



Stantec

**Foundation Investigation and
Design Report
New CBSA Building and New
Maintenance Building**

Improvements to the Canadian Plaza
of the Windsor-Detroit Tunnel
Windsor, ON

G.W.P. 3032-06-00

Geocres No. 40J6-39

Project No. 165601256

February 2012

Table of Contents

1.0 INTRODUCTION	1
2.0 SITE DESCRIPTION AND GEOLOGY	1
3.0 CONSTRUCTION HISTORY	2
4.0 INVESTIGATION PROCEDURES	2
4.1 REVIEW OF EXISTING SUBSURFACE INFORMATION	2
4.2 DRILLING INVESTIGATION	3
4.3 LOCATION AND ELEVATION SURVEY	4
4.4 LABORATORY TESTING	4
5.0 SUBSURFACE CONDITIONS	5
5.1 GENERAL	5
5.1.1 Asphalt and Concrete Pavement	5
5.1.2 Fill Material	5
5.1.3 Clay Till (Silty Clay to Sandy Clay)	6
5.1.4 Sand Till Layer	7
5.2 CHEMICAL TEST RESULTS	7
5.3 BEDROCK	8
5.4 GROUNDWATER	8
6.0 MISCELLANEOUS	9
7.0 CLOSURE	10
8.0 DISCUSSIONS	11
8.1 GENERAL	11
8.2 GEOTECHNICAL DESIGN PARAMETERS	12
8.3 FROST PENETRATION	13
8.4 SEISMIC DESIGN CONSIDERATIONS	14
8.4.1 Seismic Site Class	14
8.4.2 Zonal Acceleration Ratio	14
8.4.3 Liquefaction Potential	14
8.5 FOUNDATION OPTIONS	15
8.5.1 General	15
8.5.2 Geotechnical Resistances	16
8.5.3 Sliding Resistance	17
8.6 FLOOR SLAB DESIGN	18
8.7 LATERAL EARTH PRESSURES	18
8.7.1 Lateral Earth Pressure under Static Conditions	18
8.7.2 Lateral Earth Pressure under Seismic Conditions	19
8.8 EVALUATION OF POTENTIAL SETTLEMENT	20
8.9 CONSTRUCTION CONSIDERATIONS	21
8.9.1 Shoring of Excavations	21
8.9.2 Excavation and Backfilling	21

Table of Contents

8.9.3	Temporary Construction Unwatering.....	22
8.9.4	Bedding and Backfilling for Service Connections	23
8.10	CEMENT TYPE AND CORROSION PROTECTION.....	23
<hr/>		
9.0	SPECIFICATIONS.....	24
10.0	REFERENCES	24
11.0	CLOSURE.....	25

List of Tables

Table 4.1:	Borehole Information Summary.....	4
Table 4.2:	Geotechnical Laboratory Testing Program	4
Table 5.1:	Consolidation Test Results	7
Table 5.2:	Results of Chemical Analysis	8
Table 5.3:	Groundwater Levels	8
Table 8.1:	Geotechnical Model	13
Table 8.2:	Parameters for Seismic Site Classification	14
Table 8.3:	Foundation Options.....	15
Table 8.4:	Recommended Spread Footing Design Parameters	17
Table 8.5:	Recommended Non-Seismic Earth Pressure Parameters (Horizontal Backfill)	19
Table 8.6:	Recommended Seismic Earth Pressure Parameters (Horizontal Backfill)	20
Table 8.7:	Comparison of Shoring Systems.....	21
Table 9.1:	Specifications Referenced in Report	24

List of Appendices

APPENDIX A	Drawing No. 1 – Borehole Location Plan and Strata Plot Drawing No. 2 – Strata Plots Site Photos
APPENDIX B	Symbols and Terms Used On Borehole Records Borehole Records
APPENDIX C	Laboratory Results Laboratory Testing by Golder Associates
APPENDIX D	Design Parameters Typical Settlement Evaluation Results
APPENDIX E	2010 National Building Code Seismic Hazard Calculation

FOUNDATION INVESTIGATION REPORT

For
G.W.P. 3032-06-00

New CBSA Building and New Maintenance Building
Improvements to the Canadian Plaza of the Windsor-Detroit Tunnel
City of Windsor

1.0 Introduction

Stantec Consulting Ltd. (Stantec) was retained by the Ontario Ministry of Transportation (MTO) to complete a Foundation Investigation and Design Report for the Detailed Design of the proposed improvements to the Canadian plaza of the Windsor-Detroit Tunnel in Windsor, Ontario. The proposed improvements include the design of a new Canadian Border Services Agency (CBSA) building, a toll booth, and a new maintenance building.

This Foundation Investigation Report has been prepared specifically and solely for the proposed Canadian plaza improvements.

Project Number: G.W.P. 3032-06-00

Project Location: Immediately north of Wyandotte Street East and Goyeau Street intersection, City of Windsor, Ontario

This work was carried out under Agreement Number 3010-E-0027 with Stantec Consulting Ltd., the Detailed Design Consultant for this project.

2.0 Site Description and Geology

Site Location

The site location is shown on the Key Plan insert to Drawing No. 1 provided in Appendix A. The site is located in the City of Windsor, Ontario, immediately north of Wyandotte Street East and is bisected by Goyeau Street.

General Site Description

General site photographs showing the proposed building locations are provided in Appendix A.

The site is developed and includes building facilities and paved surfaces, including roadway and parking areas. Drainage from the site is through catch basins along the roadways and in parking zones.

The southwest corner of the site (west of Goyeau Street) currently contains the WDTM Maintenance building which is within the proposed footprint at the new CBSA building. This building is a single storey structure with a slab-on-grade foundation. An existing multi-level parking garage is located approximately 12 m west of the WDTM Maintenance building.

The southeast corner of the site, between Goyeau Street and Windsor Avenue, includes a low-rise retail building (The Beer Store), parking and landscaped areas. The existing building is to be removed as part of the proposed improvement to the Canadian Plaza. The proposed maintenance building is to be located within this area.

Physiographic Description

The site is located within a physiographic region known as the St. Clair Clay Plains (Chapman and Putnam, 1984). The predominant sediment in this region consists essentially of clay till overlain by a shallow deposit of lacustrine clay. The overburden thickness in this region generally ranges between 30 to 60 m. The predominant bedrock in this region is limestone with possibly black shale in some areas.

The region has little relief and the surface drainage is mostly northward to Lake St. Clair.

3.0 Construction History

Based on discussions with maintenance personnel for the plaza, the existing WDTM Maintenance building is built within the footprint of a former structure. The former structure included a below grade level. No records of the design, construction, or demolition were reviewed.

A former Burger King restaurant was located on the east side of Goyeau Street. The restaurant has been demolished and the former site is graded with sand and gravel surface. No record of the demolition of the restaurant was provided.

4.0 Investigation Procedures

4.1 REVIEW OF EXISTING SUBSURFACE INFORMATION

The following information was reviewed as part of the geotechnical investigation for the site:

- Geotechnical Investigation for Proposed Office Building on Park Street near the City Hall Square in Windsor (southeast corner of the intersection of Goyeau Street and Park Street) by Golder Associates (2002). The location of the building is approximately 260 m north of the site.
- Supplementary Geotechnical Investigation for Retention Treatment Basin Facility (RTB) (Contract No. 1B, Tender 34-10), City of Windsor by Golder Associates (2010). The location of the RTB facility is approximately 700 m northeast of the site.

- OGS Earth web based geotechnical borehole database operated by the Ontario Ministry of Northern Development and Mines.

The following information relevant to the Canadian Plaza site was noted in these documents.

- The local natural overburden consists of a silty clay to clayey silt till extending to a depth of greater than 30 m below ground surface.
- Within approximately 4 m from ground surface the silty clay to clayey silt till is oxidized and generally in a stiff to hard state. Although not referred to as such by Golder, this upper portion of natural soils can be considered as a weathered silty clay crust formed by long-term drying of the exposed portion of the deep till deposit.
- Below the crust, the silty clay to clayey silt till is generally stiff with undrained shear strength in the order of 60 to 100 kPa.
- The depth to bedrock is anticipated to be greater than 30 m below ground surface based on the following:
 - At City Hall Square, located 260 m from the Canadian Plaza, the Golder boreholes extended to depths of 11.1 m with corresponding elevations of 172.3 m geodetic; bedrock was not encountered.
 - At the Windsor Public Library, located 400 m south of the Canadian Plaza, the OGS Earth database includes Borehole ID 620564 which was extended to a depth of 70.6 m with a corresponding end of borehole elevation of 112.1 m geodetic; bedrock is not reported.
 - At the Retention Treatment Basin Facility, approximately 700 mm northeast of the site, Golder encountered dolostone bedrock at a depth of 34 m, corresponding to an elevation of 143.1 m geodetic.

4.2 DRILLING INVESTIGATION

Nine (9) boreholes were drilled at this site. The boreholes were designated BH11-1 through BH11-9 and their locations are shown on the Borehole Location Plan, Drawing No.1 in Appendix A.

Prior to carrying out the investigation, Stantec made arrangements to obtain utility clearances for the proposed borehole locations.

The field drilling program was carried out between September 26 and October 6, 2011. All boreholes were advanced with hollow-stem augers using a truck mount D90 drill rig equipped for soil sampling.

The subsurface stratigraphy encountered in each borehole was recorded in the field. Split spoon samples were collected at regularly spaced intervals during the course of Standard Penetration Testing (ASTM, 1999). Four thin walled Shelby tube samples were recovered at selected depths in two boreholes. All samples recovered were returned to Stantec's Ottawa laboratory for detailed classification and testing. Two Shelby tube samples were transported to the Golder Associates Office in Mississauga, Ontario.

In addition to SPT N-Value counts, the undrained shear strength of the cohesive soils was measured by carrying out in situ field vane shear tests (ASTM D2573) and in the case of very stiff samples was estimated using a pocket penetrometer on split spoon samples.

A 50 mm diameter groundwater monitoring well was installed in Boreholes BH11-1 and BH11-8. The bottom 3 m of the well consisted of Schedule #40 slotted PVC screen. The screened section of the well was backfilled with silica sand and backfilled with bentonite to the ground surface. All the monitoring wells were provided a flush mount casing.

Boreholes were backfilled with auger cuttings mixed with bentonite. In pavement areas the boreholes were topped with cold patch asphalt.

4.3 LOCATION AND ELEVATION SURVEY

The survey of the borehole locations and elevations was carried out by Stantec's Geomatics Group. The ground surface elevation at each borehole location was surveyed with reference to Geodetic datum. Table 4.1 summarizes the location and elevation information for the boreholes included in this report.

Table 4.1: Borehole Information Summary

Borehole	UTM Zone 17 Coordinates		Ground Elevation (m)	Total Depth (m)	End of Borehole Elevation (m)	No. of Soil Samples Collected
	Northing (m)	Easting (m)				
11-1	4686722.2	332222.7	183.4	31.1	152.3	28
11-2	4686750.6	332208.4	183.0	9.8	173.2	13
11-3	4686737.4	332266.2	183.2	29.6	153.6	27
11-4	4686748.5	332266.7	183.0	6.7	176.3	9
11-5	4686791.7	332235.3	183.0	9.8	173.2	12
11-6	4686778.9	332289.3	183.2	31.1	152.1	27
11-7	4686793.1	332334.6	183.5	31.7	151.8	27
11-8	4686777.3	332323.0	183.4	9.8	173.6	13
11-9	4686765.3	332295.6	183.2	9.8	173.4	13

4.4 LABORATORY TESTING

All samples were subjected to a detailed visual examination by a Geotechnical Engineer.

The geotechnical laboratory testing program is summarized in the following Table 4.2.

Table 4.2: Geotechnical Laboratory Testing Program

Test Description	Number of Tests	Remarks
Moisture Content	168	2 by Golder Associates Lab
Atterberg Limits	34	2 by Golder Associates Lab
Grain Size Distribution	37	
Consolidation (oedometer)	2	By Golder Associates Lab
Unconfined Compression (Soil)	1	By Golder Associates Lab
Specific Gravity	2	By Golder Associates Lab

It is noted that where a value is provided for the percent of clay sized particles, the value represents the percent finer than a nominal size of 0.002 mm.

Chemical testing was carried out on eight samples for pH, soluble sulphate content, chloride content and resistivity.

Samples remaining after testing will be placed in storage until one year after issuance of the final report. After the storage period, the samples will be discarded.

5.0 Subsurface Conditions

5.1 GENERAL

The subsurface conditions observed in the boreholes are presented in detail on the Borehole Records provided in Appendix B. An explanation of the symbols and terms used to describe the Borehole Records is also provided in Appendix B.

In general, the subsurface stratigraphy consisted of pavement structure and variable layers of fill material over a clay till. Asphalt pavement was encountered in four boreholes while concrete pavement was encountered in one borehole. Sand and gravel fill constituted the surficial material in four boreholes.

A borehole location plan and a stratigraphic section of the soil encountered within the boreholes are provided on Drawing No. 1 and 2 in Appendix A.

5.1.1 Asphalt and Concrete Pavement

Asphalt pavement was encountered in four boreholes (BH11-1 through BH11-4). The asphalt thickness ranged between 100 and 150 mm.

In BH11-5, a 200 mm thick concrete pavement layer was observed.

5.1.2 Fill Material

Fill of variable thickness was observed in all boreholes. Beneath the pavement the upper portion of the fill consisted of gravel with sand. The lower part of the fill consisted mainly of clay with various amounts of sand and gravel. Brick pieces were observed within the fill layer in boreholes BH11-1, BH11-3, BH11-4 and BH11-7. The fill in BH11-3 and BH11-4 also contained pieces of concrete.

West of Goyeau Street, in boreholes BH11-1 through BH11-4, the fill thickness ranged approximately between 1.3 and 5.4 m and extended to bottom elevations of 181.7 m (BH11-2) to 177.9 m (BH11-1). In BH11-5, approximately 200 mm thick fill was observed beneath the concrete pavement.

East of Goyeau Street, in boreholes BH11-6, BH11-7, BH11-8 and BH11-9 the fill consisted predominantly of sand and gravel and constituted the surficial material. The fill thickness in

these boreholes ranged approximately between 550 and 800 mm. The bottom elevations ranged between 182.9 m (BH11-7) to 182.4 m (BH11-9).

The Standard Penetration Test (SPT) blow count (N-value) for the fill layer ranged between 2 and 36 blows per 0.3 m suggesting a very loose to dense state.

Moisture content tests were carried out on all fill samples. Grain size analysis and Atterberg limits tests were completed for seven and three samples, respectively. The results are as follows:

Gravel	0 to 55%
Sand	23 to 44%
Fines (silt & clay)	12 to 73%
Liquid Limit	26 to 29%
Plastic Limit	13 to 14%
Moisture Content	3 to 22%

The results of laboratory testing indicate that the cohesive fill layer can be classified using the group symbols CL or SC defined by the Unified Soil Classification System (USCS) (ASTM 2000). The grain size distribution curves and Atterberg Limits for the fill layers are shown on Figures 1a to 1c in Appendix C.

5.1.3 Clay Till (Silty Clay to Sandy Clay)

This layer was encountered in all boreholes beneath the fill layer. The clay till extends to beyond 31.7 m below ground surface, corresponding to the termination depth of BH 11-7.

An oxidized clay till crust covers the deeper unaltered deposit. The base of the crust is estimated to be at depths ranging from 4.4 to 5.2 m, and elevations ranging from 178.2 to 178.8 m geodetic. SPT N-Values within the crust ranged from 4 to 34. Undrained shear strength estimates based on pocket penetrometer tests ranged from 150 to 225 kPa.

Beneath the clay crust, the strength of the clay gradually decreases. SPT N-values ranged from 3 to 23 and in situ field vane test results ranged from 45 to 112 kPa. An unconfined compressive strength carried out on one sample yielded an undrained shear strength of 38 kPa.

Moisture content test was carried out on 142 samples of the clay till layer. Grain size analysis and Atterberg limits tests were completed for 28 samples. The results are as follows:

Gravel	0 to 11%
Sand	4 to 33%
Fines (silt & clay)	56 to 93%
Liquid Limit	17 to 45%
Plastic Limit	11 to 21%
Moisture Content	11 to 33%

The result of the laboratory test indicates that the clay till deposit can be classified as CL (silty clay to sandy clay). The grain size distribution curves for this layer are provided in Figure 2a through 2e in Appendix C. Plasticity Charts are shown in Figure 3a through 3e.

The results of two consolidation tests carried out are included in Appendix C. The results of the consolidation tests are summarized below:

Table 5.1: Consolidation Test Results

Sample ID	Sample Elevation	Moisture Content	Initial Void Ratio/Initial Unit Weight	Estimated Preconsolidation Pressure, P _c	Recompression Index, C _r	Compression Index, C _c
BH11-1 ST-14	173.3 m	13%	0.38/22.1 kN/m ³	250 kPa	0.012	0.083
BH11-1 ST-25	157.2 m	19%	0.53/20.9 kN/m ³	444 kPa	0.031	0.136

5.1.4 Sand Till Layer

A silty sand till layer was encountered within the clay till in two boreholes. It is noted that this material forms part of the heterogeneous till deposit at the site and does not constitute a separate deposit. In BH11-2, the layer was observed at a depth of 8.5 m (el. 174.5 m) and was 0.8 m thick. In BH11-6, the layer was observed at a depth of 13.7 m (el. 169.5 m) and was 1.6 m thick.

The SPT N-value for the silty sand till ranged between 11 and 20 blows per 0.3 m suggesting a compact state. Moisture content test was carried out on three samples of the sand till. Grain size analysis was completed for two samples. The results are as follows:

Gravel	5 and 7%
Sand	57 and 72%
Silt Size	16 and 33%
Clay Size	5%
Moisture Content	13 and 17%

The result of the laboratory test indicates that this layer can be classified as SM (silty sand). The grain size distribution curves are provided in Figure 2f in Appendix C.

5.2 CHEMICAL TEST RESULTS

A total of eight samples (two from the existing fill layer and six from the clay till deposit) were submitted for analysis of pH, water soluble sulphate and chloride concentrations, and resistivity. The analysis results are provided in Table 5.2.

Table 5.2: Results of Chemical Analysis

Borehole No	Sample No.	Depth (m)	pH	Chloride (µg/g)	Sulphate (µg/g)	Resistivity (Ohm-m)
BH11-1	SS-7*	4.6 to 5.2	7.8	286	737	10.2
BH11-1	SS-17	13.7 to 14.3	7.8	10	854	13.8
BH11-2	SS-3	1.5 to 2.1	7.9	1780	85	4.0
BH11-4	SS-3*	1.5 to 2.1	7.5	393	508	9.5
BH11-5	SS-3	1.5 to 2.1	8.0	942	81	7.2
BH11-6	SS-5	3.0 to 3.6	7.5	120	94	29.7
BH11-8	SS-2	0.8 to 1.4	7.4	32	196	26.9
BH11-8	SS-6	3.8 to 4.4	7.6	32	82	47.4

*Represents sample from the existing fill layer.

5.3 BEDROCK

Bedrock was not encountered within the depth of exploration of this investigation.

5.4 GROUNDWATER

Groundwater monitoring wells were installed in BH11-1 and BH11-8. The groundwater level was measured in the wells on October 4, 5 and 6, 2011. Groundwater level was also inferred in the open boreholes prior to backfilling. The measured and inferred (i.e., at the time of drilling) groundwater levels are summarized in Table 5.3.

Table 5.3: Groundwater Levels

Table 5.3. Groundwater Levels			
Borehole No	Ground Surface Elevation (m)	Groundwater	
		Depth (m)	Elevation (m)
Measured			
BH11-1	183.4	*	-
BH11-8	183.4	8.1	175.3
Inferred (time of drilling)			
BH11-2	183.0	4.9	178.1
BH11-6	183.2	11.1	172.1

Note: * Monitoring well dry on October 4, 2011.

No standing groundwater was observed in Boreholes BH11-3, BH11-4, BH-5 and BH11-7 at the time of drilling.

6.0 Miscellaneous

The field work was carried out under the supervision of Mr. Dan Stunden, Geotechnical Engineering Technologist under the direction of Mr. Chris McGrath, P.Eng.

MultiVIEW Locates Inc. of Mississauga, Ontario, carried out the private and public utility locates for the boreholes.

The D90 drilling equipment was supplied and operated by Walker Drilling Ltd. of Utopia, Ontario.

Elevation and location survey of the borehole locations was carried out by Stantec's Geomatics Group.

Geotechnical laboratory testing was carried out at the Stantec Ottawa laboratory and the Golder Associates Mississauga laboratory. Chemical testing for pH, soluble sulphate and chloride content, and resistivity was carried out by Paracel Laboratories in Ottawa.

This report was prepared by Simon Gudina and Chris McGrath and reviewed by Raymond Haché.

7.0 Closure

A subsurface investigation is a limited sampling of a site. The subsurface conditions given herein are based on information gathered at the specific borehole locations. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information.

Respectfully Submitted;

STANTEC CONSULTING LTD.



Simon Gudina, Ph.D., P.Eng.
Geotechnical Engineer



Chris McGrath, P.Eng.
Associate, Geotechnical Engineer



Raymond Haché, M.Sc., P.Eng.
Designated Principal MTO Foundation Contact



FOUNDATION DESIGN REPORT

For
G.W.P. 3032-06-00

New CBSA Building and New Maintenance Building
Improvements to the Canadian Plaza of the Windsor-Detroit Tunnel
City of Windsor

8.0 Discussions

8.1 GENERAL

Project Purpose/Justification

The site of the Canadian Plaza of the Windsor-Detroit Tunnel is located near the intersection of Wyandotte Street East and Goyeau Street in the City of Windsor, Ontario. The purpose of the project is to improve the capacity and operations at the Canadian Plaza of the Windsor-Detroit Tunnel. Though not part of this report, it is understood that this project will also address the existing traffic concerns and future needs of border traffic in the Windsor-Detroit Tunnel Corridor (WDTC). The identified improvements to the existing plaza will require expansion that includes new plaza buildings.

Existing Facilities at the Site

The existing single-storey WDTC Maintenance building occupies the southwest corner of the site. A multi-level parking garage is located approximately 12 m west of the WDTC Maintenance building. At the time of drilling, a large transformer with an enclosure wall was observed near the southwest corner of the site. The Wyandotte Street East right-of-way is immediately south of the site. The Goyeau Street right-of-way occupies the area immediately to the east of the WDTC Maintenance building. The site east of Goyeau Street includes gravel and paved areas, a landscaped area with paver stones and retaining walls, and a retail store (The Beer Store).

Proposed Structures

The proposed improvements to the Canadian Plaza of the Windsor-Detroit Tunnel included in this report are:

- New Canadian Border Security Services Agency (CBSA) Building, and
- New WDTC Maintenance Building

Both buildings are anticipated to be single-storey buildings with slab-on grade floors. Both buildings will have no basements. The loading dock portion of the proposed new CBSA building

will have a raised floor slab elevation. For geotechnical design purposes, a uniform loading of 6 kPa is assumed for the loading dock (Table 4.1.5.3 of the 2006 Ontario Building Code).

The proposed structures will also have underground service connections including water supply and sewer lines and other municipal services.

Though not included in this report, it is understood that the proposed plaza improvement also includes Overhead Lane Designation Signs. This will be addressed in a separate report.

Based on the preliminary General Arrangement Plan shown in Drawing 1 in Appendix A, the key elevations associated with the above proposed buildings area as follows:

Existing Grade (near CBSA Finished Floor Elevation):	183.07 m
FF Elevation (New CBSA Building):	183.26 m
FF Loading Dock (CBSA Building):	184.48 m
Top of New Sidewalk (CBSA building):	183.22 m

The finished floor elevation for the new Maintenance Building is assumed to be identical with the existing ground elevation (i.e., no anticipated grade raise).

