



Stantec

**Foundation Investigation and
Design Report – Laird Road
Underpass**

Highway 6 (Hanlon Expressway) and
Laird Road Interchange
City of Guelph

G.W.P. 3002-05-00

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FOUNDATION INVESTIGATION REPORT

For

G.W.P 3002-05-00

Highway 6 (Hanlon Expressway) and Laird Road Interchange
City of Guelph

1.0 Introduction

Stantec Consulting Ltd. (Stantec) was retained by the Ministry of Transportation, Ontario (MTO) to undertake the detailed design for the replacement of an existing at-grade crossing with a grade separated interchange at Highway 6 (Hanlon Expressway) and Laird Road in the City of Guelph, Ontario.

This Foundation Investigation Report has been prepared specifically and solely for the proposed interchange structure. The geotechnical investigation and design recommendation report pertaining to the ramp embankments for the proposed interchange is presented under a separate cover.

Project Number: G.W.P.: 3002-05-00

Project Location: Highway 6 (Hanlon Expressway) and Laird Road Interchange, Guelph

The work was carried out under Agreement Number 3009-E-0003 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 inset to Drawing No. 1, provided in Appendix A. It should be noted that for project orientation purposes, Highway 6 will be assumed to run north-south (unless specifically stated) at the project location, with chainage increasing from south to north along Highway 6. Chainage on Laird Road increases from west to east.

General Site Description

It should be noted, in this report that 'Highway 6' and 'Hanlon Expressway' refer to the same entity and therefore, only the term 'Highway 6' will be used for brevity.

At the project site, Laird Road and Highway 6 intersect at-grade with traffic flow being regulated with a traffic signal; Highway 6 runs approximately NW-SE (actual orientation) while Laird

crosses Highway 6 approximately perpendicularly and runs NE-SW. Laird Road is two lanes in width. Highway 6 has two lanes in each direction separated by a grassed median (see site photos in Appendix A). Turning lanes and ramps are present at the intersection.

The existing drainage for the highway at this site consists of a mix of catch basins leading to storm sewers with ditches and culverts.

Physiographic Description

The site is located within a physiographic region known as the Guelph Drumlin Field (Chapman and Putnam, 1984). These drumlins were caused by the ice thrust which radiated from the western end of the Lake Ontario basin. The dominant soil materials of the drumlins are the stony tills and deep gravel terraces of the old meltwater spillways. The intervening low grounds largely contain fluvial materials. The till is considered to be loamy and calcareous, derived mostly from dolostone of the Amabel Formation. The till also contains fragments of the underlying bedrock and consequently is pale brown in colour.

In the vicinity of the project site the terrain is fairly flat.

3.0 Method of Investigation

3.1 DRILLING INVESTIGATION

The geotechnical investigation for the bridge foundations for the proposed interchange included six boreholes in the immediate vicinity of the footprint of the proposed bridge foundation. These boreholes are designated BH10-1 through BH10-6 and are shown on the Borehole Location Plan, Drawing No. 1 in Appendix A. Two boreholes each were advanced at the locations of the two bridge abutments while the remaining two boreholes were advanced at the location of the centre pier (in the median of Highway 6 at the existing at-grade intersection with Laird Road).

Nine additional boreholes within the general influence zones of the approach embankments to the bridge abutments (along Laird Road) were also advanced. These boreholes are designated BH10-7, BH10-8, BH10-10, BH10-16, BH10-19, BH10-20, BH10-21, BH10-26, and BH10-27 and are also shown on the Borehole Location Plan, Drawing No. 1 in Appendix A.

Prior to carrying out the investigation, Stantec contacted the public utility authorities to clear the borehole locations of both private and public utilities.

The field drilling program was carried out from July 19 through August 13, 2010. The boreholes were advanced with continuous flight hollow stem augers using a CME 55 drill rig (truck- and track-mounted depending on accessibility) equipped for soil and bedrock sampling. The drilling equipment was owned and operated by DBW Drilling Ltd. of Ajax, Ontario.

The subsurface stratigraphy encountered in each borehole was recorded in the field by an experienced Stantec Field Engineer. Split spoon samples were collected at regularly spaced

intervals (every 760 mm for up to 6 m below existing ground surface and every 1.5 m for deeper strata). All samples recovered were returned to our Ottawa laboratory for detailed classification and testing.

It is noted that during drilling, cobbles (and at times boulders) were encountered frequently in most of the boreholes advanced for this project. This resulted in slow augering and a few of the boreholes were slightly offset from the originally proposed drill locations due to the difficult augering.

Piezometers (standpipes) were installed in Boreholes BH10-1, BH10-6 and BH10-7. The water levels in these piezometers were regularly monitored and were last measured on August 17, 2010. The piezometers were decommissioned on August 17, 2010, in accordance with MOE regulations for well abandonment (O. Reg. 903). The six other boreholes were backfilled immediately after drilling with a bentonite-cement mix.

3.2 SURVEY

Surveying of the foundation borehole locations was performed by Callon Dietz, Inc. of London, Ontario, as a component part of the entire survey for the project. Survey was established relative to the centerline of the existing Highway 6 alignment, Laird Road and the proposed ramps. The ground surface elevation at each borehole location was surveyed on July 5, 2010, with reference to a Geodetic Benchmark provided by MTO. Summary information pertaining to the boreholes included in this report is given in Table 3.1.

Table 3.1: Borehole Information Summary

BH	MTM Zone 10 Coordinates		Ground surface elevation	Total depth drilled	End of borehole elevation	Depth augered	Number of soil samples	Depth cored
	Northing	Easting	m	m	m	m		m
10-1	4816938	247125	330.3	18.7	311.6	18.7	18	0
10-2	4816965	247098	330.2	22.3	307.9	18.4	22	3.81
10-3	4816960	247154	331.6	15.5	316.1	15.5	15	0
10-4	4816991	247123	331.2	19.1	312.1	19.1	18	0
10-5	4816984	247175	331.4	26.7	304.8	22.1	19	4.65
10-6	4817009	247152	330.9	19.9	311.0	19.9	18	0
10-7	4816816	247010	329.3	6.7	322.6	6.7	9	0
10-8	4816818	246974	329.3	11.3	318.0	11.3	12	0
10-10	4816877	247018	329.1	9.8	319.4	9.8	11	0
10-16	4816906	247043	329.9	9.8	320.1	9.8	11	0
10-19	4816944	247068	329.9	9.8	320.1	9.8	11	0
10-20	4817015	247208	329.5	8.2	321.3	8.2	10	0
10-21	4817034	247228	331.2	11.3	319.9	11.3	12	0
10-26	4817064	247258	331.9	6.7	325.2	6.7	9	0
10-27	4817101	247242	330.7	6.7	324.0	6.7	9	0

3.3 LABORATORY TESTING

All samples were taken to our Ottawa laboratory where they were subjected to a detailed visual examination by a Geotechnical Engineer. Routine soil testing was carried out on selected soil samples. The tests carried out included plasticity testing (8 samples), grain size analysis (58 samples) and moisture content testing (58 samples). Three samples were submitted to Parcel Laboratories of Ottawa for analysis of pH, soluble sulphate content, chloride content and resistivity.

Samples remaining after testing will be placed in storage for a period of one year after issuance of the final report. After the storage period, the samples will be discarded unless we are directed otherwise by MTO.

4.0 Subsurface Conditions

4.1 SUBSURFACE PROFILE

The subsurface conditions observed in the boreholes included in this report 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 consists from top to bottom of: dark brown sandy silt soil with frequent and partially decomposed roots and organics, a layer of gravel and sand with silt, sand and silty sand, sandy silt, sandy silt till, and inferred or confirmed bedrock. Bedrock was confirmed by coring 3.81 m and 4.65 m using NQ size rock cores in Boreholes BH10-2 and BH10-5 respectively.

Borehole location plans and stratigraphic sections of the soils encountered within the boreholes are provided on Drawings No. 1 and 2 in Appendix A.

4.1.1 Pavement

The boreholes were advanced off paved roads at the project site and therefore, no asphalt or pavement surface was encountered in any of the investigation locations reported herein.

4.1.2 Sandy Silt with Some Organics (Topsoil/Rootmat)

In all boreholes advanced at this site an approximately 500 mm thick layer of dark brown sandy overburden soil was observed. This soil had a dark brown colour and contained some organics (plant roots).

4.1.3 Sandy Silt with Gravel (Fill)

A fill layer was encountered in Borehole BH10-26. The fill predominantly contained dark brown sandy silt with gravel. The fill had a thickness of approximately 2.1 m and extended to an

approximate elevation of 329.8 m. Index tests carried out on a representative sample from the fill indicated 6% gravel, 32% sand and 62% fines (silt and clay). The moisture content was 10%. The uncorrected standard penetration test (SPT) blow count per 0.3 m penetration (N) for this layer ranged from 11 to 18 indicating a compact state.

4.1.4 Gravel and Sand with Silt

A layer of granular soil containing gravel and sand with silt was encountered immediately beneath the dark brown sandy silt layer or the fill layer in all the boreholes advanced for this project. This layer contained predominantly gravel and sand with slightly varying proportions from borehole to borehole. Cobbles and boulders were noted to be present. Except in Borehole BH10-07, the bottom elevation of this layer ranged from approximately 324.1 to 327.1 m geodetic. In Borehole BH10-07, drilling was terminated within this layer and hence the bottom elevation was not established. The thickness of this layer ranged between approximately 3.1 m (BH10-20) and 4.7 m (BH10-6) with an average thickness of approximately 3.9 m. The uncorrected standard penetration test (SPT) blow count per 0.3 m penetration (N) for this layer ranged from 10 to greater than 100 (i.e., split spoon refusal) suggesting that this layer is in a compact to very dense state of compactness. Note that split spoon refusal can be indicative of the presence of cobbles or boulders. Laboratory index tests performed on representative soil samples obtained from this layer yielded the following results:

Gravel	32 to 67%
Sand	25 to 59%
Fines	6 to 25%
Water content	3 to 9%.

The soil materials in this layer generally belong to the Unified Soil Classification System (USCS) soil categories of GP-GM, GM, GW-GM, SP-SM, or SM (generally varying from gravel with silt and sand to sand with silt and gravel). The grain size distribution plots of samples obtained from this deposit are shown in Figure 1 in Appendix C.

Three samples retrieved from this layer were submitted to Paracel Laboratories in Ottawa, Ontario, for analysis of pH, water soluble sulphates and chloride concentrations, and resistivity. The analysis results are provided in Table 4.1.

Table 4.1: Results of Chemical Analysis

Borehole No	Sample No.	Depth (m)	pH	Chloride (µg/g)	Sulphate (µg/g)	Resistivity (Ohm-m)
BH10-2	SS-2	0.76 to 1.4	8.2	118	16	91
BH10-3	SS-3	1.5 to 2.1	8.3	157	13	89
BH10-5	SS-2	0.76 to 1.4	8.4	130	11	88

4.1.5 Sand and Silty Sand

In most boreholes advanced for this project a layer of predominantly sandy soil was encountered beneath the layer of gravel and sand with silt described above. The bottom elevation of this layer varied between 322.3 m (BH10-16) and 325.7 m (BH10-3). In Boreholes BH10-08 and 10-26, drilling was terminated within this layer. The thickness of this layer varied from 1.3 to 3.2 m with an average thickness of approximately 2.2 m. The uncorrected standard penetration test (SPT) blow count per 0.3 m penetration (N) for this layer ranged from 6 to 52 suggesting that this layer is in a loose to dense state. It is noted that the observed groundwater level was generally located in this layer. Laboratory index tests performed on representative soil samples retrieved from this layer yielded the following results:

Gravel	0 to 23%
Sand	43 to 94%
Fines	3 to 37%
Water content	9 to 20%

The soil materials encountered in this layer generally belong to the Unified Soil Classification System (USCS) soil categories of SP, SP-SM, SW-SM, or SM (generally varying from sand to silty sand). The grain size distribution plots of samples obtained from this deposit are shown in Figure 2 in Appendix C.

4.1.6 Sandy Silt and Silt

A deposit of sandy silt or silt was encountered beneath the sand layer in eight of the fifteen boreholes along Laird Road. The observed bottom elevation of this layer ranged approximately between 318.2 m (BH10-1) and 322.5 m (BH10-3). The approximate thickness of this deposit ranged between 3.1 m and 5.4 m with an average thickness of approximately 4.3 m. It should be noted that drilling in BH10-10, BH10-16, BH10-19 and BH10-20 was terminated in this layer upon attaining the proposed maximum investigation depth for these boreholes and therefore, the actual extent of the layer could not be estimated. The uncorrected standard penetration test (SPT) blow count per 0.3 m penetration (N) for this layer ranged from 8 to 45 suggesting that this layer is in a loose to dense state. Laboratory index tests performed on representative soil samples retrieved from this layer yielded the following results:

Gravel	0%
Sand	4 to 37%
Fines	63 to 96%
Water content	16 to 19%

Atterberg limits tests indicated that this material is non-plastic. The soil materials encountered in this layer generally belong to the Unified Soil Classification System (USCS) soil category of ML (generally varying from sandy silt to silt). The grain size distribution plots of samples obtained from this deposit are shown in Figure 3 in Appendix C.

4.1.7 Sandy Silt with Gravel (Till)

In all the six boreholes advanced in the vicinity of the bridge foundation footprints, a deposit of silty sand with gravel (till) was encountered beneath the silty sand or sandy silt layers described above. Drilling was terminated in this layer at borehole locations BH10-1, 10-3, 10-4 and 10-6 approximately 3 m below the first refusal level. The observed bottom elevation of this layer ranged between approximately 310.1 m (BH10-5) and 316.1 m (BH10-3). The approximate thickness of the observed sandy silt till layer varied from 6.4 m (BH10-3) to 13.7 m (BH10-5) with an average thickness of approximately 9.2 m. The uncorrected SPT N-count ranged from 10 to well over 100, suggesting that the deposit is in a compact to very dense state of compactness. It should be noted that in this layer the SPT blow count typically increased with depth. Laboratory index tests performed on soil samples retrieved from this layer yielded the following results:

Gravel	1 to 29%
Sand	10 to 64%
Fines	16 to 89%
Water content	8 to 16%

Atterberg limits tests were carried out on five till samples which all produced low plastic results (see Fig. 5 in Appendix C). The USCS classification of soil samples from this layer is ML (sandy silt or sandy silt with gravel). The grain size distribution plots of samples obtained from this deposit are shown in Figure 4 in Appendix C.

It is noted that although not specifically encountered in the boreholes that penetrated this till layer, cobbles and boulders should be anticipated in the glacial till due to its depositional history.

4.2 BEDROCK

Grey limestone bedrock was encountered in boreholes BH10-2 and BH10-5. The bedrock was confirmed by coring approximately 3.8 and 4.6 m, respectively, into the bedrock using NQ-size coring equipment. Bedrock was encountered at elevations of 311.8 and 310.1 m (approximately 18.4 and 21.3 m below existing ground surface).

The rock core recovery ranged between 63 and 100% (with average of 91%). The rock quality designation (RQD) ranged between 0 and 92% (with average of 66%), indicating very poor to excellent rock mass quality. The bedrock was slightly weathered with joint spacing ranging from close to moderate and joint orientation predominantly flat. A detailed description of the rock core is provided in Field Core Logs with rock core photographs in Appendix B.

Unconfined compressive strength tests were carried out on two bedrock samples each from Boreholes BH10-2 and BH10-5. The results of these tests are summarized in Table 4.2.

Table 4.2: Unconfined Compressive Strength of Rock Cores

Borehole No.	Ground Surface Elevation (m)	Test Elevation (m)	Unconfined Compressive Strength (MPa)
BH10-2	330.2	310.8	70
		309.0	167
BH10-5	331.4	308.6	52
		305.4	82

4.3 GROUNDWATER

Groundwater monitoring wells were installed in BH10-1, BH10-6 and BH10-7 between July 22 and 27, 2010. The water levels in these wells were monitored regularly until August 17, 2010, when the monitoring wells were decommissioned according to Ontario Regulations 903.

Groundwater level, as measured in the monitoring wells on August 16, 2010, was at approximate at elevations of between 326.1 and 326.4 m (depths of between 2.9 and 4.8 m). Groundwater level readings are summarized in Table 4.3. Groundwater observations made during drilling in the other boreholes are summarized Table 4.4.

Table 4.3: Summary of Groundwater Level Readings

Borehole No	Ground Surface Elevation (m)	Groundwater	
		Depth (m)	Elevation (m)
BH10-1	330.3	4.2	326.1
BH10-6	330.9	4.8	326.1
BH10-7	329.3	2.9	326.4

Table 4.4: Inferred Groundwater Level Readings (time of drilling)

Borehole No	Ground Surface Elevation (m)	Groundwater	
		Depth (m)	Elevation (m)
BH10-2	330.2	4.3	325.9
BH10-3	331.6	5.2	326.4
BH10-4	331.2	4.9	326.3
BH10-5	331.4	5.3	326.1
BH10-8	329.3	4.1	325.2
BH10-10	329.1	3.8	325.3
BH10-16	329.9	4.6	325.3
BH10-19	329.9	4.0	325.9
BH10-20	329.5	3.2	326.3
BH10-21	331.2	5.3	325.9
BH10-26	331.9	5.5	326.4
BH10-27	330.7	4.3	326.4

Fluctuations in the groundwater level due to seasonal variations or in response to a particular precipitation event should be anticipated.

5.0 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 and timeframe described herein. 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.


This report has been prepared by Simon Gudina and Fred Griffiths. A technical review was carried out by Raymond Haché.

Respectively Submitted;

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FOUNDATION DESIGN REPORT – LAIRD ROAD UNDERPASS

For

G.W.P. 3002-05-00

Highway 6 (Hanlon Expressway) Interchange
City of Guelph

6.0 Discussion

6.1 PROJECT DESCRIPTION & BACKGROUND

Project Purpose/Justification

Highway 6 passes through the City of Guelph, Ontario. The existing highway has two lanes in each direction separated by a grassed median. Laird Road is a single lane in each direction. Turn lanes and ramps are present at the intersection which is controlled by traffic signals.

Proposed Interchange Bridge Structure

The proposed interchange will remove the existing signalized at-grade intersection at Highway 6 and Laird Road and will carry Laird Road over Highway 6 using a two-span bridge. The preliminary general arrangement of the bridge reveals the following relevant information:

- Two span bridge (approximately equal span lengths) with a total length of approximately 67 m;
- Four traffic lanes (Laird Road) resulting in an approximately 30 m wide bridge;
- Finished grade for Laird Road will be at approximate elevation of 338.9 m which is about 8 m higher than existing grades;
- Finished grade for Highway 6 will remain at approximate elevation of 331.5 m; and
- A retained soil system (RSS) may be utilized to contain soil behind the abutments. The RSS would also extend back into the approach embankments as wingwalls.

It is noted that a separate report has been generated for the high fill embankments proposed for the ramps. Discussions and recommendations concerning ramp embankment geometry, stability and settlement are contained therein.

6.2 SOIL SUMMARY

The soil conditions at this site generally consist of dense to very dense granular layer (gravel and sand with silt) over sand and silt layer over compact to very dense silty till over bedrock. All boreholes in the vicinity of the proposed bridge foundation were advanced to either 3 m past refusal or cored into bedrock for a minimum distance of 3 m.

For design purposes, the soil profile indicated in the following Table 6.1 can be used. The geotechnical soil profile was developed based on the synthesis of the measured N values and the laboratory index test results (including moisture contents) of soil samples retrieved from the site. This profile is indicated in Figure 6 in Appendix D and was developed based on the information obtained from Boreholes BH10-1 through BH10-6, BH10-19 and BH10-20.

Table 6.1: Representative Soil Profile for Foundation of Bridge Structure

Elevation (m)		Soil Type	Design Parameters		
From	To		γ	ϕ	E
330	327	Gravel and sand with silt containing cobbles and boulders (compact to very dense)	21	38	200
327	324	Sand to silty sand (compact to dense)	20	33	40
324	316	Sandy Silt (loose to dense)	20	31	25
316	310	Sandy silt with gravel (very dense) (TILL)	22	40	200
	<310	Bedrock			

Note: (1) γ = total unit weight (kN/m^3), ϕ = soil friction angle ($^\circ$), and E = soil modulus (MPa).

(2) Groundwater is assumed to be at approximate elevation of 326.0 m for design purposes. The submerged unit weight (γ') was used below this elevation.

Though not encountered, cobbles and boulders are anticipated in the till (elevation 316 to 310 m).

