

**FOUNDATION INVESTIGATION REPORT
SPENCER CREEK BRIDGE
REPLACEMENT
G.W.P. NO. 2174-08-00
MTO GEOCRES NO. 30M5-282**

Morrison Hershfield Limited
Highway 5, Township of Beverley, Ontario

TRANETOB11558AA
September 06, 2012

September 06, 2012

Morrison Hershfield
Suite 600, 235 Yorkland Boulevard
Toronto, ON M2J 1T1

Attention: Mr. Joe Ostrowski, P.Eng.

Dear Mr. Ostrowski,

**RE: Foundation Investigation Report
Spencer Creek Bridge Replacement, Highway 5, Township of Beverley, Ontario
G.W.P. No. 2174-08-00 MTO GEOCREs No. 30M5-282**

Coffey Geotechnics Inc (Coffey) is pleased to present the Final Foundation Investigation Report for the proposed Spencer Creek Bridge Replacement on Highway 5, Beverly Township, Ontario.

Please call us on 416 213 1255 should you require further clarification on any aspects of the reports.

For and on behalf of Coffey Geotechnics Inc.



Ramon Miranda, P.Eng.

Principal Engineer

Distribution: Original held by Coffey Geotechnics Inc.
1 hard copy to Morrison Hershfield
1 hard copy to MTO Project Manager
1 hard copy to MTO Pavements and Foundation Section

CONTENTS

1	INTRODUCTION	1
2	SITE DESCRIPTION AND PHYSIOGRAPHY	1
2.1	Site Description	1
2.2	Physiography	1
3	METHOD OF INVESTIGATION	2
3.1	Fieldwork	2
3.2	Laboratory Testing	4
4	SUBSURFACE CONDITIONS	4
4.1	Asphalt	5
4.2	Pavement Granular Fill	5
4.3	Embankment Fill	5
4.4	Clayey Silt	6
4.5	Bedrock	7
4.6	Groundwater Conditions	8

Tables

Table 3.1	Borehole Details
Table 4.1	Bedrock Level Observations
Table 4.2	Groundwater Level Observations

Drawings

Drawing 1	Borehole Location Plan and Soil Strata
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Appendices

Appendix A	Record of Borehole Sheets and Rock Core Photographs
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CONTENTS

Appendix B Laboratory Test Results

Figure B1 Grain Size Distribution – Pavement Granular Fill

Figure B2 Grain Size Distribution – Embankment Fill: Sandy Silt mixed with clayey silt

Figure B3 Grain Size Distribution – Clayey Silt

Figure B4 Plasticity Chart – Clayey Silt

Figure B5 Unconfined Compression Test – BH F2, RC 8

Figure B6 Unconfined Compression Test – BH F3, RC 3

Appendix C Site Photographs

Appendix D Explanation of Terms Used in Report

FOUNDATION INVESTIGATION REPORT
SPENCER CREEK BRIDGE REPLACEMENT, HIGHWAY 5,
TOWNSHIP OF BEVERLEY, ONTARIO,
G.W.P. NO. 2174-08-00 - MTO GEOCRES NO. 30M5-282

1 INTRODUCTION

At the request of Morrison Hershfield, Coffey Geotechnics Inc. (Coffey) has prepared this foundation investigation report for the proposed Spencer Creek Bridge Replacement on Highway 5, in the Township of Beverley, Ontario. The foundation investigation was carried out in general accordance with Coffey proposal, dated June 15, 2011) and the requirements of the RFP.

The purpose of the investigation was to obtain information about the subsurface conditions at the site by means of boreholes, and to assess the engineering characteristics of the subsurface soils by means of field and laboratory tests.

This report provides factual information concerning subsurface conditions, in situ test results and laboratory test results, based on the foundation investigation undertaken.

2 SITE DESCRIPTION AND PHYSIOGRAPHY

2.1 Site Description

The Bridge Site # 36–81 (Spencer Creek Bridge) is located at approximately 1.2 kilometres east of intersection of Highway 5 with Westover Road (Peters Corner), at about Station 23+800 on Highway 5, northwest of Hamilton, Ontario.

The existing structure over the Spencer Creek is a single-span (15 m) bridge with a concrete deck and asphalt wearing surface.

The direction of flow in Spencer Creek is southerly. The width of the creek is about 12 m and at the time of our investigation the water depth in the creek was about 0.7 m.

Photographs of the Site are presented in Appendix C.

2.2 Physiography

The site is located in a valley incised by the Spencer Creek near (west of) the Niagara Escarpment and according to “The Physiography of Southern Ontario” by L.J. Chapman and D.F. Putnam (1984), the general area is at confluence of the physiographic regions known as the Flamborough Plain and the Norfolk Sand Plain. The Flamborough Plain spans from Flamborough Township and extends north to Acton (in the Town of Halton Hills). It is bounded on the northwest by the Galt Moraine, and on the south by the silts and sands of glacial Lake Warren. A few drumlins are found scattered over limestone plains and swamps. The plain slopes to the south and carries little overburden like boulder glacial till or sand and gravel. Spencer Creek serves the Beverley swamp and the area north of it and flows into the Dundas Valley.

The Norfolk Sand Plain is wedge shaped and includes the western half of Regional Municipality of Haldimand-Norfolk, the eastern end of Elgin County, southern Brant, and a small corner of Oxford. In general, the plain declines from north to south in a very gentle slope (only about 0.3 m in a kilometer), while a noticeable break in the slope occurs eight to fifteen kilometers from the shore of Lake Erie. Except for the tributary of the Grand River in a small area, the drainage of the plain is through small rivers (e.g. Otter Creek and Big Creek) flowing directly to Lake Erie. This region is characterized by its sand and silt overburden (coarse-textured glaciolacustrine deposits), and usually silt and clay strata or beds of boulder clay occur within 9 m from the surface. The overburden is underlying by the bedrock of Guelph Formation, which typically consists of tan to brown, fine to medium crystalline dolostone. Ontario Geotechnical Borehole database and regional drift thickness mapping indicate that the depth to bedrock in the area of this site may be less than 5 to 12 m.

Being close to the Niagara Escarpment, the bedrock underlying the project area presents a complex picture at the interface of Guelph, Amabel and Lockport Formations, which belong to mainly the Middle Ordovician Period (i.e. approximately 430 million years old). These formations generally consist of dolostone/limestone with shale, siltstone and sandstone interbeds.

3 METHOD OF INVESTIGATION

3.1 Fieldwork

The fieldwork for the proposed bridge replacement was carried out on December 13, 14 and 15, 2011 and comprised of drilling eight boreholes (A1, A2, and F1 through F6) at the locations shown on the Borehole Location Plan and Soil Strata, Drawing 1. Table 1 below presents a summary of the borehole details.