8.2 GEOTECHNICAL DESIGN PARAMETERS

The soil conditions at this site generally consist of pavement structure and fill material over a thick clay till deposit. Bedrock was not encountered during the course of this investigation; however, a previous investigation 700 m northeast of this site encountered bedrock approximately 34 m below existing ground surface (approximate elevation of 143.1 m).

The design parameters are provided on profiles on Figures 4a and 4b in Appendix D. The design parameters provided include the following:

- Total Unit Weight (γ)
- Undrained Shear Strength (S_u)
- Preconsolidation Pressure (P'_c)
- Void Ratio (e_o)
- Compression Index (C_c)
- Recompression Index (C_r)
- Secondary Compression Index (C_{α})

For design proposes, the following soils profile will be used:

Table 8.1: Geotechnical Model

Elevation (m)		Soil Type	Design Properties		
From	To		Total unit weight, γ (kN/m ³)	Shear Strength	Deformation Properties
183.4	Variable	FILL	20	$\phi = 32^\circ$	$E_s^* = 35 \text{ MPa}$
Variable	178	Silty clay (CL) TILL (crust) Very stiff	22.0	$S_u = 150 \text{ kPa}$	See Figure 4a and 4b for soil deformation properties of cohesive soils
178	174	Silty clay to sandy clay (CL) TILL Stiff	21.5	$S_u = 80 \text{ kPa}$	
174	163	Silty clay with sand (CL) TILL Stiff	21.5	$S_u = 60 \text{ kPa}$	
163	158	Silty clay to sandy clay (CL) TILL Stiff	20	$S_u = 60 \text{ kPa}$	
158	<143.0	Silty clay to sandy clay (CL) TILL Very stiff	21	$S_u = 110 \text{ kPa}$	

*Represents the soil Young's modulus used in the calculation of immediate settlement.

A design water level elevation of 175.3 m has been selected. It is noted that the site soil properties at the proposed location of the new CBSA will be considered representative for the entire proposed plaza improvements.

The fill depth is greatest (approximately 5.5 m) near the southwest corner of the site (at BH11-1) and decreases going north and east. The existing fill will be removed and replaced with a selected granular fill over the entire footprint of the proposed CBSA building. The bottom-most elevation of the fill is approximately 177.9 m. For the proposed Maintenance building the fill thickness ranges between 500 and 800 mm.

An oxidized clay till crust covers the deeper unaltered deposit and extends to between 4.4 to 5.2 m below ground surface. Measured undrained shear strength of the crust ranged from 150 to 225 kPa. The thickness of the crust extends to over 4 m below the frost penetration depth in Windsor. This is a strong layer of limited compressibility which is suitable to support lightly and moderately loaded spread footings for buildings up to 3 to 5 storeys in height.

8.3 FROST PENETRATION

OPSD 3090.101 indicates that the frost penetration depth at the site is 1.0 m. Therefore, footings should be provided with a minimum of 1.0 m of soil cover or equivalent insulation for protection against frost heave. This depth of frost penetration should also be used in the design of frost tapers for the backfill.

Where construction is undertaken during winter, footing subgrades must be protected from freezing. Due diligence is required to ensure that granular fill materials do not include frozen material, snow or ice.

8.4 SEISMIC DESIGN CONSIDERATIONS

8.4.1 Seismic Site Class

The Seismic Site Class was evaluated according to the 2006 Ontario Building Code (OBC 2006). The measured SPT N-values and the undrained shear strength from in-situ vane tests were used to obtain the harmonic mean over a depth of 30 m beneath the footing level (below frost penetration depth). The N-values and undrained shear strength from in-situ vane test results are provided in the Borehole Records in Appendix B. Based on the evaluation using both the N-value and the undrained shear strength, this site can be classified as Seismic Site Class D (Stiff Soil). Table 8.2 summarizes the seismic site classification based on the in-situ undrained shear strength (S_u).

Table 8.2: Parameters for Seismic Site Classification

Depth Range (m)	In-Situ Undrained Shear Strength (kPa)
0 – 1.0	Frost depth
1.0 – 5.0	150
5.0 – 8.5	87
8.5 – 18.4	66
18.4 – 23.0	76
23.0 - 31.4	104
Design S_u Value	85

Note: The Design S_u value is based on the weighted harmonic mean.

8.4.2 Zonal Acceleration Ratio

A seismic hazard calculation for the site was obtained from Natural Resources Canada (copy attached in Appendix E). It indicates that for this site, the peak ground acceleration (PGA) value corresponding to 2% probability of exceedance in 50 years is 0.071. Hence, a Zonal Acceleration Ratio (ZAR) of 0.071 should be used for this site.

Even though not likely very significant in magnitude, seismically induced lateral earth pressures should be considered for this project.

8.4.3 Liquefaction Potential

The site is underlain by an extensive deposit of relatively stiff clay till. The observed groundwater is deeper than 8 m beneath the existing ground surface. Liquefaction of the site soil is not a concern for this project due to the stiff nature of the clay till and the relatively low Zonal Acceleration Ratio.

8.5 FOUNDATION OPTIONS

8.5.1 General

The native soils at this site are suitable to support the proposed building using conventional spread footing foundations. Due to presence of the relatively thick fill layer (up to 5.5 m) at the west end of the site, consideration is given below to other foundation alternatives to penetrate the fill layer.

The following table provides a comparison of the foundation options considered for the proposed new buildings at the Canadian Plaza of the Windsor-Detroit Tunnel.

Table 8.3: Foundation Options

Foundation Option	Advantages	Disadvantages	Relative Cost	Risks/ Consequences
Spread Footings supported on native soils or on structural fill placed on native soil (after removal existing fill)	<ul style="list-style-type: none"> Lower cost than using deep foundations no pile driving related concerns 	<ul style="list-style-type: none"> extensive excavation may be required requires braced excavation excavation may be difficult if perched groundwater encountered may require large size footings settlement potential stepped footings will be required for the CBSA building 	Low	<ul style="list-style-type: none"> excavation may be difficult in perched groundwater braced excavation may impact on surrounding infrastructure dewatering challenges
Piles end bearing on Bedrock	<ul style="list-style-type: none"> higher geotechnical resistance Negligible settlement Non-displacement H-piles would avoid heave issues 	<ul style="list-style-type: none"> potential difficulty in driving piles through the stiff glacial till potential downdrag load depending on backfill soil very long piles 	High	<ul style="list-style-type: none"> disturbances related to pile driving such as noise and vibration
Friction piles in stiff to very stiff clay till	<ul style="list-style-type: none"> reduced pile length and associated cost savings 	<ul style="list-style-type: none"> potential for settlement potential for downdrag depending on backfill soil reduced pile length would be relatively short and would have a low geotechnical resistance piles likely spaced closer together with potential reduction of group capacity 	Medium to High	<ul style="list-style-type: none"> disturbances related to pile driving such as noise and vibration drag loads may induce settlements in the case of pipe piles, potential for adjacent ground heave as displacement piles are driven

Foundation Option	Advantages	Disadvantages	Relative Cost	Risks/ Consequences
Rammed Aggregate Piers (RAP)	<ul style="list-style-type: none"> relatively quick improves site soil 	<ul style="list-style-type: none"> Fill is of variable thickness and may change abruptly due to the historic building previously removed from the site. The design would need to be conservative and exceed the deepest anticipated fill layer. 5.5 m is near the practical limit of this option possible effect on surrounding facilities very high mobilization cost 	Very high	<ul style="list-style-type: none"> potential impact on nearby facilities

Based on our review of the options presented above, it is anticipated that footings founded directly on native till or on structural fill over native till will be the preferred foundation type for the proposed buildings.

The following design recommendations are provided based on the preferred foundation option discussed herein.

8.5.2 Geotechnical Resistances

At this site the native glacial till includes a very strong weathered crust layer which extends to over 5 m below ground surface; below the crust is a weaker and more compressible unaltered glacial till. Recommendations provided below reflect the strength of the weathered crust as a suitable attribute to support spread footing foundations for the proposed building.

The geotechnical resistances provided herein are based on the preferred option described above. It is recommended that foundation footings be founded within native till crust layer or on granular fill placed on native till crust material. The existing fill material should be removed entirely from the footing influence zone. The excavations should be backfilled with Structural Fill consisting of a compacted OPSS Granular A material. For footings, a minimum of 300 mm layer of OPSS Granular A should be placed and compacted beneath the footings for bedding purposes.

The edges of the Structural Fill (Granular A) pad should extend at least 1 m horizontally away from the footing in all directions. The Granular A should be placed within the influence zone of the footing which is defined by a 1:1 line extending down and away from the edge of the footing in all directions to native soil.

The geotechnical resistances provided in Table 8.4 may be used in the design provided the footings are placed on undisturbed native till or granular bedding over undisturbed native till as described above.

Table 8.4: Recommended Spread Footing Design Parameters

Founding Element	Founding Elev. (m)	Footing Size (m x m)		Factored Geotechnical Resistance at ULS (kPa)	Geotechnical Reaction at SLS (kPa)
		Width (m)	Length (m)		
Footings on Granular A pad or clay till (at or below frost level)	Between 182 and 180	Square Footing			
		0.6	0.6	400	150
		0.8	0.8	400	150
		1.0	1.0	400	150
		1.50	1.50	350	150
		2.00	2.00	300	150
		Strip Footing			
		0.60	50.00	400	150
		1.00	50.00	350	150
		2.00	50.00	300	150

The Factored Geotechnical Resistances in Table 8.4 were calculated assuming a minimum 2 m thick layer of Granular A or 4 m thick layer of clay till crust beneath the footings. If a thicker layer of Granular A pad is used, possibly higher geotechnical resistances at both ULS and SLS can be developed; the geotechnical engineer will need to reassess the ULS resistances should a thicker granular pad be proposed for the purpose of developing higher resistances at ULS and SLS.

A resistance factor of 0.5 has been applied to calculate the factored geotechnical resistance at Ultimate Limit State (ULS).

The geotechnical reaction at Serviceability Limit State (SLS) typically corresponds to a maximum settlement of 25 mm. For the purpose of this section, the anticipated maximum settlement within the loading dock area was broken down into two components – that caused by approximately 1 m of additional fill load and that caused by the building (functional) load. The anticipated settlement due to the fill is evaluated in Section 8.8. The evaluation indicated that the anticipated settlement at the anticipated location of footings is in the order of 10 mm. Hence, the SLS reactions presented in above correspond to a settlement of 15 mm due to foundation loads only.

8.5.3 Sliding Resistance

The unfactored horizontal resistance of spread footings may be calculated using the following unfactored coefficients of friction:

0.55 between OPSS Granular A and cast-in-place concrete

0.40 between clay till and cast-in-place concrete

A resistance factor against sliding of 0.8 and 0.6, respectively, should be applied to the above coefficients to obtain the resistance at ULS (Table K-1 of the National Building Code of Canada (NBCC, 2005)).

8.6 FLOOR SLAB DESIGN

Except for the loading dock of the new CBSA building, no significant grade raise is anticipated for the proposed development described herein. For the loading dock grade raise, the anticipated settlement is addressed in Section 8.8 of this report. It is anticipated that the permanent floor load for the proposed structures will not exceed 6 kPa.

The site is suitable for a conventional slab-on-grade floor provided the existing fill is removed and replaced with OPSS Granular A up to the bottom of the floor slab. The floor slab may be designed using a soil modulus of subgrade reaction of 40 MPa/m. The slab-on-grade floor should float independently of all load-bearing walls and columns. Alternatively, the floor slab may be designed as a monolithic slab and footing (i.e., integral with the spread footings). For this situation, the structural design should be robust enough to accommodate differential settlement of as much as 15 mm between the footing and the remainder of the slab.

8.7 LATERAL EARTH PRESSURES

8.7.1 Lateral Earth Pressure under Static Conditions

Earth pressures will need to be considered in the design of the foundation walls, retaining walls (if any), as well as for the temporary shoring system during supported excavation.

Computation of earth pressures should be performed as described in this section. For retaining walls that are designed to allow rotation, active earth pressure may be used for design. For rigidly tied and unyielding structures, the at-rest earth pressure should be used for design. For foundation walls integrally built with foundation footings and top tie-beams, the walls are considered to be unyielding and the at-rest earth pressure should be used for design. For shoring system during excavation, the active earth pressure should be used. The unfactored soil parameters provided in Table 8.5 may be used for design of walls with a horizontal backfill. The effects of compaction (if applicable) should be accounted for by applying a compaction surcharge.

The total active (P_A), at-rest (P_O) and passive (P_P) thrusts can be calculated using the following equations:

$$P_A = \frac{1}{2} K_a \gamma H^2$$

$$P_O = \frac{1}{2} K_o \gamma H^2$$

$$P_P = \frac{1}{2} K_p \gamma H^2$$

where H is the height of the wall. Values for K_a , K_o , K_p , and γ are provided in Tables 8.5 below. The thrust acts at a point one third up the height of the wall.

Table 8.5: Recommended Non-Seismic Earth Pressure Parameters (Horizontal Backfill)

Parameter	OPSS Gran A and Gran B Type II	Existing Fill	Clay Till
Bulk Unit Weight, γ (kN/m ³)	22.0	21.5	22.0
Effective Friction Angle	35°	30°	29°
Coefficient of Active Earth Pressure (K_a)	0.27	0.33	0.35
Coefficient of Earth Pressure at Rest (K_o)	0.43	0.50	0.52
Coefficient of Passive Earth Pressure (K_p)	3.69	3.00	2.88

8.7.2 Lateral Earth Pressure under Seismic Conditions

The foundation walls and any permanent retaining walls (if any) should also be designed to resist the earth pressures induced under seismic loading conditions. The seismic earth pressures may be calculated using the parameters detailed in Table 8.6 below.

The total active and passive thrusts under seismic loading conditions can be calculated using the following equations:

- $P_{AE} = \frac{1}{2} K_{AE} \gamma H^2 (1 - k_v)$
- $P_{PE} = \frac{1}{2} K_{PE} \gamma H^2 (1 - k_v)$

where:

- K_{AE} = active earth pressure coefficient (combined static and seismic)
- K_{PE} = passive earth pressure coefficient (combined static and seismic)
- H = height of wall
- k_h and k_v = horizontal and vertical acceleration coefficient
- γ = total unit weight

For this site, the following design parameters were used to develop the recommended K_{AE} and K_{PE} values. A site specific Seismic Hazard Calculation sheet prepared by Natural Resources Canada is provided in Appendix E. For buildings the PGA value corresponding to a 2% probability of exceedance in 50 years is typically selected.

- Zonal Acceleration Ratio, A or PGA 0.071
- Horizontal Acceleration Coefficient, k_h 0.036 yielding 0.106 non-yielding
- Vertical Acceleration Coefficient, k_v 0.024 yielding 0.071 non-yielding

The above k_h value corresponds to $\frac{1}{2}$ of the A value for yielding walls and 1.5 times for non-yielding walls. The k_v value corresponds to 0.67 of the k_h value. The angle of friction between the soil and the wall has been set at 0° to provide a conservative estimate.

Recommended seismic earth pressure parameters are provided in Table 8.6 below.

Table 8.6: Recommended Seismic Earth Pressure Parameters (Horizontal Backfill)

Parameter	OPSS Gran A and Gran B Type II		Existing Fill		Clay Till	
Bulk Unit Weight, γ (kN/m ³)	22.0		21.5		22.0	
Effective Friction Angle	35°		30°		29°	
	Yielding wall	Non-yielding	Yielding wall	Non-yielding	Yielding wall	Non-yielding
Active Earth Pressure (K_{AE})	0.29	0.34	0.36	0.41	0.37	0.42
Height of Application of P_{AE} from base as a ratio of wall height, (H)	0.345	0.369	0.344	0.365	0.343	0.364
Passive Earth Pressure, (K_{PE})	3.62	3.46	2.94	2.79	2.82	2.68
Height of Application of P_{PE} from base as a ratio of wall height, (H)	0.322	0.294	0.321	0.292	0.321	0.291

8.8 EVALUATION OF POTENTIAL SETTLEMENT

A preliminary evaluation of the potential settlement at the site was carried out to estimate the anticipated maximum vertical settlement of the site soil due to the proposed improvements. The loading dock is anticipated to be approximately 1.1 m higher than the existing grade; any additional fill for grade raise will result in settlement of the existing clay till deposit. The evaluation was carried out using commercial software Settle3D. The following assumptions were made in carrying out the settlement evaluation:

- The geotechnical soil model provided in Table 8.1 will be considered representative of the site soil condition.
- The net grade raise of approximately 1 m is required for the proposed loading dock finished floor elevation (the CBSA building);
- Existing ground surface elevation is approximately at 183.4 m;
- Existing fill of up to approximately 5.5 m thick will be removed from beneath the CBSA footprint;
- After excavation, OPSS Granular A fill will be placed up to the anticipated grade of the loading dock finished floor level for the entire footprint of the loading dock; and
- Only the settlement induced by the fill is calculated.

The evaluation results are presented in Figures 5a and 5b in Appendix D.

Figure 5a shows a representative plot of the settlement induced due to the placement of approximately 1 m of fill. This figure indicates that the maximum anticipated settlement is approximately 16 mm. The maximum settlement will occur near the centre of the footprint. Along the outer perimeter of the loading dock (anticipated location of footings), the anticipated settlement is approximately 10 mm.

Figure 5b shows a typical total stress profile near the centre of the footprint as induced by the fill. This Figure indicates that the induced total stress will not exceed the preconsolidation pressure anticipated for the site soils.

8.9 CONSTRUCTION CONSIDERATIONS

8.9.1 Shoring of Excavations

Due to the existence of surrounding facilities and road pavements, excavation at the site is anticipated to require shoring.

For the new CBSA building, the sides of excavation requiring shoring include: west side due to the presence of transformer and enclosure wall, south side due to the close proximity of the Wyandotte Street East road right-of-way, and east side due to the Goyeau Street right-of-way.

It is noted that the location of the proposed new Maintenance building will involve excavation of less than 800 mm hence shoring does not appear to be required.

The following table compares the available shoring system considered for excavation of the proposed plaza improvements:

Table 8.7: Comparison of Shoring Systems

Shoring Options	Advantages	Disadvantages	Relative Cost	Risks/ Consequences
H-Piles with timber lagging; struts /rakers	<ul style="list-style-type: none">• simple installation	<ul style="list-style-type: none">• more difficult to control unwatering	Low	<ul style="list-style-type: none">• no significant risk anticipated
Steel sheet pile (SSP)	<ul style="list-style-type: none">• no unwatering required	<ul style="list-style-type: none">• Difficult to drive in very stiff soil or if obstructions encountered	High	<ul style="list-style-type: none">• Debris / concrete pieces in the fill may cause drilling difficulty

H-piles with Timber Lagging shoring presents itself as the most viable option for shoring of excavation at the site. This will be supported with struts or rakers from the excavation side.

The contractor will ultimately be responsible to develop and implement a shoring system meeting the requirements of OPSS 539, including establishing appropriate geotechnical design parameters.

For temporary excavations with a horizontal backfill, the unfactored soil parameters provided in Table 8.5 above may be used for design.

Shoring design should meet the requirements of Performance Level 1b as per OPSS 539 and should consider traffic loading. Performance Level 1b specifies a Maximum Angular Distortion of 1:1000 and a Maximum Horizontal Displacement of 10 mm.

8.9.2 Excavation and Backfilling

As discussed below, all fill must be removed from the building footprint, including any fill within the influence zone of the footings. It should be noted that previous building demolition works

have been carried out on both the east side and west side of Goyeau Street. The boreholes drilled for this project do not necessarily delineate adequately the bottom of fill profile at the site. It should be anticipated that abrupt fill depth changes will be present in areas of former foundations. As well, it cannot be confirmed that all previous foundation elements have been removed from the site.

Excavation and backfill for the new buildings should be carried out in accordance with OPSS 902 Construction Specification for Excavation and Backfilling – Structures. The Granular A pad shall be compacted in accordance with OPSS 501 construction specification for compaction.

All vegetation, fill, organic soils and other deleterious materials must be removed from beneath the proposed building footprint. Where deleterious materials are encountered, the material should be excavated, wasted and replaced. The lateral extent of such excavation should include all deleterious materials within the influence zone of the foundations.

Any side slopes for open cut excavations should conform to Occupational Health and Safety Act (OHSA) Regulations for Construction Projects current at the time of construction. Within the anticipated excavation depth for this project, the soils encountered at the site can be classified as Type 3 Soil.

Generally, it is anticipated that construction requirements for temporary open excavations will include 1H:1V side slopes extending from the base of the excavation.

Grading work for this project should be carried out in accordance with OPSS 206 Construction Specification for Grading and SP 206S03.

Excavation side slopes, if any, should be protected from erosion and should be inspected regularly for signs of instability. Slopes should be flattened as required to maintain safe working conditions.

Shoring should be provided in accordance with the recommendations provided herein, when excavations are in close proximity to existing infrastructure and embankments.

8.9.3 Temporary Construction Unwatering

The groundwater level during geotechnical investigation end of September 2011 for this project was at approximate elevation of 175.3 m (approximately 8.1 m below existing grade). As such, standing groundwater may not be encountered during construction excavations. However, excavation may encounter perched water within the soil and fill materials. Given the soil conditions encountered at the site, seepage within the depth of excavation is anticipated to be slow and therefore unwatering of the excavation using conventional sump and pump techniques should be adequate. The estimated hydraulic conductivity for the fill and native soil at the site is expected to be in the order of 1×10^{-7} to 1×10^{-5} m/s.

8.9.4 Bedding and Backfilling for Service Connections

Bedding and backfill for service connections should be in accordance with OPSD typical details. It is recommended that a minimum of 150 mm of OPSS Granular A material be placed below the pipe invert as bedding material. Granular pipe backfill placed above the invert should consist of OPSS Granular A material. A minimum of 300 mm vertical and side cover should be provided. These materials should be compacted to at least 95% of Standard Proctor Maximum Dry Density (SPMDD).

The native soils (clay till) have a high silt content and are very susceptible to disturbance due to moisture and construction equipment. The base of overburden excavations should not be exposed for extended periods of time. Mud slabs may be required to protect the trench bottom in some areas if long term exposure is required.

Trench backfill placed within the upper 1.0 m should be compatible in nature to the soils exposed in the trench walls, or alternatively frost tapers should be constructed. These materials should be compacted to a minimum of 95% SPMDD. Below 1.0 m, the trench backfill should consist of compactable site generated materials or imported OPSS Select Subgrade Material. These materials should be compacted to a minimum of 95% SPMDD.

It should be noted that reuse of the site generated material will be highly dependent on the materials' moisture content at time of placement. Backfill should be compacted in lifts not exceeding 300 mm.

Existing services that cross above the proposed pipes will need to be supported. The Contractor should be responsible for designing and providing these supports in accordance with pipe or utility manufacture's specifications. Special attention should be given for pressurized systems, in regards to unconfined or exposed lengths of pipe.

8.10 CEMENT TYPE AND CORROSION PROTECTION

Eight samples of the fill and native till were tested for pH, water soluble sulphate and chloride concentrations, and resistivity. The testing was completed to determine the potential for degradation of the concrete in the presence of soluble sulphates and the potential for corrosion of exposed steel used in foundations and buried infrastructure. The analysis results are summarized in the Table 5.2.