6.3 FOUNDATION OPTIONS

For the bridge foundation both shallow and deep foundation options can be considered. Shallow foundations will likely be placed within the granular layer at approximate elevation of 330.0 m. Deep foundations can be supported in the dense glacial till or driven to bedrock. Even though the site soil is expected to have adequate bearing resistance to enable use of shallow foundation for the bridge structure, deep foundation will be considered as a possible alternative. Integral abutment bridges are preferred from a structural perspective and require foundation flexibility.

The Table 6.2 compares the foundation options from a foundations design and constructability perspective:

Table 6.2: Comparison of Foundation Options for Bridge Structure

Option	Advantages	Disadvantages	Relative Cost	Risk/Consequences
Shallow foundation on gravel and sand	<ul style="list-style-type: none"> Excavation and drilling through difficult deposit not needed Generally suitable to support bridge piers 	<ul style="list-style-type: none"> May necessitate large footing area Not suitable for integral abutment bridge construction 	Low to medium	
Piles End bearing on Till	<ul style="list-style-type: none"> Reduced differential settlement Suitable for integral abutment bridge 	<ul style="list-style-type: none"> Difficulty driving piles through boulders and cobbles, may require pre-augering 	Medium	<ul style="list-style-type: none"> Pile damage during installation Negative pile interaction if closely spaced
Frictional	<ul style="list-style-type: none"> Reduced pile length 	<ul style="list-style-type: none"> Pile capacity may not be fully utilized Difficulty driving piles through cobbles and boulders, may require pre-augering 	Medium	<ul style="list-style-type: none"> Larger settlement Pile damage during installation
Drilled Caissons	<ul style="list-style-type: none"> Can transmit very large axial and lateral loads 	<ul style="list-style-type: none"> Difficult to drill through boulders and cobbles Not suitable for integral bridge abutment 	High	<ul style="list-style-type: none"> Risk of cave-in, especially below groundwater table during drilling

Note: All options presented in Table 6.2 are suitable for a semi-integral abutment bridge configuration.

Based on the comparison presented above in Table 6.2, a combination of a spread footing foundation for the centre pier and piles end bearing on till for the abutment foundations will provide a suitable solution for the conditions presented herein. Although the foundation soils encountered at the site during drilling are generally good and will provide adequate support for shallow foundation, the recommended foundation combination will meet the requirements of the preferred integral abutment bridge configuration.

7.0 Recommendations

The design recommendations presented in the following sections have been developed in accordance with the requirements and methods described in the Canadian Highway Bridge Design Code (CHBDC, 2006).

7.1 FOUNDATIONS – SPREAD FOOTING

As discussed in Section 6.3, a spread footing for the centre pier and piles for the abutment foundations is the recommended foundation combination. This section provides relevant foundation recommendations for the proposed center pier footing.

It is recommended that the pier of the bridge for the proposed interchange be founded on a shallow foundation at elevation of approximately 329.5 m. This footing elevation is approximately 1.5 m below the existing ground elevation.

7.1.1 Geotechnical Resistance

The geotechnical resistances provided in Table 7.1 may be used in the design provided the footings are placed on undisturbed native soil as described above.

Table 7.1: Geotechnical Resistance for Shallow Foundation (Spread Footing)

Founding Element	Founding Elev. (m)	Footing Width (m)	Factored Geotechnical Resistance at ULS (kPa)	Geotechnical Resistance at SLS (kPa)
Bridge pier footing	329.5	1.5	800	560
		2.0	890	440
		2.5	950	360
		3.0	1000	310
		3.5	1040	280
		4.0	1080	250

In accordance with Section 6.6.2 of the CHBDC, a resistance factor of 0.5 has been applied to calculate the factored geotechnical resistance at Ultimate Limit State (ULS).

The geotechnical resistance at Serviceability Limit State (SLS) corresponds to a maximum settlement of 25 mm. The geotechnical resistance at SLS was evaluated using linear deformation behaviour. Accordingly, the anticipated geotechnical resistance for a maximum 50 settlement mm would be twice the corresponding values for 25 mm maximum settlement.

7.1.2 Sliding Resistance

The unfactored horizontal resistance of spread footings made of cast-in-place concrete placed on native soil may be calculated using an unfactored coefficient of friction of 0.55. Since this is an unfactored value, a factor of 0.8 should be used in accordance with Table 6.1 of the CHBDC.

7.2 FOUNDATIONS – PILES

Pile foundation consisting of HP310x110 piles are recommended to support the proposed integral abutments for both the west and east abutments of the bridge. It is anticipated that the underside of the pile caps will be at approximate elevation of 333.2 m.

7.2.1 Axial Pile Resistance in Compression

The factored axial resistance at ULS for an HP310x110 pile is typically 2000 kN. This resistance value assumes that piles are successfully driven to competent bedrock. However, the proposed piles are end-bearing on competent till and as such may not utilize the maximum capacity of the pile. The standard practice for HP310x110 piles end bearing on glacial till with SPT N values greater than 100 blows per 0.3 m is to utilize a factored geotechnical resistance at ULS of 1800 kN and an unfactored resistance at SLS of 1600 kN. These values are appropriate for this site.

It is anticipated that the piles will be driven to approximate elevation 314 m.

Drag loads in the order of 500 kN unfactored and 625 kN at ULS have been calculated based on the assumption that the approach embankments are constructed after pile driving (see Section 7.6.3). Provided that the dead loads associated with the superstructure and substructure do not exceed 1375 kN at ULS, embankment staging to reduce drag loads is not required.

7.2.2 Lateral Resistance of Piles

The geotechnical resistance of the pile against lateral loads is mobilized due to the passive resistance of the surrounding soil. Assessed values for horizontal passive resistance and geotechnical resistances at SLS for the proposed pile can be generated from information provided in Table C6.4 of the Commentaries to the Canadian Highway Bridge Design Code (CHBDC, 2006). A value at ULS of 120 kN and a value at SLS of 50 kN may be used for an HP 310x110 pile. It should be noted that a horizontal displacement at the ground surface of 10 mm was assumed for the SLS condition.

The passive lateral resistance for vertical piles can be calculated according to Sections C6.8.7.1 and C6.8.7.2 of the Canadian Highway Bridge Design Code (CHBDC, 2006). The resistance can be calculated with the unfactored soil parameters presented in Table 7.2. The till layer was conservatively assumed to have zero cohesion.

The lateral capacity of piles was evaluated using the program called LPILE Plus v5.0 developed by Ensoft, Inc. (Ensoft, 2004). The input parameters are given in Table 7.2. A moment of inertia of $237 \times 10^6 \text{ mm}^4$ was used for a 310x110 pile section. A modulus of elasticity of 200 GPa was used for the pile material (steel). The pile was modelled with a total length of 17 m and embedment length of 1.5 m into the competent till. The p-y modulus values were based on values suggested by Ensoft, Inc. (Ensoft, 2004).

Table 7.2: Recommended Parameters for Lateral Pile Capacity Evaluation

Soil Layer	Depth Range (m)		Unit weight, γ	Friction angle, ϕ	p-y Modulus, k
	From	To	kN/m ³	Degrees	kN/m ³
Loose Sand ⁽¹⁾ in CSP	333.2	328.2	20	33	5,000
Sand and Gravel	328.2	327.0	21	38	61,000
Sand to silty sand	327.0	324.0	20	33	15,600 10,580 ⁽²⁾
Silt	324.0	316.0	20	31	16,300
Silt with Sand gravel (Till)		<316.0	22	40	34,000

Notes:

⁽¹⁾ Represents the sand filled around the pile in CSP.⁽²⁾ Corresponds to submerged (below groundwater) condition (elevation of 326.0 m).

Two plots from LPILE are presented in Figures 7 and 8 in Appendix D.

Figure 7 presents the p-y plot that gives the non-linear response of the pile-soil interaction. It provides a series of curves obtained from LPILE generated for selected depths below the pile head. These plots can be used in the structural evaluation of the proposed bridge founded on H-piles.

Figure 8 shows the deformed shape of the pile for lateral (shear) force ranging between 50 and 100 kN. This plot indicates that the pile undergoes negligible deflection below a depth of approximately 4.0 m from the ground surface (6.5 m from the pile head).

Group action of piles (pile interaction) for lateral loading should be considered if centerline spacing of piles is less than 8 pile diameters (or least lateral dimension of pile) parallel to the direction of lateral load, or less than 4 pile diameters, perpendicular to the load. The effect of interaction between piles can be considered by applying a reduction factor to the coefficient of lateral subgrade reaction (p-y modulus). The following reduction factors may be used to account for pile group action:

Table 7.3: Recommended Reduction Factors for Pile Groups

Pile spacing / pile diameter	Reduction Factor	Pile spacing / pile diameter	Reduction Factor
Load Parallel to Pile Spacing		Load Perpendicular to Pile Spacing	
7	1.0	4	1.0
4	0.8	3	0.9
3	0.7	2	0.75
2	0.6	-	-

7.2.3 Axial Pile Resistance in Tension

For design against uplift, the axial pile resistance in tension provided in Table 7.4 is recommended. This value is based on a minimum pile length of 13.5 m (elevation of

approximately 327.5 to 314 m). This length corresponds to the portion of the pile below the CSP level.

Table 7.4: Recommended Axial Pile Resistance in Tension

Pile Type	Minimum Pile Length (m)	Factored Geotechnical Resistance (Tension) at ULS (kN)
310 x 110	13.5	300

A resistance factor, Φ , of 0.3 has been applied to ULS resistance. The factored geotechnical resistance in tension at ULS provided above does not include the weight of the pile.

7.3 EARTH PRESSURE DESIGN

Earth pressures will need to be considered in the design of abutments and retained soil systems.

The bridge abutments should be backfilled with granular material in accordance with OPSD 3101.150.

Computation of earth pressures should be in accordance with Section 6.9 of the CHBDC. 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. The unfactored soil parameters provided in Table 7.5 may be used for design of walls with a horizontal backfill. The effects of compaction should be accounted for by applying a compaction surcharge as shown in Figure 6.6 of the CHBDC.

The total active (P_A) and passive (P_P) thrusts can be calculated using the following equations

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

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

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

Table 7.5: Recommended Lateral Earth Pressure Parameters

Parameter	OPSS Gran B Type I	OPSS Gran A and Gran B Type II
Bulk Unit Weight, γ (kN/m ³)	21.2	22.8
Effective Friction Angle	32°	35°
Coefficient of Active Earth Pressure (K_a)	0.31	0.27
Coefficient of Earth Pressure at Rest (K_o)	0.47	0.43
Coefficient of Passive Earth Pressure (K_p)	3.25	3.69

7.4 SEISMIC DESIGN CONSIDERATIONS

7.4.1 Zonal Acceleration Ratio

Table A3.1.1 of the CHBDC indicates that the Zonal Acceleration Ratio (ZAR) for Guelph is 0.05. A seismic hazard calculation for the site was obtained from the Natural Resources Canada (copy attached in Appendix E). It indicates that for this site, the peak ground acceleration (PGA) value corresponding to a 10% probability of exceedance in 50 years is 0.053, which is in close agreement with the ZAR of Guelph.

7.4.2 Soil Profile Type

The site soil is composed of predominantly dense granular material (gravel and sand) and dense sandy silt deposit overlying limestone bedrock. The depth to bedrock is in the order of 15 to 20 m below existing ground surface. It is recommended that Soil Profile I as defined in Section 4.4.6 of the Canadian Highway Bridge Design Code (CHBDC) be used in the seismic design of this site.

7.4.3 Liquefaction of Foundation Soils

Seismic liquefaction refers to a situation where a sudden loss of stiffness and strength of soil occurs due to cyclic loading effects of earthquake. Liquefaction can cause loss of bearing resistance and/or excessive settlement. An assessment for seismically induced liquefaction has been carried out for this site. This assessment indicates that liquefaction of the foundation soils is not a concern at this site due to low peak horizontal acceleration at the site and the compact to very dense soil conditions.

7.4.4 Seismic Forces on Abutments and Retaining Walls

Based on the bridge importance category (Clause 4.4.2 of CHBDC) and the low zonal acceleration ratio for the site, the bridge under consideration will be assigned a Seismic Performance Zone of 1 (Clause 4.4.4 of CHBDC). Therefore, the bridge need not be analyzed for seismic loads. However, the minimum requirements specified in Clauses 4.4.10.2 and 4.4.10.5 of CHBDC shall be met.

7.5 RETAINED SOIL SYSTEM (RSS)

A Retained Soil System (RSS) is being considered for the abutments (false abutment) to contain the soil behind the abutment. The RSS extends immediately from the abutments back into the approach embankments effectively serving as wingwalls (for both west and east abutments).

Retained soil systems are listed in the Ministry of Ontario (MTO) Designated Sources for Materials (DSM) and under Special Provisions 599S22 and 599S23. The RSS should be tendered with the following attributes:

Application: False Abutment

Geometry: Vertical (GV)

Performance: High

Appearance: High

Site Specific Geotechnical Considerations

A 300 mm thick Granular A Leveling Pad should be constructed beneath the RSS.

The overall external stability of RSS founded at an approximate elevation of 330.0 m was evaluated. The evaluation indicated that no sliding or general slope stability failure will be expected for the site soil condition. The evaluated factor of safety against general stability failure is in excess of the required factor of safety of 1.5.

The factored geotechnical resistance at ULS for the RSS built on the site soil is 950 kPa. This geotechnical resistance was evaluated based on assumed RSS dimensions, i.e., having a length equal to the width of the bridge and a width of 0.8H where H is the height of RSS wall (based on MTO's RSS Design Guidelines, MTO (2007)). A wall height of 7.0 m was assumed. The SLS resistance for 25 mm total settlement was estimated to be 175 kPa.

For a 1.2 m wide RSS cantilever wingwall, a factored geotechnical resistance at ULS of 475 kPa may be used. The SLS resistance for 25 mm total settlement was estimated to be 500 kPa.

The minimum soil cover to the underside of the concrete leveling pad should be 800 mm.

Unit weight and effective friction angles provided in Section 7.3 of this report may be used for design of the RSS.

7.6 EMBANKMENT DESIGN

7.6.1 General

The proposed interchange also includes approach and ramp embankments. For the bridge structure, only the approach embankments are anticipated to have a direct potential impact on the performance of the structure. In this section, issues related to embankment design, i.e., geometry and slope stability as well as settlement, will be discussed and related recommendations provided.

7.6.2 Slope Stability Evaluation

A slope stability evaluation was carried out using commercially available limit equilibrium based software called SLOPE/W (GEO-SLOPE, 2007). The analysis included the effect of dynamic loading due to traffic by considering an equivalent static load equivalent to 0.8 m of additional fill, as per Section 6.9.5 of the CHBDC. The analyses also considered seismic loading using one-half of the ZAR.

Slope stability analysis results for two embankment fill materials (Select Subgrade Material and Earth Borrow) under traffic loads are presented in Figures 9 and 10 in Appendix D. A 2H:1V slope is required for embankments constructed of Select Subgrade Material (SSM) while a 2.5H:1V slope is required for embankments constructed of Earth Borrow. Figures 11 and 12 provide the results under simultaneous seismic and traffic loads.

The slope stability evaluation results indicate that the failure planes generally tend to be relatively shallow (veneer type of failure). The beneficial effects of any vegetation on the slope and the apparent cohesion of granular material were disregarded in carrying out the slope stability evaluation. The actual factor of safety against shallow failure planes is anticipated to be greater than that presented herein.

7.6.3 Evaluation of Potential Ground Settlement due to Approach Embankment

Settlement of the underlying soil due to the proposed approach embankment was evaluated. The following assumptions were made in evaluating the settlement of the site soil under the proposed approach embankments:

- Typical soil profile given Table 6.1 was considered representative;
- The load from the bridge abutments will be transferred to deeper and more competent strata by the piles (other than that by the centre pier) and hence does not contribute to the settlement of the site soil;
- Only immediate (elastic) settlement was considered due to the presence of non-cohesive soils;
- A Poisson's ratio of 0.35 was used for all soil types;
- The existing grade is at approximate elevation of 330.0 m;
- Groundwater is at elevation of 326.0 m (approximately 4.0 m below the existing ground surface);
- The maximum embankment height is approximately 8.2 m (in the immediate vicinity of the bridge abutment);
- Embankment extends approximately 250 m east and west from the abutments;
- The top width of the embankment is 30.0 m;
- The distance between the abutments is approximately 67 m; and
- The pier footing is approximately 4.0 m wide by 30.0 m long.

Evaluation of soil settlement due to the effects discussed above was performed using a computer program called Settle3D (Rocscience, 2009). It is a three-dimensional computer program for the analysis of the immediate vertical settlement and consolidation of soil under surface loads such as embankments. Settlement evaluation was carried out for embankments

constructed using Select Subgrade Material (SSM) with 2H:1V slopes and using Earth Borrow with 2.5H:1V slopes.

The analysis result indicates that for the conditions presented herein, the maximum total vertical settlement of the existing materials is approximately 50 and 45 mm, respectively, under SSM and Earth Borrow embankments. The maximum settlement will take place approximately 20 m back from each abutment. This settlement will take place rapidly and is expected to be completed during construction of the embankment. Plots of settlement contours from typical Settle3D analysis are given in Figures 13 and 14 in Appendix D.

The settlement beneath the abutment centerline which will be caused by the 8.2 m high SSM embankment was evaluated to be 38 mm; a profile of settlement versus depth below original grade (elevation 330.0 m) for this location is provided on Figure 15 in Appendix D. Due to the anticipated settlements, the following was considered.

- Assuming that the piles are driven prior to construction of the embankment, the drag loads of each integral abutment pile would be in the order of 500 kN unfactored and 625 kN at ULS. The dead loads associated with the superstructure and substructure are understood to be 1280 kN per pile at ULS. For HP310x110 piles, the combined drag loads and dead loads per pile are not expected to exceed the structural capacity of the piles. Therefore, embankment staging to minimize drag loads is not required.
- Upon completion of the pile installations and construction of the portion of approach embankment below the elevation corresponding to the underside of the abutment walls, it is anticipated that settlements of less than 12 mm would be induced by the construction of the remaining embankment height. Therefore there will be no special staging requirements.

It is noted that there will also be a minor amount of self-weight settlement of the embankment fill. This self-weight settlement was estimated using charts provided by Poulos and Davis (1974) for embankments having similar geometries to the SSM and Earth Borrow embankments presented herein. The estimated self-weight settlement was approximately 20 mm and 30 mm, respectively, for the SSM and Earth Borrow embankment fills. This settlement is also expected to be completed by the end of construction.

No settlement monitoring will be required for this project.

7.7 FROST PROTECTION

The design frost penetration depth for foundations at the site is 1.4 m based on OPSD 3090.101. Spread footings should be provided with 1.4 m of earth cover or equivalent insulation for frost protection.

The minimum soil cover to the underside of the levelling pad for RSS is the greater of 800 mm and 40% of the actual frost penetration depth. In this case, 800 mm is the greater of the two values and therefore, the minimum frost penetration depth for RSS.

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.

8.0 Construction Considerations

8.1 EXCAVATION, BACKFILLING AND MATERIAL REUSE

Excavation and backfill for the bridge structure of the new interchange should be carried out in accordance with OPSS 902 Construction Specification for Excavation and Backfilling – Structures.

Any vegetation, fill, organic soils and other deleterious materials must be removed from beneath the foundation of the bridge structure and the embankments for the proposed interchange. Where deleterious materials are encountered, the material should be excavated, wasted and replaced. The lateral extent of such excavation should include all deleterious material within the influence zone of the foundations and embankments.

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

Side slopes for open cut excavations should conform to Occupational Health and Safety Act regulations for Construction Projects (OHSA). The surficial gravel and sand with silt is compact to very dense and should be considered as a Type 3 soil.

Deep excavations are not anticipated for this project, however should a Roadway Protection System be selected by the Contractor it should be designed and constructed in accordance with OPSS 539 to Performance Level 2. Conceptually an H-pile with timber lagging system would be appropriate for this site.

Groundwater was encountered more than 4 m below existing grades. Groundwater control is not anticipated to be required during construction of the foundation. It is noted that the contractor will be responsible to protect the site from the effects of runoff and precipitation.

It is noted that the native surficial soil observed at this site is a gravel and sand with silt deposit which ranged in thickness from 2 m to greater than 6 m in depth. All of the 23 gradation tests carried out on this material reported herein met the gradation limits for OPSS Select Subgrade Material. If a similar material is used to construct the embankments, the SSM embankment configuration could be used for design.