Table 3.1 – Borehole Details

Borehole No./Location	Approximate Station	Offset from Hwy 5 C/L	Existing Ground Elevation (m)	Drilled/Tested Depth (m)
A1 West Approach	23+765	5.1 m Left of C/L	240.4	5.6
A2 East Approach	23+840	5.0 m Right of C/L	238.8	3.5
F1 West Abutment (Northern End)	23+784	5.2 m Left of C/L	239.8	4.9

Borehole No./Location	Approximate Station	Offset from Hwy 5 C/L	Existing Ground Elevation (m)	Drilled/Tested Depth (m)
F2 West Abutment (Southern End)	23+786	5.2 m Right of C/L	239.8	8.8
F3 East Abutment (Northern End)	23+820.5	5.2 m Left of C/L	239.1	7.1
F4 East Abutment (Southern End)	23+822.5	5.2 m Right of C/L	239.1	4.4
F5 West Abutment (Northern End)	23+781	5.2 m Left of C/L	239.9	8.7
F6 East Abutment (Southern End)	23+825.5	5.2 m Right of C/L	239.0	7.4

Davis Drilling Limited of Milton, Ontario carried out the drilling operation under the direction and supervision of Coffey geotechnical personnel. As shown on Table 3.1, the depths of the boreholes varied from 3.5 to 8.8 m. The boreholes were drilled using a track mounted (Bombardier) drill rig. Each borehole was advanced using a solid stem flight auger or hollow stem augers within the overburden materials, to depths of about 3.5 m to 5.6 m below the ground surface. Standard Penetration Tests (SPTs) were carried out at frequent depth intervals, to assess the soil strength and obtain samples for logging and testing purposes. SPTs were carried out in general accordance with ASTM D1586. The test consists of freely dropping a 63.5 kg hammer over a vertical distance of 0.76 m to drive a 51 mm outside diameter (OD) split-barrel (SS-split-spoon) sampler into the ground. The number of blows of the hammer required to drive the sampler into the relatively undisturbed ground by a vertical distance of 0.30 m is recorded as the Standard Penetration Resistance or the N-value of the soil which is indicative of the compactness condition of granular (or cohesionless) soils (gravels, sands and silts) or the consistency of cohesive soils (clays and clayey soils).

Boreholes F5 and F6 were straight augered without sampling through the overburden to refusal on presumed bedrock. In Boreholes F2, F3, F5 and F6, rock was cored by at least 3 m to a maximum depth of

8.8 m below the ground surface, using NQ coring technique. Rock core samples were stored in wooden boxes and colour photographed.

The soil and rock samples were described in the field, placed in appropriate containers, labelled and transported to our Etobicoke geotechnical laboratory where the samples underwent further detailed visual examination and samples were selected for geotechnical laboratory testing.

Groundwater levels and inflows observed in the open boreholes during drilling were recorded. In Boreholes F1 and F4, a piezometer was installed in each borehole to enable long term groundwater level monitoring. The remaining boreholes were grouted upon their completion using a cement/bentonite mixture as per MTO procedures.

The borehole locations were determined in the field, based on the existing site features. The borehole location coordinates and ground elevations were subsequently measured by the client's surveyors and were provided to Coffey.

Appendix A presents the Record of Borehole Sheets and rock core photographs.

3.2 Laboratory Testing

Soil and rock samples obtained during the investigation were taken to our Etobicoke laboratory. The following tests were performed on selected soil samples:

- Natural moisture content tests;
- Unit weight tests;
- Grain size analyses (sieve);
- Grain size analyses (sieve and hydrometer tests);
- Atterberg Limits tests.

Selected rock core samples were tested for Unconfined Compression Strength Test at Golder Associates Material Testing Laboratory in Mississauga.

The results of all laboratory tests are presented on the Record of Borehole Sheets in Appendix A. Appendix B presents laboratory test results sheets.

4 SUBSURFACE CONDITIONS

Detailed descriptions of the materials encountered in the boreholes are presented on the Record of Borehole Sheets in Appendix A, which also includes rock core photographs. Explanation of Terms Used in Report is presented in Appendix D.

Drawing 1 presents the borehole location plan as well as the generalized subsurface profile along the proposed Spencer Creek Bridge.

All the boreholes were advanced from paved shoulder and encountered asphalt and pavement granular fill. Below the pavement granular fill, an embankment fill, consisting generally of sandy silt mixed with clayey

silt, was encountered. In some of the boreholes, the embankment fill is underlain by native soils, consisting of clayey silt, to the surface of the bedrock. The bedrock encountered in the boreholes consists of dolostone/limestone and the surface of the bedrock was inferred or proven at depths ranging from 3.5 to 5.6 m below the existing road surface level or at Elevations 235.3 to 234.7 m.

The Record of Borehole Sheets and soil strata indicate the subsurface conditions at the borehole locations. However, the material boundaries indicated on the logs are approximate, based on visual observations. These boundaries typically represent a transition from one material type to another and should not be regarded as an exact plane of geological change.

The following description of the individual soil strata is to assist the designers of the project with an understanding of the anticipated subsurface conditions underlying the site.

4.1 Asphalt

All the boreholes drilled from paved shoulder of Highway 5 contacted an asphaltic concrete surface layer ranging in thickness from 100 to 240 mm.

4.2 Pavement Granular Fill

All the boreholes contacted pavement granular fill under the asphalt. The pavement fill consisting of a 0.15 to 0.2 m thick layer of granular base over 0.4 to 0.7 m thick granular sub-base. The base course consists of sand and gravel to gravelly sand with traces to some silt, while the granular sub-base consists of sand with some gravel to sand with traces to some gravel and some silt.

Five grain size analyses were carried out on representative samples from the granular soils that make up this granular fill. The results are presented on the Record of Borehole Sheets in Appendix A, and the grain size distribution curves are presented in Figure B1 in Appendix B. The results indicate the following grain size distribution.

Gravel	7 – 42 %
Sand	45 – 79 %
Silt and Clay	10 – 14 %

Standard Penetration Tests performed in this pavement fill yielded N-values ranging from 11 to 36 blows/0.3 m, indicating compact to dense compactness condition.

4.3 Embankment Fill

Below the pavement fill, embankment fill was encountered in all the sampled boreholes. The embankment fill, contacted in the boreholes, generally consists of sandy silt mixed with clayey silt. The embankment fill was found to extend to depths of 1.7 to 4.4 m below the existing road surface or to Elevations ranging between 238.7 and 234.7 m (probably representing the original ground surface level before the existing bridge was constructed minus the stripped material thickness). The fill contains traces of gravel, rootlets and organics. In Borehole F3, the bottom portion of fill was found to be comprised of organic silt with some sand and some peat (fibrous black organic matter) with a natural moisture content 52%. The presence of

some organic rich soils was also noted in most of the remaining boreholes. In fact, in general, at the bottom of this embankment fill, the presence of some organic contaminated soils is typical, exhibiting a dark brown/greyish black to black colour. This is probably due to the mixing of the existing organic soils with the fill when the embankment was first constructed (i.e. inadequate stripping).