The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with soil and groundwater at the site. The soluble sulphate concentrations for the samples tested ranged between 81 and 854 µg/g. Soluble sulphate concentrations less than 1000 µg/g generally indicate that a low degree of sulphate attack is expected for concrete in contact with soil and groundwater. Type GU (General Use) Portland Cement should therefore be suitable for use in concrete at this site.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The soil pH values were 7.4 and 8.0 which are within what is considered the normal range for soil pH of 5.5 to 9.0. The pH levels of the tested

soil do not indicate a highly corrosive environment. The test results provided in the Table 5.2 may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects.

9.0 Specifications

The following specifications are referenced in this report:

Table 9.1: Specifications Referenced in Report

Document	Title
OPSD 3090.101	Foundation Frost Depths for Southern Ontario
OPSS 206	Construction Specification for Grading
SP 206S03	Earth Excavation, Grading
OPSS 501	Construction Specification for Compaction
OPSS 539	Construction Specification for Temporary Protection System
OPSS 902	Construction Specification for Excavation and Backfilling - Structures

10.0 References

- ASTM. 1999. Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils (ASTM D1586). ASTM International, West Conshohocken, PA.
- ASTM. 2000. Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) (ASTM D2487). ASTM International, West Conshohocken, PA.
- Boone, S.J. 2010. A Critical Reappraisal of "Preconsolidation Pressure" Interpretations Using Oedometer Tests. Canadian Geotechnical Journal, 47(3): 281 – 296.
- Chapman, L.J., and Putnam, D.F. 1984. The Physiography of Southern Ontario, Ontario Geological Survey Special Volume 2. Ontario Research Foundation, Toronto, Ontario.
- NBCC. 2005. National Building Code of Canada. Structural Commentaries. National Research Council of Canada, Ottawa, Canada.
- Ontario Building Code. 2006. 2006 Building Code Compendium. Ontario Ministry of Municipal Affairs and Housing, Toronto, Ontario.

11.0 Closure

A soil investigation is a limited sampling of a site. The conclusions given herein are based on information gathered at the specific borehole locations. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information and its effects on the above recommendations.

We trust the information presented herein meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

This report was prepared by Simon Gudina and Chris McGrath, and reviewed by Raymond Haché.

Respectfully submitted,

STANTEC CONSULTING LTD.



Simon Gudina, Ph.D., P.Eng.
Geotechnical Engineer



Chris McGrath, P.Eng.
Associate, Geotechnical Engineer



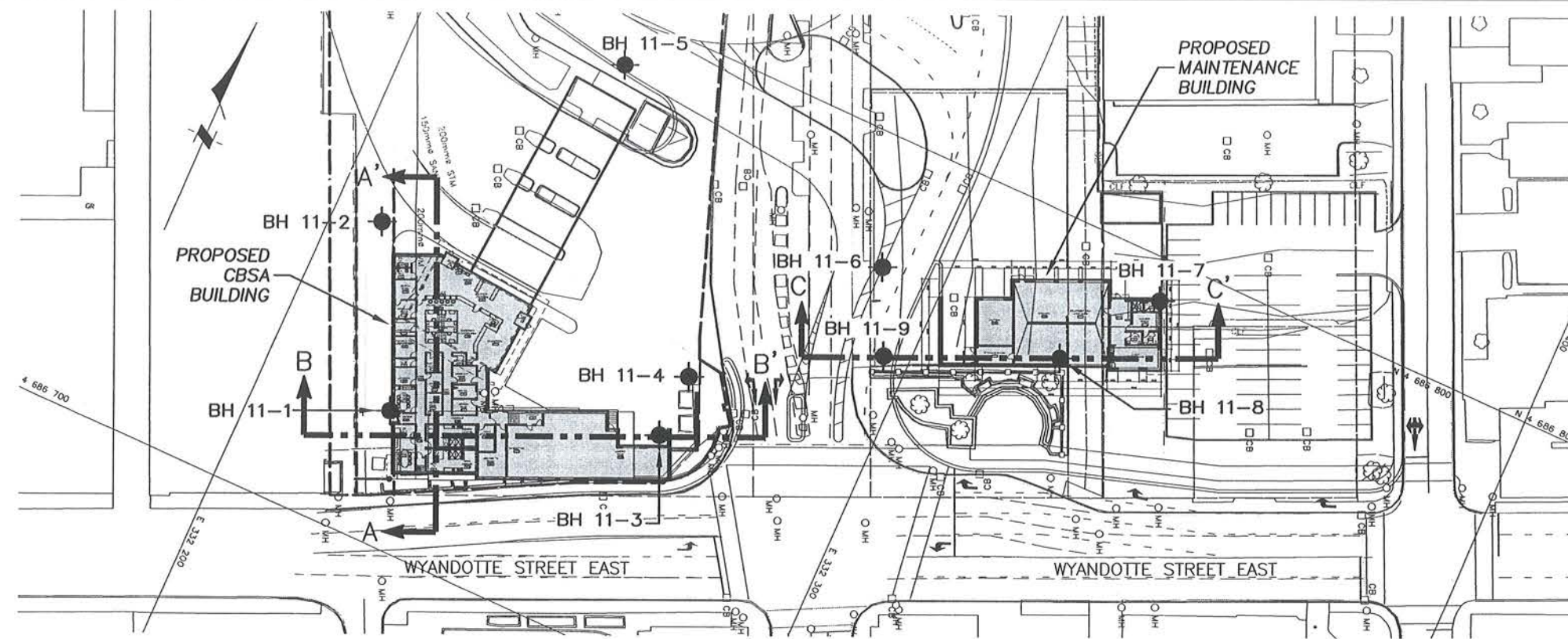
Raymond Haché, M.Sc., P.Eng.
Designated Principal MTO Foundation Contact

APPENDIX A

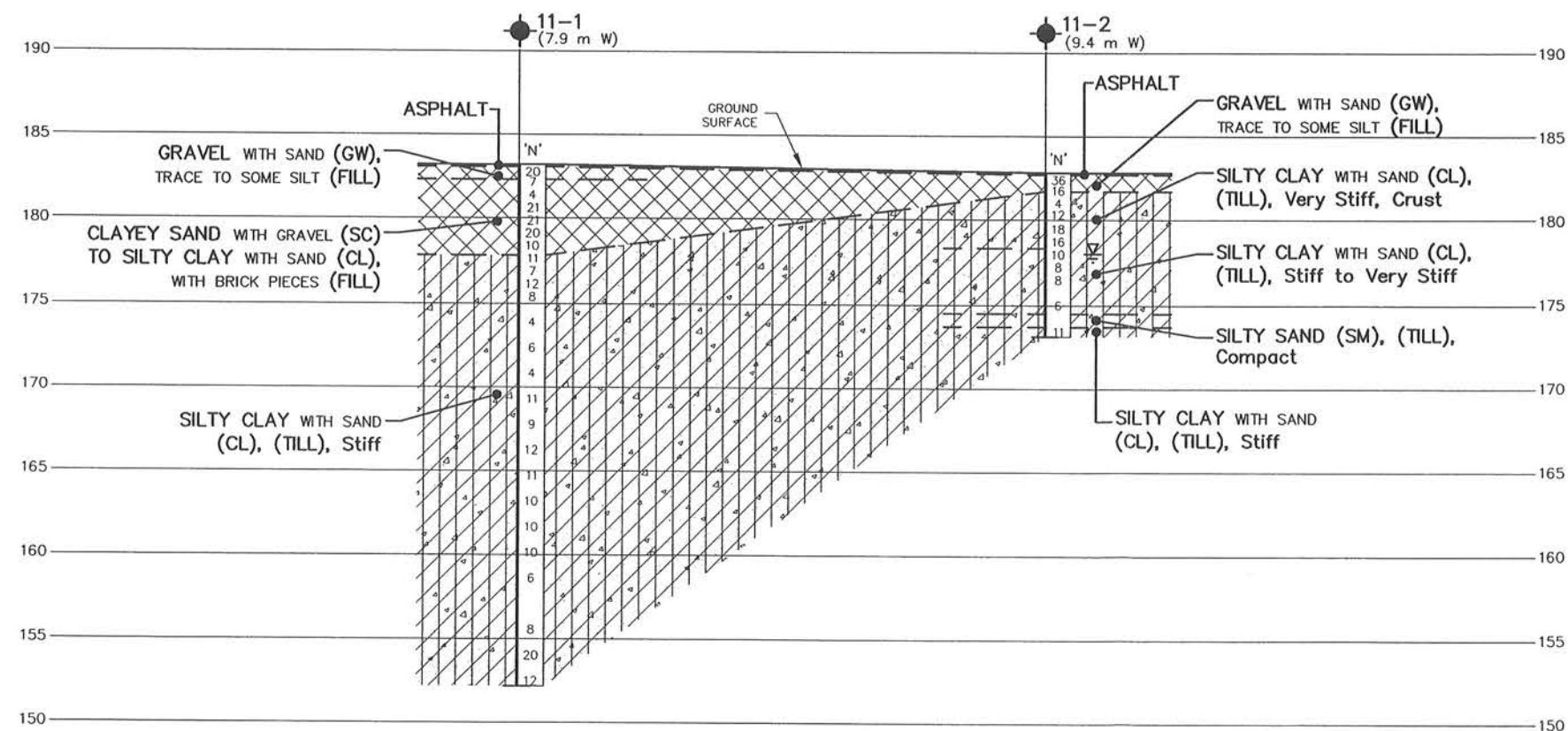
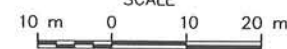
Drawing No. 1 – Borehole Location Plan and Strata Plot

Drawing No. 2 – Strata Plots

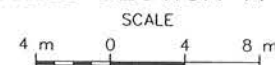
Site Photos



PLAN



CROSS SECTION A-A'

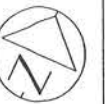


METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



PLATE No
CONT
WP 3032-06-00



WINDSOR-DETROIT TUNNEL PLAZA
WINDSOR, ONTARIO
BOREHOLE LOCATIONS & SOIL STRATA



SHEET



LEGEND

- | | |
|---|---|
|  | Borehole |
| N | Blows/0.3m (Std Pen Test,
475 J/blow) |
|  | WL at time of investigation
(Sept 2011) |
| (9.1 m W) | Offset and Direction from
Cross-section Line in meters |

No	ELEVATION	UTM_ZONE 17 COORDINATES	
		NORTH	EAST
11-1	183.4	4686722.2	332222.7
11-2	183.0	4686750.6	332208.4
11-3	183.2	4686737.4	332266.2
11-4	183.0	4686748.5	332266.7
11-5	183.0	4686791.7	332235.3
11-6	183.2	4686778.9	332289.3
11-7	183.5	4686793.1	332334.6
11-8	183.4	4686777.3	332323.0
11-9	183.2	4686765.3	332295.6

≡NOTES≡

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

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REVISIONS			
	DATE	BY	DESCRIPTION

GEOCRES No 40J6-39

HWY No			DIST
SUBM'D SC	CHECKED	DATE 2011-12-14	SITE
DRAWN GBB	CHECKED	APPROVED <i>[Signature]</i>	DWG 1


REVISIONS					
	DATE	BY	DESCRIPTION		
GEOCES No 40J6-39					
HWY No		DIST			
SUBM'D	SG	CHECKED	DATE 2011-12-14	SITE	
DRAWN	CBB	CHECKED	APPROVED 	DWG 2	



Photo No. 1: Photo taken looking south showing proposed CBSA building location near BH11-2



Photo No. 2: Photo taken looking south showing the proposed CBSA building location near boreholes BH11-3 and BH11-4

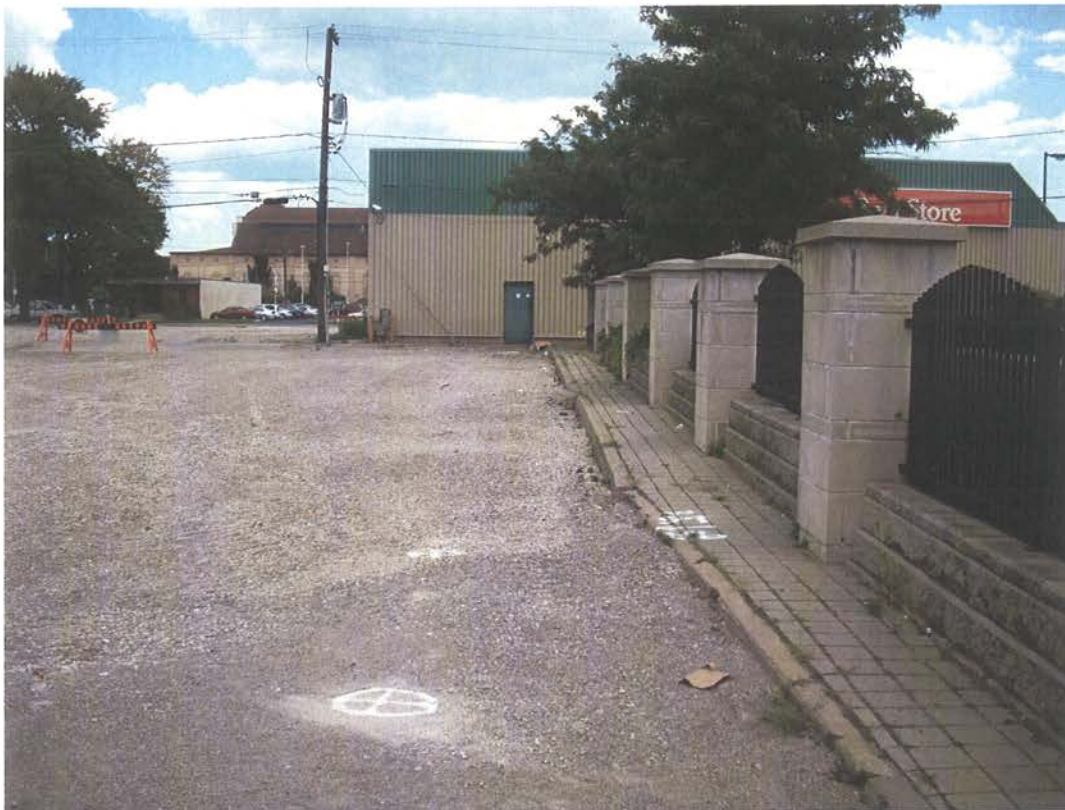


Photo No. 3: Photo taken looking south showing the proposed location of the Maintenance Building



Photo No. 4: Photo taken from the west side of Goyeau Street looking southeast at the location of the Maintenance Building



APPENDIX B

Symbols and Terms Used on Borehole Records

Borehole Records

SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

<i>Topsoil</i>	- mixture of soil and humus capable of supporting vegetative growth
<i>Peat</i>	- mixture of visible and invisible fragments of decayed organic matter
<i>Till</i>	- unstratified glacial deposit which may range from clay to boulders
<i>Fill</i>	- material below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

<i>Desiccated</i>	- having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
<i>Fissured</i>	- having cracks, and hence a blocky structure
<i>Varved</i>	- composed of regular alternating layers of silt and clay
<i>Stratified</i>	- composed of alternating successions of different soil types, e.g. silt and sand
<i>Layer</i>	- > 75 mm in thickness
<i>Seam</i>	- 2 mm to 75 mm in thickness
<i>Parting</i>	- < 2 mm in thickness

Terminology describing soil types:

The classification of soil types are made on the basis of grain size and plasticity in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488). The classification excludes particles larger than 76 mm (3 inches). The USCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing cobbles, boulders, and non-matrix materials (organic matter or debris):

Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter, construction debris) is based upon the proportion of these materials present:

<i>Trace, or occasional</i>	Less than 10%
<i>Some</i>	10-20%
<i>Frequent</i>	> 20%

Terminology describing compactness of cohesionless soils:

The standard terminology to describe cohesionless soils includes compactness (formerly "relative density"), as determined by the Standard Penetration Test N-Value (also known as N-Index). A relationship between compactness condition and N-Value is shown in the following table.

Compactness Condition	SPT N-Value
<i>Very Loose</i>	<4
<i>Loose</i>	4-10
<i>Compact</i>	10-30
<i>Dense</i>	30-50
<i>Very Dense</i>	>50

Terminology describing consistency of cohesive soils:

The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests.

Consistency	Undrained Shear Strength	
	kips/sq.ft.	kPa
<i>Very Soft</i>	<0.25	<12.5
<i>Soft</i>	0.25 - 0.5	12.5 - 25
<i>Firm</i>	0.5 - 1.0	25 - 50
<i>Stiff</i>	1.0 - 2.0	50 - 100
<i>Very Stiff</i>	2.0 - 4.0	100 - 200
<i>Hard</i>	>4.0	>200



ROCK DESCRIPTION

Terminology describing rock quality:

RQD	Rock Mass Quality
0-25	<i>Very Poor</i>
25-50	<i>Poor</i>
50-75	<i>Fair</i>
75-90	<i>Good</i>
90-100	<i>Excellent</i>

Rock quality classification is based on a modified core recovery percentage (RQD) in which all pieces of sound core over 100 mm long are counted as recovery. The smaller pieces are considered to be due to close shearing, jointing, faulting, or weathering in the rock mass and are not counted. RQD was originally intended to be done on NW core; however, it can be used on different core sizes if the bulk of the fractures caused by drilling stresses are easily distinguishable from *in situ* fractures. The terminology describing rock mass quality based on RQD is subjective and is underlain by the presumption that sound strong rock is of higher engineering value than fractured weak rock.

Terminology describing rock mass:

Spacing (mm)	Joint Classification	Bedding, Laminations, Bands
> 6000	<i>Extremely Wide</i>	-
2000-6000	<i>Very Wide</i>	<i>Very Thick</i>
600-2000	<i>Wide</i>	<i>Thick</i>
200-600	<i>Moderate</i>	<i>Medium</i>
60-200	<i>Close</i>	<i>Thin</i>
20-60	<i>Very Close</i>	<i>Very Thin</i>
<20	<i>Extremely Close</i>	<i>Laminated</i>
<6	-	<i>Thinly Laminated</i>

Terminology describing rock strength:

Strength Classification	Unconfined Compressive Strength (MPa)
<i>Extremely Weak</i>	< 1
<i>Very Weak</i>	1 – 5
<i>Weak</i>	5 – 25
<i>Medium Strong</i>	25 – 50
<i>Strong</i>	50 – 100
<i>Very Strong</i>	100 – 250
<i>Extremely Strong</i>	> 250

Terminology describing rock weathering:

Term	Description
<i>Fresh</i>	No visible signs of rock weathering. Slight discolouration along major discontinuities
<i>Slightly Weathered</i>	Discolouration indicates weathering of rock on discontinuity surfaces. All the rock material may be discoloured.
<i>Moderately Weathered</i>	Less than half the rock is decomposed and/or disintegrated into soil.
<i>Highly Weathered</i>	More than half the rock is decomposed and/or disintegrated into soil.
<i>Completely Weathered</i>	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.



STRATA PLOT

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



Boulders
Cobbles
Gravel



Sand



Silt



Clay



Organics



Asphalt



Concrete



Fill



Bedrock

SAMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)
ST	Shelby tube or thin wall tube
DP	Direct-Push sample (small diameter tube sampler hydraulically advanced)
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond coring bits.

WATER LEVEL MEASUREMENT



measured in standpipe, piezometer, or well



inferred

RECOVERY

For soil samples, the recovery is recorded as the length of the soil sample recovered. For rock core, recovery is defined as the total cumulative length of all core recovered in the core barrel divided by the length drilled and is recorded as a percentage on a per run basis.

N-VALUE





Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (64 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (305 mm) into the soil. For split spoon samples where insufficient penetration was achieved and N-values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75). Some design methods make use of N value corrected for various factors such as overburden pressure, energy ratio, borehole diameter, etc. No corrections have been applied to the N-values presented on the log.

DYNAMIC CONE PENETRATION TEST (DCPT)

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to A size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone one foot (305 mm) into the soil. The DCPT is used as a probe to assess soil variability.

OTHER TESTS

S	Sieve analysis
H	Hydrometer analysis
k	Laboratory permeability
γ	Unit weight
G_s	Specific gravity of soil particles
CD	Consolidated drained triaxial
CU	Consolidated undrained triaxial with pore pressure measurements
UU	Unconsolidated undrained triaxial
DS	Direct Shear
C	Consolidation
Q_u	Unconfined compression
I_p	Point Load Index (I_p on Borehole Record equals $I_p(50)$ in which the index is corrected to a reference diameter of 50 mm)

	Single packer permeability test; test interval from depth shown to bottom of borehole
	Double packer permeability test; test interval as indicated
	Falling head permeability test using casing
	Falling head permeability test using well point or piezometer



Stantec

RECORD OF BOREHOLE No BH 11-1

1 OF 4

METRIC

W.P. 3032-06-00 LOCATION Windsor - Detroit Tunnel Plaza, Windsor, ON N: 4 686 722 E: 332 223 ORIGINATED BY DS
 DIST HWY BOREHOLE TYPE Hollow Stem Augers, Split Spoon Sampler, Shelby Tubes COMPILED BY JF/KKB
 DATUM Geodetic DATE 2011 09 28 - 2011 09 29 CHECKED BY CM

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					
183.4	Asphalt						20 40 60 80 100						GR SA SI CL
189.9	150 mm ASPHALT						20 40 60 80 100						
0.2	FILL: Well graded gravel with sand (GW), trace to some silt		1	SS	20								50 38 (12)
	Brown												
182.3	FILL: clayey sand with gravel (SC) to silty clay with sand (CL), with brick pieces		2	SS	7								20 31 31 18
1.1	Brown												
	- Sample wet		3	SS	4								
			4	SS	21								
	- Red brick pieces		5	SS	21								0 27 41 32
			6	SS	20								
	- Red brick pieces		7	SS	10								
177.9	Silty clay with sand (CL), TILL		8	SS	11								PP = 75 kPa
5.5	Stiff												
	Grey		9	SS	7								PP = 100 kPa 1 27 42 30
			10	SS	12								
			11	SS	8								PP = 75 kPa
			12	BS									Monitoring well backfilled with bentonite from 8.38m to 15.24m
			13	SS	4								

Continued Next Page

Numbers refer to Sensitivity
 ○ 3% STRAIN AT FAILURE

ONTARIO MTO STANTEC 165601256 - WINDSOR TUNNEL.GPJ ONTARIO MOT.GDT 12/2/28

RECORD OF BOREHOLE No BH 11-1

4 OF 4

METRIC

W.P. 3032-06-00 LOCATION Windsor - Detroit Tunnel Plaza, Windsor, ON N: 4 696 722 E: 332 223 ORIGINATED BY DS
 DIST HWY BOREHOLE TYPE Hollow Stem Augers, Split Spoon Sampler, Shelby Tubes COMPILED BY JF/KKB
 DATUM Geodetic DATE 2011 09 28 - 2011 09 29 CHECKED BY CM

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					WATER CONTENT (%)							

RECORD OF BOREHOLE No BH 11-2

1 OF 1

METRIC

W.P. 3032-06-00 LOCATION Windsor - Detroit Tunnel Plaza, Windsor, ON N: 4 686 751 E: 332 208 ORIGINATED BY DS
 DIST HWY BOREHOLE TYPE Hollow Stem Augers, Split Spoon Sampler COMPILED BY JF/KKB
 DATUM Geodetic DATE 2011 09 27 - 2011 09 27 CHECKED BY CM