8.2 PILE INSTALLATION

It is essential that the compatibility of the pile driving equipment, the soil conditions, and the pile type being driven is properly accounted for in order to achieve the required pile penetration and a satisfactory pile foundation.

Piles shall have reinforced tips according to Ontario Provincial Standard Detail, OPSD 3000.100 Type I.

Holes need to be pre-augered to 5 m below the base of the pile cap before the installation of CSP. After placement of CSP in the hole, the annular space around the CSP should be backfilled before the commencement of pile driving.

The pile driving equipment shall be appropriate to the driving conditions and capable of delivering a minimum specified energy of 50 kJ.

The Hiley Formula as outlined in MTO's Structural Manual (MTO, 2002) shall be used as a tool for pile driving control. It is recommended that pile driving note 2 be used in the contract drawings.

“Piles to be driven in accordance with standard SS103-11 using an ultimate Geotechnical Resistance of ____kN per pile but must be driven below El. 314 m Geodetic.”

The Ultimate Geotechnical Resistance inserted in the note should be twice the maximum factored design load at ULS (i.e., $2 \times 1800 \text{ kN} = 3600 \text{ kN}$).

8.3 CEMENT TYPE AND CORROSION PROTECTION

Three samples of the soil in the vicinity of the anticipated foundation for the bridge structure were submitted to Paracel Laboratories in Ottawa, Ontario for analysis of 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 for the bridge structure and any buried infrastructure. The analysis results are summarized in Table 4.1.

The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected on concrete in contact with soil and groundwater at the site. The maximum concentration of soluble sulphate was 16 µg/g. Soluble sulphate concentrations less than 1000 µg/g generally indicate that a low degree of sulphate attack is expected on 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 maximum reported soil pH was 8.4 which is 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 Table 4.1 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
OPSD 3101.150	Walls – Abutment, Backfill – Minimum Granular Requirement
OPSS 902	Construction Specification for Excavation and Backfilling - Structures
OPSS 206	Construction Specification for Grading
SP 206S03	Earth Excavation, Grading
OPSS 539	Construction Specification for Temporary Protection System
SP599S22	Retained Soil System, False Abutment
SP599S23	Retained Soil System, False Abutment

10.0 References

Chapman, L.J., and Putnam, D.F. 1984. The physiography of Southern Ontario, Ontario Geological Survey Special Volume 2. Ontario Research Foundation, Toronto, Ontario.

CHBDC, 2006. Canadian Highway Bridge Design Code. Canadian Standards Association, Mississauga, Ontario.

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GEO-SLOPE International Ltd. 2007. Stability Modeling with SLOPE/W 2007©. Calgary, AB.

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Ontario Ministry of Transportation (MTO). 1996. Integral Abutment Bridges. Structural Office, Report SO-96-01.

Ontario Ministry of Transportation (MTO). 2002. Structural Manual. Bridge Office, St. Catharines, Ontario.

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Poulos, H.G., and Davis, E.H. 1974. Elastic Solutions for Soil and Rock Mechanics. John Wiley & Sons, Inc., New York.

Rocscience, 2009. Settle3D Settlement and Consolidation Analysis: Theory Manual, Rocscience, Inc.

11.0 Closure

The recommendations made in this report are in accordance with our present understanding of the project. We request that we be permitted to review our recommendations when the drawings and specifications are complete.

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 has been prepared by Simon Gudina and Fred Griffiths. Technical review was carried out by Raymond Haché.

Respectfully submitted,

STANTEC CONSULTING LTD.


Simon Gudina, Ph.D.


Fred J. Griffiths, Ph.D., P.Eng.
Principal


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

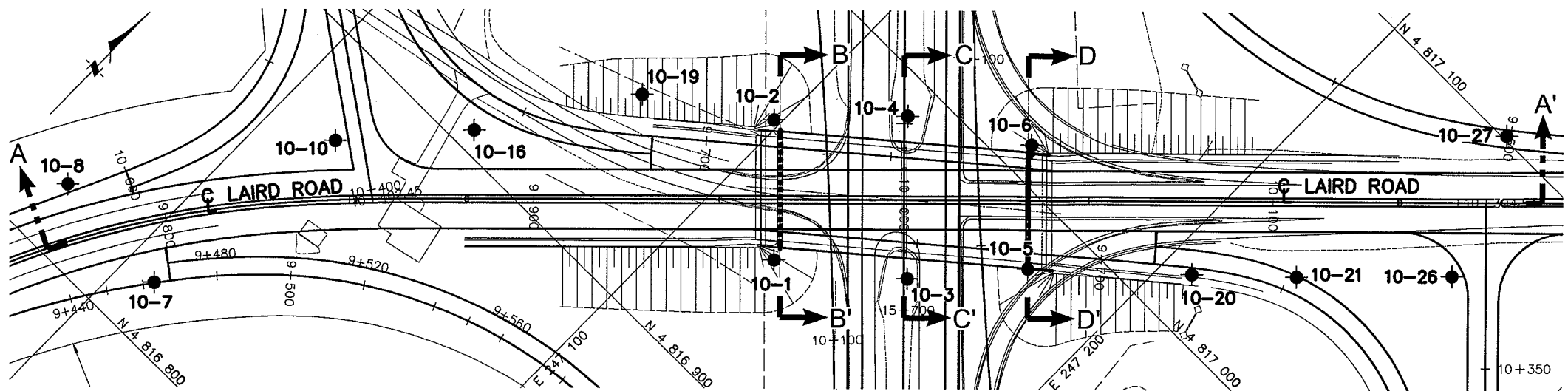


APPENDIX A

Drawings No. 1 and 2 – Borehole Location Plan and Soil Strata Plots

Site Photographs

165000749-1_Structure.dwg
GGB
11/07/08
T:\Autocad\Drawings\Project Drawings\165000749-1_Structure.dwg (PLAN (STRUCTURE))
Printed: Jul 08, 2011



PLAN

SCALE
15 m 0 15 30 m

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

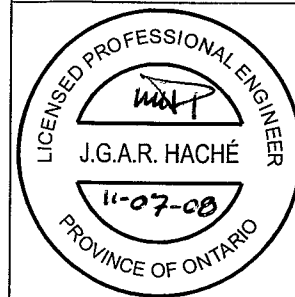
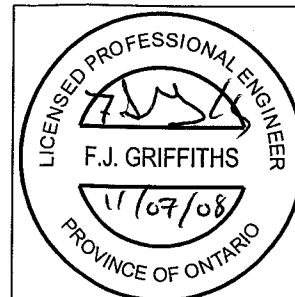
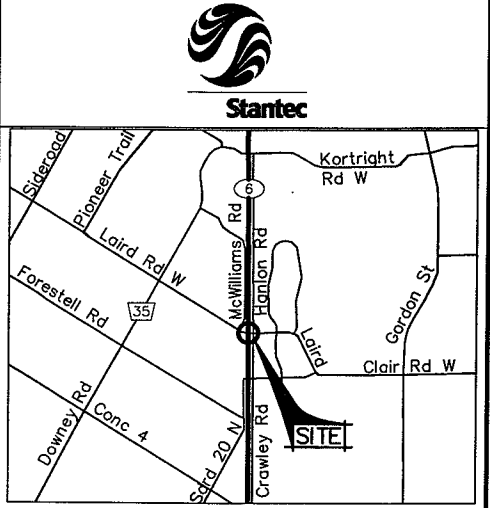


PLATE No
CONT 2011-3027
WP 3002-05-00

HWY 6/LAIRD RD INTERCHANGE
STA 9+777 TO STA 10+173
BOREHOLE LOCATIONS



SHEET 140



KEY PLAN

1 km 0 1 2 km

LEGEND

- Bore Hole
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- ↓ WL at time of investigation July 2010

No	ELEVATION	MTM ZONE 10 COORDINATES	
		NORTH	EAST
10-1	330.3	4 816 937.8	247 124.5
10-2	330.2	4 816 964.5	247 098.1
10-3	331.6	4 816 959.5	247 153.6
10-4	331.2	4 816 990.6	247 123.1
10-5	331.4	4 816 984.3	247 175.0
10-6	330.9	4 817 008.7	247 152.4
10-7	329.3	4 816 815.7	247 009.5
10-8	329.3	4 816 818.1	246 974.4
10-10	329.1	4 816 877.2	247 017.6
10-16	329.9	4 816 905.7	247 042.5
10-19	329.9	4 816 944.4	247 068.1
10-20	329.5	4 817 014.7	247 207.6
10-21	331.2	4 817 034.2	247 228.3
10-26	331.9	4 817 063.8	247 258.0
10-27	330.7	4 817 101.0	247 241.9

NOTES

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

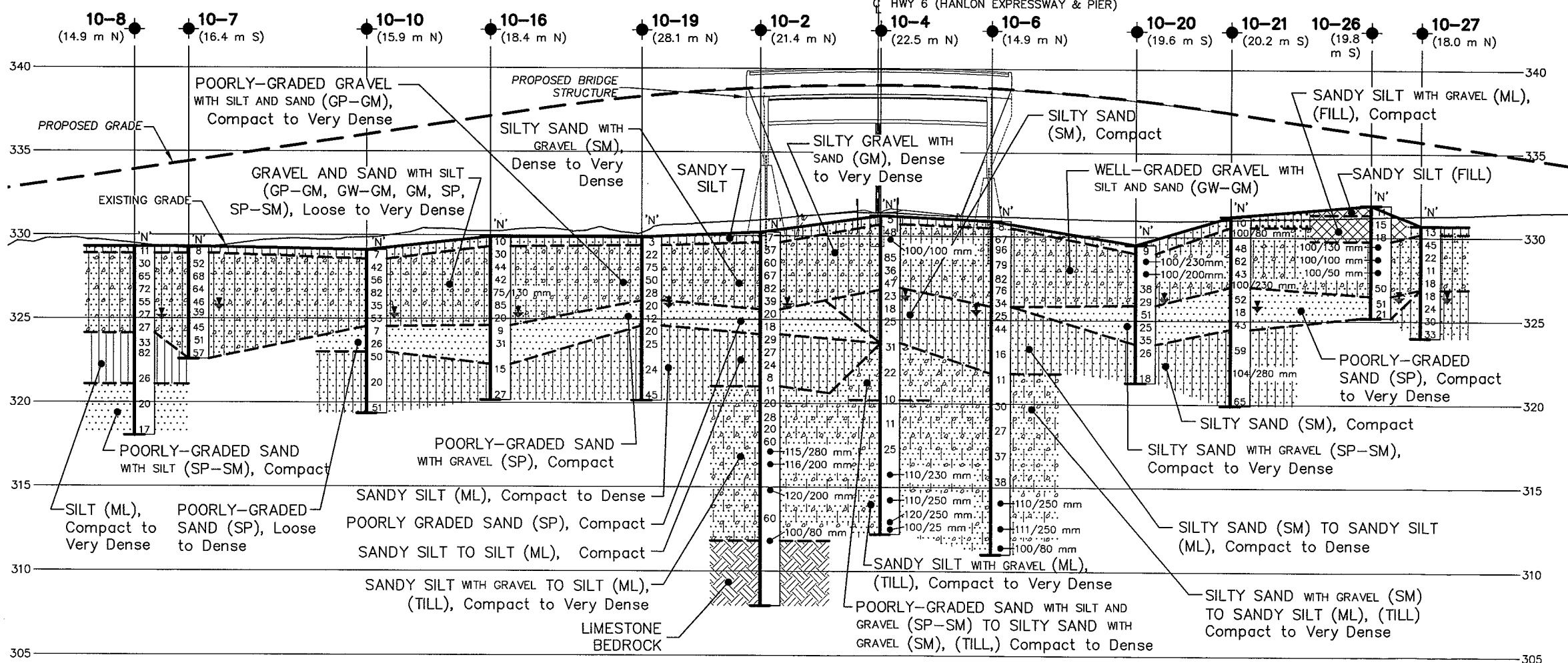
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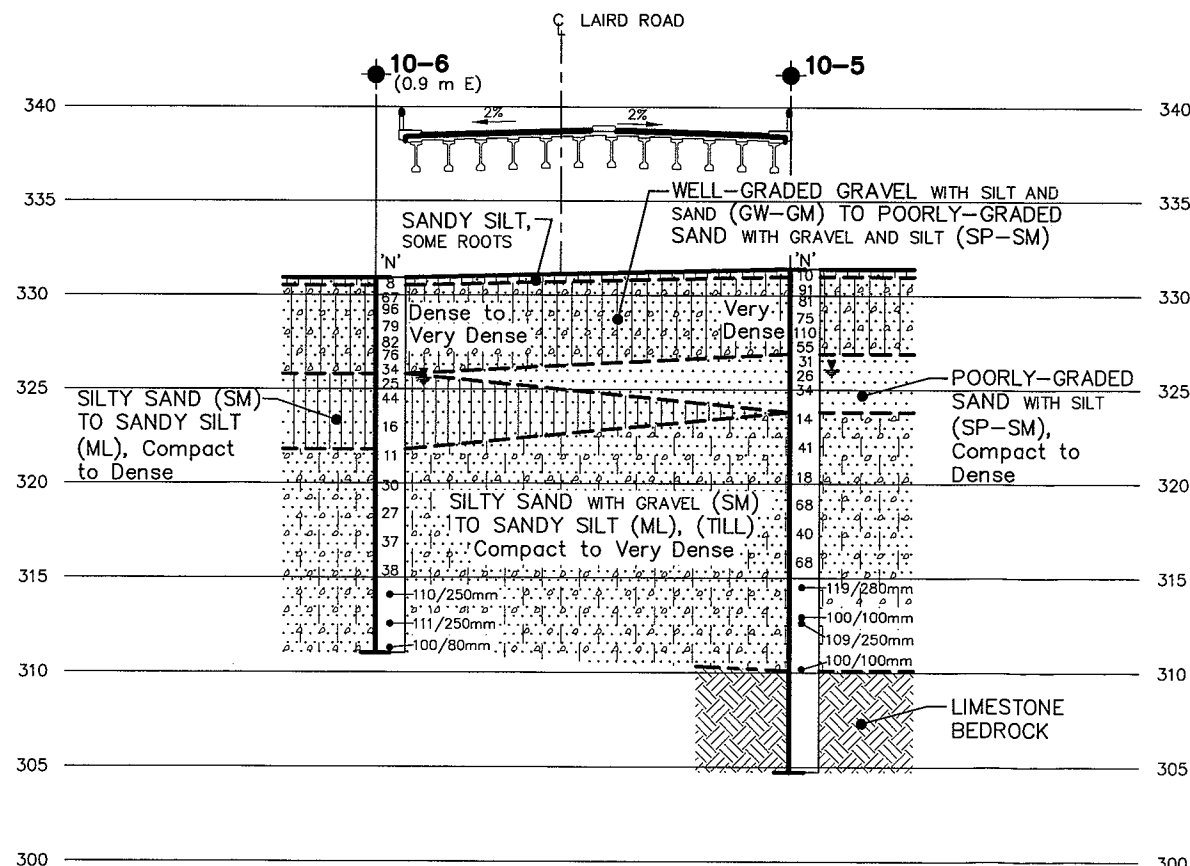
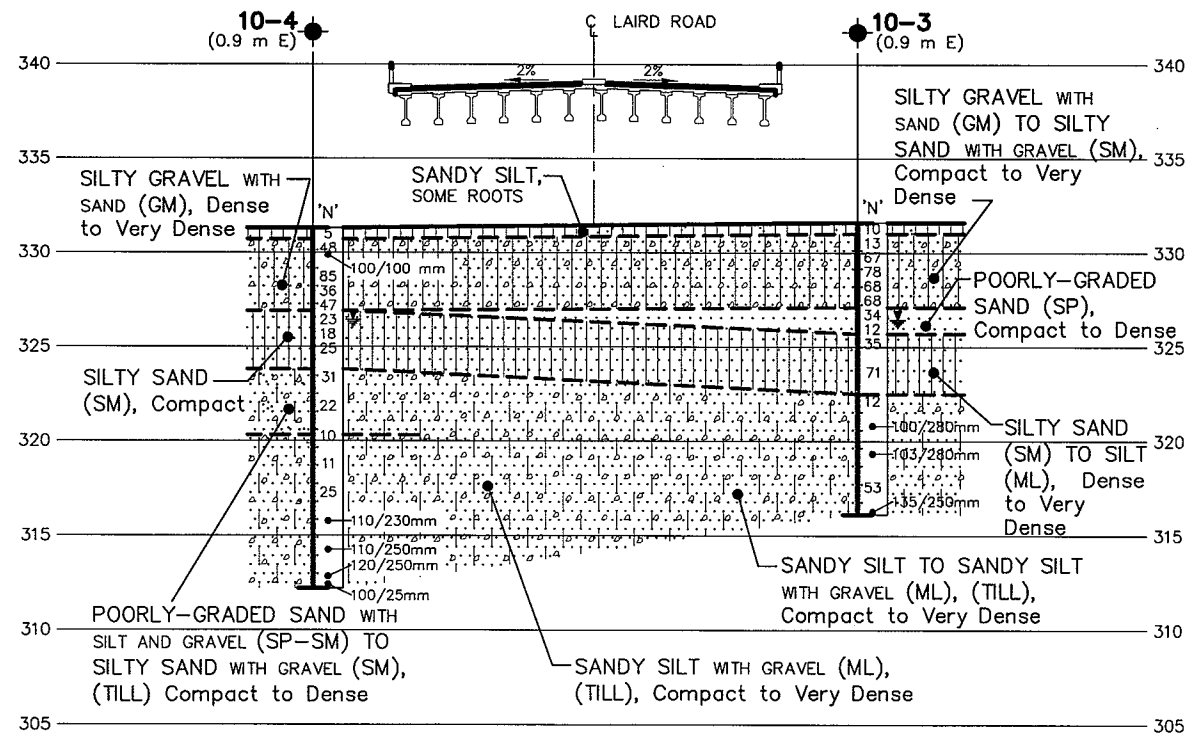
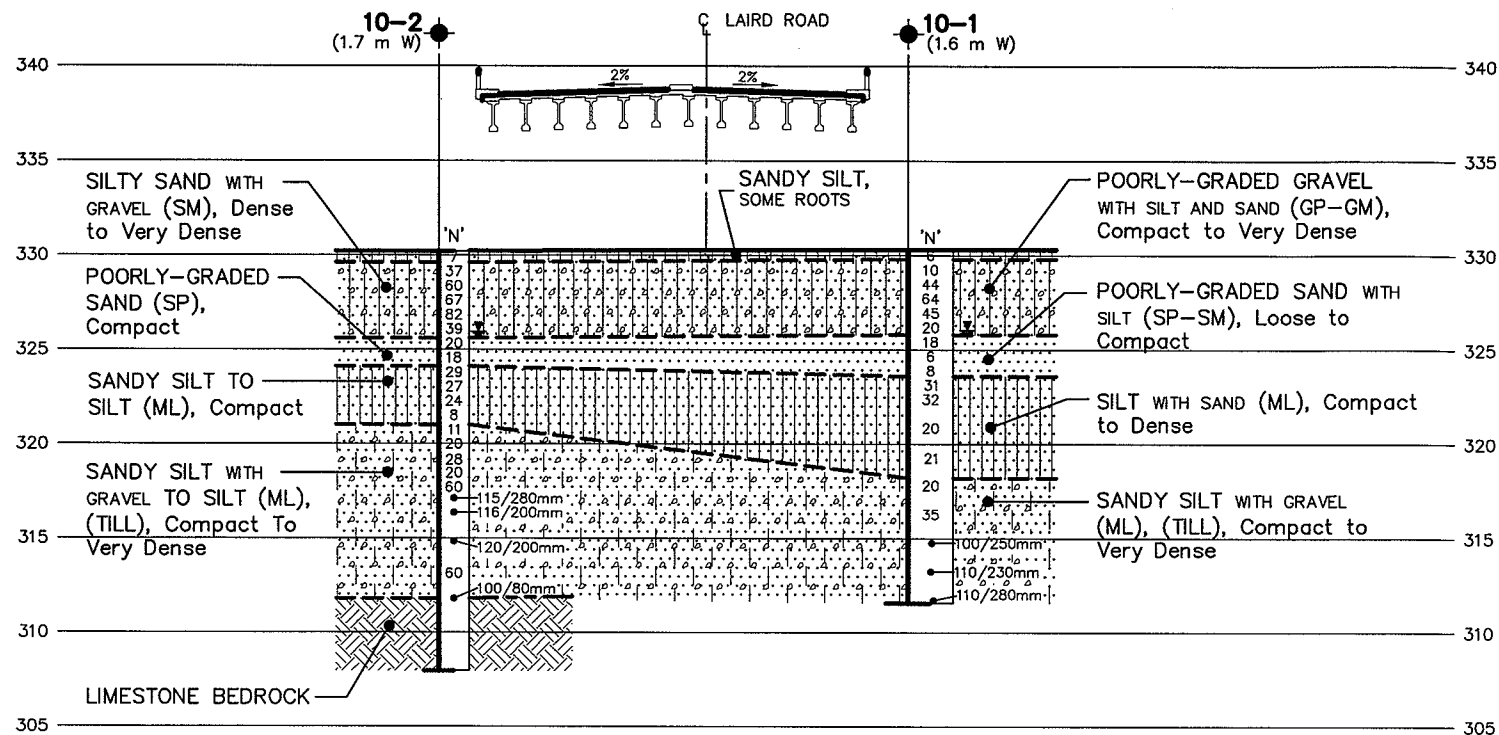
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SUB'D SC	CHECKED	DATE 2010-09-30	SITE 35-595
DRAWN GGB	CHECKED	APPROVED	DWG 1

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.