Five grain size analyses were performed on representative samples from this fill and results are presented on the Record of Borehole Sheets in Appendix A, and the grain size distribution curves are presented in Figure B2 in Appendix B. The results indicate the following grain size distribution.

Gravel	1 – 15 %
Sand	20 – 34 %
Silt	38 – 51 %
Clay	14 – 19 %

The soil is basically fine grained granular (i.e. non-cohesive) soil, but at some locations where clay content is high, it attains a basically cohesive character.

The recorded N-values range from 1 to 11 blows/0.3 m, showing very loose to compact relative density, or a very soft to stiff consistency.

The measured bulk unit weight of one selected sample is 20.5 kN/m³.

4.4 Clayey Silt

Underneath the embankment fill, in Boreholes A1, A2, F1 and F2, a clayey silt deposit was encountered at depths ranging from 1.7 to 4.3 m or Elevations 238.7 to 235.5 m, with thicknesses ranging from 0.6 to 3.9 m. The lower extent of the deposit extends to the bedrock surface. This cohesive deposit generally consists of clayey silt with traces of sand and gravel. In Borehole A1, a thin layer of sandy silt with some clay was contacted within this cohesive deposit.

The following are the grain size distributions of the selected three samples retrieved from this deposit, as shown in Figure B3 in Appendix B.

Gravel:	0 – 18 %
Sand:	2 – 23 %
Silt:	41 – 73 %
Clay:	18 – 27 %

Atterberg Limits tests conducted on two representative samples from this deposit indicated the following test results, also shown in Figure B4 in Appendix B.

Liquid Limit:	22 – 24 %
Plastic Limit:	14 %
Plasticity Index:	8 – 10 %

It is noted that in Borehole A2, the top layer of this deposit (0.4 m thick) is described as silty clay and Atterberg Limits tests performed on this sample show the following results, also shown in Figure B4 in Appendix B.

Liquid Limit: 33 %

Plastic Limit: 20 %

Plasticity Index: 13 %

Based on the above results (see Figure B4 in Appendix B), the material is considered to have a low plasticity (i.e. a CL material).

Standard Penetration Tests carried out in this cohesive deposit yielded N-values ranging from 2 to in excess of 24 blows/0.3 m. Based on the SPT results, the clayey silt deposit is considered to have a soft to very stiff consistency, but generally firm to stiff.

4.5 Bedrock

The fill and/or the clayey silt are underlain by bedrock. Bedrock was encountered or inferred at all borehole locations at Elevations ranging between 235.3 and 234.7 m. As presented on the individual Record of Borehole Sheets in Appendix A and also in Table 4.1 below, the presence of bedrock was inferred from refusal to augering in Boreholes F1, F4, A1 and A2, while in Boreholes F2, F3, F5 and F6, the rock was proven, after auger refusal, by diamond drilling and obtaining cores of the rock by NQ coring.

Table 4.1 – Bedrock Level Observations

Borehole No.	Ground (Road) Surface Elevation	Depth below Ground Surface/Elevation of the Bedrock Surface	TCR *	RQD **
	(m)	(m)	(%)	(%)
F1	239.8	4.9 / 234.9 ***	N/A	N/A
F2	239.8	5.1 / 234.7	94 - 100	83 - 92
F3	239.1	4.0 / 235.1	89	64
F4	239.1	4.4 / 234.7 ***	N/A	N/A
F5	239.9	5.2 / 234.7	93 - 100	91 - 100
F6	239.0	4.3 / 234.7	97	90
A1	240.4	5.6 / 234.8 ***	N/A	N/A

Borehole No.	Ground (Road) Surface Elevation	Depth below Ground Surface/Elevation of the Bedrock Surface	TCR *	RQD **
	(m)	(m)	(%)	(%)
A2	238.8	3.5 / 235.3 ***	N/A	N/A

* TCR = Total Core Recovery

** RQD = Rock Quality Designation

*** Inferred bedrock depth/elevation (no coring)

From the table presented above, the surface of the bedrock appears to be relatively flat, exhibiting an elevation difference of 0.6 m (i.e. between Elevations 235.3 and 234.7 m) at the borehole locations. It should however be pointed out that the surface of the bedrock may be different at other locations than at the boreholes, especially within the creek bed where it may be lower due to scour. From the rock cores, the bedrock is described as a light grey, slightly weathered, fine grained dolostone/limestone. As mentioned before, from the published information, the bedrock in this area is known to consist of dolostones, limestones with sandstone and shale and some siltstone gypsum and salt inclusions, and belongs to the Middle Ordovician Period (i.e. approximately 430 million years old).

The Total Core Recovery (TCR) measured in the rock cores ranged from 89 to 100% and Rock Quality Designation (RQD) values of 64 to 100% were recorded. Based on these values, the rock mass quality can be described as fair to excellent but typically good to excellent. Unconfined Compression tests were performed on two selected rock core samples from Boreholes F2 and F3 and the tests yielded Unconfined Compression Strength (UCS) values of 50 MPa (Borehole F2) and 148 MPa (Borehole F3). These results indicate that the rock can be classified as being generally strong to very strong, according to the International Society of Rock Mechanics (ISRM) classification.

4.6 Groundwater Conditions

Groundwater levels were observed in the open boreholes while drilling and upon completion of each borehole. Standpipe piezometers were installed in each of Boreholes F1 and F4. The observations made in the boreholes are shown on the individual Record of Borehole Sheets in Appendix A, and are summarized in the following Table 4.2.

Table 4.2 – Groundwater Level Observations

Borehole No.	Depth/Elevation of the Tip of Piezometer (m)	Date of Water Level Measurement	Measured Water Level Depth/Elevation (m)	Comments
F1	4.9 / 234.9 piezometer installed	Dec. 14, 2011 (completion) Dec. 15, 2011	No water observed * 2.4 / 237.4	First reading measured just after installing piezometer; the second reading one day thereafter.
F2	-	Dec. 14, 2011 (completion)	5.1 / 234.7 *	Measured upon borehole completion of overburden drilling, before coring.
F3	-	Dec. 14, 2011 (completion)	4.0 / 235.1 **	Wet cave-in depth measured upon completion of overburden drilling, before coring.
F4	4.4 / 234.7 piezometer installed	Dec. 14, 2011 (completion) Dec. 15, 2011	No water observed * 2.5 / 236.6	First reading measured just after installing piezometer; the second reading one day thereafter.
A1	-	Dec. 13, 2011 (completion)	No water observed *	Measured upon borehole completion.
A2	-	Dec. 13, 2011 (completion)	No water observed *	Measured upon borehole completion.

