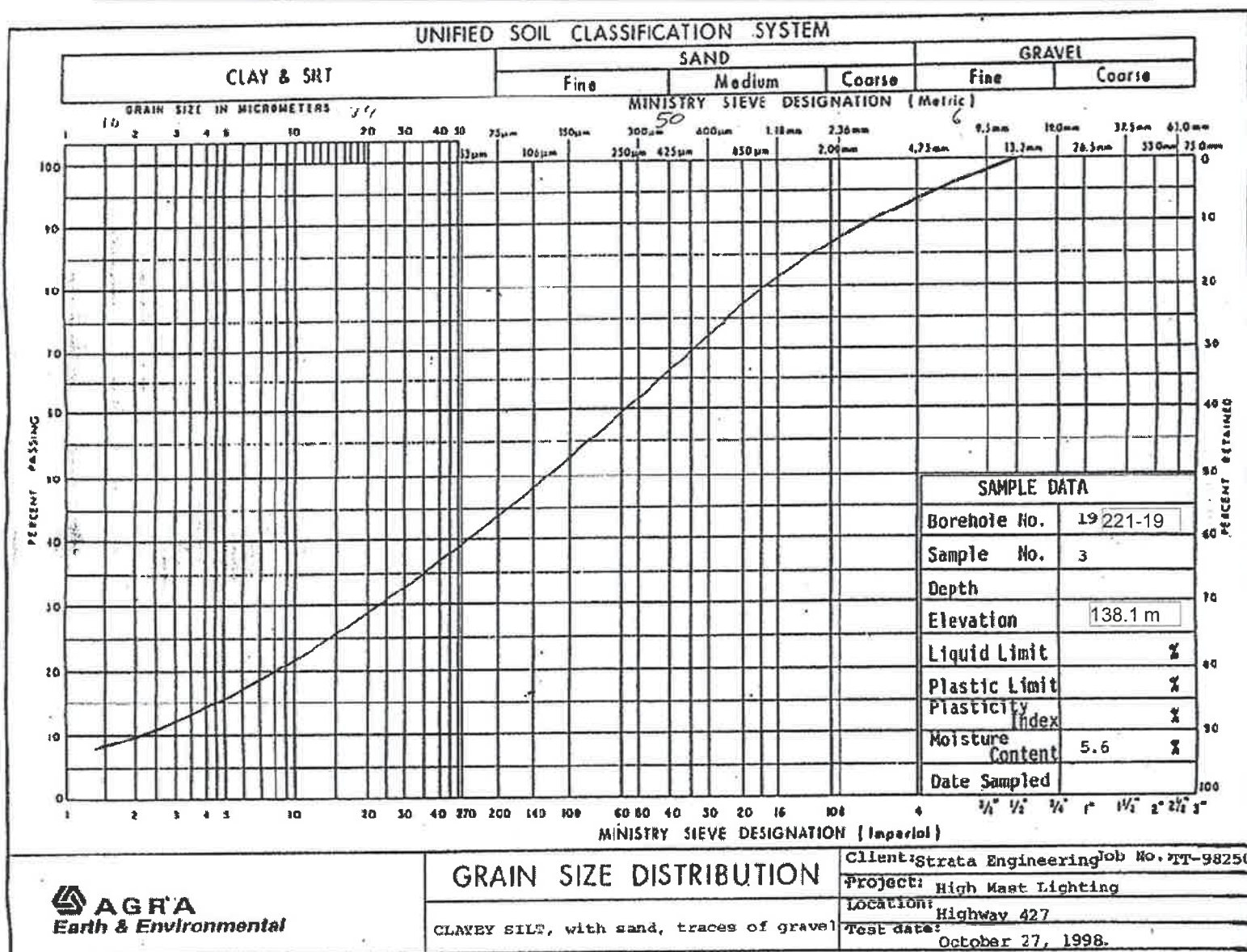
Date: June 2011

Project No: 10-1111-0011

Prepared By: SB Reviewed By: LCC *llc*



Figure G5.3 – Grain Size Distribution – Silt and Sand Till



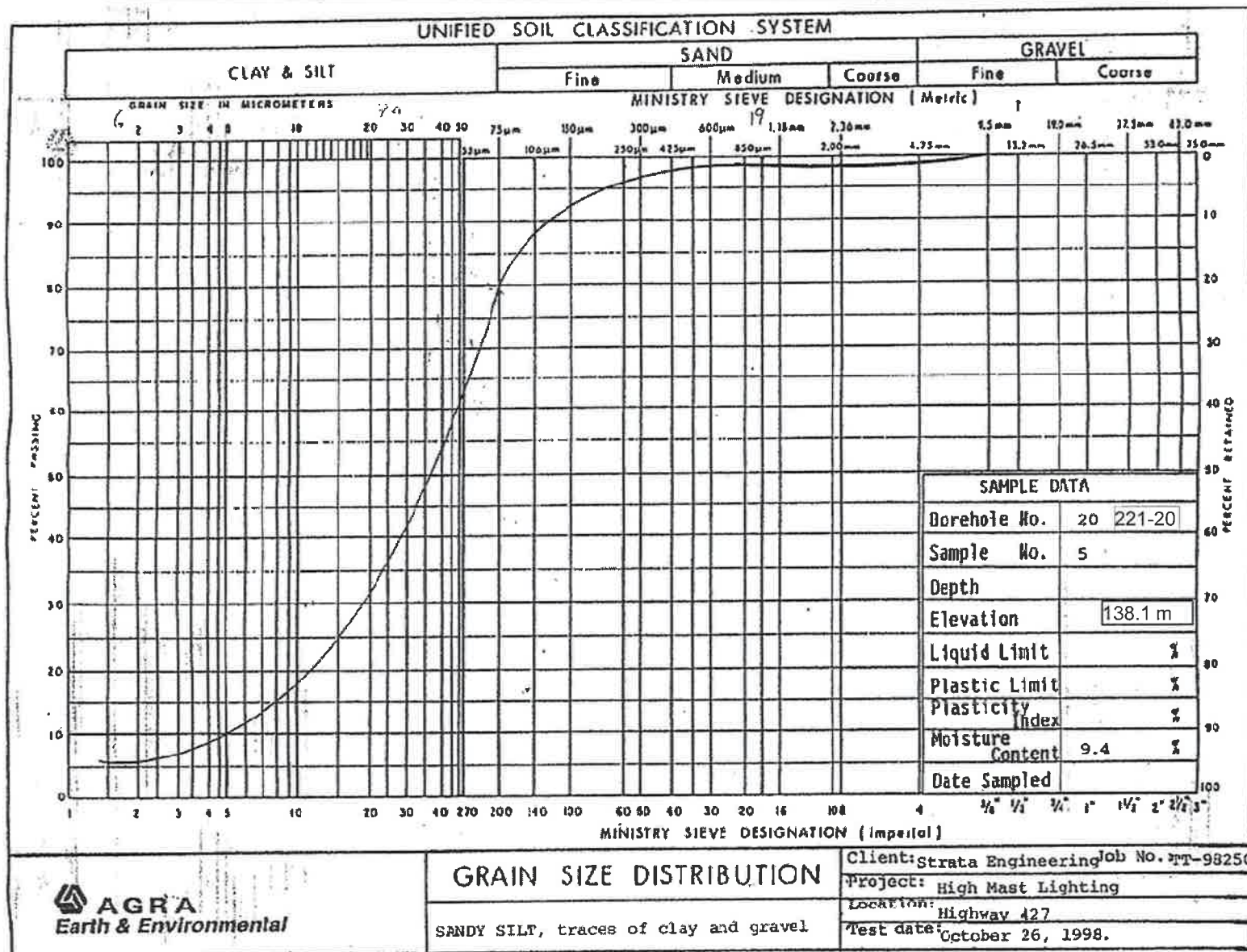
Date: June 2011

Project No: 10-1111-0011

Prepared By: SB Reviewed By: LCC



Figure G5.4 – Grain Size Distribution - Sandy Silt Till

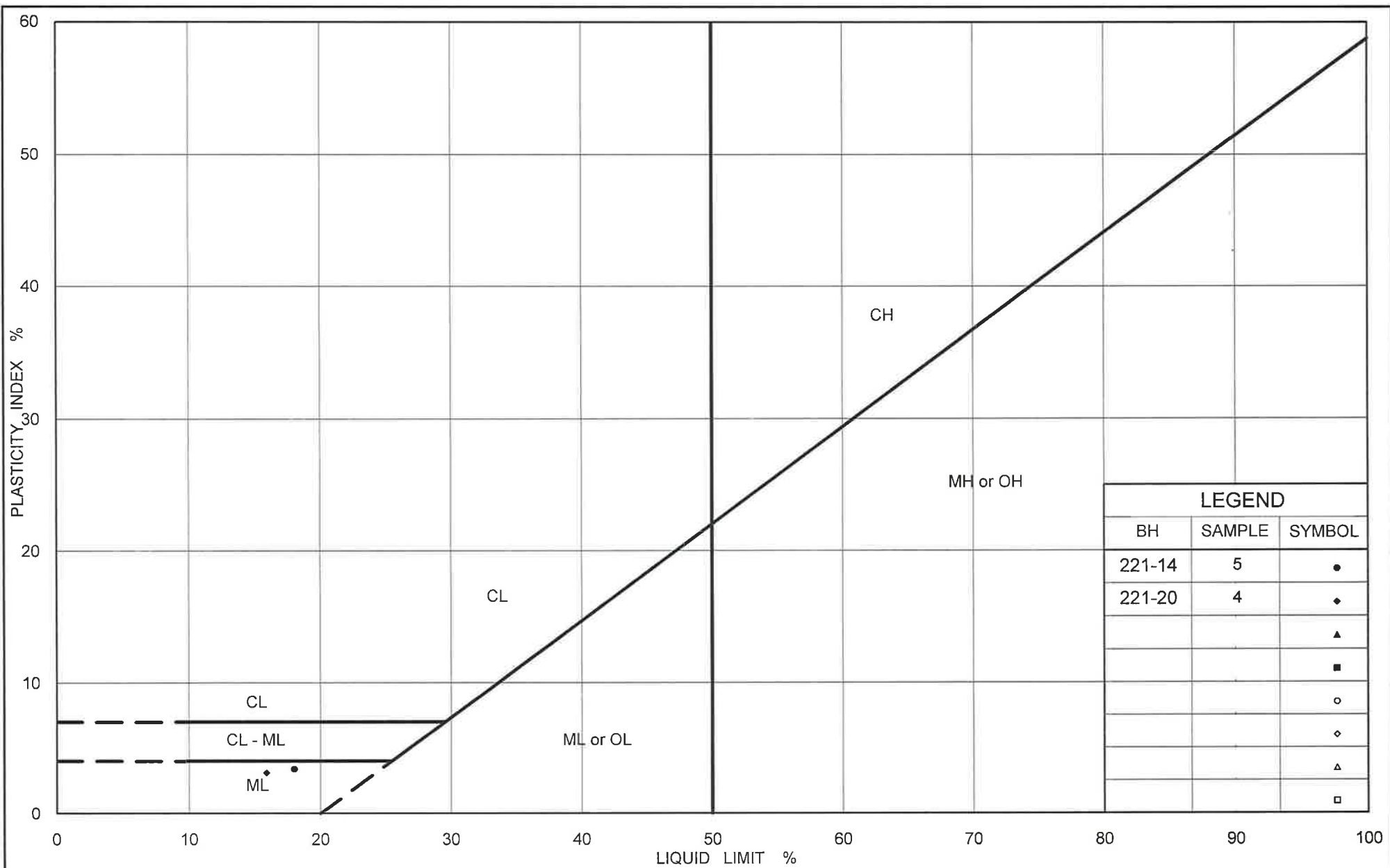


Date: June 2011

Project No: 10-1111-0011

Prepared By: SB Reviewed By: LCC *ll*





LEGEND		
BH	SAMPLE	SYMBOL
221-14	5	●
221-20	4	◆
		▲
		■
		○
		◇
		△
		□

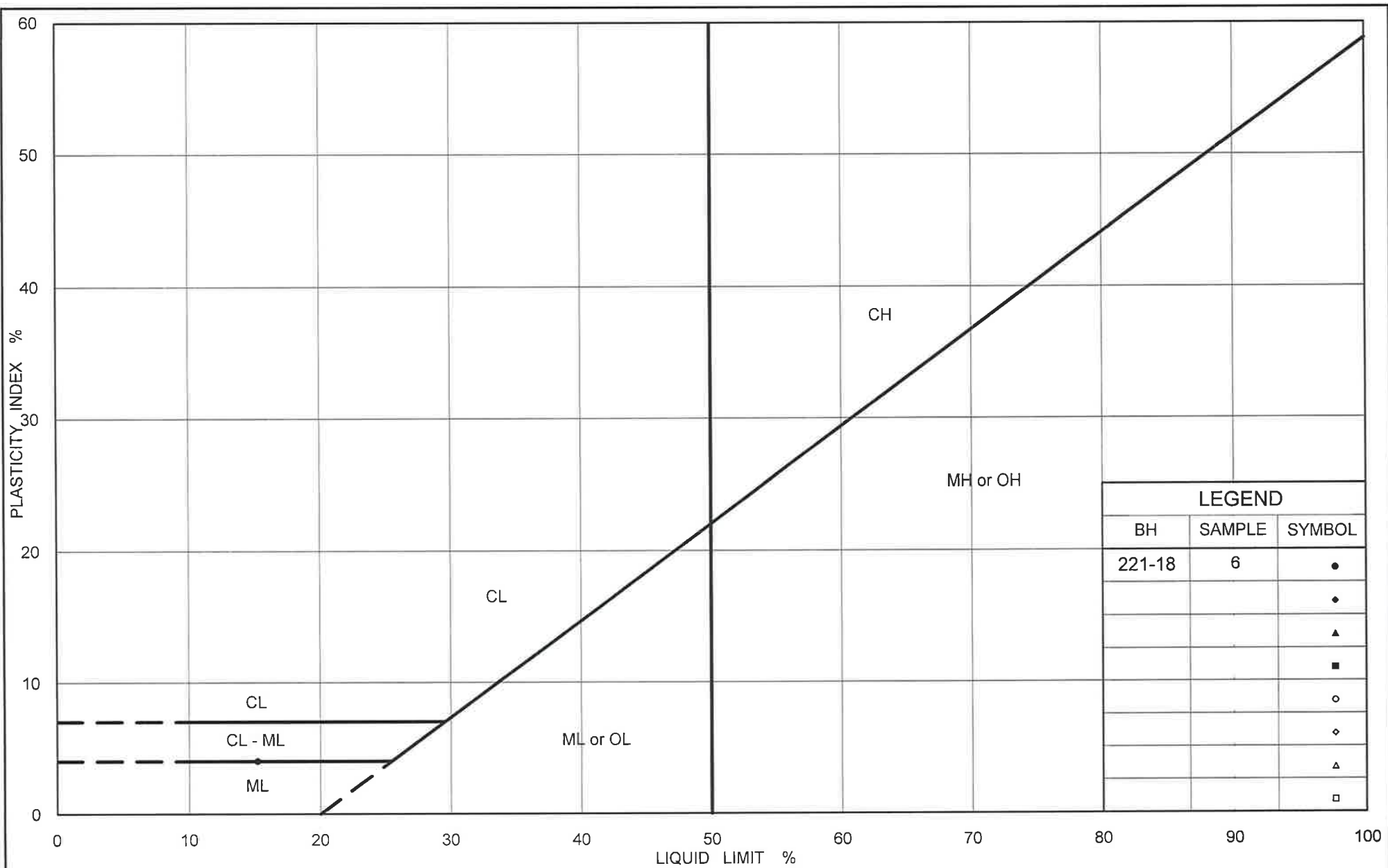