PROFILE A-A' ALONG CL OF LAIRD ROAD

SCALE
15 m 0 15 30 m HORIZONTAL
3 m 0 3 6 m VERTICAL





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

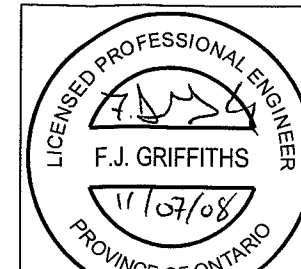
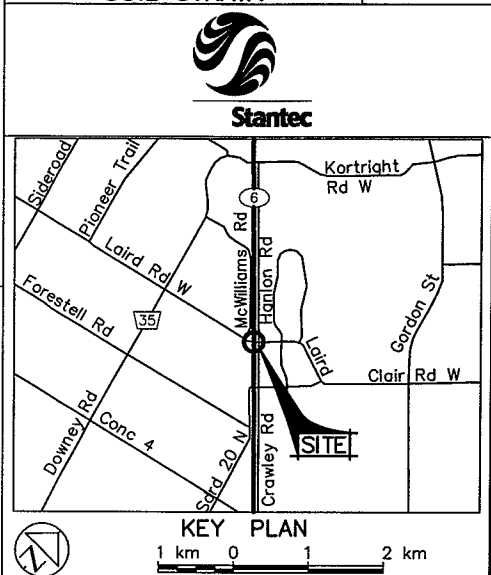


PLATE No
CONT 2011-3027
WP 3002-05-00

HWY 6/LAIRD RD INTERCHANGE
 STA 9+777 TO STA 10+173

SOIL STRATA

SHEET 141



LEGEND

- Bore Hole
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- ↓ WL at time of investigation July 2010
- (0.9 m E) Offset From Cross Section Line

No	ELEVATION	MTM ZONE 10 COORDINATES NORTH	EAST
10-1	330.3	4 816 937.8	247 124.5
10-2	330.2	4 816 964.5	247 098.1
10-3	331.6	4 816 959.5	247 153.6
10-4	331.2	4 816 990.6	247 123.1
10-5	331.4	4 816 984.3	247 175.0
10-6	330.9	4 817 008.7	247 152.4

NOTES

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

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

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

GEORES No 40PB-192

HWY No 6	CHECKED	DATE 2010-09-01	DIST
SUBM'D SG	CHECKED	APPROVED	SITE 35-595
DRAWN GBB	CHECKED		DWG 2



Photograph 1. Looking north at the Highway 6-Laird Road intersection along Highway 6 (Google Earth Pro® Image).



Photograph 2. Looking west at the Highway 6-Laird Road intersection along Laird Road (Google Earth Pro® Image).



Photograph 3. Looking south at the Highway 6-Laird Road intersection along Highway 6 (Google Earth Pro® Image).



Photograph 4. Looking east at the Highway 6-Laird Road intersection along Laird Road (Google Earth Pro® Image).

APPENDIX B

Symbols and Terms Used on Borehole Records

Borehole Records

Rock Core Records

Rock Core Photographs

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 10-01

1 OF 2

METRIC

W.P. 3002-05-00 LOCATION 9+964 16.5m Rt CL Laird Road N: 4 816 938 E: 247 125 ORIGINATED BY M.A.
 DIST HWY 6 BOREHOLE TYPE Splittings, Hollow Stem Augers COMPILED BY KF
 DATUM Geodetic DATE 2010 07 26 - 2010 07 27 CHECKED BY SG

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										
330.3								20	40	60	80	100							
0.0	Sandy silt, dark brown, some roots		1	SS	6														
329.8																			
0.5	Poorly-graded gravel with silt and sand (GP-GM), compact to very dense, moist, brown to light brown		2	SS	10														
	- occasional cobbles																		
			3	SS	44														
			4	SS	64														
			5	SS	45														
			6	SS	20														
325.8			7	SS	18														
4.6	Poorly-graded sand with silt (SP-SM), loose to compact, wet, brown		8	SS	6														
			9	SS	8														
323.6			10	SS	31														
6.7	Silt with sand (ML), compact to dense, wet, brown		11	SS	32														
			12	SS	20														
			13	SS	21														

Continued Next Page

3, 3

Numbers refer to Sensitivity

3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH 10-01

2 OF 2

METRIC

W.P. 3002-05-00 LOCATION 9+964 16.5m Rt CL Laird Road N: 4 816 938 E: 247 125 ORIGINATED BY MA
 DIST HWY 6 BOREHOLE TYPE Splittings, Hollow Stem Augers COMPILED BY KF
 DATUM Geodetic DATE 2010 07 26 - 2010 07 27 CHECKED BY SG

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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
								○ UNCONFINED	✕ FIELD VANE	● QUICK TRIAXIAL						✕ LAB VANE
318.2							20	40	60	80	100	10	20	30		
12.2	Sandy silt with gravel (ML), compact to very dense, moist, grey, TILL		14	SS	20		318									16 32 (52)
							317									
							316									
			15	SS	35		315									
							314									
			16	SS	100/ 250mm		313									
							312									
			17	SS	110/ 230mm											
311.6			18	SS	110/ 280mm											
18.7	End of Borehole															
	25 mm standpipe installed															
	Groundwater level measured in standpipe on August 16, 2010 at elevation 326.1 m															

ONTARIO MTO STANTEC 165000749 - HWY 6 & LAIRD RD.GPJ ONTARIO MOT.GDT 5/5/11

RECORD OF BOREHOLE No BH 10-02

1 OF 2

METRIC

W.P. 3002-05-00 LOCATION 9+964 21.0m Lt CL Laird Road N: 4 816 965 E: 247 098 ORIGINATED BY MA
 DIST HWY 6 BOREHOLE TYPE Splitspoons, Hollow Stem Augers, NQ Coring Equipment COMPILED BY KF
 DATUM Geodetic DATE 2010 07 19 - 2010 07 20 CHECKED BY SG

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 ● QUICK TRIAXIAL	✕ FIELD VANE ✕ LAB VANE						
330.2							20 40 60 80 100								
0.0	Sandy silt, dark brown, some roots		1	SS	7		330								
329.6															
0.6	Silty sand with gravel (SM), dense to very dense, moist, brown to light brown		2	SS	37		329								
	- frequent cobbles						329								
	- occasional boulders		3	SS	60		328			●				32 48 (20)	
			4	SS	67		328			●				42 43 (15)	
			5	SS	82		327								
			6	SS	39		326								
325.6															
4.6	Poorly-graded sand (SP), compact		7	SS	20		325				●			3 94 (3)	
			8	SS	18		325								
324.1															
6.1	Sandy silt to silt (ML), compact, wet, grey		9	SS	29		324				●			0 37 (63)	
	- becomes loose		10	SS	27		323								
			11	SS	24		322								
			12	SS	8		322				●			0 4 (96)	
321.0															
9.1	Sandy silt with gravel to silt (ML), compact to very dense, moist, grey, TILL		13	SS	11		321								
			14	SS	20		320								
			15	SS	28		319								
			16	SS	20										

Continued Next Page

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

RECORD OF BOREHOLE No BH 10-03

1 OF 2

METRIC

W.P. 3002-05-00 LOCATION 10+000 22.0m Rt CL Laird Road N: 4 816 960 E: 247 154 ORIGINATED BY M.A
 DIST HWY 6 BOREHOLE TYPE Splitterspoons, Hollow Stem Augers COMPILED BY KF
 DATUM Geodetic DATE 2010 07 29 - 2010 07 29 CHECKED BY SG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED × FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
								20 40 60 80 100									
						20 40 60 80 100					10 20 30						
331.6																	
0.0	Sandy silt, dark brown, some roots		1	SS	10												
331.0							331										
0.6	Silty gravel with sand (GM) to silty sand with gravel (SM), compact to very dense, moist, brown to light brown		2	SS	13												
	- frequent cobbles						330										
			3	SS	67												
			4	SS	78		329										
			5	SS	68		328										
			6	SS	68												
327.1																	
4.6	Poorly-graded sand (SP), compact to dense, moist, brown/grey		7	SS	34		327										
			8	SS	12		326										
325.7																	
5.9	Silty sand (SM) to silt (ML), dense to very dense, moist, brown/grey		9	SS	35		325										
							324										
			10	SS	71												
							323										
322.5																	
9.1	Sandy silt to sandy silt with gravel (ML), compact to very dense, moist, brown/grey, TILL		11	SS	12		322										
							321										
			12	SS	100/ 280mm												
							320										

ONTARIO MTO STANTEC 165000749 - HWY 6 & LAIRD RD.GPJ ONTARIO MOT.GDT 5/5/11

Continued Next Page

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

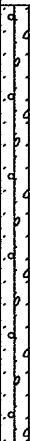
RECORD OF BOREHOLE No BH 10-03

2 OF 2

METRIC

W.P. 3002-05-00 LOCATION 10+000 22.0m Rt CL Laird Road N: 4 816 960 E: 247 154 ORIGINATED BY MA
 DIST HWY 6 BOREHOLE TYPE Splittingspoons, Hollow Stem Augers COMPILED BY KF
 DATUM Geodetic DATE 2010 07 29 - 2010 07 29 CHECKED BY SG

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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20	40	60	80	100					

316.1 15.5	Sandy silt to sandy silt with gravel (ML), compact to very dense, moist, brown/grey, TILL (continued)		13	SS	103/ 280mm		319										
			14	SS	53												
			15	SS	135/ 250mm												
	End of Borehole																
	Groundwater level inferred during drilling																

RECORD OF BOREHOLE No BH 10-04

1 OF 2

METRIC

W.P. 3002-05-00 LOCATION 10+000 22.5m Lt CL Laird Road N: 4 816 991 E: 247 123 ORIGINATED BY M.A.
 DIST HWY 6 BOREHOLE TYPE Splittingspoons, Hollow Stem Augers COMPILED BY KF
 DATUM Geodetic DATE 2010 08 03 - 2010 08 03 CHECKED BY SG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				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				
331.2							20	40	60	80	100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	
0.0	Sandy silt, dark brown, some roots		1	SS	5										
330.6															
0.6	Silty gravel with sand (GM), dense to very dense, moist, brown to light brown		2	SS	48										52 34 (14)
			3	SS	100/ 100mm										
			4	SS	85										
			5	SS	36										46 41 (13)
			6	SS	47										
326.8															
4.4	Silty sand (SM), compact, wet, brown		7	SS	23										
			8	SS	18										1 82 (17)
			9	SS	25										
323.6															
7.6	Poorly-graded sand with silt and gravel (SP-SM) to silty sand with gravel (SM), compact to dense, wet, brown, TILL		10	SS	31										41 53 (6)
			11	SS	22										
320.2															
11.0	Sandy silt with gravel (ML), compact to very dense, moist, grey, TILL		12	SS	10										20 64 (16)

Continued Next Page

×³, ×³: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH 10-05

1 OF 3

METRIC

W.P. 3002-05-00 LOCATION 10+034 19.0m Rt CL Laird Road N: 4 816 984 E: 247 175 ORIGINATED BY M.A
 DIST HWY 6 BOREHOLE TYPE Splitterspoons, Hollow Stem Augers, NQ Coring Equipment COMPILED BY KF
 DATUM Geodetic DATE 2010 07 27 - 2010 07 28 CHECKED BY SG

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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)		
								20	40	60	80						100	10	20
331.4																			
0.0	Sandy silt, dark brown, some roots		1	SS	10														
331.0																			
0.5	Well-graded gravel with sand and silt (GW-GM) to poorly-graded sand with gravel and silt (SP-SM), very dense, brown to light brown		2	SS	91														
	- frequent cobbles		3	SS	81														
	- occasional boulders		4	SS	75														
			5	SS	110														
			6	SS	55														
326.9																			
4.6	Poorly-graded sand with silt (SP-SM), compact to dense, brown		7	SS	31														
	- becomes wet		8	SS	26														
			9	SS	34														
323.8																			
7.6	Silty sand with gravel (SM) to sandy silt (ML), compact to very dense, moist, brown/grey, TILL		10	SS	14														
			11	SS	41														
			12	SS	18														

Continued Next Page

× 3, × 3

Numbers refer to Sensitivity

○ 3%

STRAIN AT FAILURE

METRIC

W.P.	3002-05-00	LOCATION	10+034 19.0m Rt CL Laird Road	N: 4 816 984 E: 247 175	ORIGINATED BY	MA
DIST	HWY 6	BOREHOLE TYPE	Spiltspoons, Hollow Stem Augers, NQ Coring Equipment		COMPILED BY	KF
DATUM	Geodetic	DATE	2010 07 27 - 2010 07 28		CHECKED BY	SG

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 x LAB VANE					
	Silty sand with gravel (SM) to sandy silt (ML), compact to very dense, moist, brown/grey, TILL (<i>continued</i>)		13	SS	68		319						
			14	SS	40		318						
			15	SS	68		317						
			16	SS	119/ 280mm		316						
			17	SS	109/ 250mm		315						
			18	SS	100/ 100mm		314						
			19	SS	100/ 100mm		313						
310.1 21.3	Grey LIMESTONE bedrock - fair to good quality - slightly weathered - flat to dipping - close joint spacing - rough planar		20	NQ	REC 93/ RQD 71		310						
			21	NQ	REC 96/		309						
							308						

Continued Next Page

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

RECORD OF BOREHOLE No BH 10-06

1 OF 2

METRIC

W.P. 3002-05-00 LOCATION 10+034 15.0 Lt CL Laird Road N: 4 817 009 E: 247 152 ORIGINATED BY M.A
 DIST HWY 6 BOREHOLE TYPE Splittings, Hollow Stem Augers COMPILED BY KF
 DATUM Geodetic DATE 2010 07 21 - 2010 07 22 CHECKED BY SG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20 40 60 80 100									
								○ UNCONFINED	✕ FIELD VANE	● QUICK TRIAXIAL	✕ LAB VANE						
330.9																	
0.0	Sandy silt, dark brown, some roots		1	SS	8												
330.5																	
0.4	Well-graded gravel with sand and silt (GW-GM) to poorly-graded sand with gravel and silt (SP-SM), dense to very dense, brown to light brown		2	SS	67												
			3	SS	96												
			4	SS	79												
			5	SS	82												
			6	SS	76												
			7	SS	34												
325.8																	
5.2	Silty sand (SM) to sandy silt (ML), compact to dense, wet, grey		8	SS	25												
			9	SS	44												
			10	SS	16												
321.8																	
9.1	Silty sand with gravel (SM) to sandy silt (ML), compact to very dense, moist, grey, TILL		11	SS	11												
			12	SS	30												

Continued Next Page

Numbers refer to Sensitivity $\times 3, \times 3$ \circ 3% STRAIN AT FAILURE

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

RECORD OF BOREHOLE No BH 10-07

1 OF 1

METRIC

W.P. 3002-05-00 LOCATION 9+476 6.3m Lt CL Ramp W-S N: 4 816 816 E: 247 010 ORIGINATED BY M.A.
 DIST HWY 6 BOREHOLE TYPE Splitspoons, Hollow Stem Augers COMPILED BY KF
 DATUM Geodetic DATE 2010 07 22 - 2010 07 22 CHECKED BY SG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					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	WATER CONTENT (%) w _p w w _L					
329.3							20	40	60	80	100				
0.0	Sandy silt, moist, dark brown, some roots		1	SS	8										
328.9															
0.4	Silty sand with gravel (SM) to well-graded gravel with silt and sand (GW-GM), dense to very dense, moist to wet, brown - hard augering - cobbles and boulders encountered		2	SS	52										
			3	SS	68										
			4	SS	64										42 42 (16)
			5	SS	46										
			6	SS	39										56 35 (9)
			7	SS	45										
			8	SS	51										39 55 (6)
			9	SS	57										
322.6															
6.7	End of Borehole 25 mm standpipe installed Groundwater level measured in standpipe on August 18, 2010 at elevation 326.4 m														

RECORD OF BOREHOLE No BH 10-08

1 OF 1

METRIC

W.P. 3002-05-00 LOCATION 9+777 14.0m Lt CL Laird Road N: 4 816 818 E: 246 974 ORIGINATED BY M.A.
 DIST HWY 6 BOREHOLE TYPE Splittings, Hollow Stem Augers COMPILED BY KF
 DATUM Geodetic DATE 2010 07 26 - 2010 07 26 CHECKED BY SG

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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								20 40 60 80 100	20 40 60 80 100	10 20 30								
329.3																		
0.0	Sandy silt, moist, dark brown, some roots		1	SS	11													
328.9																		
0.4	Well-graded gravel with silt and sand (GW-GM) to poorly graded sand with silt and gravel (SP-SM), compact to very dense, moist, brown		2	SS	30										54 34 (12)			
			3	SS	65													
			4	SS	72													
			5	SS	55													
			6	SS	27													
			7	SS	27													
324.1																		
5.2	Silt (ML), compact to very dense, wet, brown																	
			8	SS	33													
			9	SS	82													
			10	SS	26										0 15 (85) Non-plastic			
321.1																		
8.2	Poorly graded sand with silt (SP-SM), compact, wet, brown																	
			11	SS	20													
			12	SS	17										0 90 (10)			
318.0																		
11.3	End of Borehole																	
	Groundwater level inferred during drilling																	

RECORD OF BOREHOLE No BH 10-10

1 OF 1

METRIC

W.P. 3002-05-00 LOCATION 10+387 8.4m Rt CL Ramp N-E/W N: 4 816 877 E: 247 018 ORIGINATED BY MA
 DIST HWY 6 BOREHOLE TYPE Splittspoons, Hollow Stem Augers COMPILED BY KF
 DATUM Geodetic DATE 2010 08 04 - 2010 08 04 CHECKED BY SG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
								20	40	60						80
329.1	Sandy silt, moist, dark brown, some roots		1	SS	7	▽	329									
328.6																
0.6	Silty gravel with sand (GM) to well-graded gravel with silt and sand (GW-GM), dense to very dense, wet, brown - frequent cobbles	2	SS	42	328											
		3	SS	56	327										47 40 (13)	
		4	SS	82	326											
		5	SS	35	325										50 41 (9)	
		6	SS	53	324											
324.6	Poorly graded sand (SP), loose to compact, wet, brown		7	SS	7		323								8 88 (4)	
8			SS	26	322											
323.0	Silt (ML), compact to dense, wet, brown		9	SS	50		321									
10			SS	20	320											
11			SS	51												
319.4	End of Borehole															
9.8	Groundwater level inferred during drilling															

RECORD OF BOREHOLE No BH 10-16

1 OF 1

METRIC

W.P. 3002-05-00 LOCATION 9+760 13.7m Lt CL Ramp E-S N: 4 816 906 E: 247 043 ORIGINATED BY MA
 DIST HWY 6 BOREHOLE TYPE Splittspoons, Hollow Stem Augers COMPILED BY KF
 DATUM Geodetic DATE 2010 08 05 - 2010 08 05 CHECKED BY SG

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									
					○ UNCONFINED	✕ FIELD VANE											
					● QUICK TRIAXIAL	✕ LAB VANE											
					WATER CONTENT (%)												
					20 40 60 80 100					10 20 30							
329.9																	
0.0	Sandy silt, moist, dark brown, some roots		1	SS	10	▽											
329.3																	
0.6	Silty gravel with sand (GM) to poorly graded sand (SP), loose to very dense, moist to wet, brown		2	SS	30			329									52 36 (12)
	- some cobbles																
	- becoming less gravelly with depth		3	SS	44			328									
			4	SS	42			327									
			5	SS	75/ 130mm			326									
			6	SS	85												
			7	SS	20		325										
324.6																	
5.3	Poorly graded sand (SP), loose to dense, wet, brown		8	SS	9		324									11 85 (4)	
			9	SS	31		323										
322.3																	
7.6	Sandy silt (ML), compact, wet, brown		10	SS	15		322									0 49 (51) Non-plastic	
							321										
			11	SS	27												
320.1																	
9.8	End of Borehole																
	Groundwater level inferred during drilling																