* Groundwater level measured not stabilized

** Cave-in depth measured

Based on the above observations and in particular the measurements conducted in the standpipe piezometers installed in Boreholes F1 and F4, which are believed to represent the stabilized groundwater conditions at the time of our investigation, in general, the groundwater table at the site at the time of our investigation was about 2 to 3.5 m below the existing highway surface level or between about Elevations 238 and 236 m. The water level measured in the Spencer Creek on November 01, 2011 was at Elevation 235.5 m.

It should be noted that groundwater levels are subject to variations due to the influence of rainfall, temperature, local drainage, seasons and other factors. There may also be potential for the development of perched groundwater following periods of rainfall and groundwater may rise up to or within pavement granular fill. In addition, the water level in the watercourse would influence the groundwater level at the site.

For and on behalf of Coffey Geotechnics Inc.



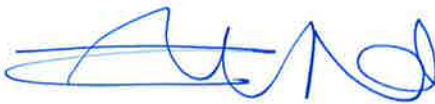
Sanket Shah, B.Eng., E.I.T.

Engineer-in-Training



Ramon Miranda, P.Eng.

Principal

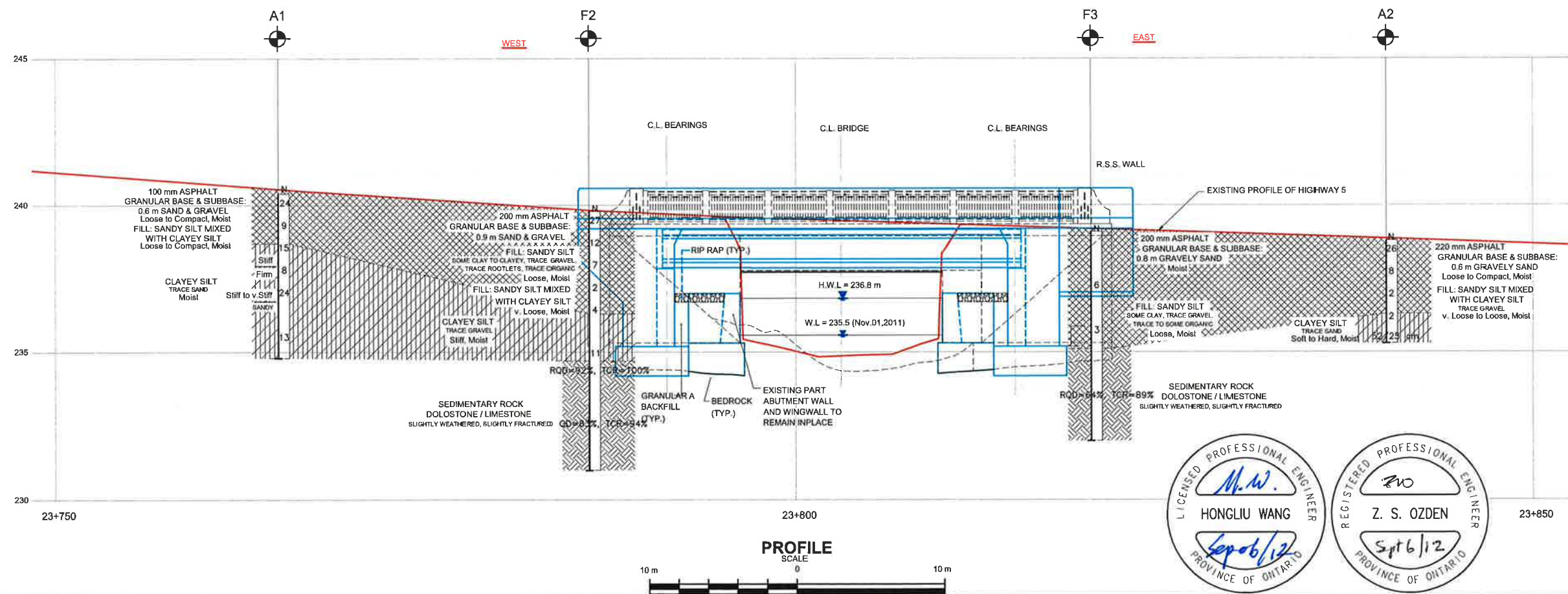
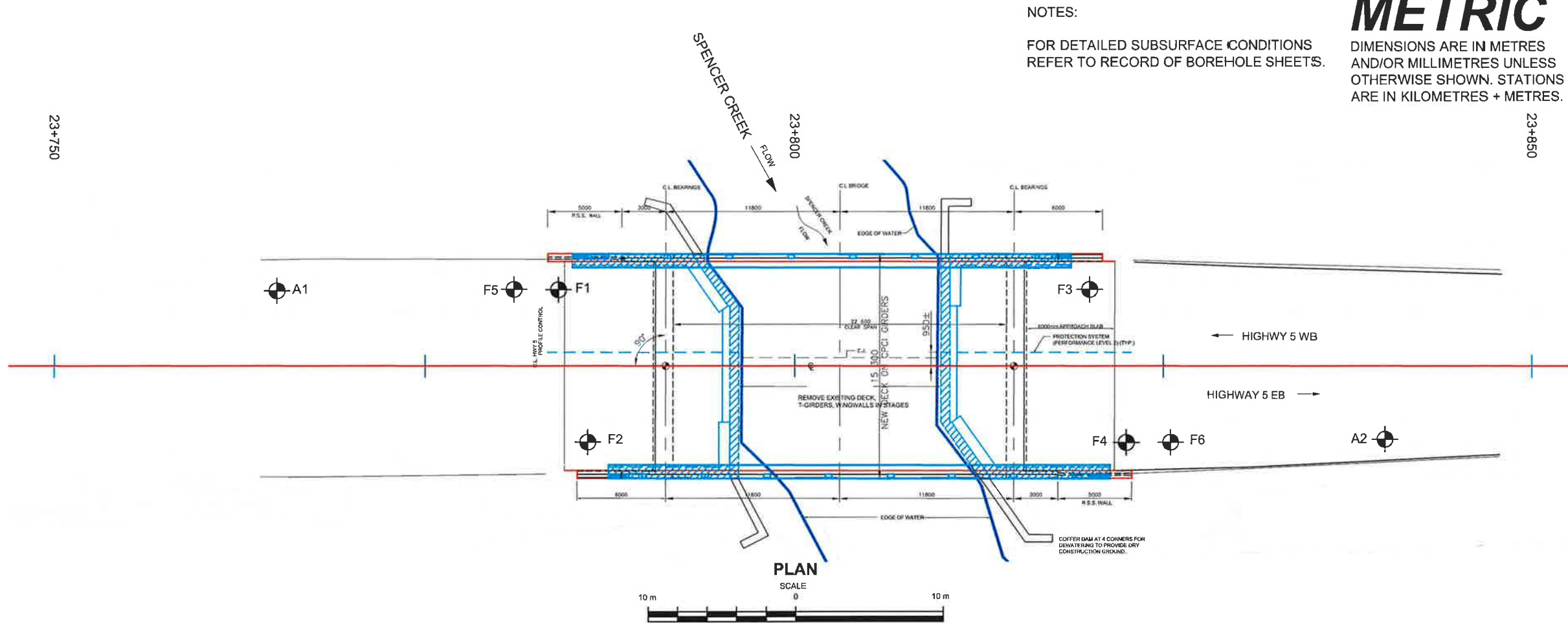


Zuhtu Ozden, P.Eng.