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									
								20 40 60 80 100									
183.0	Asphalt														GR SA SI CL		
182.9	120 mm ASPHALT																
0.1	FILL: Well graded gravel with sand (GW), trace to some silt Brown, wet		1	SS	36										42 44 (14)		
			2	SS	16												
181.7	Silty clay with sand (CL), TILL Very stiff Brown and grey mottled (crust)		3	SS	4										PP = 185 kPa		
1.3			4	SS	12										PP = 225 kPa		
	-Brown below 2.8 m		5	SS	18										2 24 44 30 PP = 225 kPa		
			6	SS	16										PP = 212 kPa		
178.4	Silty clay with sand (CL), TILL Stiff to very stiff Grey		7	SS	10										PP = 135 kPa		
4.6			8	SS	8										PP = 135 kPa		
			9	SS	8												
			10	BS													
			11	SS	6												
174.5	Silty Sand (SM), TILL Compact Grey, very wet		12	BS											5 57 33 5 Non-plastic		
173.7	Silty clay with sand (CL), TILL Stiff, grey		13	SS	11										Groundwater level inferred during drilling (wet sampler)		
173.2	End of Borehole																
9.8																	

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

ONTARIO MTO STANTEC 165601256 - WINDSOR TUNNEL GPJ ONTARIO MOT GDT 12/2/28

RECORD OF BOREHOLE No BH 11-3

1 OF 3

METRIC

W.P. 3032-06-00 LOCATION Windsor - Detroit Tunnel Plaza, Windsor, ON N: 4 686 737 E: 332 266 ORIGINATED BY DS
 DIST HWY BOREHOLE TYPE Hollow Stem Augers, Split Spoon Sampler, Shelby Tubes COMPILED BY JF/KKB
 DATUM Geodetic DATE 2011 09 30 - 2011 09 30 CHECKED BY CM

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 (%)
								○ UNCONFINED ● QUICK TRIAXIAL	✕ FIELD VANE ✕ LAB VANE						
183.2	Asphalt						20 40 60 80 100								
180.9 0.1	100 mm ASPHALT														
182.7 0.5	FILL: well graded gravel with sand (GW) Brown		1	SS	7										
	FILL: clayey gravel with sand (GC), with concrete and brick pieces		2	SS	9										
	Brown		3	SS	10									35 33 (32)	
			4	SS	3										
179.9 3.3	- Red brick pieces		5	SS	17									PP = 185 kPa	
	Silty clay with sand(CL), TILL		6	SS	20									2 26 42 30	
	Very stiff													PP = 210 kPa	
	Brown (crust)		7	SS	8									PP = 225 kPa	
178.7 4.5	Silty clay with sand to sandy clay (CL), TILL		8	ST											
	Stiff		9	SS	8										
	Grey		10	SS	7										
	- 200 mm sand layer, wet		11	BS											
			12	SS	10										
			13	BS											

Continued Next Page

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

RECORD OF BOREHOLE No BH 11-3

2 OF 3

METRIC

W.P. 3032-06-00 LOCATION Windsor - Detroit Tunnel Plaza, Windsor, ON N: 4 686 737 E: 332 266 ORIGINATED BY DS
 DIST HWY BOREHOLE TYPE Hollow Stem Augers, Split Spoon Sampler, Shelby Tubes COMPILED BY JF/KKB
 DATUM Geodetic DATE 2011 09 30 - 2011 09 30 CHECKED BY CM

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							WATER CONTENT (%)
								○ UNCONFINED	✕ FIELD VANE						
								● QUICK TRIAXIAL	✕ LAB VANE						
						20 40 60 80 100	20 40 60 80 100	10 20 30							
	Silty clay with sand to sandy clay (CL), TILL (continued)						173								
	Stiff														
	Brown to grey														
	- occasional sand seams, 10.7m to 23.1m		14	SS	12		172								
							171								
			15	SS	7										
							170								
			16	SS	3		169								
							168								
			17	ST											
			18	SS	9		167								
							166								
			19	SS	10										
							165								
			20	SS	8		164								

Continued Next Page

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

RECORD OF BOREHOLE No BH 11-4

1 OF 1

METRIC

W.P. 3032-06-00 LOCATION Windsor - Detroit Tunnel Plaza, Windsor, ON N: 4 686 749 E: 332 267 ORIGINATED BY DS
DIST HWY BOREHOLE TYPE Hollow Stem Augers, Split Spoon Sampler COMPILED BY KKB
DATUM Geodetic DATE 2011 09 26 - 2011 09 26 CHECKED BY CM

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									WATER CONTENT (%)		
								○ UNCONFINED	✕ FIELD VANE	● QUICK TRIAXIAL	✕ LAB VANE								
183.0	Asphalt							20	40	60	80	100							
182.9	120 mm ASPHALT							20	40	60	80	100							
0.1	FILL: Silty clay with sand and gravel (CL), with concrete and brick pieces		1	SS	16														
	Brown																		
			2	SS	5														
			3	SS	5														
	-Red brick pieces																		
	-Split spoon refusal on inferred brick		4	SS	26														
	-Pieces of concrete																		
179.6	Silty clay with sand (CL), TILL		5	SS	29														
3.4	Very stiff																		
	Brown (crust)		6	SS	15														
178.6	Silty clay with sand (CL), TILL																		
4.4	Very stiff to stiff																		
	Grey		7	SS	11														
			8	SS	12														
			9	SS	11														
176.3	End of borehole																		
6.7																			

ONTARIO MTO STANTEC 165601256 - WINDSOR TUNNEL GPJ ONTARIO MOT.GDT 12/2/28

RECORD OF BOREHOLE No BH 11-5

1 OF 1

METRIC

W.P. 3032-06-00 LOCATION Windsor - Detroit Tunnel Plaza, Windsor, ON N: 4 686 792 E: 332 235 ORIGINATED BY DS
 DIST HWY BOREHOLE TYPE Hollow Stem Augers, Split Spoon Sampler COMPILED BY KKB
 DATUM Geodetic DATE 2011 09 26 - 2011 09 26 CHECKED BY CM

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 ● QUICK TRIAXIAL	✕ FIELD VANE ✕ LAB VANE					
183.0	Concrete							20 40 60 80 100						
0.0 182.8	200 mm CONCRETE							20 40 60 80 100						
0.2 182.6	FILL: Well graded gravel with sand (GW) Brown													
0.4	Silty clay with sand (CL), TILL		1	AS						○				
	Stiff to very stiff										○			
	Brown and grey mottled (crust)		2	SS	10		182				○			PP = 225 kPa
			3	SS	34		181				○			PP = 225 kPa
	-Hard @ 1.8 m													
			4	SS	26		180				○	○		
			5	SS	21						○			PP = 200 kPa
			6	SS	15		179				○			PP = 185 kPa
178.5 4.5	Sandy silty clay (CL), TILL													
	Very stiff to stiff		7	SS	15		178				○			PP = 135 kPa
	Grey													
			8	SS	11		177				○			PP = 100 kPa
			9	SS	9						○			PP = 65 kPa
							176				✕ ²			
			10	SS	9		175				○			
			11	BS			174				○	○	○	2 30 40 28 PP = 100 kPa
			12	SS	6						○			
173.2 9.8	End of borehole													

ONTARIO MTO STANTEC 165601256 - WINDSOR TUNNEL.GPJ ONTARIO MOT.GDT 12/2/28

RECORD OF BOREHOLE No BH 11-6

1 OF 4

METRIC

W.P. 3032-06-00 LOCATION Windsor - Detroit Tunnel Plaza, Windsor, ON N: 4 686 779 E: 332 289 ORIGINATED BY DS
 DIST HWY BOREHOLE TYPE Hollow Stem Augers, Split Spoon Sampler COMPILED BY KKB
 DATUM Geodetic DATE 2011 09 27 - 2011 09 27 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		w _p	w	w _L	WATER CONTENT (%)				
								○ UNCONFINED ● QUICK TRIAXIAL	✕ FIELD VANE ✕ LAB VANE								
183.2	Sand&Gravel						20 40 60 80 100										GR SA SI CL
0.0	FILL: Well graded gravel with sand (GW)		1	SS	6		183										
	Brown																
182.6	Silty clay with sand to sandy clay (CL), TILL		2	SS	10		182										
0.6	Stiff to very stiff																
	Brown to grey (crust)		3	SS	9		181										PP = 150 kPa
			4	SS	18		180										PP = 225 kPa
			5	SS	28		180										2 25 42 31 PP = 225 kPa
			6	SS	14		179										PP = 210 kPa
178.7	Silty clay with sand to sandy clay (CL), TILL		7	SS	11		178										PP = 110 kPa
4.5			8	SS	9		177										PP = 85kPa
	Stiff to firm		9	SS	9		176										PP = 60 kPa
	Grey		10	BS			175										
			11	SS	8												
			12	SS	4												2 24 42 32
			13	BS													

Continued Next Page

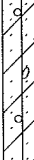
×³, ×³: Numbers refer to Sensitivity ○³% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH 11-6

4 OF 4

METRIC

W.P. 3032-06-00 LOCATION Windsor - Detroit Tunnel Plaza, Windsor, ON N: 4 686 779 E: 332 289 ORIGINATED BY DS
 DIST HWY BOREHOLE TYPE Hollow Stem Augers, Split Spoon Sampler COMPILED BY KKB
 DATUM Geodetic DATE 2011 09 27 - 2011 09 27 CHECKED BY CM

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						
							20 40 60 80 100	20 40 60 80 100						
152.1	Silty clay with sand to sandy clay (CL), TILL (continued) Very stiff Grey		27	SS	21		153							1 20 46 33
31.1	End of borehole Groundwater level inferred during drilling (wet sampler)													

RECORD OF BOREHOLE No BH 11-7

1 OF 4

METRIC

W.P. 3032-06-00 LOCATION Windsor - Detroit Tunnel Plaza, Windsor, ON N: 4 686 793 E: 332 335 ORIGINATED BY DS
DIST HWY BOREHOLE TYPE Hollow Stem Augers, Split Spoon Sampler COMPILED BY KKB
DATUM Geodetic DATE 2011 10 05 - 2011 10 06 CHECKED BY CM

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						
183.5	Sand&Gravel							20 40 60 80 100						GR SA SI CL
0.0	FILL: Well graded gravel with sand (GW)							20 40 60 80 100						
183.3	Brown							20 40 60 80 100						
0.2	FILL: Well graded gravel with sand (GW), with brick pieces, trace to some silt		1	SS	12		183							55 33 (12)
182.9	Dark brown													
0.6	Silty clay to silty clay with sand (CL), TILL													
	Firm to very stiff		2	SS	9		182							PP = 225 kPa
	Brown (crust)													
			3	SS	6		181							2 24 44 30
			4	SS	6		180							PP = 210 kPa
			5	SS	16		179							PP = 225 kPa
			6	SS	23		178							PP = 225 kPa
			7	SS	16		177							PP = 200 kPa
178.3	Silty clay with sand to sandy clay (CL), TILL													
5.2	Stiff		8	SS	9		176							PP = 135 kPa
	Grey		9	SS	8		175							0 28 42 30
			10	SS	7		174							
			11	BS										
			12	SS	23									
	-250mm sand layer, wet													
	-Occasional sand seams, 9.1m to 18.5m		13	SS	8									3 30 44 23

ONTARIO MTO STANTEC 165601256 - WINDSOR TUNNEL GPJ ONTARIO MOT GDT 12/2/28

Continued Next Page

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

RECORD OF BOREHOLE No BH 11-7

2 OF 4

METRIC

W.P. 3032-06-00 LOCATION Windsor - Detroit Tunnel Plaza, Windsor, ON N: 4 686 793 E: 332 335 ORIGINATED BY DS
DIST HWY BOREHOLE TYPE Hollow Stem Augers, Split Spoon Sampler COMPILED BY KKB
DATUM Geodetic DATE 2011 10 05 - 2011 10 06 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		w _p	w			w _L						
								○ UNCONFINED	✕ FIELD VANE											
								● QUICK TRIAXIAL	✕ LAB VANE											
								WATER CONTENT (%)												
								20	40	60	80	100	10	20	30	GR	SA	SI	CL	
	Silty clay with sand to sandy clay (CL), TILL (continued)						173													
	Stiff		14	SS	9															
	Grey						172													
			15	SS	9		171													
							170													
	Very stiff @14m		16	SS	20		169													
			17	SS	11		168													
							167													
			18	SS	10		166													

ONTARIO MTO STANTEC 165601256 - WINDSOR TUNNEL.GPJ ONTARIO MOT.GDT 12/2/28

Continued Next Page

\times^3 , \times^3 : Numbers refer to Sensitivity
 \circ^3 : STRAIN AT FAILURE

METRIC

W.P.	3032-06-00	LOCATION	Windsor - Detroit Tunnel Plaza, Windsor, ON	N: 4 686 793 E: 332 335	ORIGINATED BY	DS	
DIST		HWY		BOREHOLE TYPE	Hollow Stem Augers, Split Spoon Sampler	COMPILED BY	KKB
DATUM	Geodetic	DATE	2011 10 05 - 2011 10 06		CHECKED BY	CM	

[illegible]

Continued Next Page

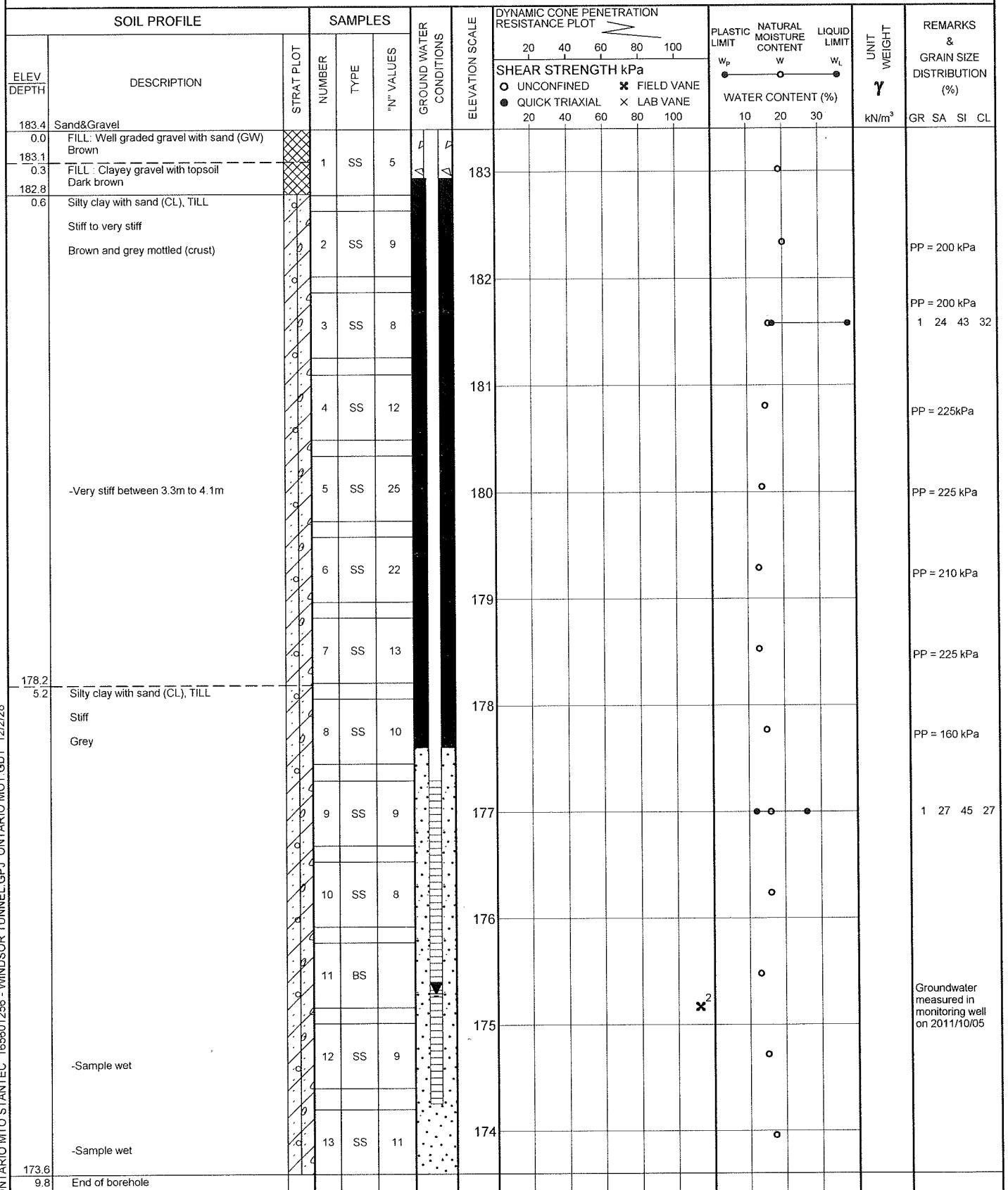
✕³, ✕³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

RECORD OF BOREHOLE No BH 11-8

1 OF 1

METRIC

W.P. 3032-06-00 LOCATION Windsor - Detroit Tunnel Plaza, Windsor, ON N: 4 686 777 E: 332 323 ORIGINATED BY DS
 DIST HWY BOREHOLE TYPE Hollow Stem Augers, Split Spoon Sampler COMPILED BY KKB
 DATUM Geodetic DATE 2011 10 04 - 2011 10 04 CHECKED BY CM



ONTARIO MTO STANTEC 165801256 - WINDSOR TUNNEL.GPJ ONTARIO MOT GDT 12/2/28

RECORD OF BOREHOLE No BH 11-9

1 OF 1

METRIC

W.P. 3032-06-00 LOCATION Windsor - Detroit Tunnel Plaza, Windsor, ON N: 4 686 765 E: 332 296 ORIGINATED BY DS
 DIST HWY BOREHOLE TYPE Hollow Stem Augers, Split Spoon Sampler COMPILED BY KKB
 DATUM Geodetic DATE 2011 10 04 - 2011 10 04 CHECKED BY CM

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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
183.2	Sand&Gravel						20	40	60	80	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											

ONTARIO MTO STANTEC 165601256 - WINDSOR TUNNEL GPJ ONTARIO MOT GDT 12/2/28

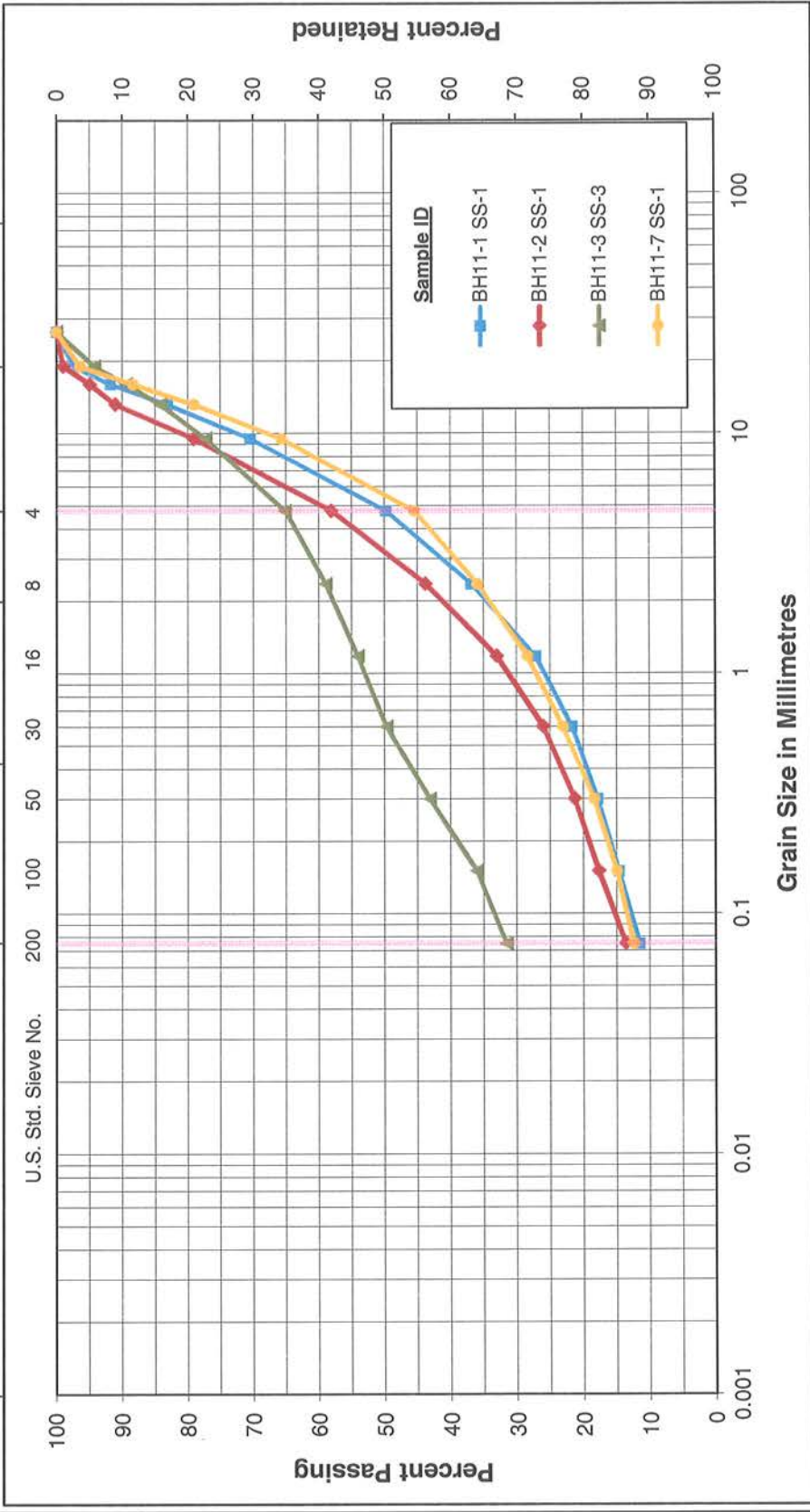
APPENDIX C

Laboratory Results

Laboratory Testing by Golder Associates

Unified Soil Classification System

CLAY & SILT	SAND				Gravel	
	Fine	Medium	Coarse		Fine	Coarse



Stantec

GRAIN SIZE DISTRIBUTION

FILL: Clayey sand with gravel (SC) to poorly graded gravel with silty clay and sand (GP-GC)

Figure No. 1a

Project No. 165601256

GWP No. 3032-06-00

Unified Soil Classification System

CLAY & SILT	SAND			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
U.S. Std. Sieve No.	200	100	60	4.75	75

Grain Size Distribution Data (Estimated from Chart):