RECORD OF BOREHOLE No BH 10-19

1 OF 1

METRIC

W.P. 3002-05-00 LOCATION 9+929 28.0m Lt CL Laird Road N: 4 816 944 E: 247 068 ORIGINATED BY MA
 DIST HWY 6 BOREHOLE TYPE Splittspoons, Hollow Stem Augers COMPILED BY KF
 DATUM Geodetic DATE 2010 07 30 - 2010 07 30 CHECKED BY SG













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													
							UNCONFINED FIELD VANE QUICK TRIAXIAL LAB VANE					WATER CONTENT (%)									
329.9	0.0	Sandy silt, moist, dark brown, some roots	1	SS	3	▽	329														
329.4	0.5	Poorly-graded gravel with silt and sand (GP-GM), compact to very dense, moist, brown to light brown	2	SS	22		328														
		- occasional cobbles	3	SS	75		327														
			4	SS	50		326														
			5	SS	28		325														
326.1	3.8	Poorly-graded sand with gravel (SP), compact, wet, brown	6	SS	20		324														
			7	SS	12		323														
			8	SS	20		322														
			9	SS	25		321														
			10	SS	24																
			11	SS	45																
320.1	9.8	End of Borehole																			
		Groundwater level inferred during drilling																			

RECORD OF BOREHOLE No BH 10-20

1 OF 1

METRIC

W.P. 3002-05-00 LOCATION 10+078 20.0m Rt Laird Road N: 4 817 015 E: 247 208 ORIGINATED BY MA
 DIST HWY 6 BOREHOLE TYPE Splittings, Hollow Stem Augers COMPILED BY KF
 DATUM Geodetic DATE 2010 08 13 - 2010 08 13 CHECKED BY SG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20	40	60	80	100					
329.5	0.0	Sandy silt, moist, dark brown, some roots		1	SS	9											
329.0	0.5	Well-graded gravel with sand and silt (GW-GM) to poorly graded sand with silt and gravel (SP-SM), dense to very dense, moist, brown to light brown - frequent cobbles		2	SS	100/ 230mm											
				3	SS	100/ 200mm											
				4	SS	38											
				5	SS	29											
325.9	3.7	Silty sand with gravel (SP-SM), compact to very dense, wet, brown		6	SS	51										34 57 (9)	
				7	SS	25											
				8	SS	35										20 43 (37)	
323.6	5.9	Silty sand (SM), compact, wet, brown		9	SS	26											
																	
				10	SS	18										0 53 (47)	
321.3	8.2	End of Borehole															
		Groundwater level inferred during drilling															

ONTARIO MTO STANTEC 165000749 - HWY 6 & LAIRD RD GPJ ONTARIO MOT.GDT 5/5/11

RECORD OF BOREHOLE No BH 10-21

1 OF 1

METRIC

W.P. 3002-05-00 LOCATION 9+750 1.4m Lt CL Ramp W-N N: 4 817 034 E: 247 228 ORIGINATED BY M.A.
 DIST HWY 6 BOREHOLE TYPE Splittings, Hollow Stem Augers COMPILED BY KF
 DATUM Geodetic DATE 2010 08 12 - 2010 08 12 CHECKED BY SG

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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20 40 60 80 100									
								20 40 60 80 100									
							UNCONFINED FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)					
331.2	0.0	Sandy silt, moist, dark brown, some roots	1	SS	10	▽	331										
330.6	0.6	Well graded gravel with silt and sand (GW-GM), dense to very dense, wet, brown	2	SS	100/ 80mm		330										
		- frequent cobbles	3	SS	48		329										
			4	SS	62		328										
			5	SS	43		327										
			6	SS	100/ 230mm		326										
327.0	4.2	Poorly graded sand (SP), compact to very dense, wet, brown	7	SS	52		325										
			8	SS	18		324										
			9	SS	43		323										
324.5	6.7	Silty sand (SM), very dense, wet, brown	10	SS	59		322										
			11	SS	104/ 280mm		321										
			12	SS	65		320										
319.9	11.3	End of Borehole															
		Groundwater level inferred during drilling															




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

RECORD OF BOREHOLE No BH 10-26

1 OF 1

METRIC

W.P. 3002-05-00 LOCATION 10+371 7.0m Lt CL Ramp S-E/W N: 4 817 064 E: 247 258 ORIGINATED BY M.A.
 DIST HWY 6 BOREHOLE TYPE Splitterspoons, Hollow Stem Augers COMPILED BY KF
 DATUM Geodetic DATE 2010 08 12 - 2010 08 12 CHECKED BY SG

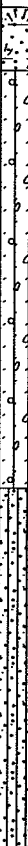

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
331.9	0.0	Sandy silt, moist, dark brown, FILL		1	SS	11	331									6 32 (62)
331.3	0.6	Sandy silt with gravel (ML), dark brown, compact, moist, FILL		2	SS	15										
				3	SS	18										
329.8	2.1	Silty gravel with sand (GM) to poorly graded sand with silt and gravel (SP-SM), compact to very dense, moist to wet, brown		4	SS	100/ 130mm	329									49 39 (12)
		- frequent cobbles		5	SS	100/ 100mm										
				6	SS	100/ 50mm										
				7	SS	50										
326.4	5.5	Poorly graded sand with silt (SP-SM), compact to very dense, wet, brown		8	SS	51	326									14 81 (5)
325.2	6.7	End of Borehole		9	SS	21										
		Groundwater level inferred during drilling														

RECORD OF BOREHOLE No BH 10-27

1 OF 1

METRIC

W.P. 3002-05-00 LOCATION 9+508 8.0m Lt CL Ramp E-N N: 4 817 101 E: 247 242 ORIGINATED BY MA
 DIST HWY 6 BOREHOLE TYPE Splittings, Hollow Stem Augers COMPILED BY KF
 DATUM Geodetic DATE 2010 08 13 - 2010 08 13 CHECKED BY SG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20 40 60 80 100									
								20 40 60 80 100									
								PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT									
								W _p W W _L					WATER CONTENT (%)				
								○ UNCONFINED × FIELD VANE									
								● QUICK TRIAXIAL × LAB VANE									
330.7																	
0.0	Sandy silt, moist, dark brown		1	SS	13												
330.2							330										
0.5	Silty gravel with sand (GM), compact to dense, moist, brown		2	SS	45												
							329										
			3	SS	22												
							328										
			4	SS	11												
							327										
			5	SS	18												
326.9																	
3.8	Silty sand (SM), compact to dense, wet, brown		6	SS	18												
			7	SS	24												
			8	SS	30												
			9	SS	33												
324.0																	
6.7	End of Borehole																
	Groundwater level inferred during drilling																



Stantec

Field Core Log

Client:	MTO	Project No.:	165000749
Project:	Highway 6 and Laird Road Interchange, Guelph	Date:	July 20, 2010
Contractor:	DBW	Borehole No.:	BH10-2
		Logger:	M. Abdel-Mesih

DEPTH FROM (m)	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO (m)	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES						OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	
18.44	1	62	0	18.9	Grey limestone	S	S	1	B	F	C-M	RP		T	
18.9	2	98	74	20.42	Grey limestone		S	1	B	F	C-M	RP		T	
20.42	3	100	92	22.25	Grey limestone	VS	S	1	B	F	C-M	RP		T	

STRENGTH (MPa)
EH = Extremely Strong = > 250
VS = Very Strong = 100-250
S = Strong = 50-100
MS = Medium Strong = 25-50
W = Weak = 5 - 25

WEATHERING
U = Unweathered = No Signs
S = Slightly = Oxidized
M = Moderately = Discoloured
H = Highly = Friable
C = Completely = Soil-like

SPACING
VW = Very Wide = >3m
W = Wide = 1-3 m
M = Moderate = 0.3-1 m
C = Close = 5-30 cm
VC = Very Close = <5 cm

DISCONTINUITY TYPE
B = Bedding Joint
J = Cross Joint
F = Fault
S = Shear Plane

ORIENTATION
F = Flat = 0-20°
D = Dipping = 20-50°
V = n-Vertical = >50°

FILLING
T = Tight, Hard
O = Oxidized
SA = Slightly Altered, Clay Free
S = Sandy, Clay Free
Si = Sandy, Silty, Minor Clay
NC = Non-softening Clay
SC = Swelling, Soft Clay

ROUGHNESS
RU = Rough Undulating
RP = Rough Planar
SU = Smooth Undulating
SP = Smooth Planar
LU = Slickensided Undulating
LP = Slickensided Planar



Stantec

Field Core Log

Client:	MTO	Project No.:	165000749
Project:	Highway 6 and Laird Road Interchange, Guelph	Date:	July 28, 2010
Contractor:	DBW	Borehole No.:	BH10-5
		Logger:	M. Abdel-Mesih

DEPTH FROM (m)	RUN NO.	% CORE RECOVERY	% RQD	DEPTH TO (m)	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.)	STRENGTH	WEATHERING	DISCONTINUITIES						OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								NO. OF SETS	TYPE/S	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	
22.05	1	93	71	23.01	Grey limestone	S	S	1	B	F	C	RP		T	
23.01	2	96	75	24.84	Grey limestone		S	1	B	D		RP		T	
24.84	3	96	84	26.7	Grey limestone	S	S	1	B	F		RP		T	

STRENGTH (MPa)
EH = Extremely Strong = > 250
VS = Very Strong = 100-250
S = Strong = 50-100
MS = Medium Strong = 25-50
W = Weak = 5 - 25

WEATHERING
U = Unweathered = No Signs
S = Slightly = Oxidized
M = Moderately = Discoloured
H = Highly = Friable
C = Completely = Soil-like

SPACING
VW = Very Wide = >3m
W = Wide = 1-3 m
M = Moderate = 0.3-1 m
C = Close = 5-30 cm
VC = Very Close = <5 cm

DISCONTINUITY TYPE
B = Bedding Joint
J = Cross Joint
F = Fault
S = Shear Plane

ORIENTATION
F = Flat = 0-20°
D = Dipping = 20-50°
V = n-Vertical = >50°

FILLING
T = Tight, Hard
O = Oxidized
SA = Slightly Altered, Clay Free
S = Sandy, Clay Free
Si = Sandy, Silty, Minor Clay
NC = Non-softening Clay
SC = Swelling, Soft Clay

ROUGHNESS
RU = Rough Undulating
RP = Rough Planar
SU = Smooth Undulating
SP = Smooth Planar
LU = Slickensided Undulating
LP = Slickensided Planar



Photo No. 1: BH10-2 – Depth 18.44 m to 22.25 m



Photo No. 2: BH10-5 – Depth 22.05 m to 26.7 m

APPENDIX C

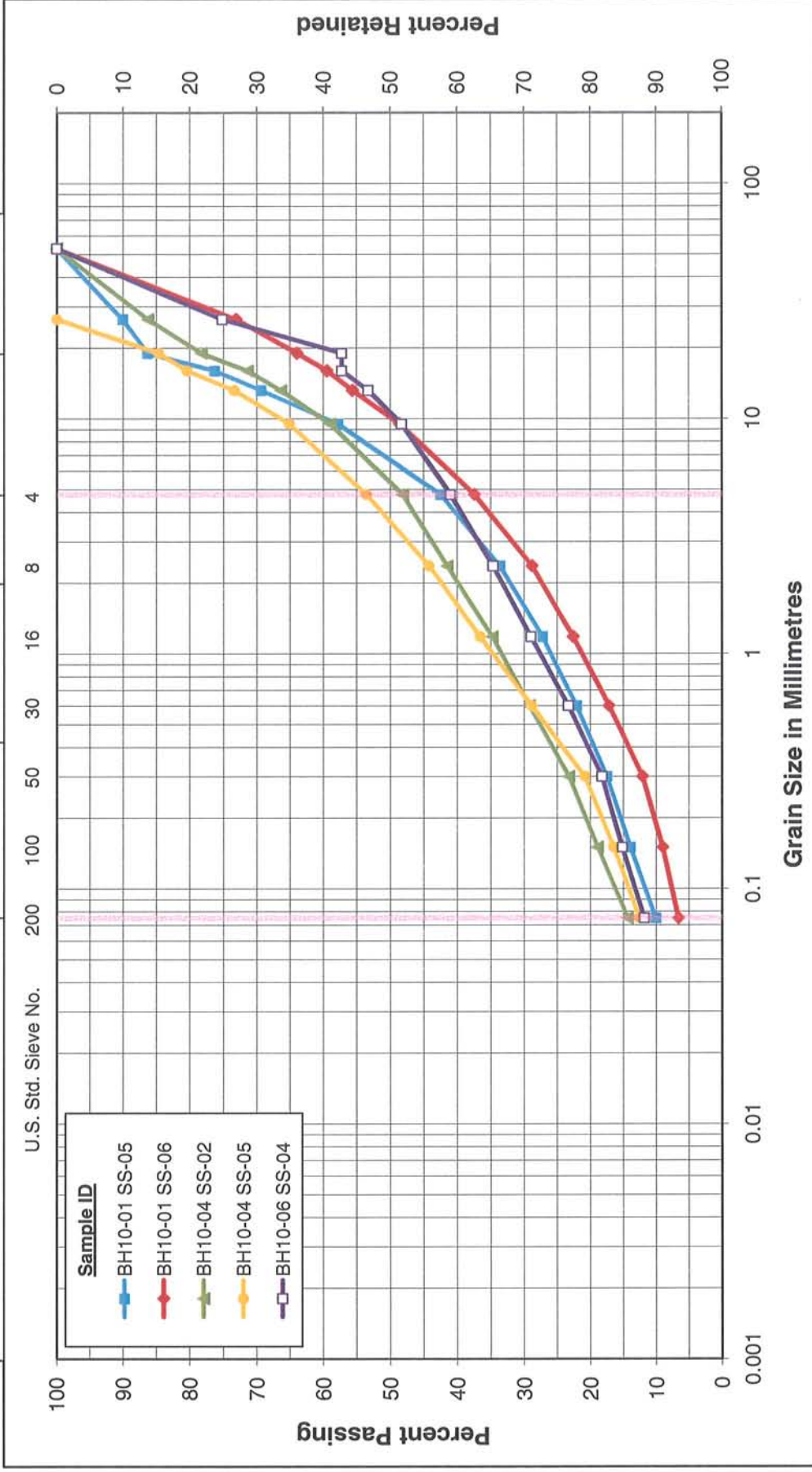
Laboratory Test Results

Figures 1 – 4: Grain Size Distribution Plots

Figure 5: Plasticity Chart

Unified Soil Classification System

CLAY & SILT			SAND			Gravel	
			Fine	Medium	Coarse	Fine	Coarse



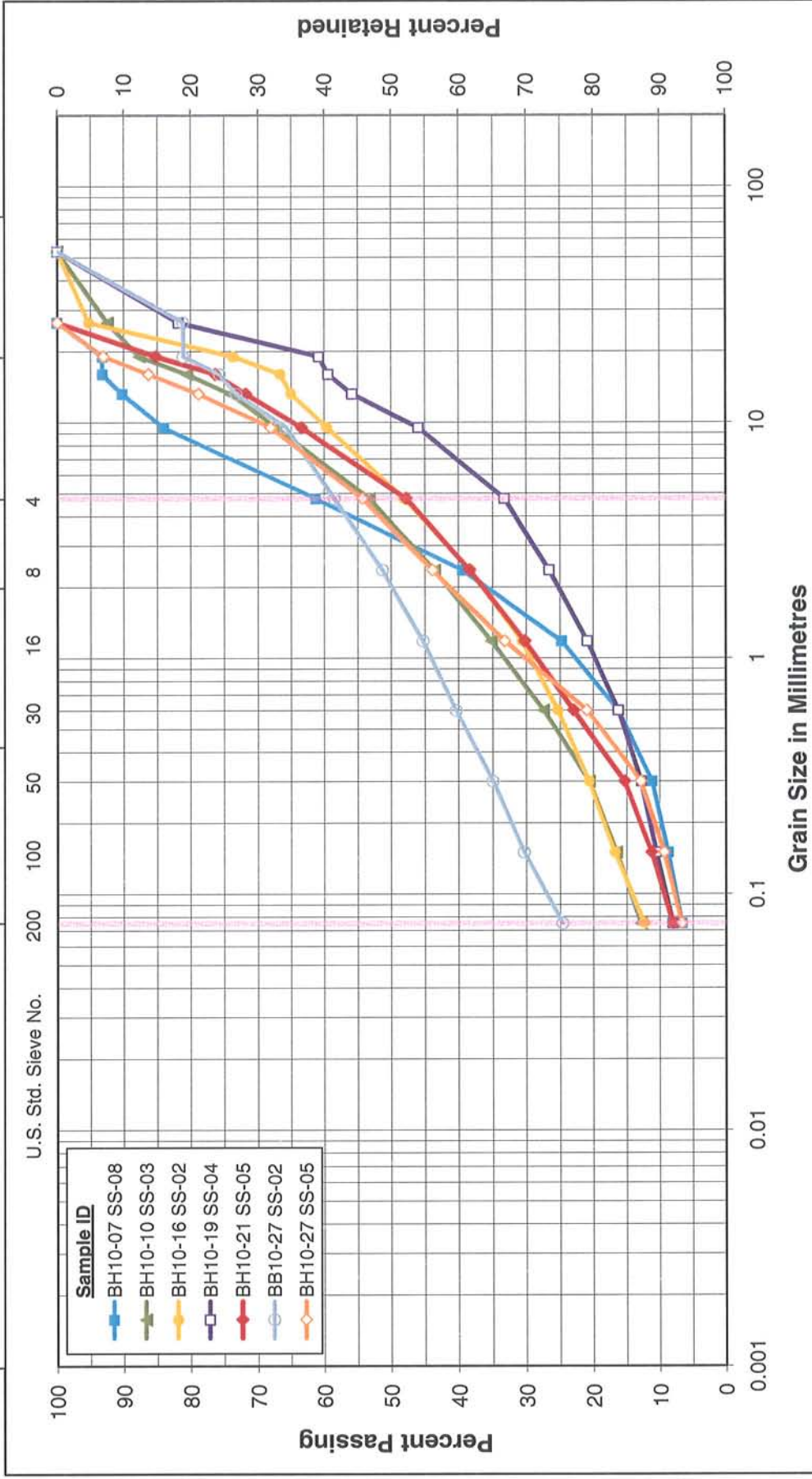
GRAIN SIZE DISTRIBUTION
Gravel with Silt and Sand (GP-GM, GM, GW-GM)

Figure No. 1a

Project No. 165000749

Unified Soil Classification System

CLAY & SILT		SAND			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



GRAIN SIZE DISTRIBUTION

Gravel with Silt and Sand (GW-GM, GP-GM)

Figure No. 1b

Project No. 165000749

	SAND			Gravel	
CLAY & SILT	Fine	Medium	Coarse	Fine	Coarse



Well-graded Gravel with Silt and Sand (GW-GM)