PLASTICITY CHART Silty Sand to Sandy Silt Till

Figure No. G6

Project No. 10-1111-0011

Checked By: LCC *[Signature]*



PLASTICITY CHART Lower Clayey Silt Till

Figure No. G7

Project No. 10-1111-0011

Checked By: LCC *[Signature]*



APPENDIX H

Non-Standard Special Provisions



FINAL FOUNDATION REPORT - OVERHEAD SIGNS HIGHWAY 427 NB COLLECTOR REHABILITATION

OVERHEAD SIGN FOUNDATIONS - Item No.

Special Provision

SCOPE

Excavations for the overhead sign foundations will be advanced through fill materials (where present) into clayey silt till and silty sand to sandy silt till. Lenses or layers of cohesionless soils should also be expected to be present within the clayey silt till. The cohesionless soil deposits and lenses/interlayers should be expected to be unstable below the groundwater level. Where cohesionless soil deposits, layers or lenses are encountered, appropriate construction procedures and equipment will be required to minimize ground loss during drilling and concrete placement.

BASIS OF PAYMENT

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION



FINAL FOUNDATION REPORT - OVERHEAD SIGNS HIGHWAY 427 NB COLLECTOR REHABILITATION

OVERHEAD SIGN FOUNDATIONS - Item No.

Special Provision

SCOPE

The soils in this area are glacially derived, and should be expected to contain cobbles and/or boulders. Cobbles and/or boulders were encountered in some of the boreholes drilled along the Highway 427 corridor near the sign support locations, as noted on the borehole records; however, these boreholes are not located at the exact sign location. Appropriate equipment and procedures will be required to penetrate the cobbles and/or boulders as part of caisson installation for the overhead sign supports.

BASIS OF PAYMENT

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Ltd.
2390 Argentia Road
Mississauga, Ontario, L5N 5Z7
Canada
T: +1 (905) 567 4444