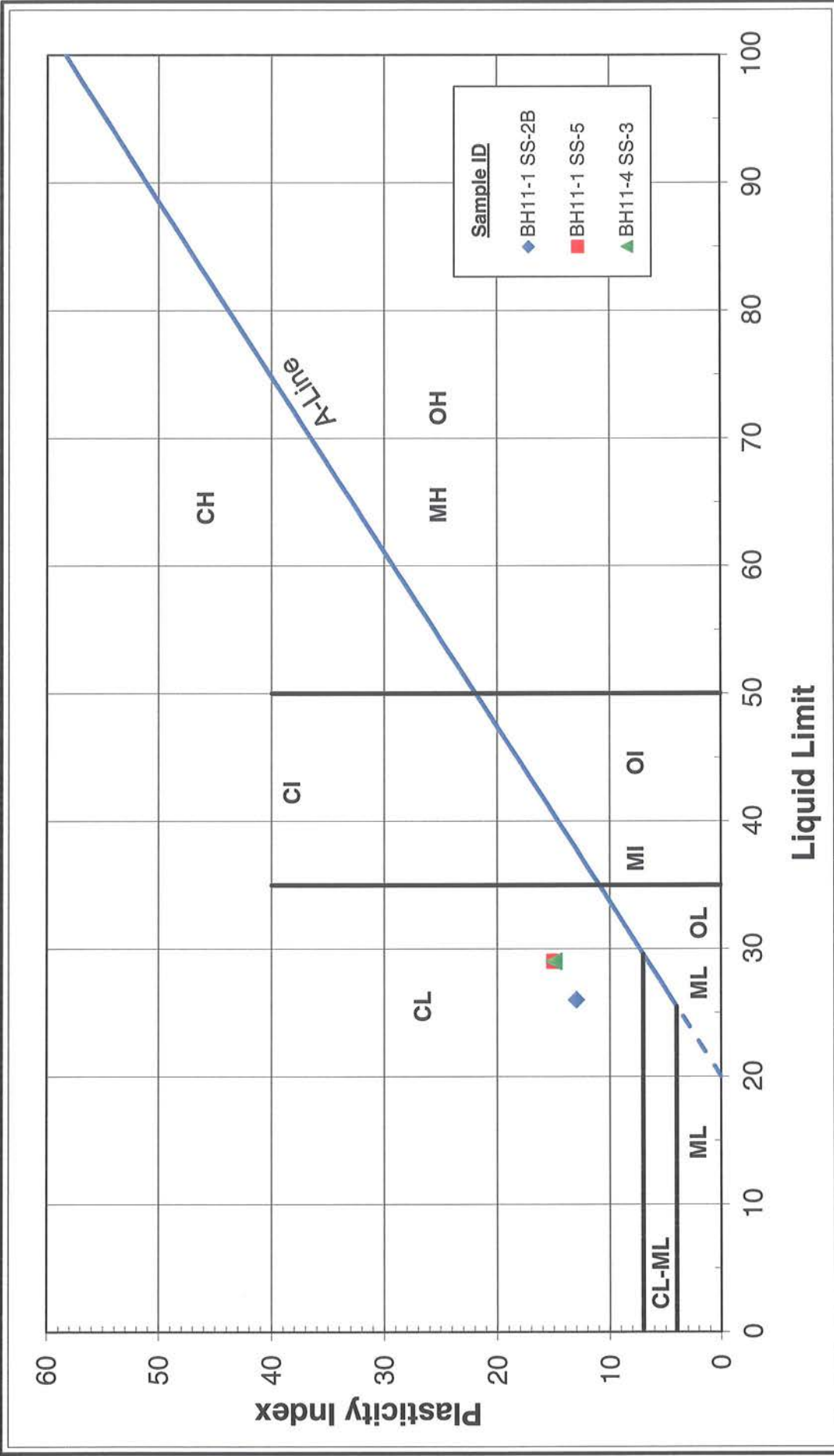
Grain Size (mm)	BH11-1 SS-2B (%)	BH11-1 SS-5 (%)	BH11-3 SS-3 (%)	BH11-4 SS-3 (%)
0.075	100	100	100	100
0.15	100	100	100	100
0.3	100	100	100	100
0.6	100	100	100	100
1.18	100	100	100	100
2.5	100	100	100	100
4.75	100	100	100	100
7.5	100	100	100	100
15	100	100	100	100
30	100	100	100	100
60	100	100	100	100
75	100	100	100	100
100	100	100	100	100
200	100	100	100	100
425	100	100	100	100
750	100	100	100	100
1500	100	100	100	100
3000	100	100	100	100
6000	100	100	100	100
12500	100	100	100	100
25000	100	100	100	100
50000	100	100	100	100
100000	100	100	100	100
200000	100	100	100	100
400000	100	100	100	100
800000	100	100	100	100
1600000	100	100	100	100
3200000	100	100	100	100
6400000	100	100	100	100
12800000	100	100	100	100
25600000	100	100	100	100
51200000	100	100	100	100
102400000	100	100	100	100
204800000	100	100	100	100
409600000	100	100	100	100
819200000	100	100	100	100
1638400000	100	100	100	100
3276800000	100	100	100	100
6553600000	100	100	100	100
13107200000	100	100	100	100
26214400000	100	100	100	100
52428800000	100	100	100	100
104857600000	100	100	100	100
209715200000	100	100	100	100
419430400000	100	100	100	100
838860800000	100	100	100	100
1677721600000	100	100	100	100
3355443200000	100	100	100	100
6710886400000	100	100	100	100
13421772800000	100	100	100	100
26843545600000	100	100	100	100
53687091200000	100	100	100	100
107374182400000	100	100	100	100
214748364800000	100	100	100	100
429496729600000	100	100	100	100
858993459200000	100	100	100	100
1717986918400000	100	100	100	100
3435973836800000	100	100	100	100
6871947673600000	100	100	100	100
13743895347200000	100	100	100	100
27487790694400000	100	100	100	100
54975581388800000	100	100	100	100
109951162777600000	100	100	100	100
219902325555200000	100	100	100	



FILL: Silty clay with sand (CL) to clayey sand with gravel (SC)

Project No. 165601256
GWP No. 3032-06-00





CLAY & SILT	SAND			Gravel	
	Fine	Medium	Coarse	Fine	Coarse



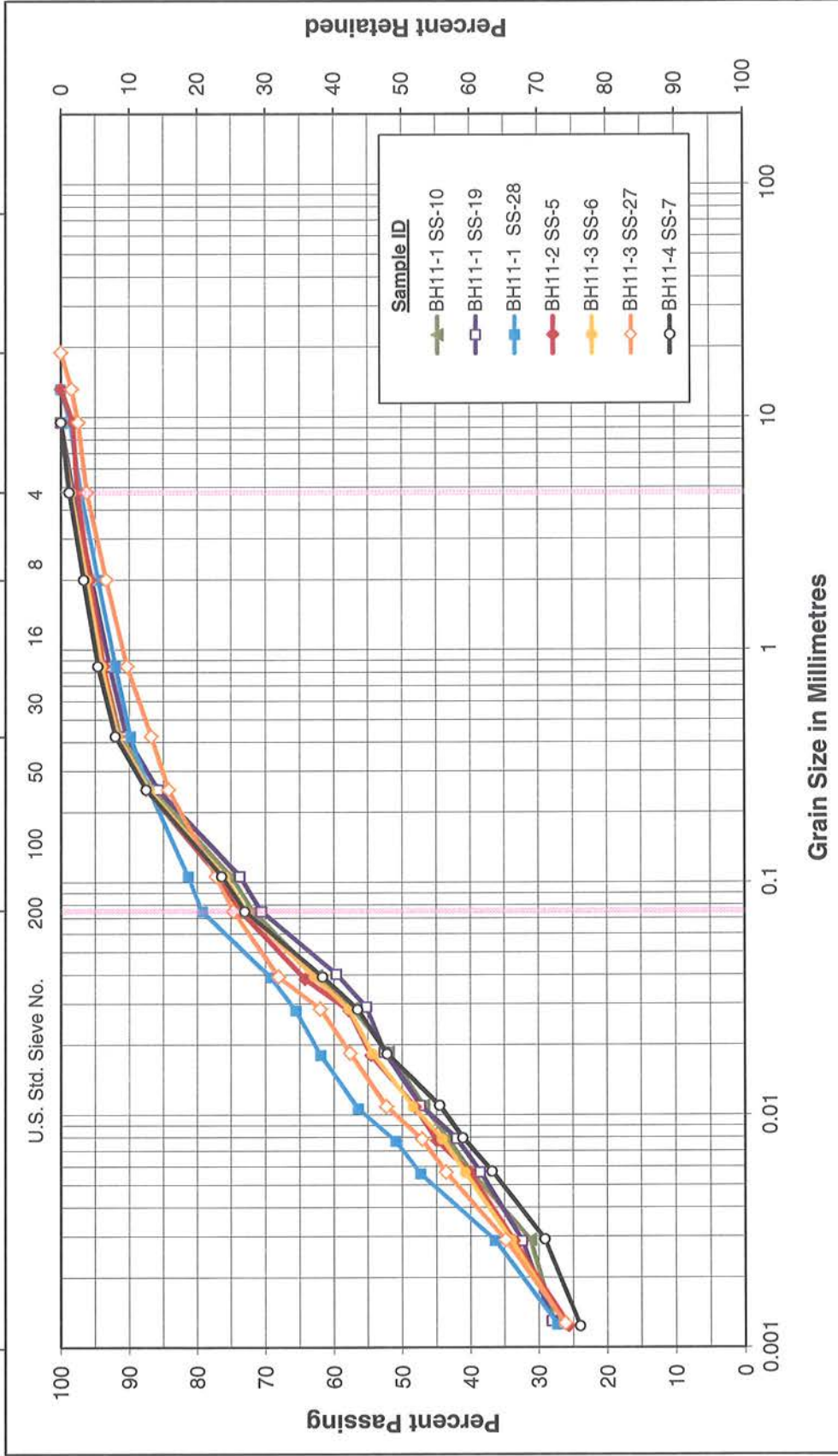
Project No. 165601256
GWP No. 3032-06-00



Stantec

Unified Soil Classification System

CLAY & SILT		SAND			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



GRAIN SIZE DISTRIBUTION

Silty clay with sand (CL), TILL

Figure No. 2b

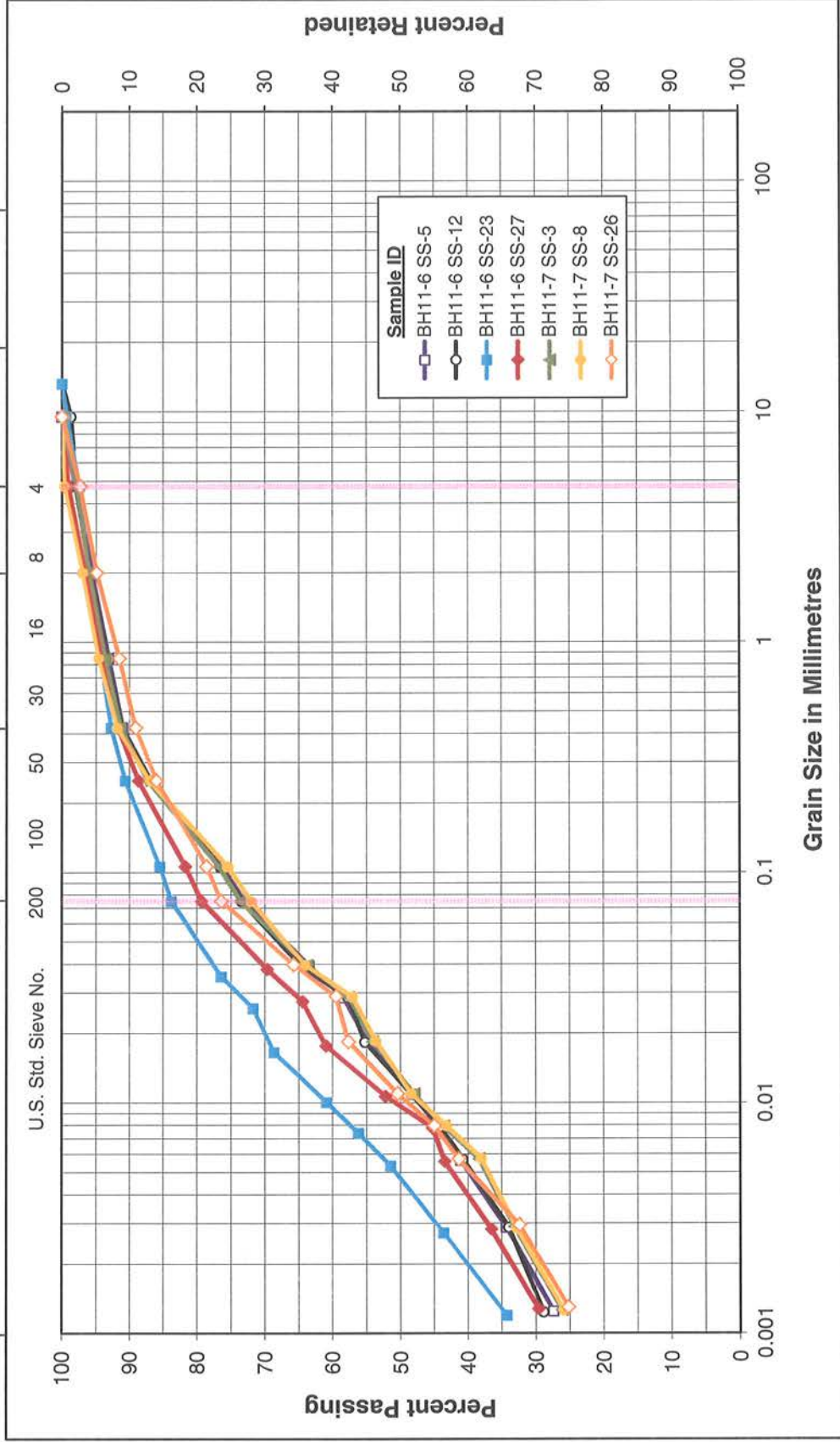
Project No. 165601256
GWP No. 3032-06-00