Senior Principal

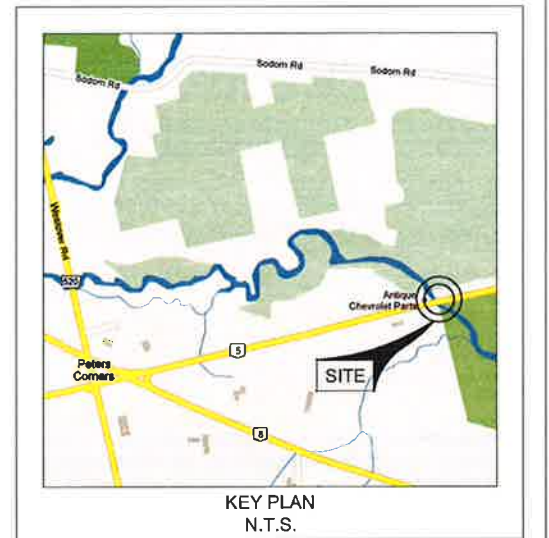


Drawings



CONT No. - GWP: 2174-08-00	SHEET
SPENCER CREEK BRIDGE REPLACEMENT HIGHWAY 5 BOREHOLE LOCATION PLAN AND SOIL STRATA	

coffey geotechnics
SPECIALISTS MANAGING THE EARTH



LEGEND			
	Borehole & Cone		
	Blows/0.3m (Std. Pen. Test), 475 J/blow		
	Water Level at Time of Investigation (W. L. NOT STABILIZED)		
	Water Level in Piezometer		
	Piezometer		
No.	ELEVATION	EASTING	NORTHING
A1	240.4	259867.3	4793823.1
A2	238.8	259942.8	4793828.5
F1	239.8	259865.9	4793827.1
F2	239.8	259889.9	4793817.3
F3	239.1	259921.1	4793834.4
F4	239.1	259925.7	4793824.8
F5	239.9	259882.9	4793826.5
F6	239.0	259928.6	4793825.4

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

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

REVISIONS	DATE	BY	DESCRIPTION

Geocres No. 30M5-282			
TRANETOB11558AA			
SUBMD	CHECKED	DATE Feb.10, 2012	SITE -
DRAWN	SSH	CHECKED RM	APPROVED ZO DWG 1



Appendix A

Record of Borehole Sheets and Rock Core Photographs

TRANETOB11558AA: Spencer Creek Bridge

RECORD OF BOREHOLE No A1

1 OF 1

METRIC

GWP G.W.P 2174-08-00 LOCATION Station 23+765, 5.1 m Lt C/L of Highway 5 (N 4793823.1, E 259867.3) ORIGINATED BY AS
 DIST HWY 5 BOREHOLE TYPE Solid Stem Auger COMPILED BY SK
 DATUM Geodetic DATE 12/13/2011 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
240.4	GROUND SURFACE													
0.0	100 mm ASPHALT													
239.7	GRANULAR BASE: 0.2 m Sand and Gravel some silt, brown, loose to compact, moist		1	SS	24		240							40 47 (13)
0.7	GRANULAR SUBBASE: 0.4 m Sand, some gravel, some silt brown, loose to compact, moist		2	SS	9									
238.7	FILL: Sandy Silt mixed with clayey silt brown, loose to compact, moist		3	SS	15		239							
1.7			4	SS	8		238							1 8 64 27
	CLAYEY SILT tr. sand, brown, moist	stiff firm	5	SS	24		237							
		stiff to v. stiff sandy	6	SS	13		236							
234.8	brown to dk. brown						235							
5.6	End of Borehole Auger refusal @ 5.6 m probably on bedrock Borehole dry (not stabilized)* and open upon completion													

+ 3, x 3 : Numbers refer to
Sensitivity

20
15 10 5
(%) STRAIN AT FAILURE

TRANETOB11558AA: Spencer Creek Bridge

1 OF 1

METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)	WATER CONTENT (%)				
							20 40 60 80 100	20 40 60 80 100					
238.8 0.0	GROUND SURFACE 220 mm ASPHALT		1	SS	26								
238.0 0.8	GRANULAR BASE: 0.15 m Gravelly Sand brown, loose to compact, moist GRANULAR SUBBASE: 0.4 m Sand, some gravel, tr. to some silt brown, loose to compact, moist		2	SS	8								
236.3 2.5	FILL: Sandy Silt mixed with clayey silt tr. gravel brown, v. loose to loose, moist some org. greyish black silty clay		3	SS	2								
235.3 3.5	CLAYEY SILT tr. sand greyish black to grey, soft to hard, moist		4	SS	2								
235.3 3.5	End of Borehole Auger refusal @ 3.5 m probably on bedrock Borehole dry (not stabilized)* and open upon completion		5	SS	52/25.0 cm								

(%) STRAIN AT FAILURE

TRANETOB11558AA: Spencer Creek Bridge

RECORD OF BOREHOLE No F1

1 OF 1

METRIC

GWP G.W.P 2174-08-00 LOCATION Station 23+784, 5.2 m Lt C/L of Highway 5 (N 4793827.1, E 259885.9) ORIGINATED BY AS
 DIST HWY 5 BOREHOLE TYPE Solid Stem Auger COMPILED BY SK
 DATUM Geodetic DATE 12/14/2011 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
FLEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
239.8 0.0	GROUND SURFACE													
	240 mm ASPHALT		1	SS	33		239							42 45 (13)
	GRANULAR BASE: 0.15 m Sand and Gravel some silt, brown, loose to compact, moist													
238.7 1.1	GRANULAR SUBBASE: 0.7 m Sand, tr. to some gravel, some silt brown, loose to compact, moist		2	SS	15									
	FILL: Sandy Silt mixed with clayey silt tr. gravel, tr. org. brown, v. loose to compact, moist		3	SS	5		238							1 30 51 18
			4	SS	1		237							
	org. silt some rootlets greyish black		5	SS	1		236							
235.5 4.3	CLAYEY SILT													
234.9 4.9	some sand to sandy, tr. gravel brown, stiff to hard, moist		6	SS	59/15 cm		235							18 23 41 18
	End of Borehole Auger refusal @ 4.9 m on bedrock Piezometer installed to 4.9 m Water level Records: Dec 14, 2011 dry Dec 15, 2011 2.4 m													Spoon bouncing @ 4.9 m