Project No. 165000749

	SAND			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
CLAY & SILT					

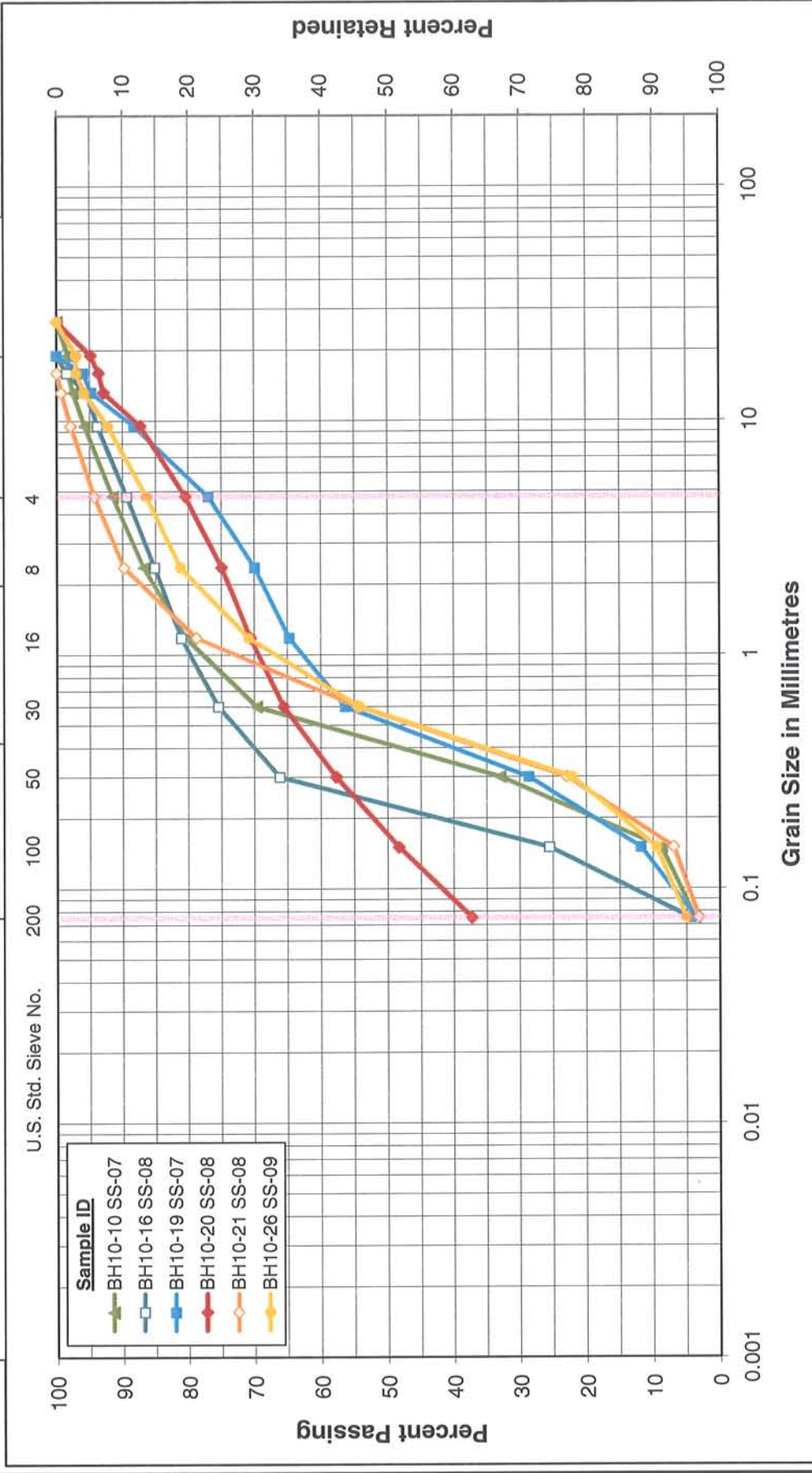


Sand with Silt and Gravel (SP-SM)

Project No. 165000749

Unified Soil Classification System

CLAY & SILT	SAND			Gravel	
	Fine	Medium	Coarse	Fine	Coarse



GRAIN SIZE DISTRIBUTION

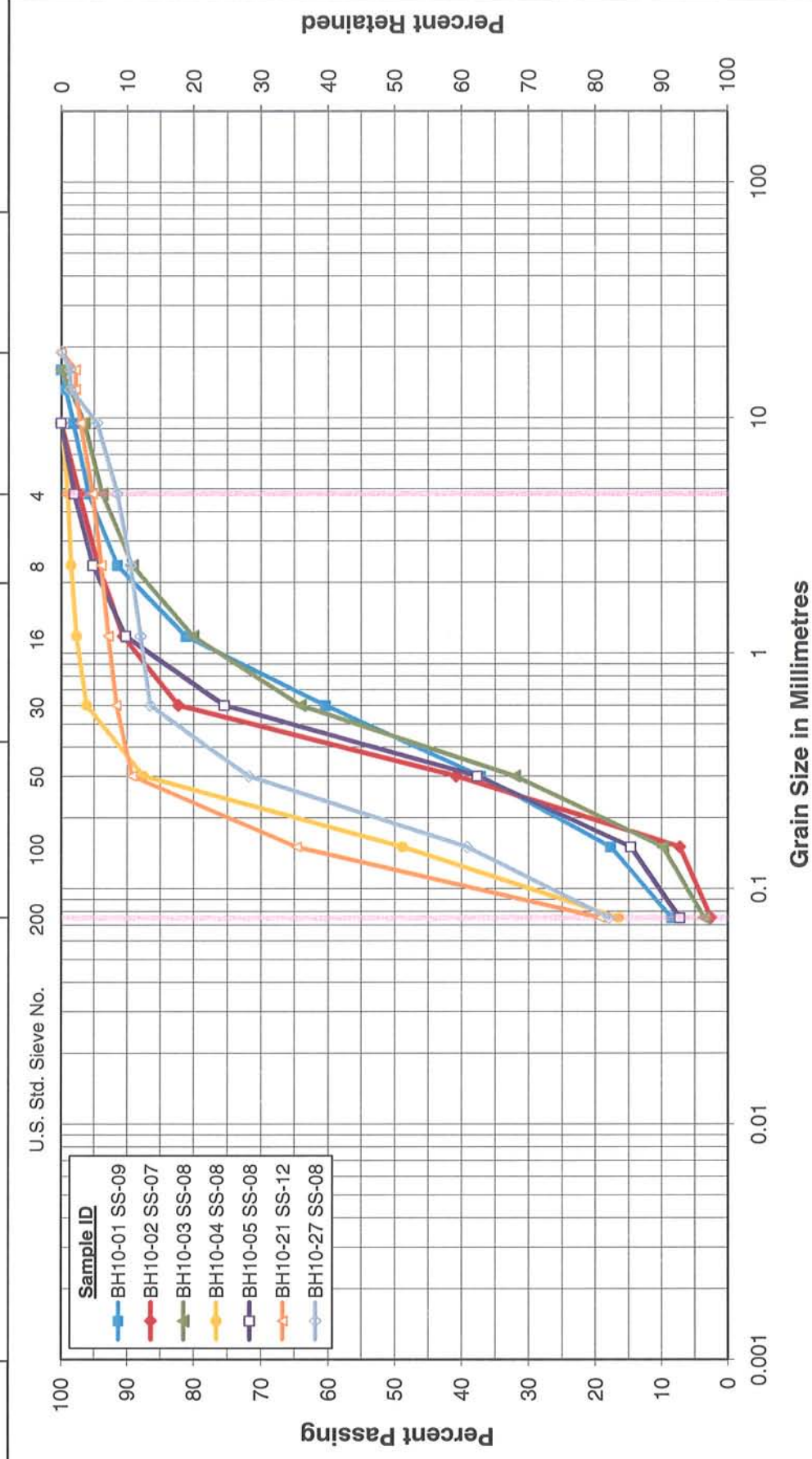
Silty Sand with Gravel (SM)

Figure No. 2a

Project No. 1650000749

Unified Soil Classification System

CLAY & SILT	SAND			Gravel	
	Fine	Medium	Coarse	Fine	Coarse



GRAIN SIZE DISTRIBUTION

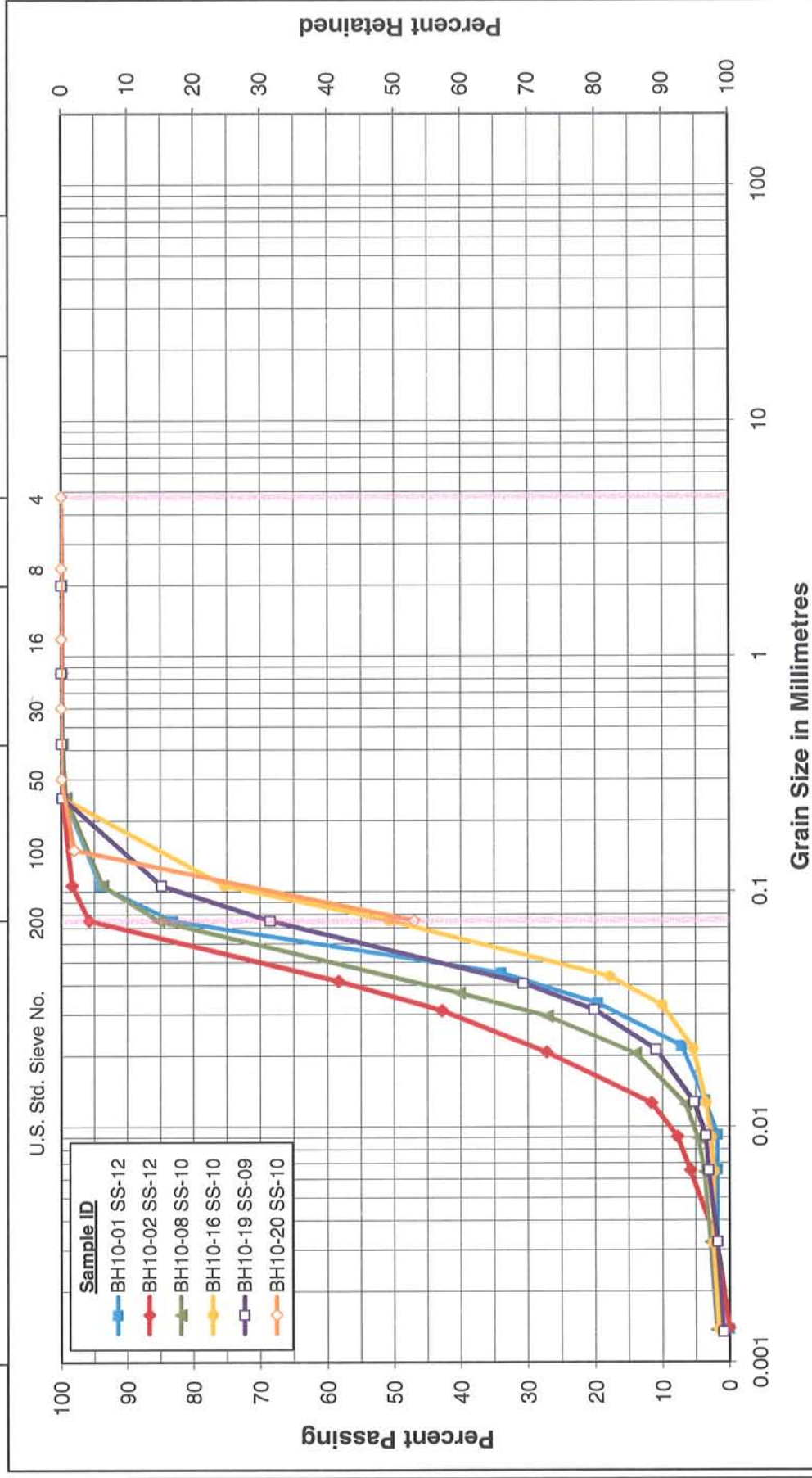
Sand (SP, SW-SM, SP-SM)

Figure No. 2b

Project No. 165000749

Unified Soil Classification System

CLAY & SILT	SAND				Gravel	
	Fine	Medium	Coarse		Fine	Coarse



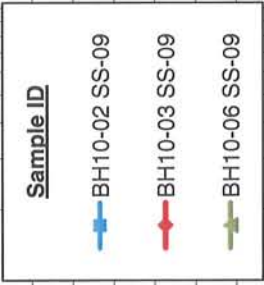
GRAIN SIZE DISTRIBUTION

Silt to Sandy Silt (ML)

Figure No. 3a

Project No. 165000749

CLAY & SILT	SAND			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

**Stantec**

Sandy Silt (ML)

Project No. 165000749

CLAY & SILT	SAND			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

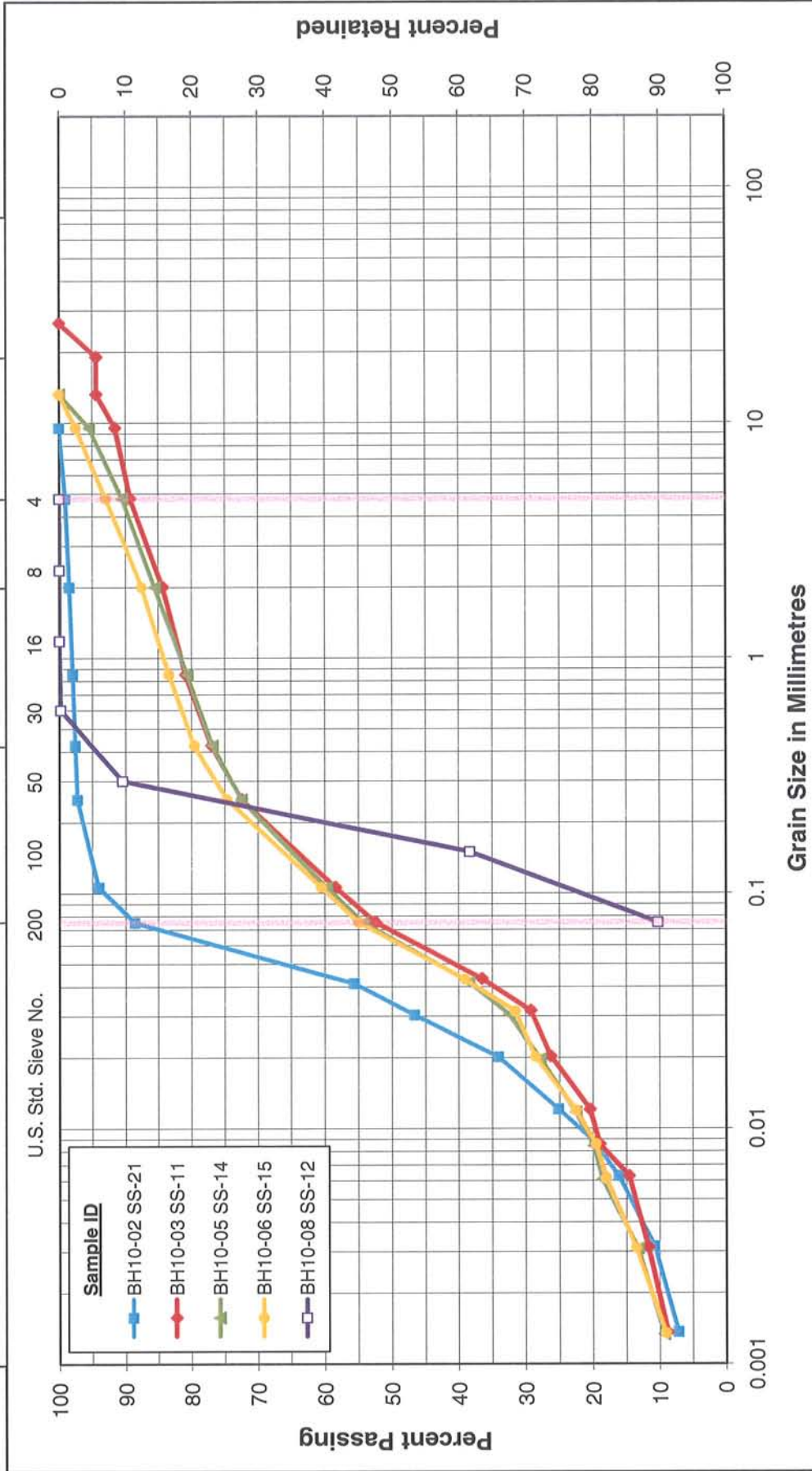


Sandy Silt with Gravel (ML) / TILL

Project No. 165000749

Unified Soil Classification System

CLAY & SILT		SAND				Gravel	
		Fine	Medium	Coarse	Fine		
U.S. Std. Sieve No.							



GRAIN SIZE DISTRIBUTION
 Gravel and Sand with Silt, Sand, Silt
 (GW-GM, SW-SM, SP, ML) / TILL

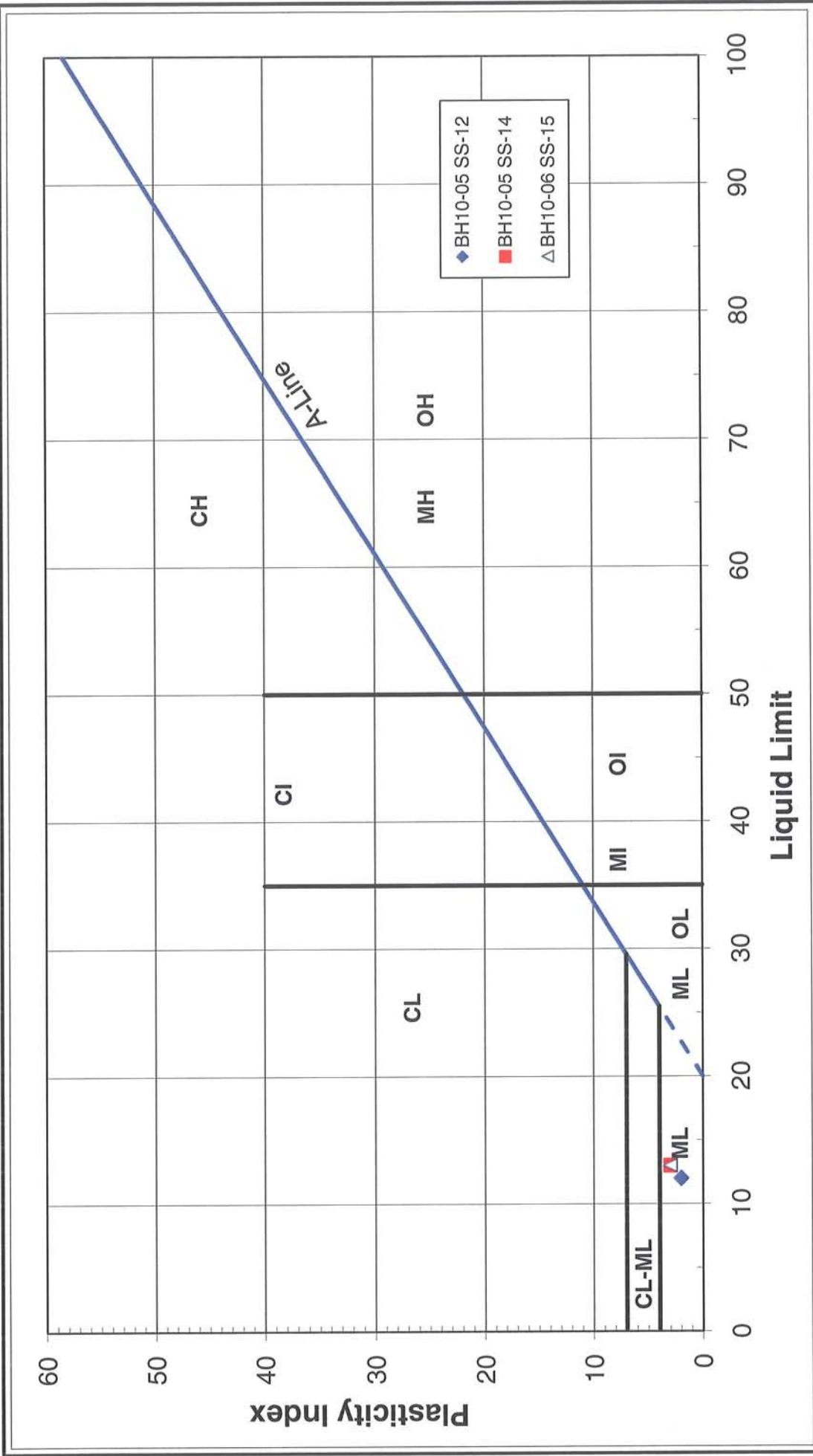
Figure No. 4b

Project No. 165000749



Figure No. 5a

Project No. 165000749



PLASTICITY CHART

Figure No. 5b

Project No. 165000749

APPENDIX D

Figure 6: Design Parameters

Figure 7: p-y Curves for HP310x110 (LPILE)

Figure 8: Lateral Deflection for HP310x110 (LPILE)