Stantec

Unified Soil Classification System

CLAY & SILT		SAND			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



GRAIN SIZE DISTRIBUTION

Silty clay with sand (CL), TILL

Figure No. 2c

Project No. 165601256

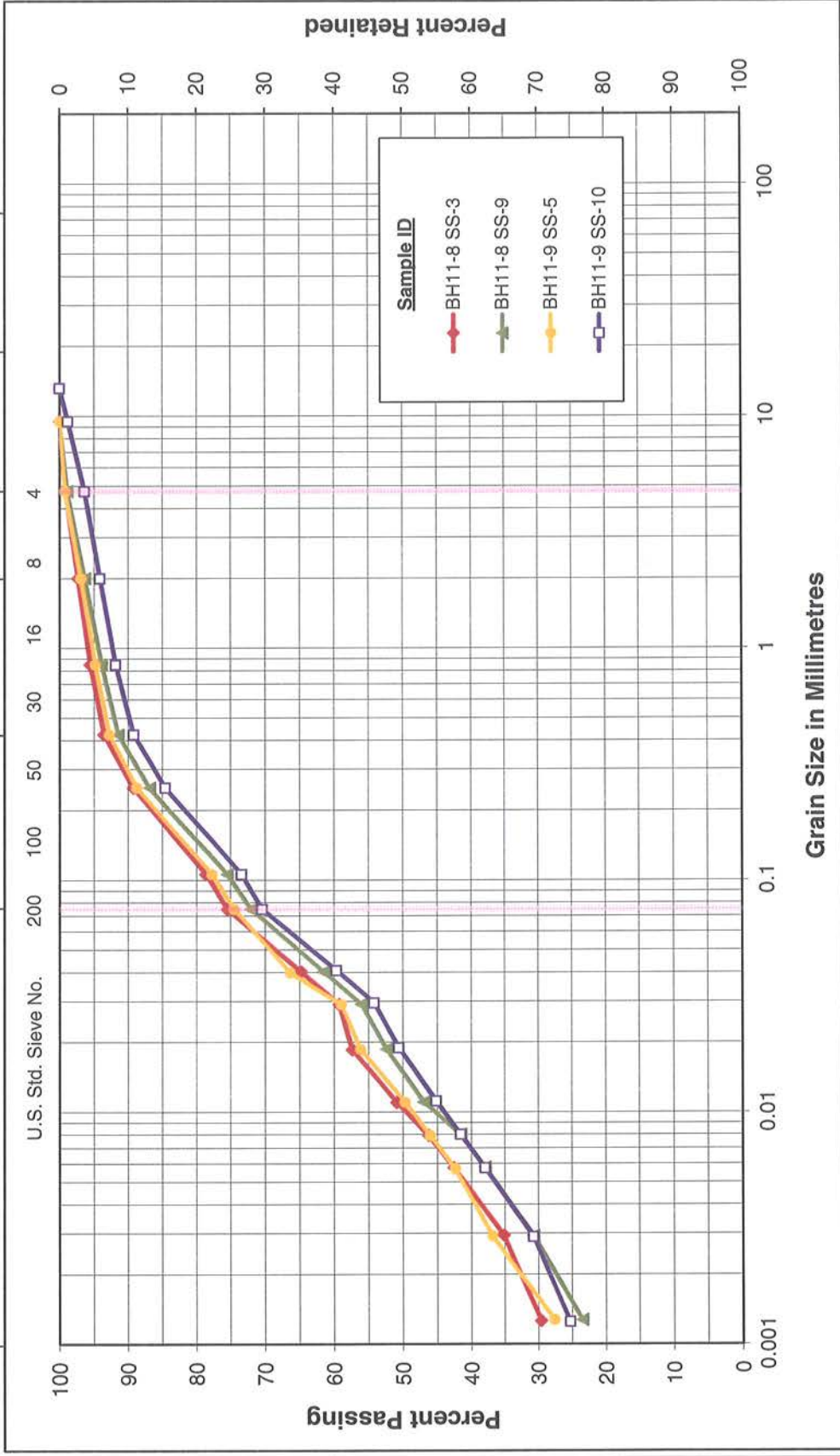
GWP 3032-06-00



Stantec

Unified Soil Classification System

CLAY & SILT		SAND			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



GRAIN SIZE DISTRIBUTION

Silty clay with sand (CL), TILL

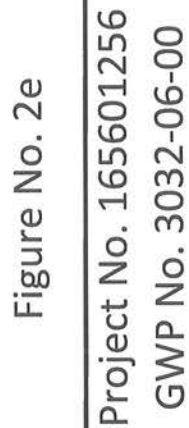
Figure No. 2d

Project No. 165601256
GWP No. 3032-06-00



Stantec

CLAY & SILT	SAND			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

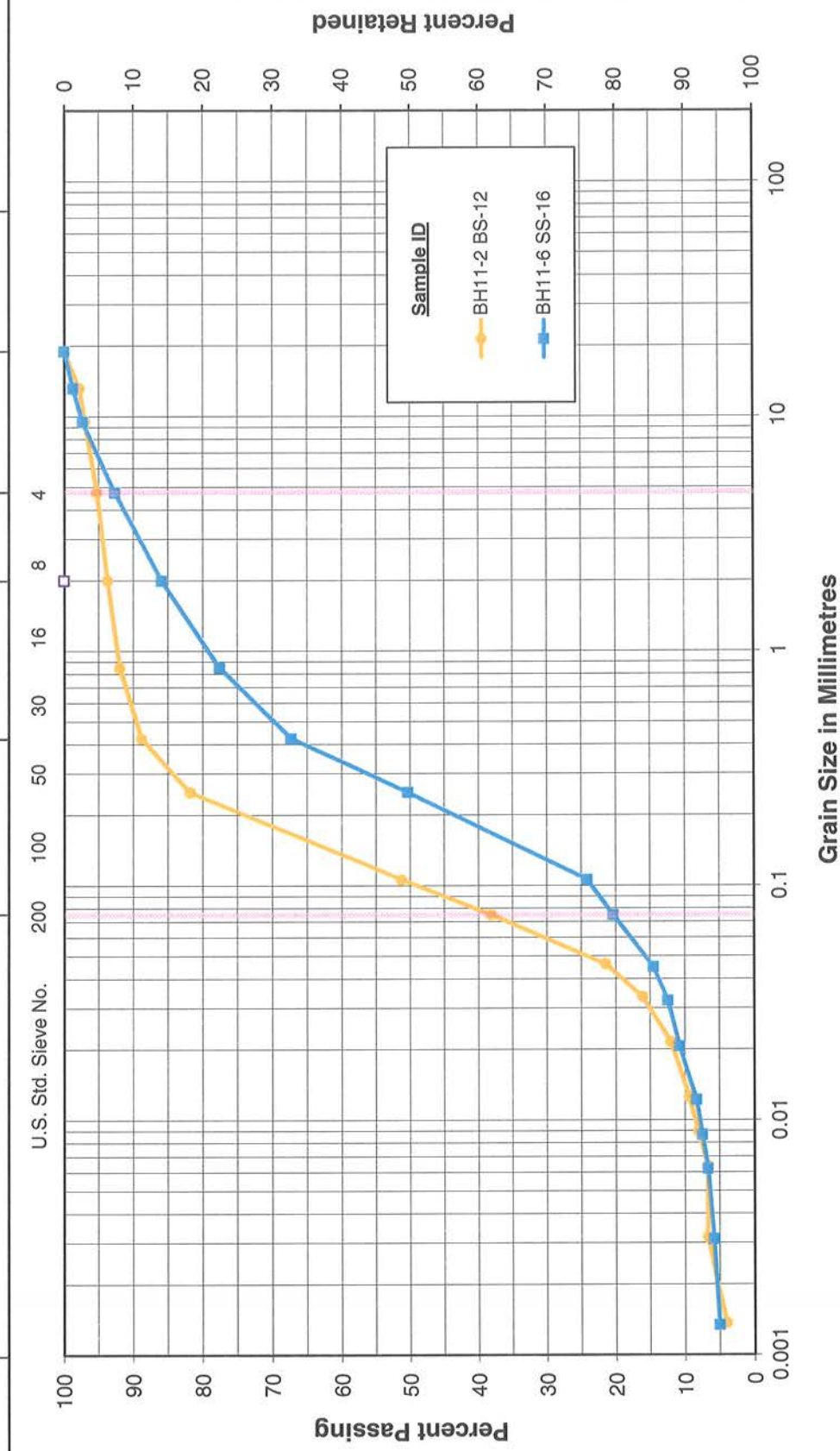


Sandy clay (CL), TILL



Unified Soil Classification System

CLAY & SILT		SAND			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



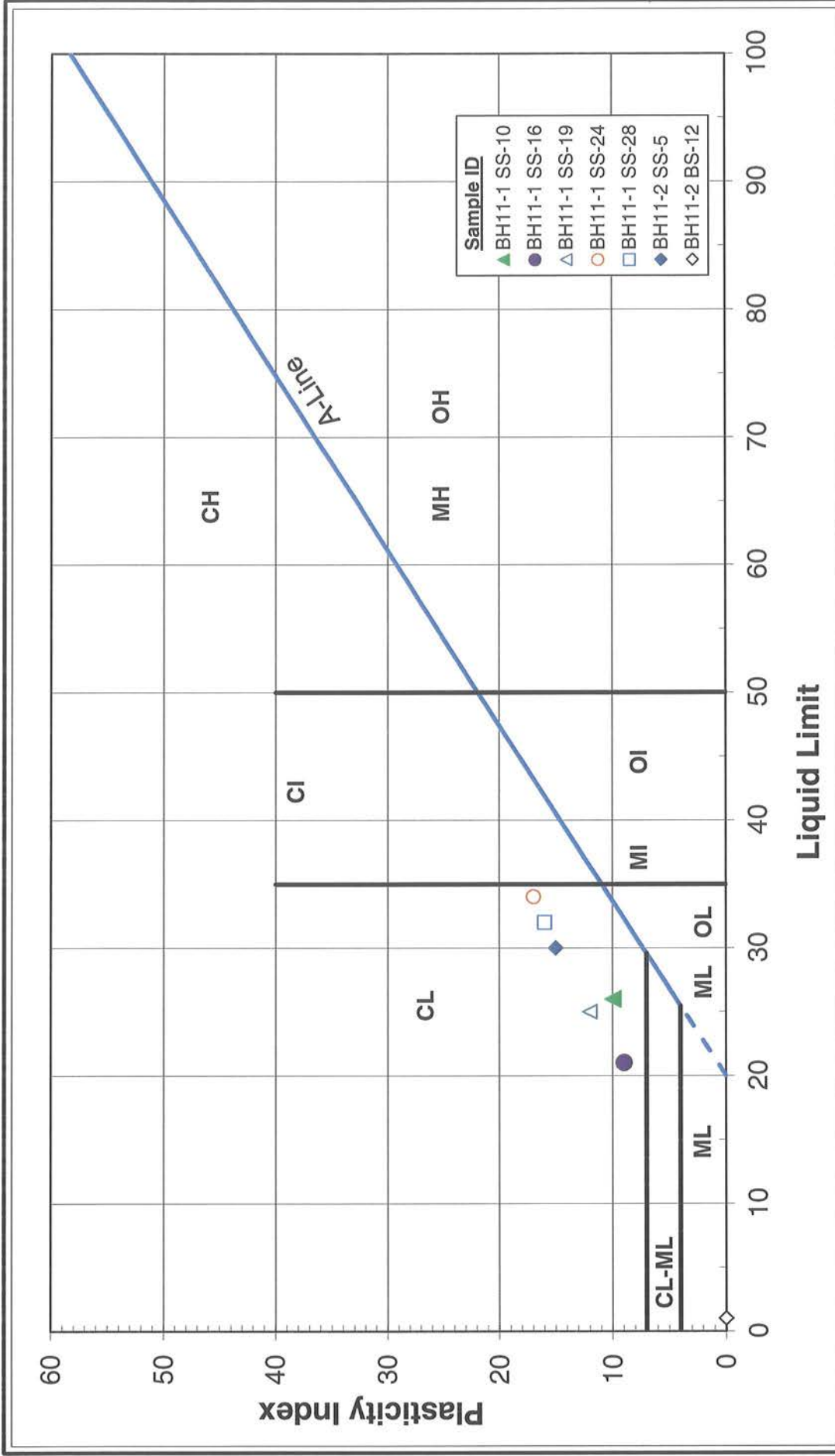
GRAIN SIZE DISTRIBUTION

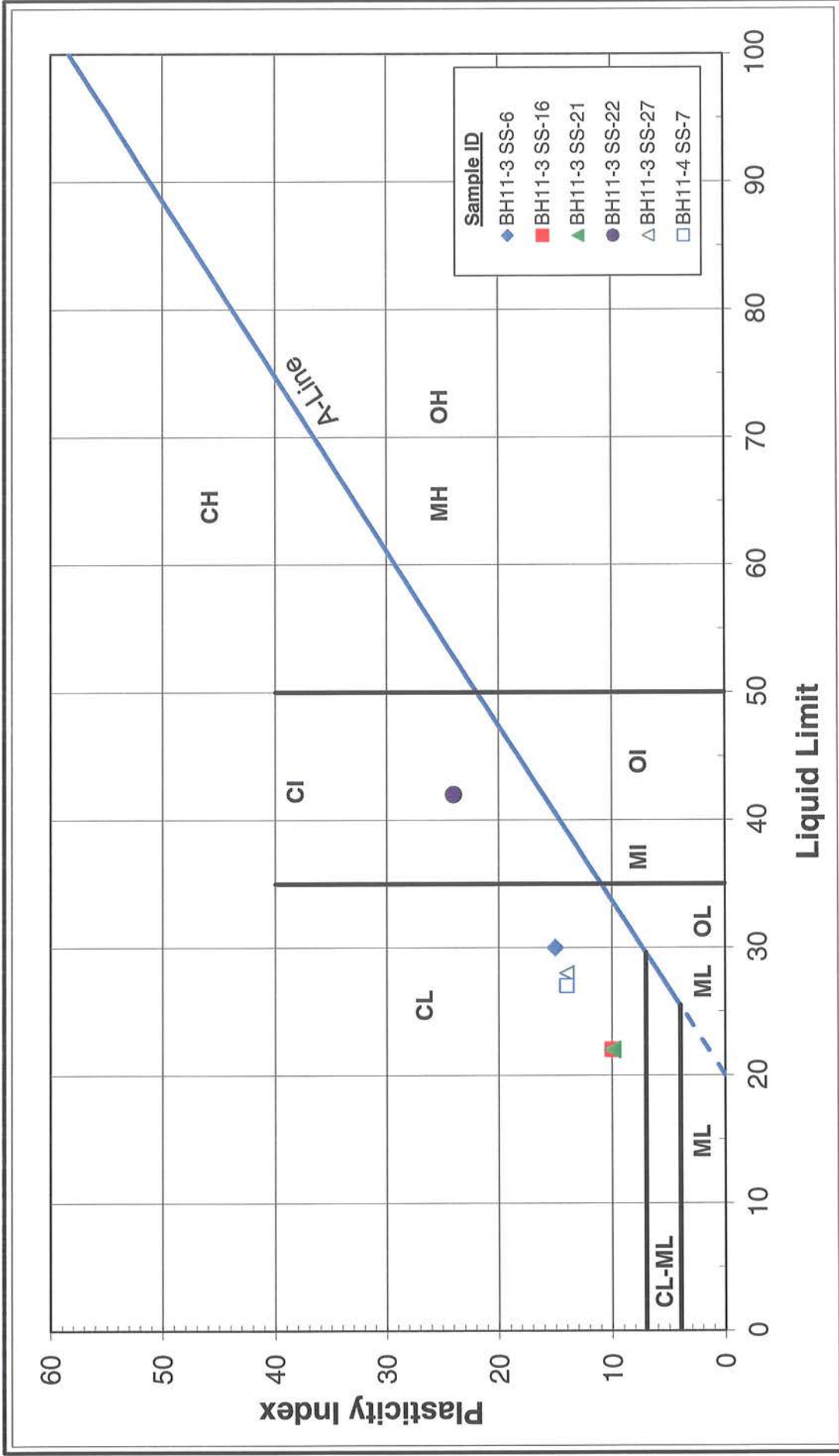
Silty sand (SM), TILL

Figure No. 2f

Project No. 165601256
GWP No. 3032-06-00





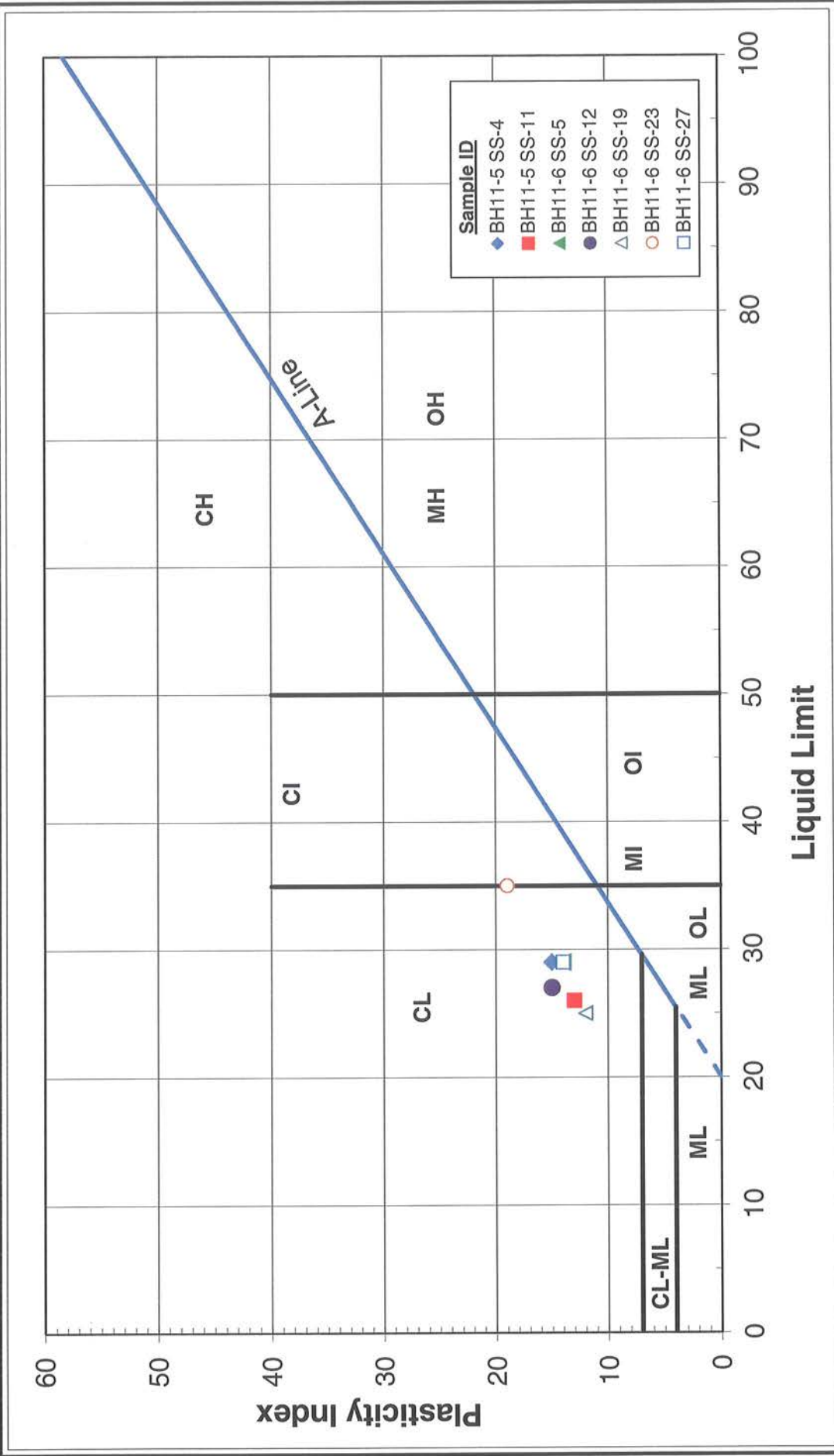


PLASTICITY CHART

Figure No. 3b

Project No. 165601256

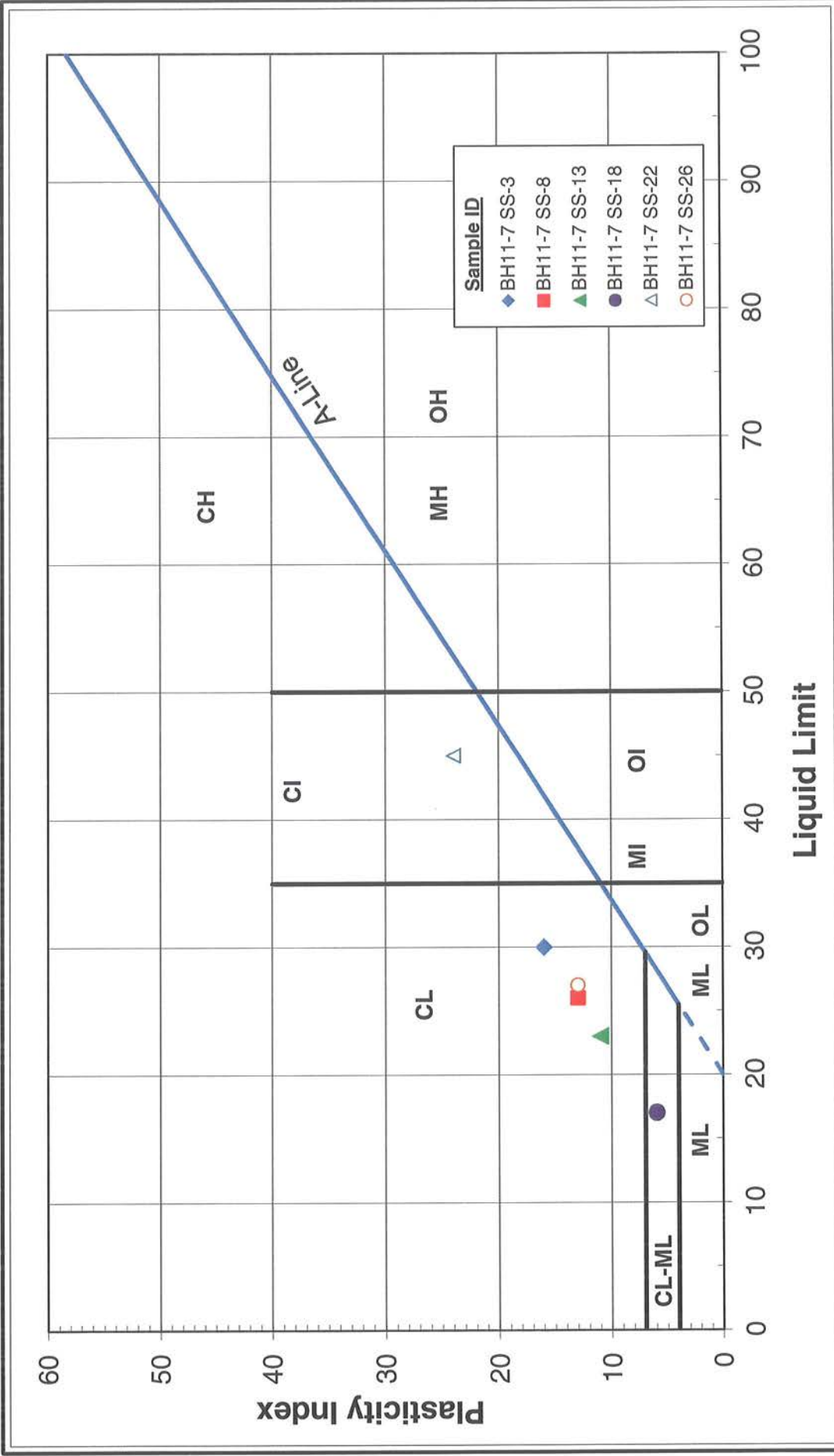
GWP No. 3032-06-00



PLASTICITY CHART

Figure No. 3c

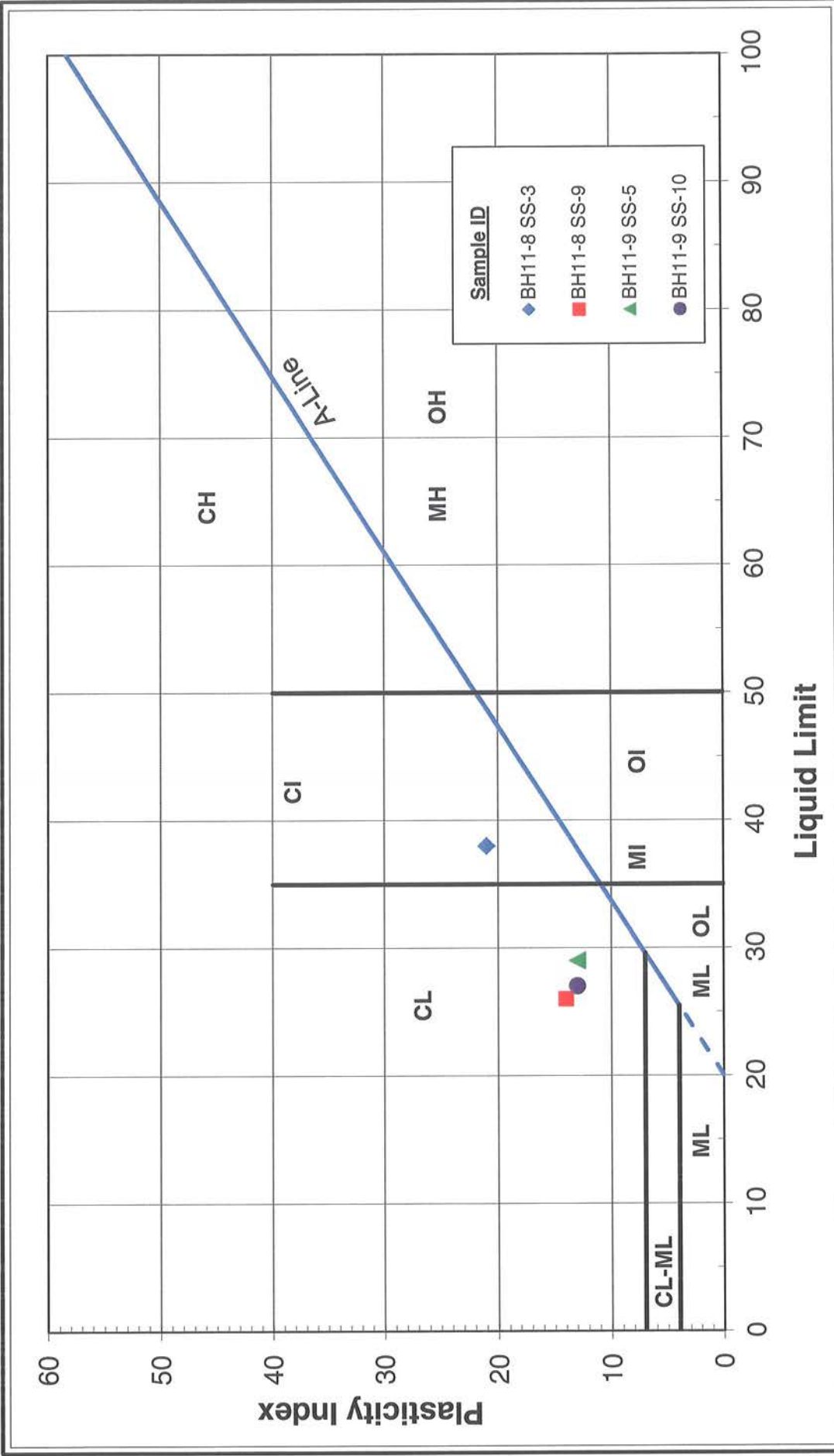
Project No. 165601256
GWP 3032-06-00



PLASTICITY CHART

Figure No. 3d

Project No. 165601256
GWP No. 3032-06-00



PLASTICITY CHART

Figure No. 3e

Project No. 165601256

GWP No. 3032-06-00



January 17, 2012

Project No. 11-1183-0076

165601256

Christopher McGrath
Stantec
200 - 2781 Lancaster Road
Ottawa, Ontario
K1B 1A7

GEOTECHNICAL LABORATORY TESTING

Dear Sir

This letter reports the results of laboratory testing carried out on the samples received at our office in Mississauga. The results of the test are summarized in the attached tables and figures.

The testing services reported herein have been performed in accordance with the indicated recognized standard, unless noted otherwise. This report is for the sole use of the designated client. This report constitutes a testing service only and does not represent any results interpretation or opinion regarding specification compliance or material suitability.

We trust that the results are sufficient for your current requirements. If you have any questions, please do not hesitate to call us.

GOLDER ASSOCIATES LTD.

Marijana Manojlovic
Laboratory Manager

MM/lg



Golder Associates Ltd.

2390 Argentia Road, Mississauga, Ontario, Canada L5N 5Z7
Tel: +1 (905) 567 4444 Fax: +1 (905) 567 6561 www.golder.com

Golder Associates: Operations in Africa, Asia, Australasia, Europe, North America and South America

Golder, Golder Associates and the GA globe design are trademarks of Golder Associates Corporation.



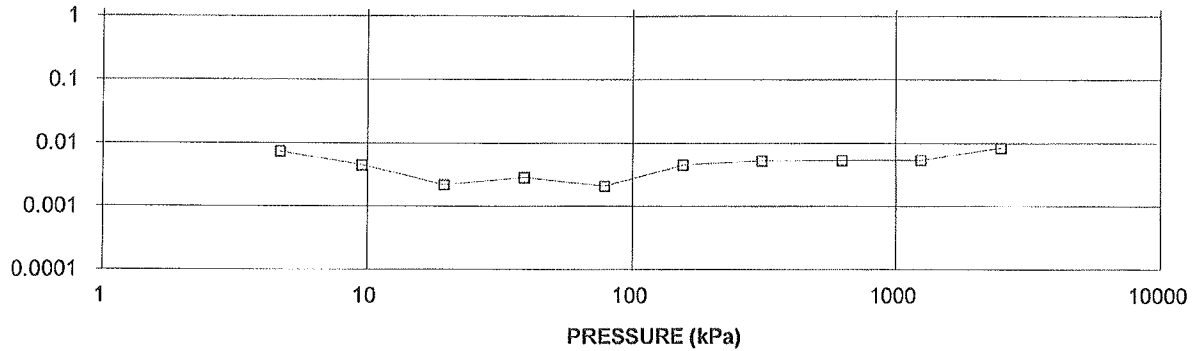
CONSOLIDATION TEST SUMMARY					FIGURE			
SAMPLE IDENTIFICATION								
Project Number	11-1183-0076				Sample Number	ST 1		
Borehole Number	1				Sample Depth, m	9.8-10.4		
TEST CONDITIONS								
Test Type	Standard				Load Duration, hr	24		
Oedometer Number	2							
Date Started	10/21/2011							
Date Completed	11/02/2011							
SAMPLE DIMENSIONS AND PROPERTIES - INITIAL								
Sample Height, cm	2.54				Unit Weight, kN/m ³	22.02		
Sample Diameter, cm	6.33				Dry Unit Weight, kN/m ³	19.44		
Area, cm ²	31.45				Specific Gravity, measured	2.74		
Volume, cm ³	79.85				Solids Height, cm	1.837		
Water Content, %	13.25				Volume of Solids, cm ³	57.78		
Wet Mass, g	179.31				Volume of Voids, cm ³	22.07		
Dry Mass, g	158.33				Degree of Saturation, %	95.1		
TEST COMPUTATIONS								
Pressure	Corr. Height	Void Ratio	Average Height	t ₉₀	c _v	m _v	k	
kPa	cm		cm	sec	cm ² /s	m ² /kN	cm/s	
0.00	2.539	0.382	2.539					
4.71	2.537	0.381	2.538	184	7.42E-03	1.67E-04	1.22E-07	
9.52	2.536	0.380	2.536	304	4.49E-03	1.15E-04	5.04E-08	
19.41	2.526	0.375	2.531	623	2.18E-03	4.02E-04	8.59E-08	
38.96	2.511	0.366	2.518	470	2.86E-03	2.98E-04	8.36E-08	
77.93	2.488	0.354	2.499	634	2.09E-03	2.34E-04	4.80E-08	
155.65	2.455	0.336	2.471	287	4.51E-03	1.65E-04	7.28E-08	
311.30	2.422	0.318	2.438	240	5.25E-03	8.48E-05	4.36E-08	
622.57	2.379	0.295	2.400	228	5.36E-03	5.33E-05	2.80E-08	
1245.68	2.336	0.271	2.357	217	5.43E-03	2.77E-05	1.48E-08	
2493.17	2.290	0.246	2.313	135	8.40E-03	1.44E-05	1.18E-08	
1245.68	2.289	0.246	2.290					
311.30	2.305	0.254	2.297					
77.93	2.322	0.264	2.313					
19.41	2.340	0.274	2.331					
4.71	2.350	0.279	2.345					
Note: k calculated using cv based on t ₉₀ values.								
SAMPLE DIMENSIONS AND PROPERTIES - FINAL								
Sample Height, cm	2.35				Unit Weight, kN/m ³	23.15		
Sample Diameter, cm	6.33				Dry Unit Weight, kN/m ³	21.01		
Area, cm ²	31.45				Specific Gravity, measured	2.74		
Volume, cm ³	73.91				Solids Height, cm	1.837		
Water Content, %	10.20				Volume of Solids, cm ³	57.78		
Wet Mass, g	174.48				Volume of Voids, cm ³	16.13		
Dry Mass, g	158.33							
Prepared By: LFG Golder Associates Checked By: 								