+ 3 x 3 Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

TRANETO11558AA: Spencer Creek Bridge

RECORD OF BOREHOLE No F2

1 OF 1

METRIC

GWP G.W.P. 2174-08-00 LOCATION Station 23+786, 5.2 m Rt C/L of Highway 5 (N 4793817.32, E 259889.93) ORIGINATED BY AS
 DIST HWY 5 BOREHOLE TYPE Hollow Stem Auger, NQ Coring, NW Casing COMPILED BY SK
 DATUM Geodetic DATE 12/14/2011 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR. X LAB VANE				
239.8	GROUND SURFACE							20 40 60 80 100		10 20 30		GR SA SI CL
0.0	200 mm ASPHALT GRANULAR BASE: 0.2 m Sand and Gravel brown, loose to compact, moist GRANULAR SUBBASE: 0.7 m Sand, tr. to some gravel, some silt brown, loose to compact, moist		1	SS	27		239					7 79 (14)
238.7			2	SS	12							
1.1	FILL: Sandy Silt some clay to clayey tr. gravel, tr. rootlets, tr. org. brown, loose, moist		3	SS	7		238					5 28 48 19
237.5												
2.3	FILL: Sandy Silt mixed with clayey silt tr. gravel, tr. rootlets, tr. org. brown, v. loose, moist		4	SS	2		237					
	black, some org.		5	SS	4							
236.3							236					
3.5												
	CLAYEY SILT tr. gravel, grey, stiff, moist		6	SS	11		235					0 2 73 25 NQ Coring started @ 5.1 m
234.7			7	RC RQD=92% TCR=100%			234					UCS = 50.5 MPa
5.1	SEDIMENTARY BEDROCK dolostone / limestone light grey, slightly weathered slightly fractured						233					
			8	RC RQD=83% TCR=94%			232					
231.0							231					
8.8	End of Borehole Water level @ 5.1 m (not stabilized)* upon completion.											

+³, X³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

TRANETOB11558AA: Spencer Creek Bridge

RECORD OF BOREHOLE No F3

1 OF 1

METRIC

GWP G.W.P 2174-08-00 LOCATION Station 23+820.5, 5.2 m Lt C/L of Highway 5 (N 4793834.44, E 259921.1) ORIGINATED BY AS
DIST 5 HWY 5 BOREHOLE TYPE Hollow Stem Auger, NQ Coring, NW Casing COMPILED BY SK
DATUM Geodetic DATE 12/14/2011 CHECKED BY ZO

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			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
239.1 0.0	GROUND SURFACE						239							
238.1 1.0	200 mm ASPHALT GRANULAR BASE: 0.2 m Gravelly Sand brown, moist GRANULAR SUBBASE: 0.6 m Sand, some gravel, some silt brown, moist						238							
	FILL: Sandy Silt some clay, tr. gravel tr. to some org. brown, loose, moist		1	SS	6		237						12 34 38 16	
	org. silt some sand tr. rootlets black, some peat, v. loose		2	SS	3		236							
235.1 4.0	SEDIMENTARY BEDROCK dolostone / limestone light grey, slightly weathered moderately fractured		3	RCRQD=64% TCR=89%			235							NQ Coring started @ 4.0 m
							234							UCS = 148 MPa
							233							
232.0 7.1	End of Borehole Wet cave @ 4.0 m upon completion.						232							

+³, X³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

TRANETO11558AA: Spencer Creek Bridge

RECORD OF BOREHOLE No F4

1 OF 1

METRIC

GWP G.W.P 2174-08-00 LOCATION Station 23+822.5, 5.2 m Rt C/L of Highway 5 (N 4793824.8, E 259925.7) ORIGINATED BY AS
DIST HWY 5 BOREHOLE TYPE Solid Stem Auger COMPILED BY SK
DATUM Geodetic DATE 12/14/2011 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
239.1 0.0	GROUND SURFACE													
238.1 1.0	210 mm ASPHALT GRANULAR BASE: 0.2 m Sand and Gravel some silt, brown, compact to dense, moist GRANULAR SUBBASE: 0.6 m Sand, some gravel, some silt brown, compact to dense, moist		1	SS	36		239							41 46 (13)
			2	SS	11		238						20.5	
	FILL: Sandy Silt mixed with clayey silt tr. gravel, tr. org. brown, soft to firm / v. loose to loose, moist		3	SS	6		237							15 20 51 14
			4	SS	3		236							
	some org. black tr. rootlets		5	SS	6		235							
234.7 4.4	End of Borehole Auger refusal @ 4.4 m on bedrock Piezometer installed to 4.4 m Water level Records: Dec 14, 2011 dry Dec 15, 2011 2.5 m													

TRANETOB11558AA: Spencer Creek Bridge

RECORD OF BOREHOLE No F5

1 OF 1

METRIC

GWP G.W.P 2174-08-00 LOCATION Station 23+781, 5.2 m Lt C/L of Highway 5 (N 4793826.49, E 259882.92) ORIGINATED BY AS
DIST HWY 5 BOREHOLE TYPE Hollow Stem Auger, NQ Coring, NW Casing COMPILED BY SK
DATUM Geodetic DATE 12/14/2011 CHECKED BY ZO

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	● POCKET PENETR						× LAB VANE		
239.9	GROUND SURFACE																	
0.0																		

METRIC

(%) STRAIN AT FAILURE

BOREHOLE F2 RC7



BOREHOLE F2 RC8



BOREHOLE F3 RC3



BOREHOLE F5 RC1



BOREHOLE F5 RC2



BOREHOLE F6 RC1



Appendix B

Laboratory Test Results

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT			SAND			GRAVEL		
			Fine	Medium	Coarse	Fine	Coarse	