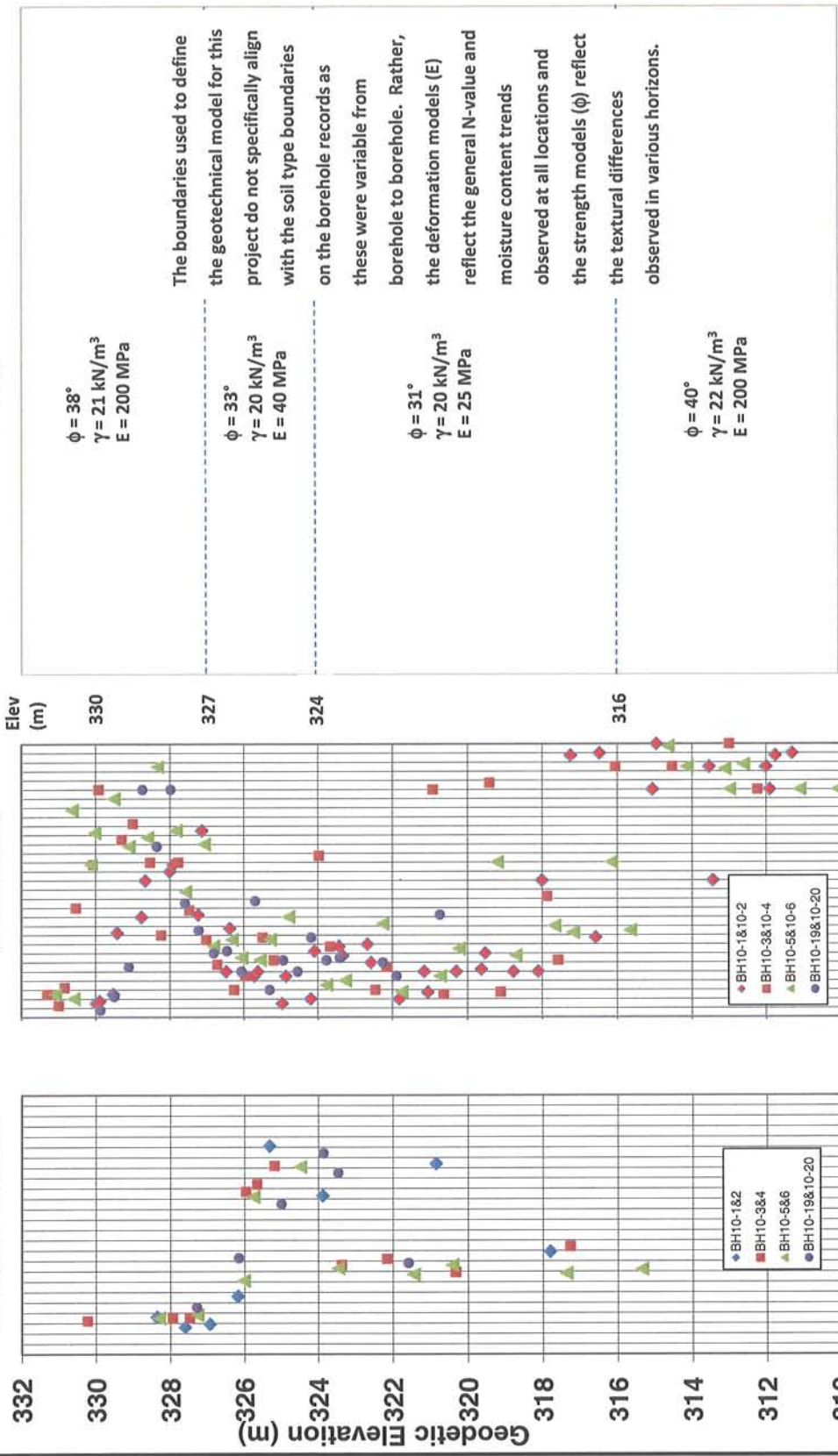
Figure 9-12: Typical Slope Stability Evaluation Results (Slope/W)

Figure 13-15: Typical Settlement Evaluation Results (Settle3D)

Design Parameters

Measured N

Moisture Content



Stantec Consulting Ltd.

Project No. 16500749

Figure 6



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Project No. 165000749
Highway 6 and Laird Road Interchange

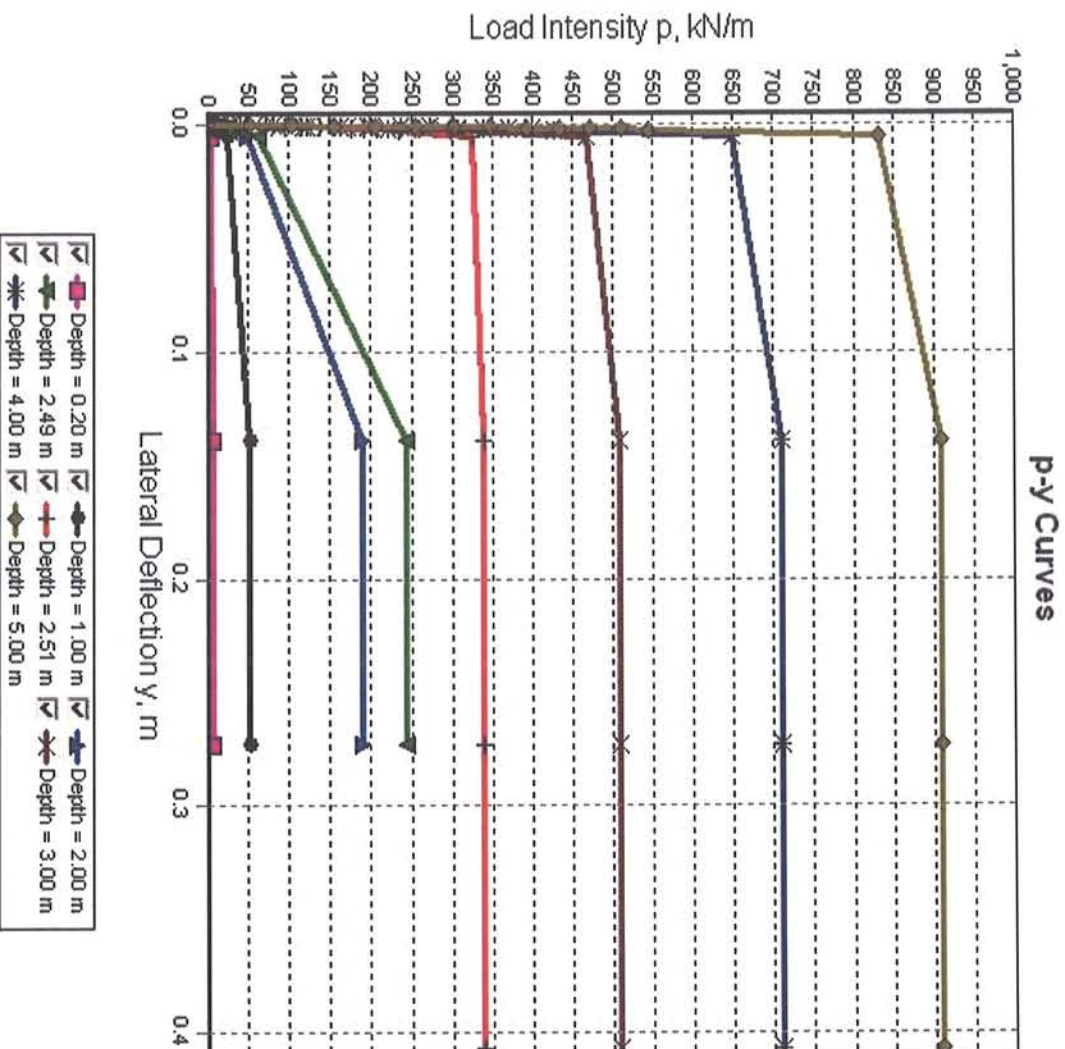


Figure 7
p-y Curves for Proposed HP 310x110 Piles



Stantec

Project No. 165000749
Highway 6 and Laird Road Interchange

LPile Results - Lateral Deflection

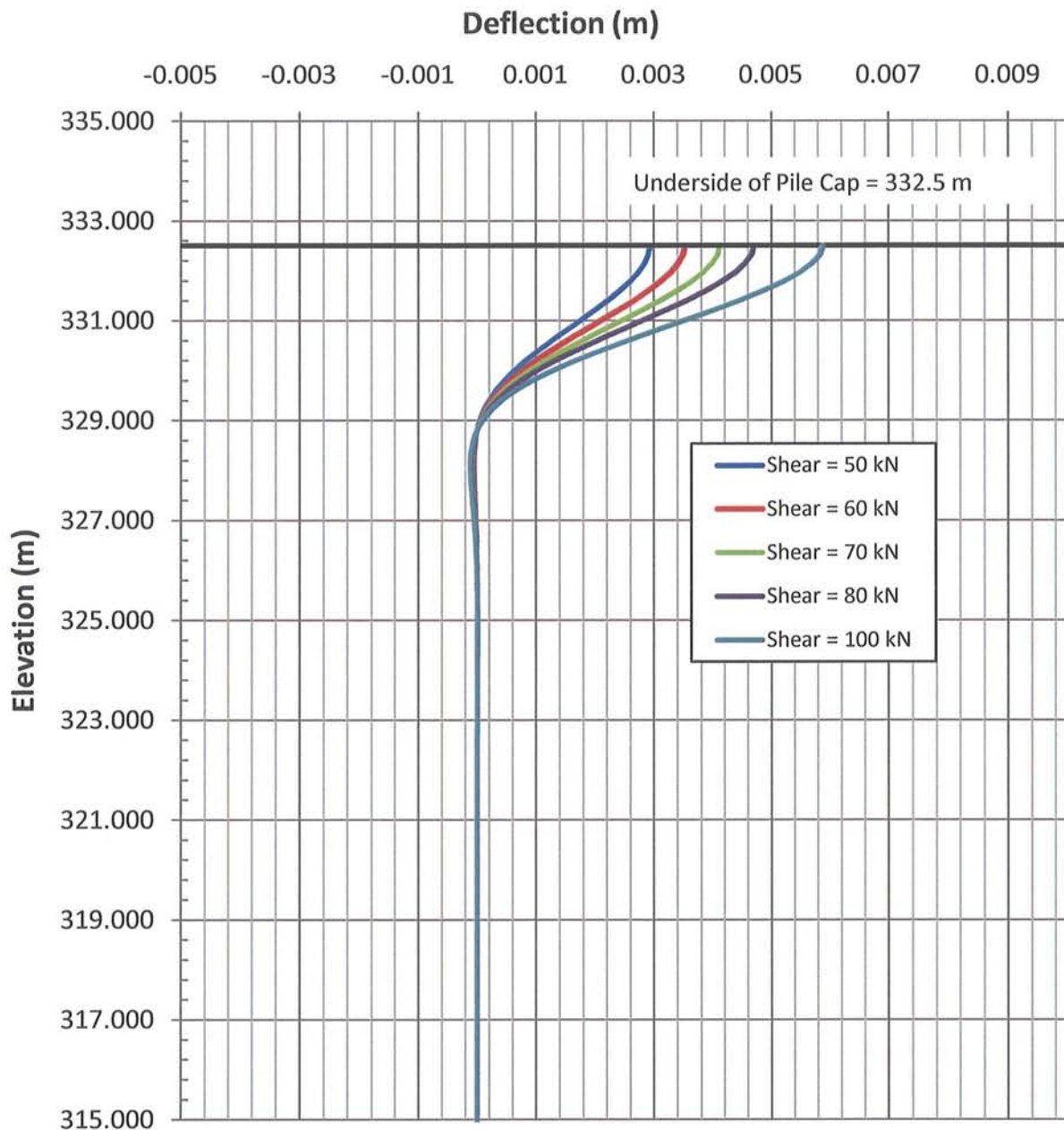
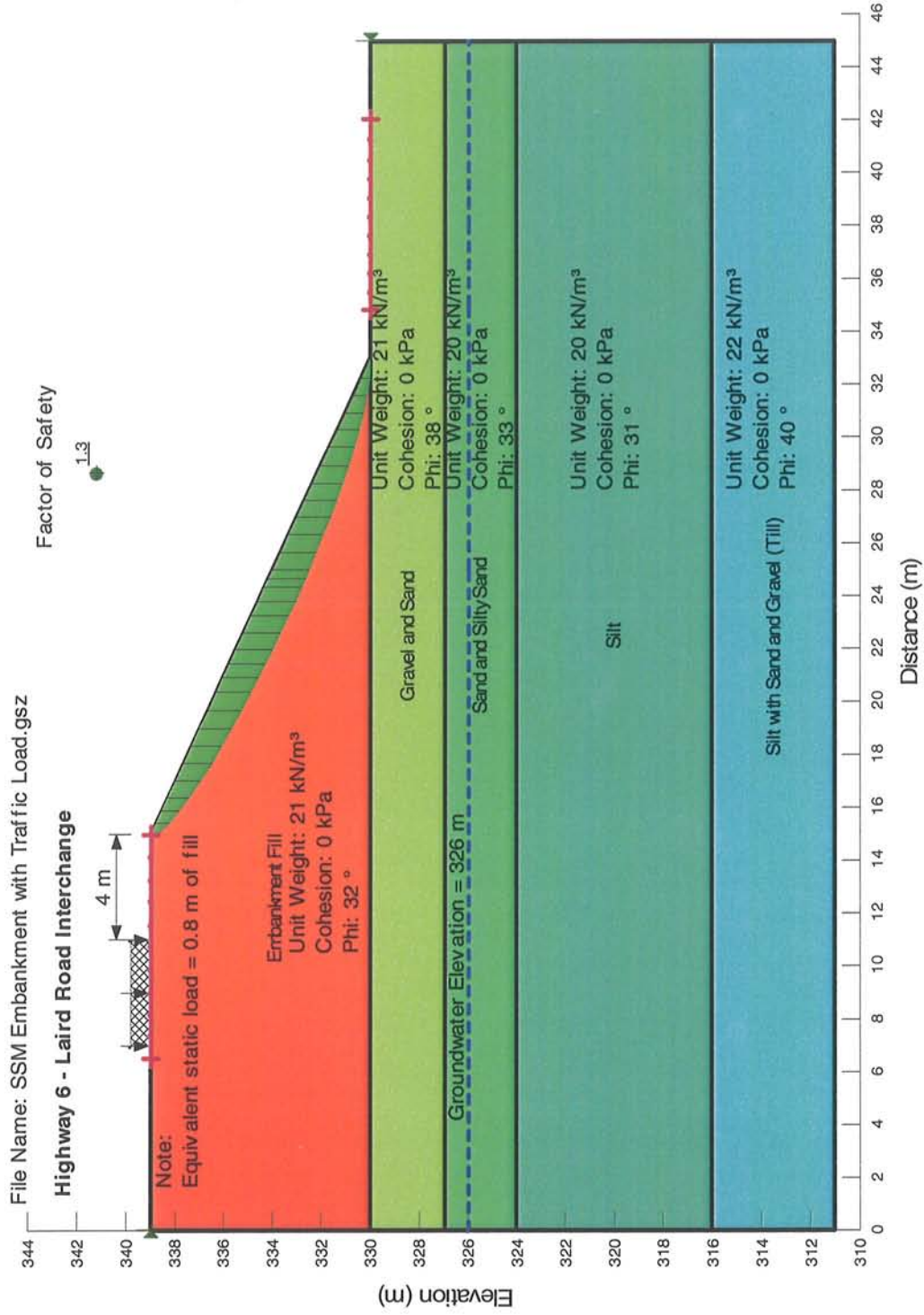


Figure 8
Lateral Deflection of HP 310x110 Piles



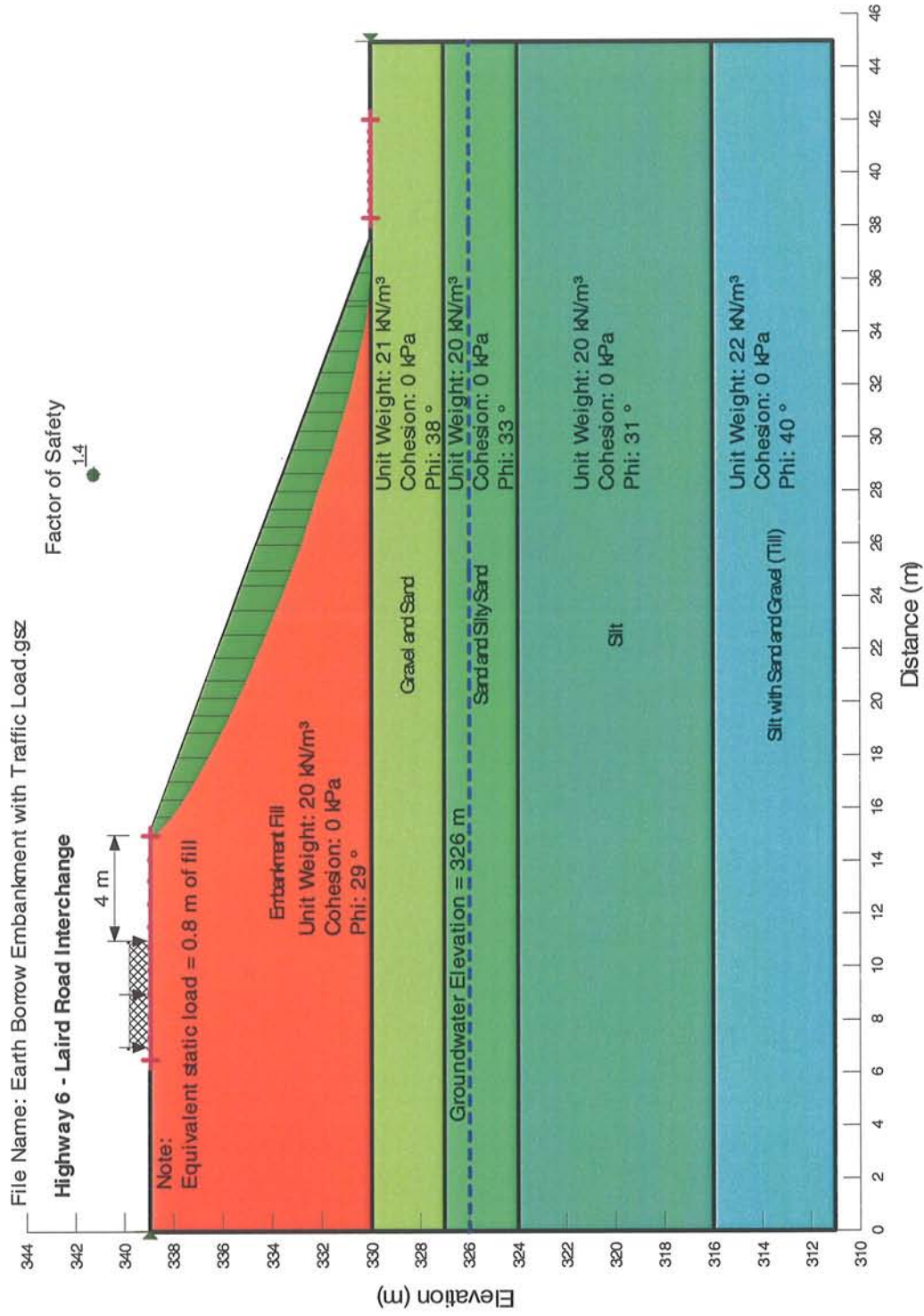
Static Slope Stability Analysis
 Highway 6 - Laird Road Interchange
 SSM: Side slope at 2H:1V