CONSOLIDATION TEST SUMMARY

FIGURE

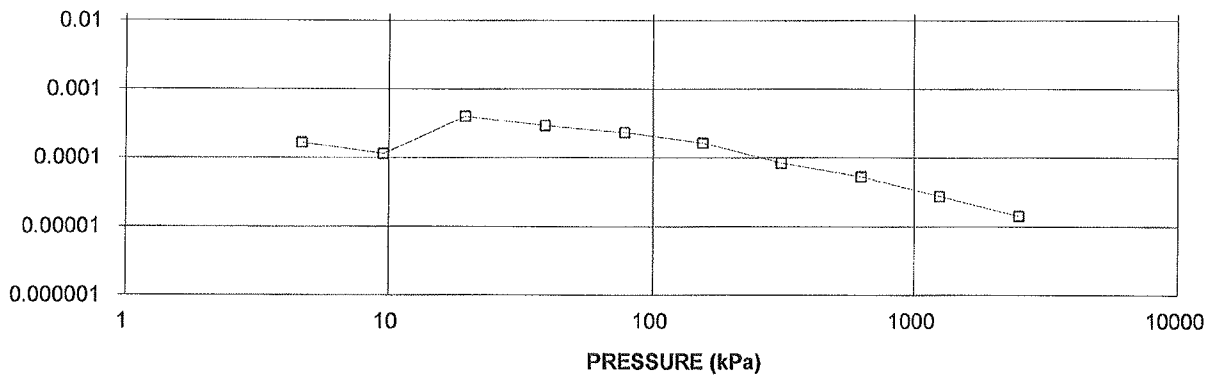
COEFFICIENT OF CONSOLIDATION,
cm²/s

CONSOLIDATION TEST
C_v cm²/s VS PRESSURE (kPa)
BH 1 ST 1



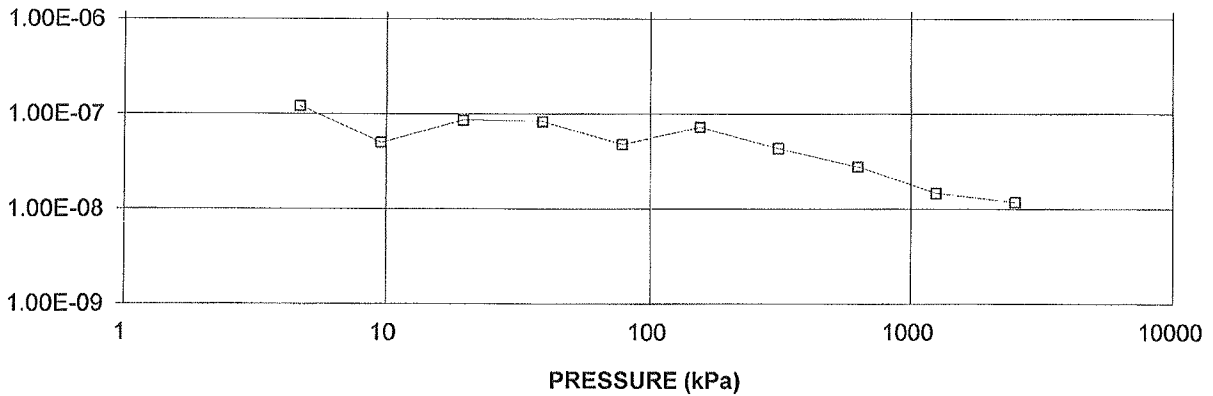
VOLUME COMPRESSIBILITY, m²/kN

CONSOLIDATION TEST
M_v m²/kN vs PRESSURE (kPa)
BH 1 ST 1



HYDRAULIC CONDUCTIVITY, cm/s

CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs PRESSURE
BH 1 ST 1



Project No. 11-1183-0076

Prepared By: LFG

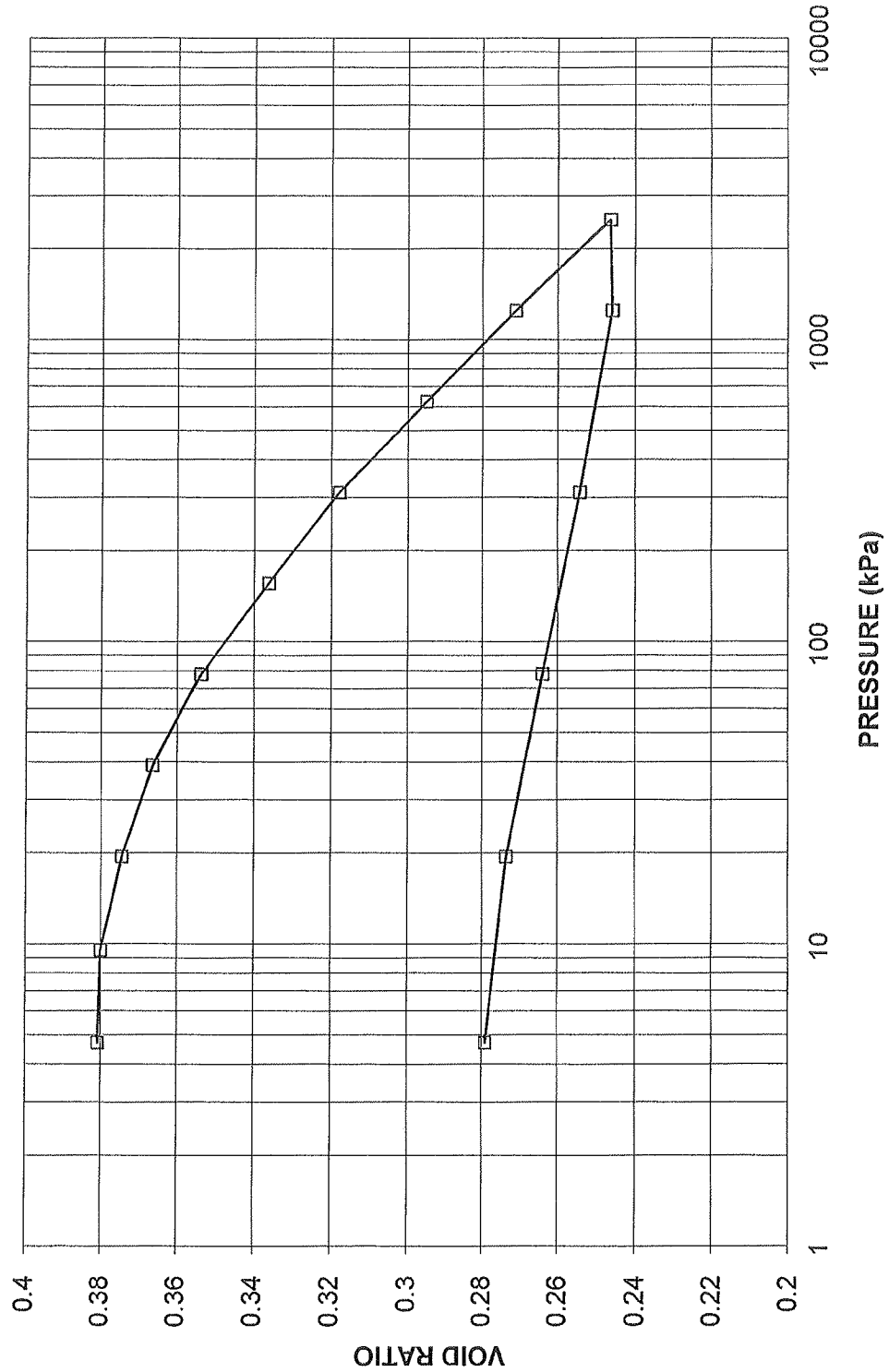
Golder Associates

Checked By: *[Signature]*

**CONSOLIDATION TEST
VOID RATIO VS LOG PRESSURE**

FIGURE

**CONSOLIDATION TEST
VOID RATIO vs PRESSURE
BH 1 ST 1**

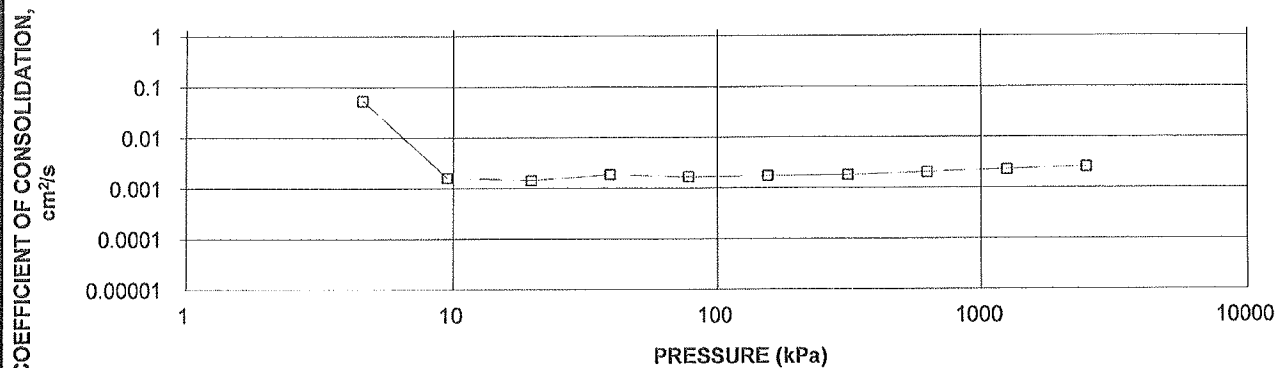


CONSOLIDATION TEST SUMMARY					FIGURE		
SAMPLE IDENTIFICATION							
Project Number	11-1183-0076			Sample Number	ST 2		
Borehole Number	1			Sample Depth, m	25.9-26.5		
TEST CONDITIONS							
Test Type	Standard			Load Duration, hr	24		
Oedometer Number	1						
Date Started	10/21/2011						
Date Completed	11/02/2011						
SAMPLE DIMENSIONS AND PROPERTIES - INITIAL							
Sample Height, cm	2.53			Unit Weight, kN/m ³	20.87		
Sample Diameter, cm	6.34			Dry Unit Weight, kN/m ³	17.56		
Area, cm ²	31.58			Specific Gravity, measured	2.74		
Volume, cm ³	80.02			Solids Height, cm	1.656		
Water Content, %	18.82			Volume of Solids, cm ³	52.31		
Wet Mass, g	170.31			Volume of Voids, cm ³	27.71		
Dry Mass, g	143.33			Degree of Saturation, %	97.4		
TEST COMPUTATIONS							
Pressure kPa	Corr. Height cm	Void Ratio	Average Height cm	t ₉₀ sec	C _v cm ² /s	m _v m ² /kN	k cm/s
0.00	2.534	0.530	2.534				
4.63	2.534	0.530	2.534	25	5.44E-02	8.52E-06	4.55E-08
9.48	2.529	0.527	2.531	844	1.61E-03	4.31E-04	6.80E-08
19.55	2.521	0.522	2.525	936	1.44E-03	3.10E-04	4.38E-08
38.79	2.508	0.514	2.514	712	1.88E-03	2.69E-04	4.96E-08
77.60	2.488	0.502	2.498	778	1.70E-03	2.01E-04	3.35E-08
155.12	2.452	0.480	2.470	735	1.76E-03	1.82E-04	3.14E-08
310.27	2.401	0.449	2.426	683	1.83E-03	1.30E-04	2.33E-08
621.02	2.346	0.416	2.373	577	2.07E-03	7.02E-05	1.42E-08
1241.03	2.281	0.377	2.313	487	2.33E-03	4.11E-05	9.37E-09
2483.95	2.212	0.336	2.247	406	2.64E-03	2.18E-05	5.63E-09
1241.03	2.216	0.338	2.214				
310.27	2.249	0.358	2.232				
77.60	2.289	0.382	2.269				
19.55	2.322	0.402	2.305				
4.63	2.342	0.414	2.332				
Note: k calculated using cv based on t ₉₀ values.							
SAMPLE DIMENSIONS AND PROPERTIES - FINAL							
Sample Height, cm	2.34			Unit Weight, kN/m ³	21.95		
Sample Diameter, cm	6.34			Dry Unit Weight, kN/m ³	19.00		
Area, cm ²	31.58			Specific Gravity, measured	2.74		
Volume, cm ³	73.97			Solids Height, cm	1.656		
Water Content, %	15.50			Volume of Solids, cm ³	52.31		
Wet Mass, g	165.55			Volume of Voids, cm ³	21.66		
Dry Mass, g	143.33						
Prepared By: LFG Golder Associates Checked By: 							

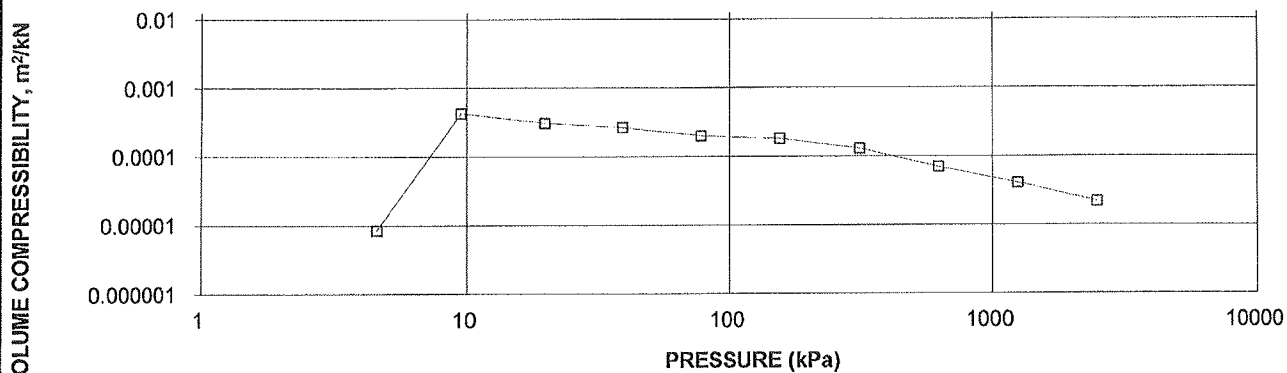
CONSOLIDATION TEST SUMMARY

FIGURE

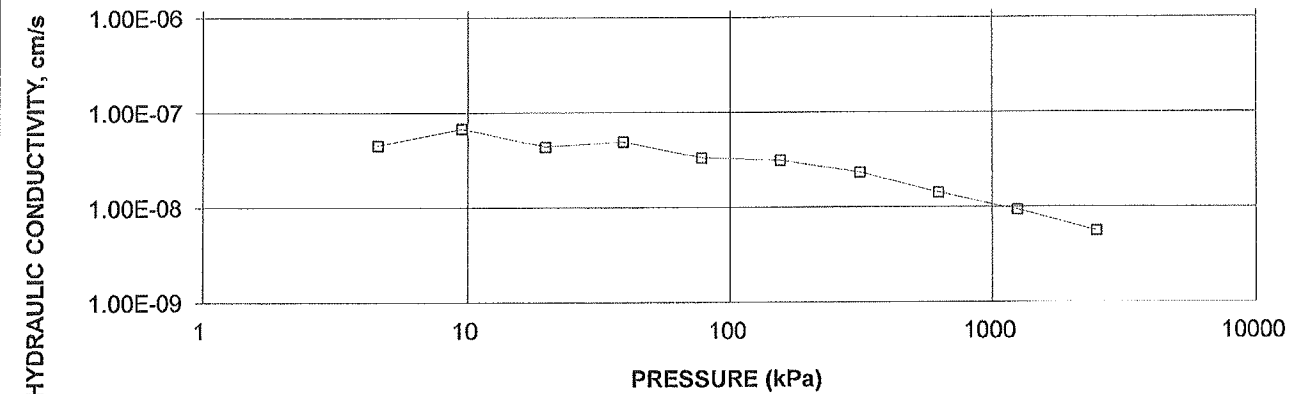
CONSOLIDATION TEST
 C_v cm²/s VS PRESSURE (kPa)
 BH 1 ST 2



CONSOLIDATION TEST
 M_v m²/kN vs PRESSURE (kPa)
 BH 1 ST 2



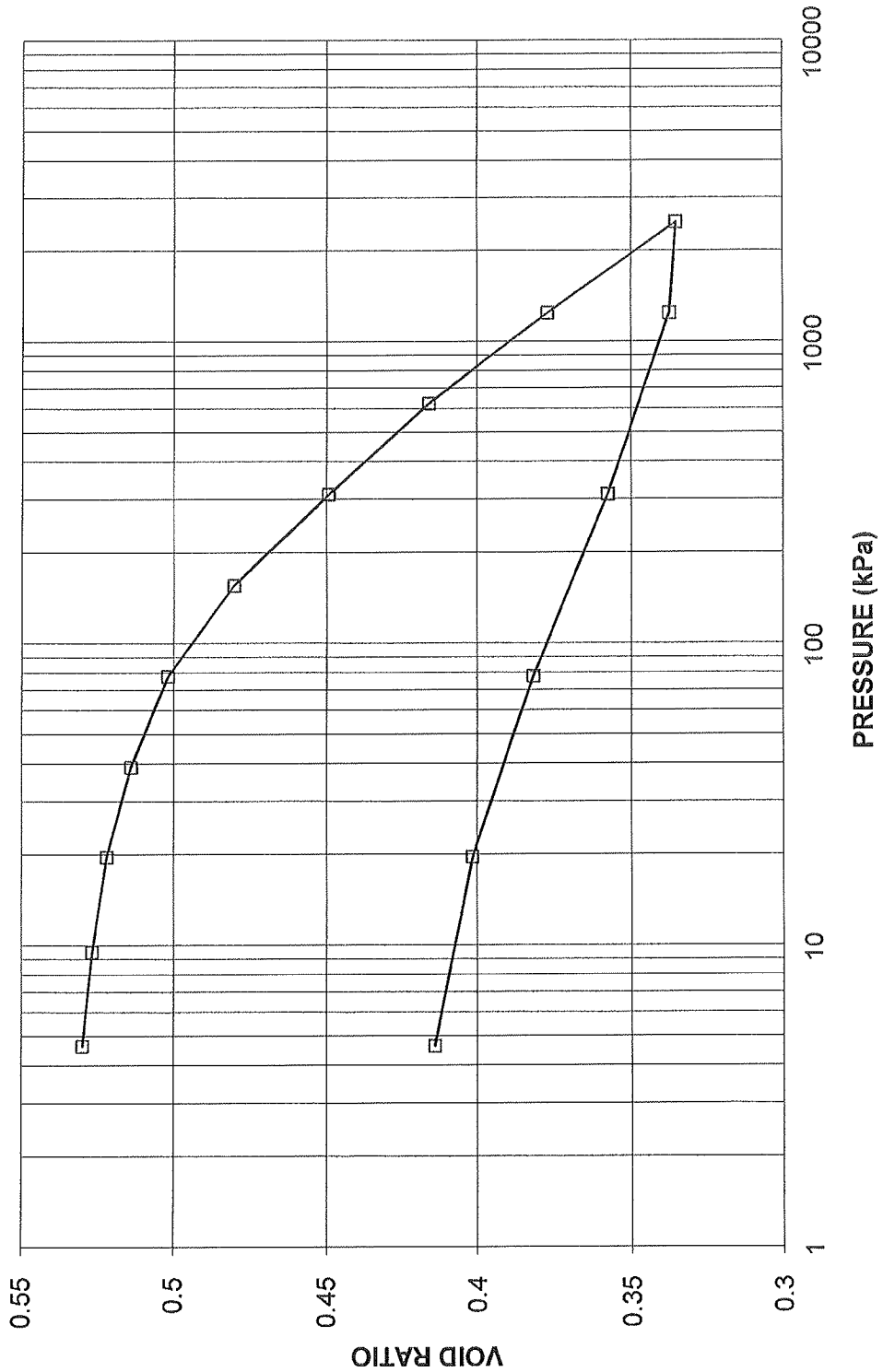
CONSOLIDATION TEST
 HYDRAULIC CONDUCTIVITY vs PRESSURE
 BH 1 ST 2



CONSOLIDATION TEST
VOID RATIO VS LOG PRESSURE

FIGURE

CONSOLIDATION TEST
VOID RATIO vs PRESSURE
BH 1 ST 2



UNCONFINED COMPRESSION TEST (UC)

ASTM D 2166 - 06

SAMPLE IDENTIFICATION

PROJECT NUMBER	11-1183-0076	SAMPLE NUMBER	ST 1
BOREHOLE NUMBER	1	SAMPLE DEPTH, m	9.8-10.4

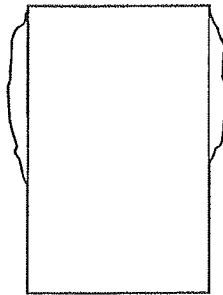
TEST CONDITIONS

MACHINE SPEED, mm/min	0.76	TYPE OF SPECIMEN	Thin wall tube sample
RATE OF AXIAL STRAIN, %/min	0.75	L/D	2.03

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	10.11	WATER CONTENT, (specimen) %	12.18
SAMPLE DIAMETER, cm	4.97	UNIT WEIGHT, kN/m ³	21.88
SAMPLE AREA, cm ²	19.42	DRY UNIT WT., kN/m ³	19.51
SAMPLE VOLUME, cm ³	196.29	SPECIFIC GRAVITY, measured	2.74
WET WEIGHT, g	438.20	VOID RATIO	0.38
DRY WEIGHT, g	390.62		

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	14.9	COMPRESSIVE STRESS, kPa	76
----------------------	------	-------------------------	----

REMARKS:

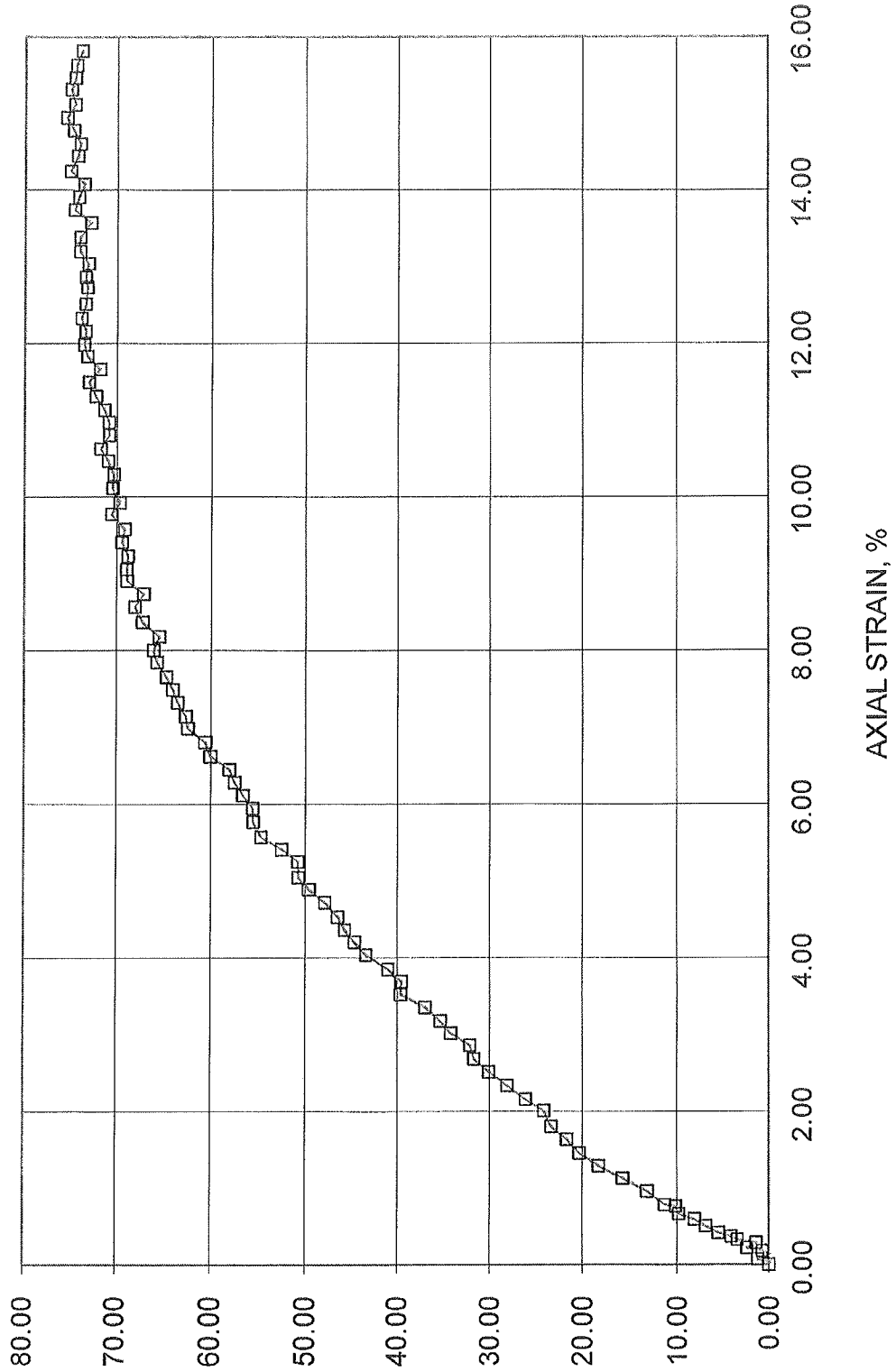
DATE:

11/4/2011

UNCONFINED COMPRESSION TEST (UC)

FIGURE

Borehole 1 Sample ST 1 Depth 9.8-10.4m



SPECIFIC GRAVITY TEST RESULTS

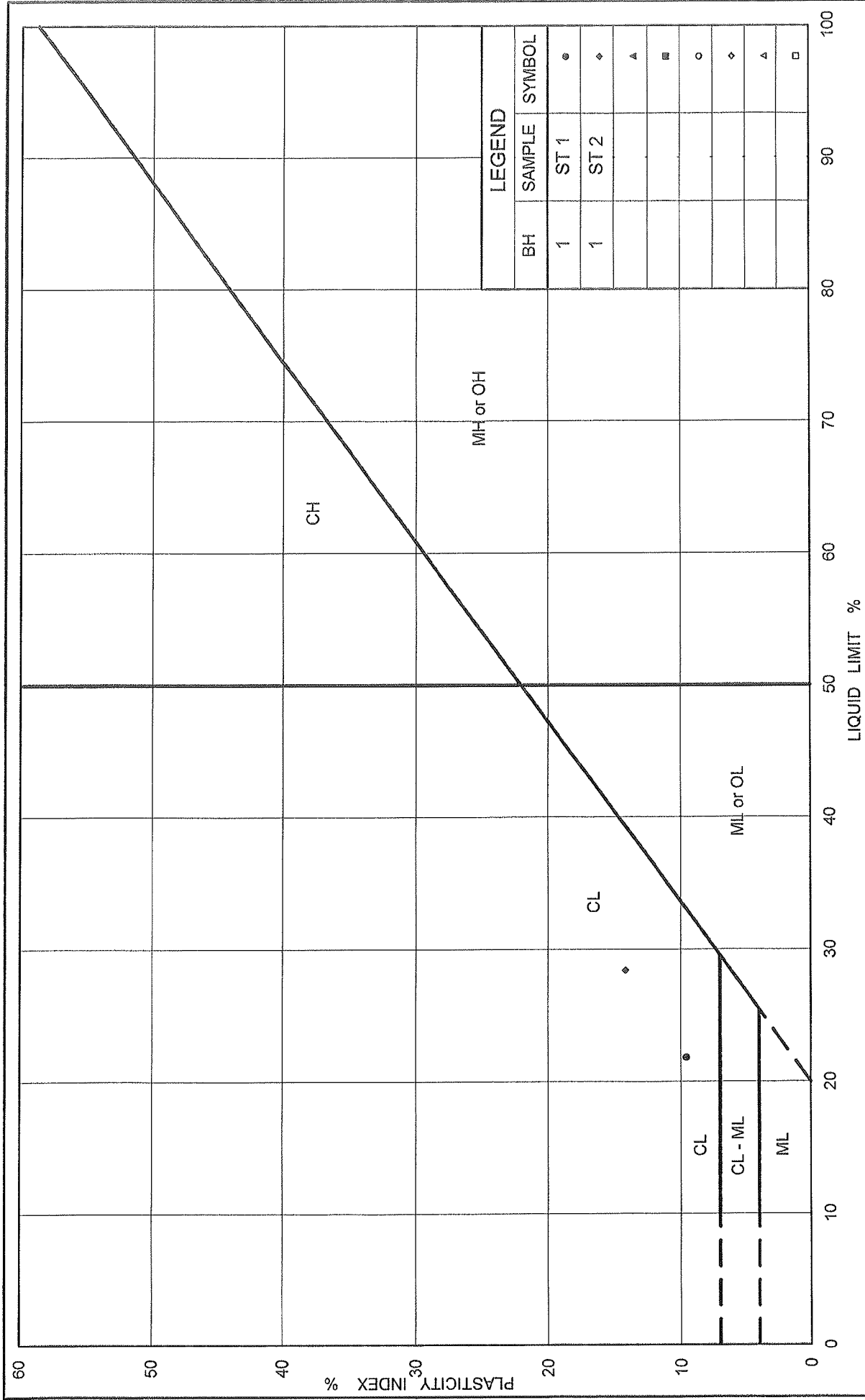
ASTM D 854-06 TEST METHOD A

PROJECT NUMBER	11-1183-0076		
PROJECT NAME	Stantec / Lab Testing / 165601256		
DATE TESTED	November, 2011		
Borehole No.	Sample No.	Specific Gravity	
1	ST 1	2.74	
1	ST 2	2.74	

Note: Test carried out on soil particles <4.75mm using distilled water.

Checked By: 

Golder Associates



	PLASTICITY CHART		Figure No.
			Project No. 11-1183-0076
			Checked By: <i>ML</i>

SUMMARY OF WATER CONTENT DETERMINATIONS

ASTM D 2216-05

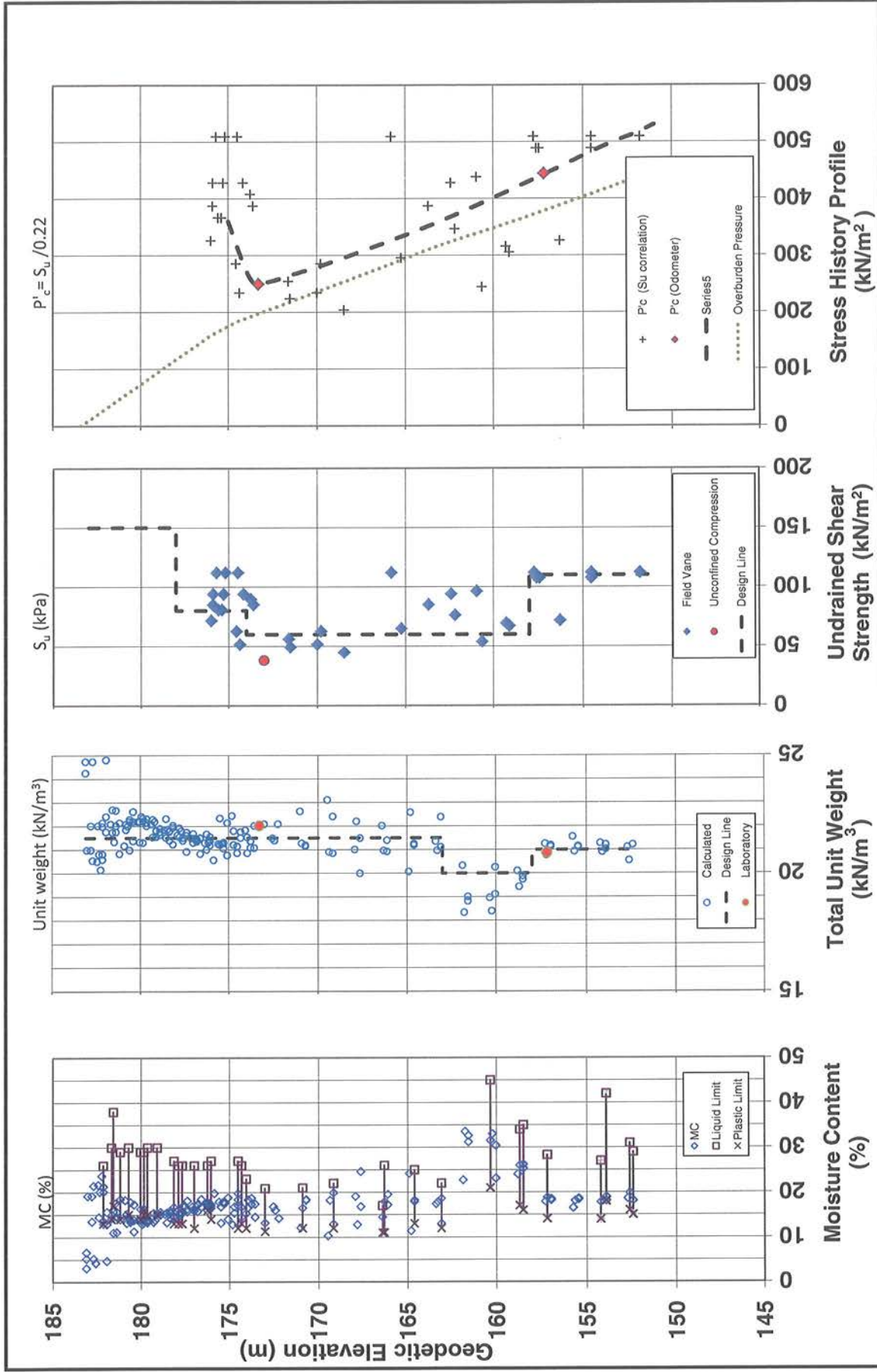
PROJECT NUMBER 11-1183-0076
PROJECT NAME Stantec / Lab Testing / 165601256
DATE TESTED November, 2011

Borehole No.	Sample No.	Depth (ft)	Depth (m)	Water Content (%)	Atterberg Limits LL, PL, PI
1	ST 1	32.0-34.0	9.75-10.36	13.3%	LL=21.8, PL=12.2, PI=9.6
1	ST 2	85.0-87.0	25.91-26.52	18.8%	LL=28.4, PL=14.2, PI=14.2

APPENDIX D

Design Parameters

Typical Settlement Evaluation Results



Stantec Consulting Ltd.

Canadian Plaza of the Windsor-
Detroit Tunnel
GWP No. 3032-06-00

Figure 4a

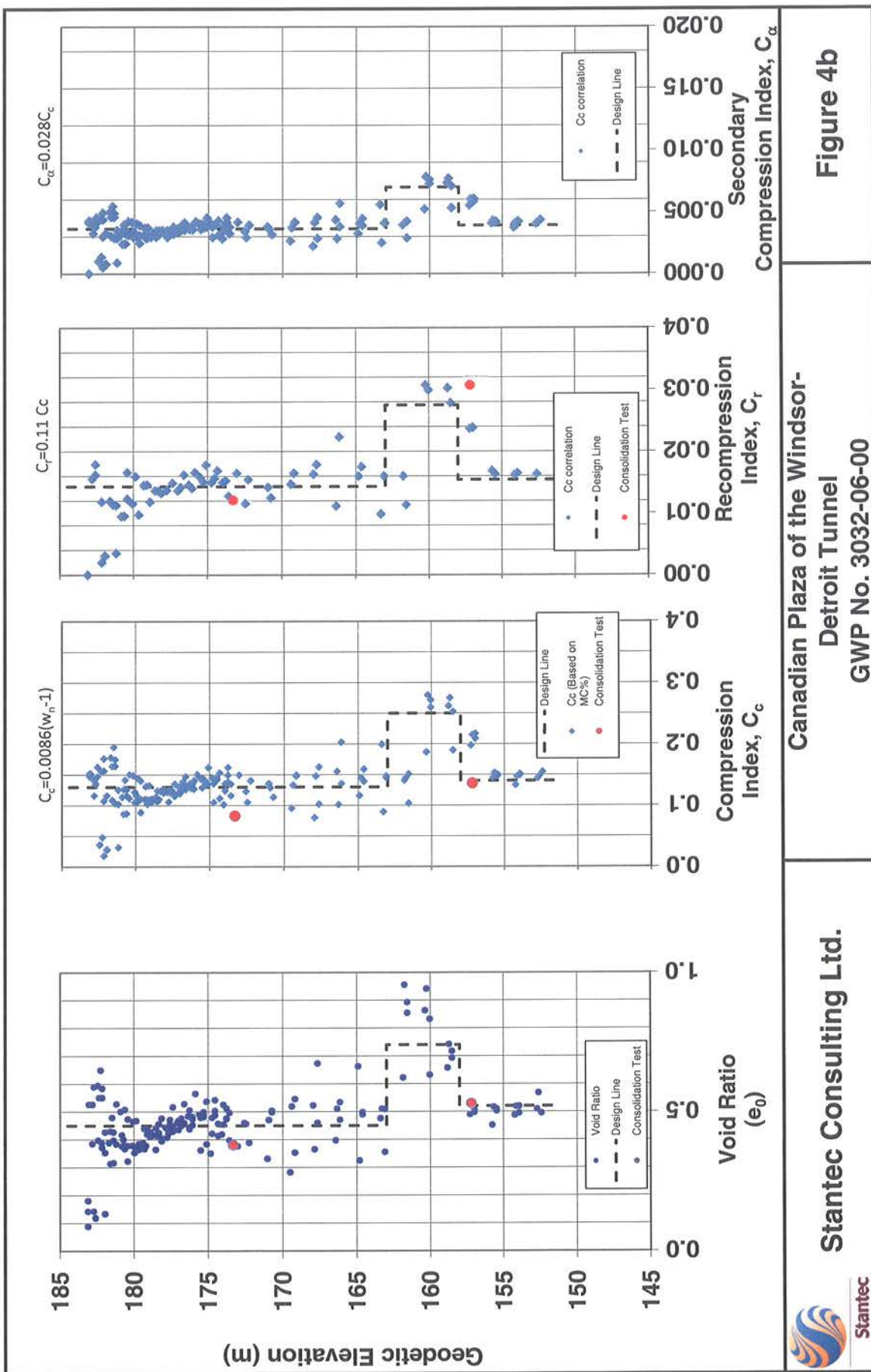
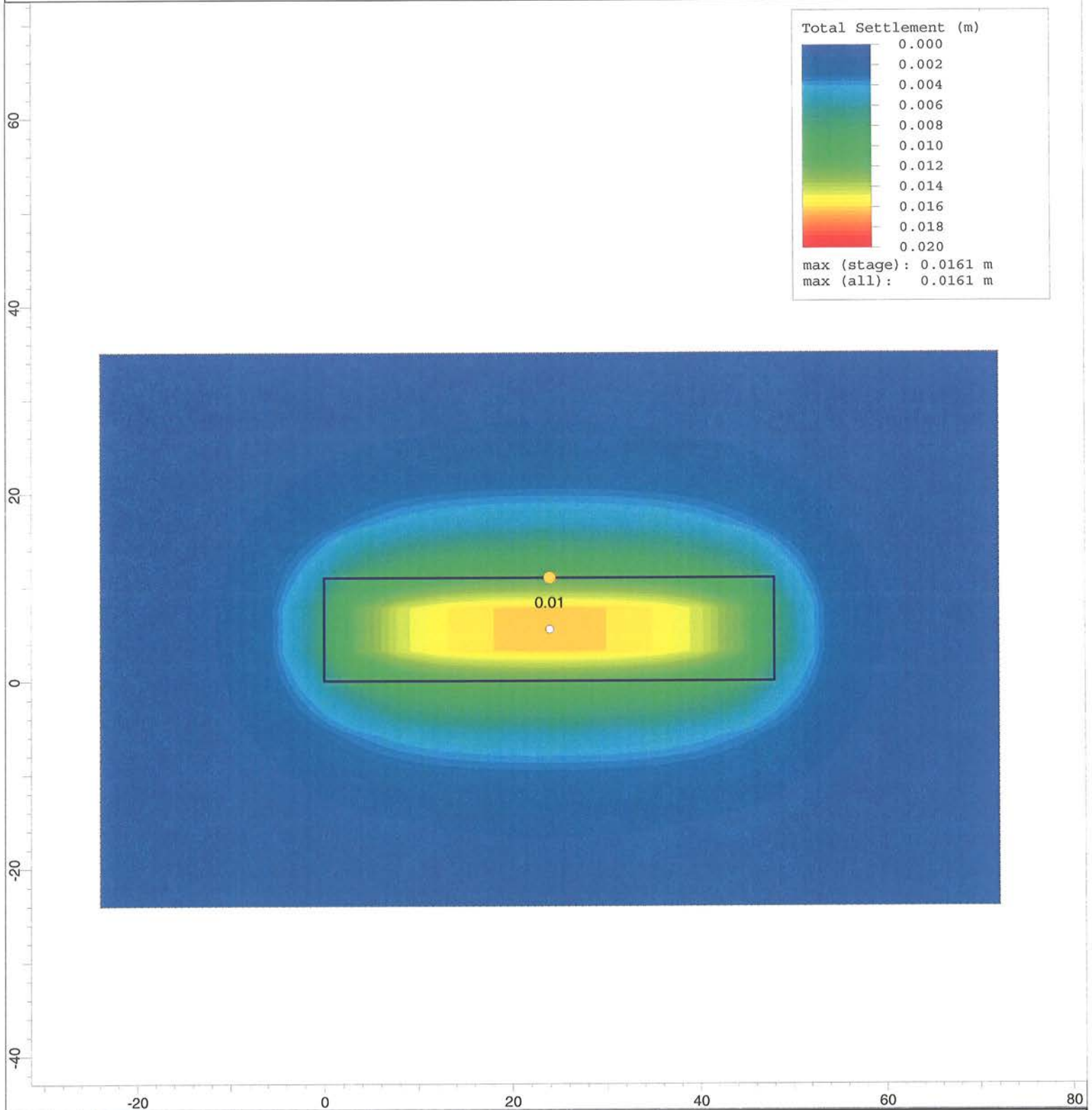


Figure 5a

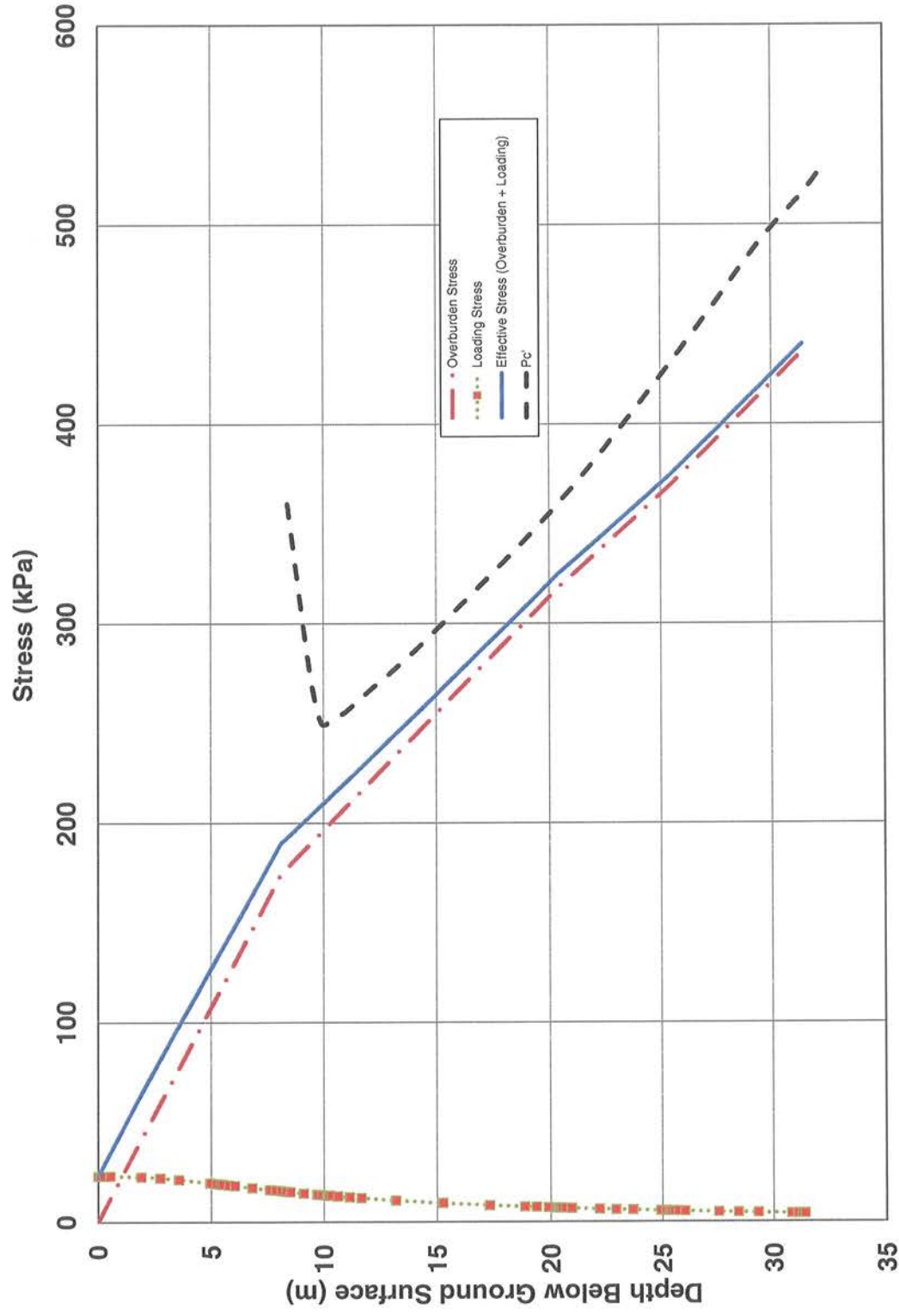


SETTLE3D 2.011

Stantec

Project		Canadian Plaza of the Windsor-Detroit Tunnel GWP No. 3032-06-00	
Analysis Description		Settlement due to Fill for Loading Dock	
Drawn By	SG	Company	Stantec
Date	12/9/2011, 12:56:28 PM	File Name	Windsor_Detroit_TunnelPlaza_1mFill.s3z

Typical Stress Profile



APPENDIX E

2010 National Building Code Seismic Hazard Calculation

2010 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Requested by: SG, Stantec

November 22, 2011

Site Coordinates: 42.3154 North 83.0358 West

User File Reference: Windsor-Detroit Tunnel Plaza

National Building Code ground motions:

2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.2)	Sa(0.5)	Sa(1.0)	Sa(2.0)	PGA (g)
0.147	0.083	0.045	0.014	0.071

Notes. Spectral and peak hazard values are determined for firm ground (NBCC 2010 soil class C - average shear wave velocity 360-750 m/s). Median (50th percentile) values are given in units of g. 5% damped spectral acceleration (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are tabulated. Only 2 significant figures are to be used. *These values have been interpolated from a 10 km spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the calculated values.*

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.2)	0.019	0.053	0.087
Sa(0.5)	0.009	0.031	0.049
Sa(1.0)	0.004	0.015	0.025
Sa(2.0)	0.002	0.005	0.009
PGA	0.006	0.020	0.035

References

National Building Code of Canada 2010 NRCC no. 53301; sections 4.1.8, 9.20.1.2, 9.23.10.2, 9.31.6.2, and 6.2.1.3

Appendix C: Climatic Information for Building Design in Canada - table in Appendix C starting on page C-11 of Division B, volume 2

User's Guide - NBC 2010, Structural Commentaries NRCC no. 53543 (in preparation)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File xxxx
Fourth generation seismic hazard maps of Canada: Maps and grid values to be used with the 2010 National Building Code of Canada (in preparation)

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information

Aussi disponible en français