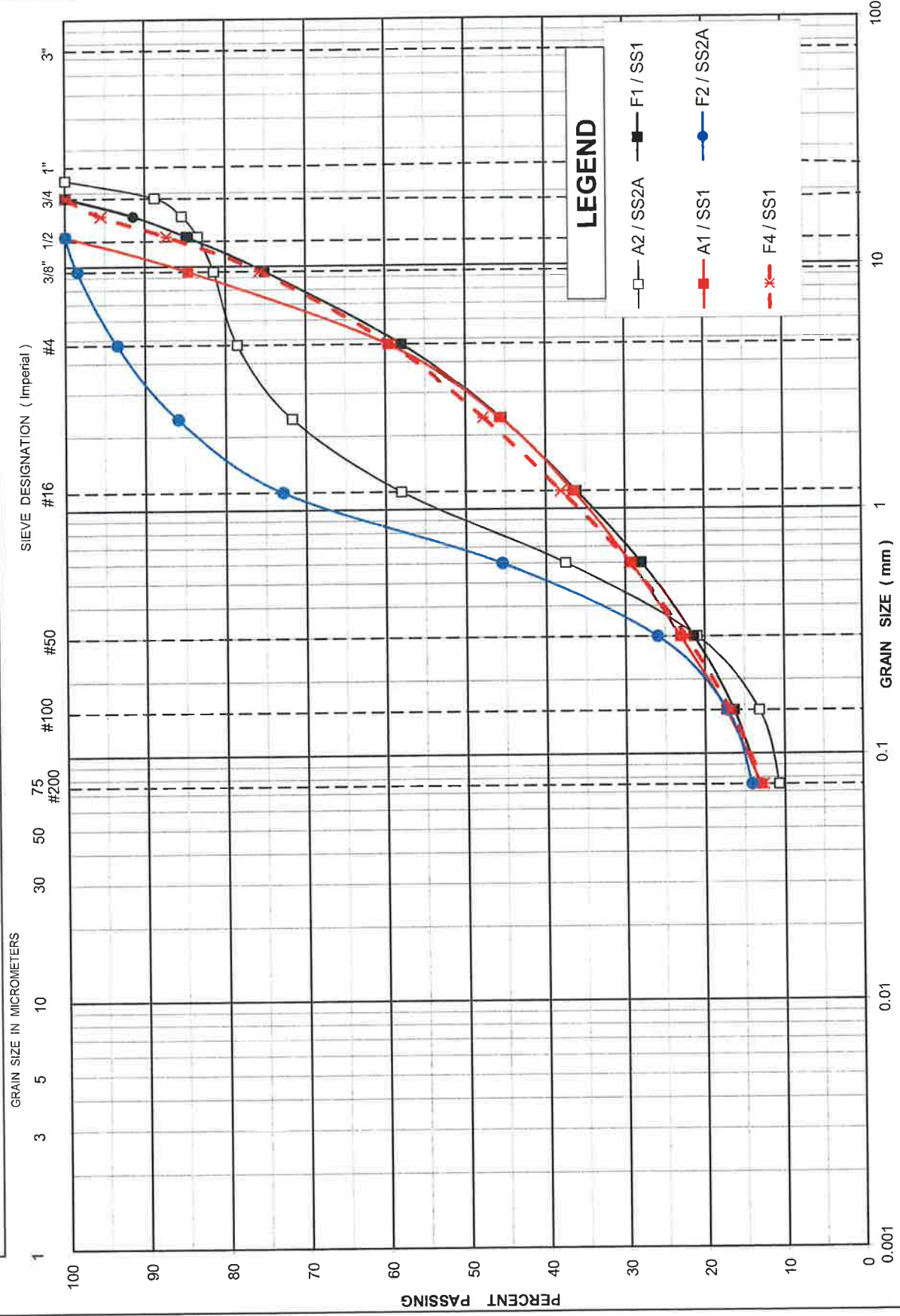


FIGURE NO.: B1

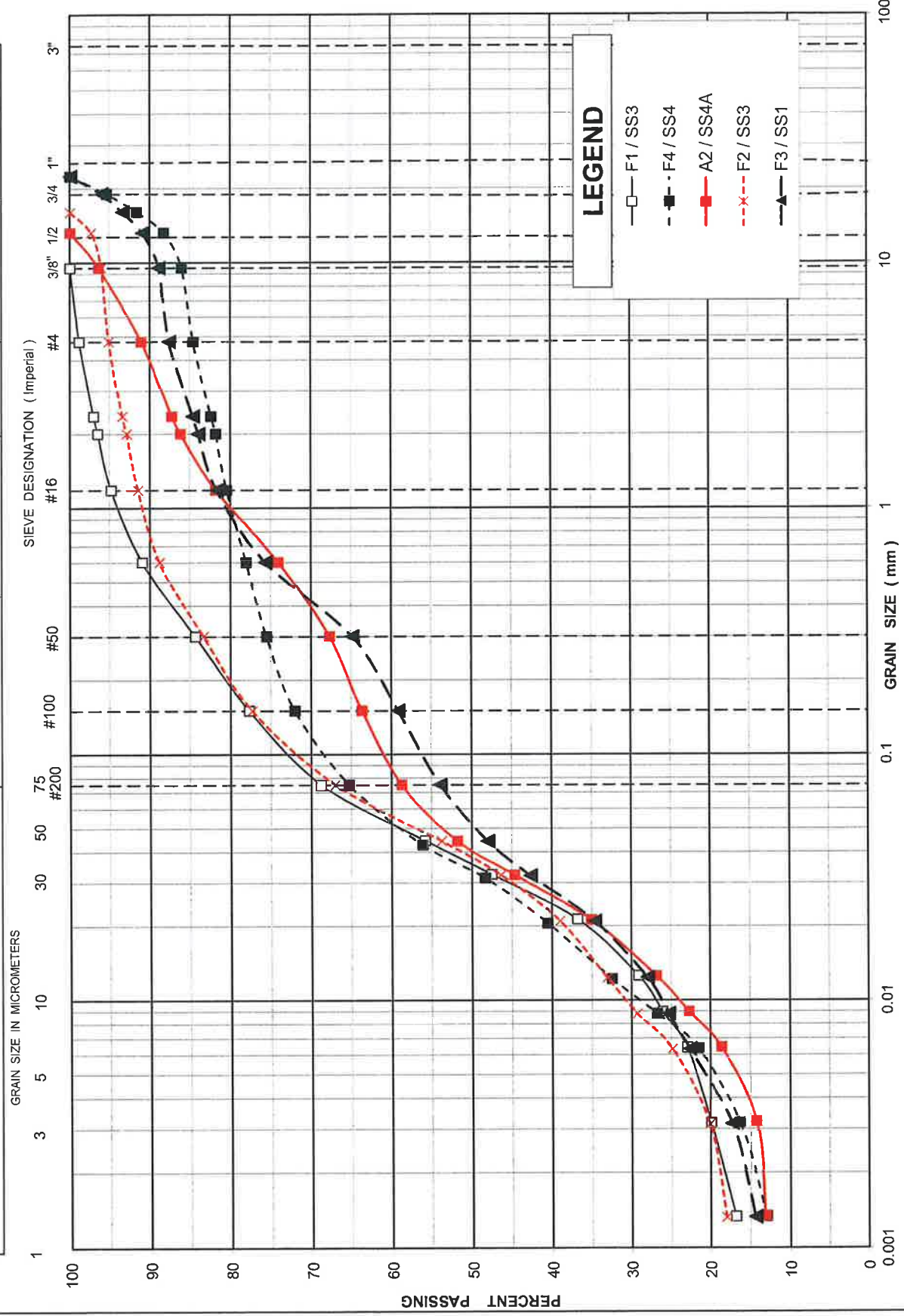
PROJECT NO: TRANETOB11558AA

DATE: Jan, 2012

GRAIN SIZE DISTRIBUTION
PAVEMENT GRANULAR FILL

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT			SAND			GRAVEL		
			Fine	Medium	Coarse	Fine	Coarse	