Figure 9

Project No. 165000749



Stantec



Static Slope Stability Analysis

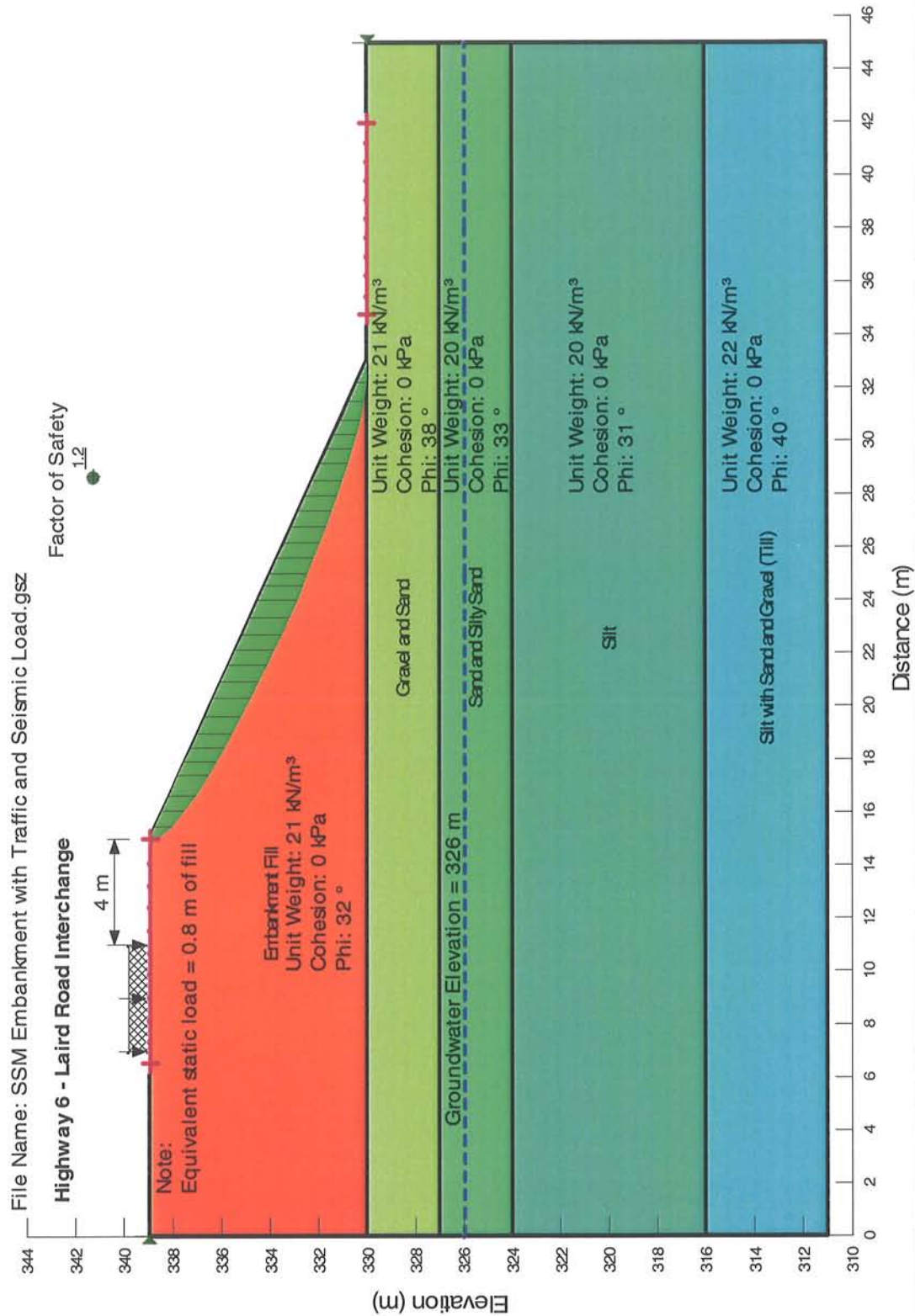
Highway 6 - Laird Road Interchange
Earth Borrow: Side slope at 2.5H:1V

Figure 10

Project No. 165000749



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Seismic Slope Stability Analysis
Highway 6 - Laird Road Interchange
SSM: Side slope at 2H:1V

Figure 11

Project No. 165000749

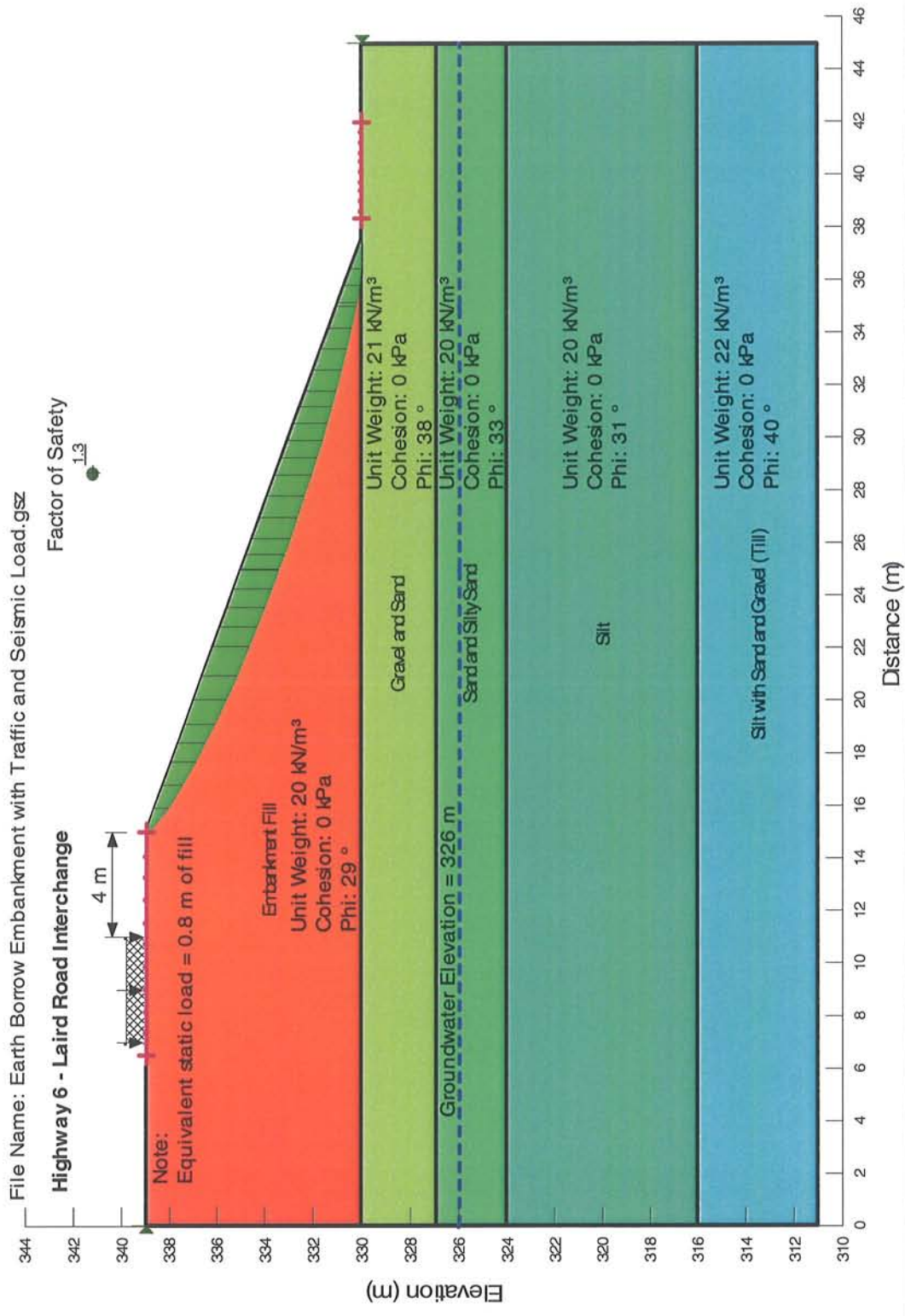


Figure 12

Seismic Slope Stability Analysis

Highway 6 - Laird Road Interchange

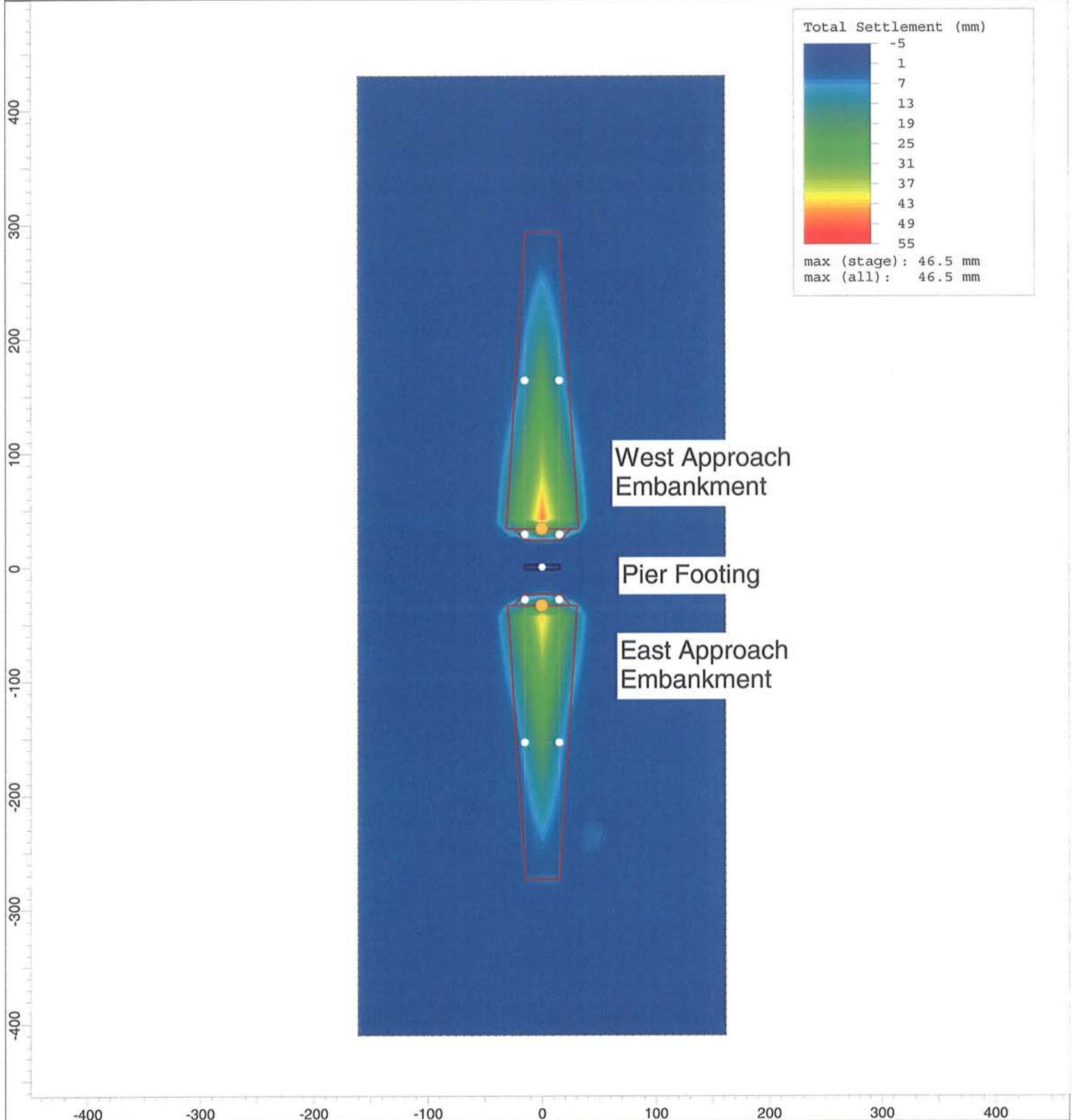
Earth Borrow: Side slope at 2.5H:1V

Project No. 165000749



Stantec

Figure 13




 Stantec	Project Highway 6 - Laird Road Interchange		
	Analysis Description Settlement Due to Approach Embankment and Granular Pad - SSM		
	Drawn By SG	Company	Stantec Consulting Ltd
	Date 9/17/2010, 12:48:15 PM	File Name	W-E Embankment - SSM with GranPad.s3z

Figure 14

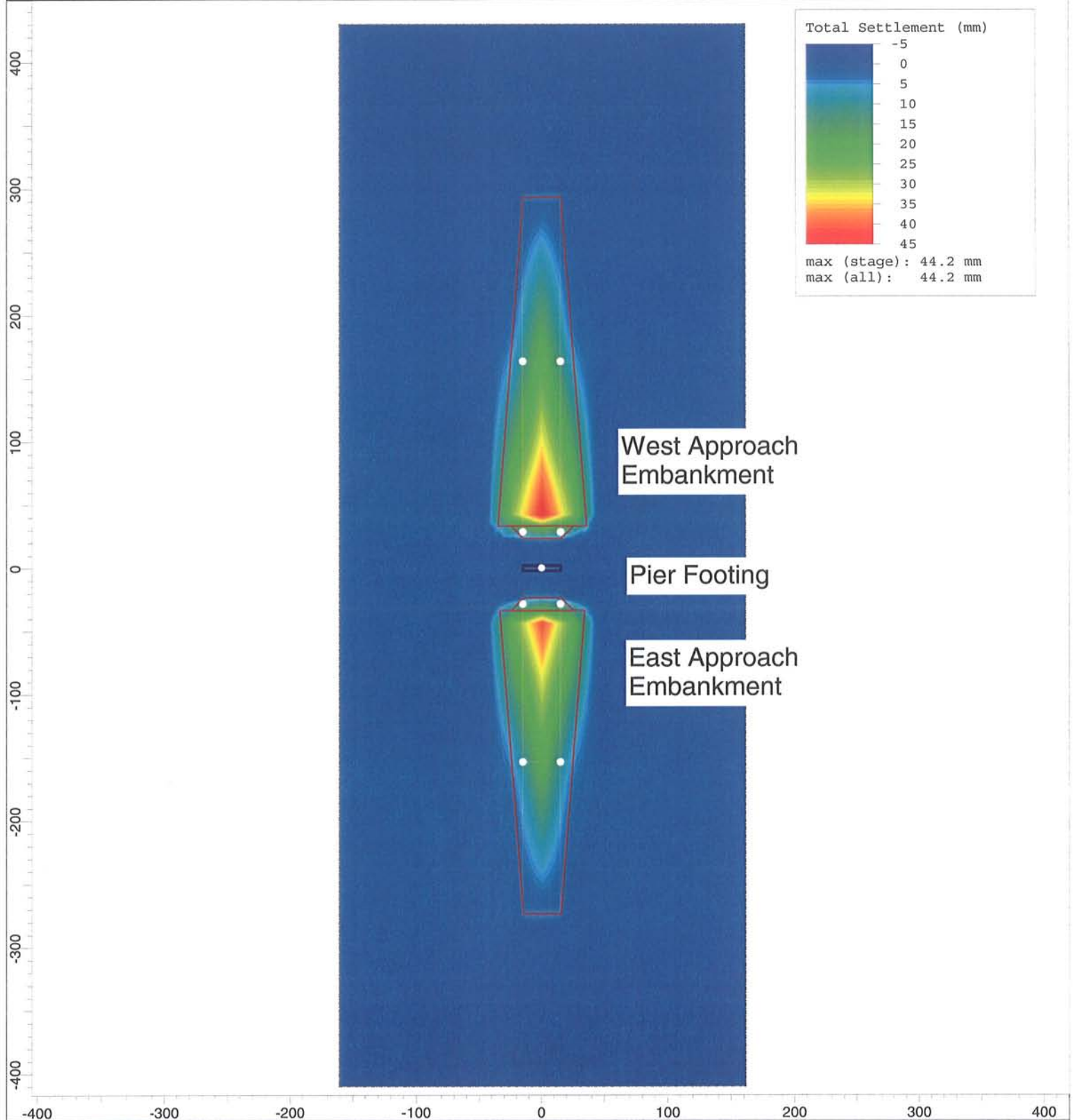
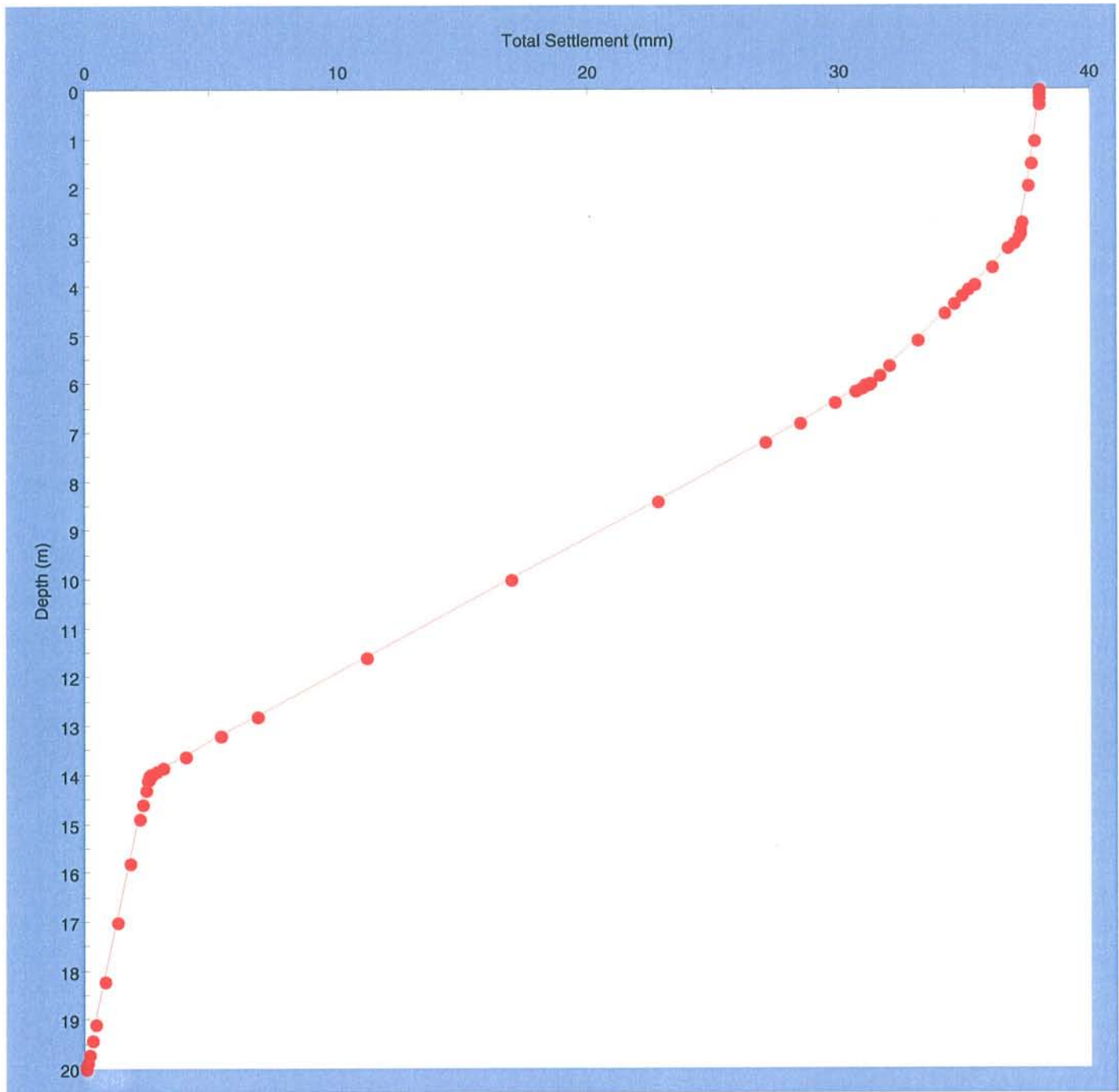


Figure 15

Total Settlement vs. Depth



Query Point 1 (Stage 1)
Reference Stage: None



Stantec

SETTLE3D 2.010

Project		Highway 6 - Laird Road Interchange	
Analysis Description		Settlement Profile at Abutment Location - SSM	
Drawn By	SG	Company	Stantec Consulting Ltd
Date	9/17/2010, 12:48:15 PM	File Name	W-E Embankment - SSM with GranPad-a.s3z

APPENDIX E

Geological Survey of Canada Seismic Hazard Calculation

2005 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: Simon Gudina, Stantec

August 16, 2010

Site Coordinates: 43.5833 North 80.3333 West

User File Reference: Highway 6, Guelph

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)
0.202	0.101	0.049	0.014	0.121

Notes. Spectral and peak hazard values are determined for firm ground (NBCC 2005 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 ($S_a(T)$, 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)	0.031	0.085	0.128
Sa(0.5)	0.016	0.042	0.063
Sa(1.0)	0.006	0.019	0.031
Sa(2.0)	0.002	0.006	0.009
PGA	0.017	0.053	0.080

References

National Building Code of Canada 2005 NRCC no. 47666; 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 2005, Structural Commentaries NRCC no. 48192

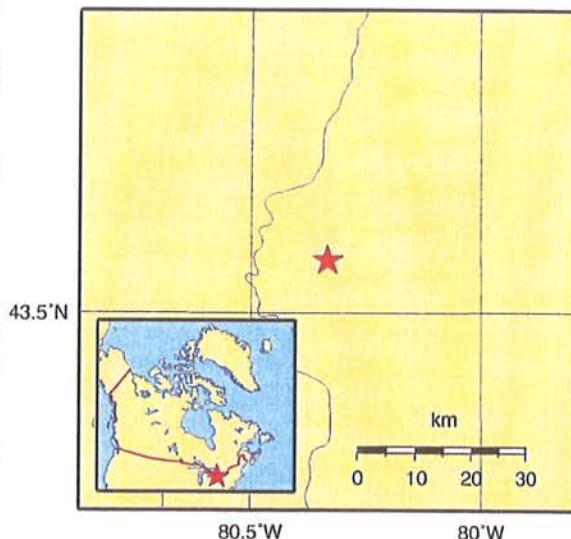
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File xxxx

Fourth generation seismic hazard maps of Canada: Grid values to be used with the 2005 National Building Code of Canada (in preparation)

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

Aussi disponible en français



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