CLAY AND SILT	SAND		GRAVEL	
	Fine	Medium	Coarse	Coarse



coffey geotechnics
SPECIALISTS MANAGING THE EARTH

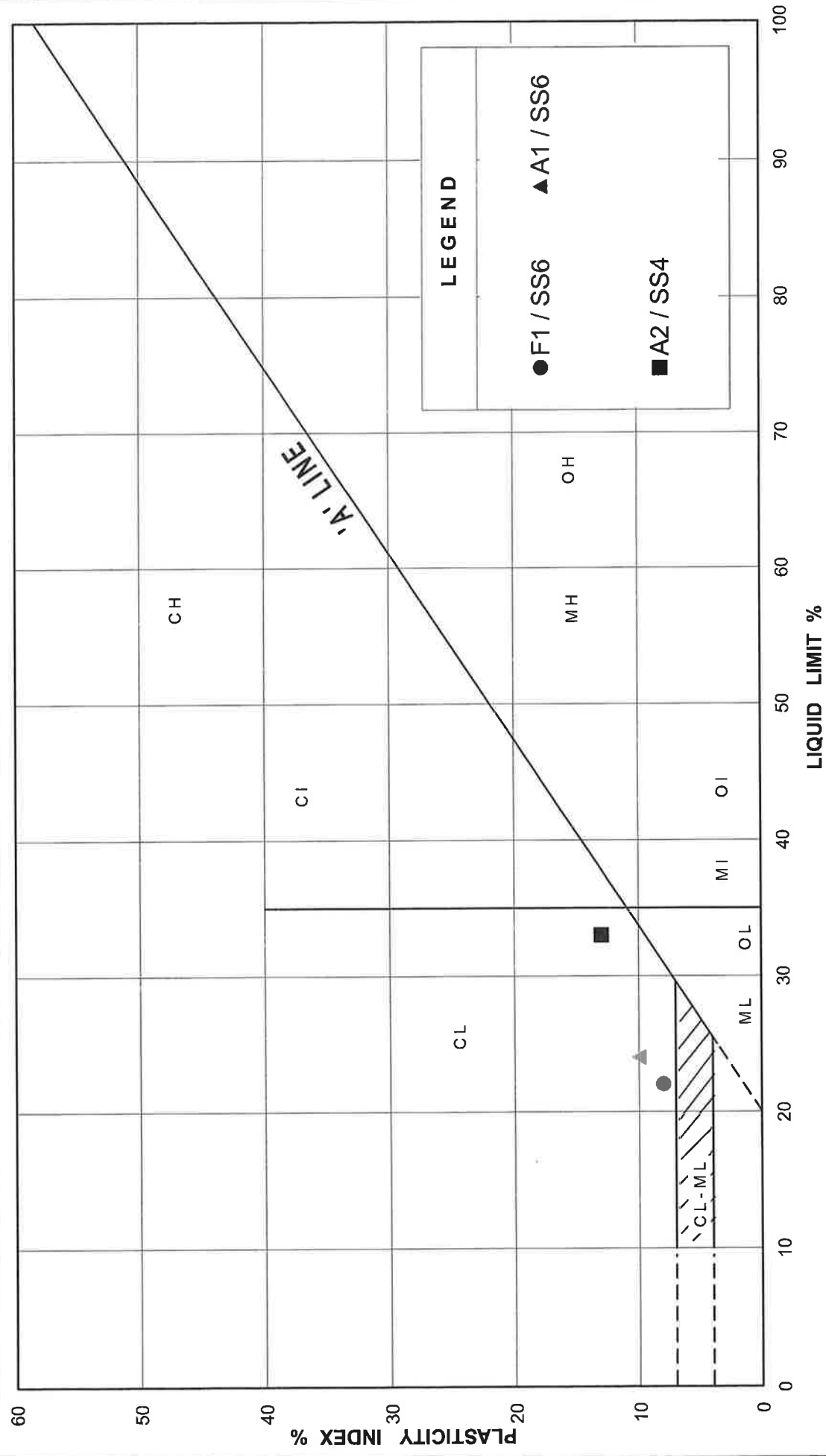


FIGURE No. B4

REF. No. TRANETOB11558AA

DATE Jan 2012

PLASTICITY CHART

CLAYEY SILT

UNCONFINED COMPRESSION TEST (UC)
ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	12-1183-0004	SAMPLE NUMBER	8
BOREHOLE NUMBER	F2	SAMPLE DEPTH, m	6.14-6.33

TEST CONDITIONS

MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST, min	>2 <15	L/D	2.46

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	11.64	WATER CONTENT, (specimen) %	0.15
SAMPLE DIAMETER, cm	4.74	UNIT WEIGHT, kN/m ³	26.64
SAMPLE AREA, cm ²	17.63	DRY UNIT WT., kN/m ³	26.60
SAMPLE VOLUME, cm ³	205.23	SPECIFIC GRAVITY, assumed	2.80
WET WEIGHT, g	557.75	VOID RATIO	0.03
DRY WEIGHT, g	556.90		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	50.5
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REMARKS:

DATE:

1/10/2012

Checked By: *ML*

Golder Associates

FIGURE NO.: B5

UNCONFINED COMPRESSION TEST (UC)
ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	12-1183-0004	SAMPLE NUMBER	3
BOREHOLE NUMBER	F3	SAMPLE DEPTH, m	5.13-5.31

TEST CONDITIONS

MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST, min	>2 <15	L/D	2.46

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	11.75	WATER CONTENT, (specimen) %	0.11
SAMPLE DIAMETER, cm	4.78	UNIT WEIGHT, kN/m ³	26.94
SAMPLE AREA, cm ²	17.93	DRY UNIT WT., kN/m ³	26.91
SAMPLE VOLUME, cm ³	210.61	SPECIFIC GRAVITY, assumed	2.80
WET WEIGHT, g	578.70	VOID RATIO	0.02
DRY WEIGHT, g	578.04		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	148.1
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REMARKS:

DATE:

1/10/2012

Checked By: *[Signature]*

Golder Associates

FIGURE NO.: B6

Appendix C

Site Photographs



Photograph 1. Existing Spencer Creek Bridge (looking east)



Photograph 2. Existing Spencer Creek Bridge (looking west)



Photograph 3. Existing Spencer Creek Bridge (looking northwest from south side)



Photograph 4. Existing Spencer Creek Bridge (East Abutment - looking north from south side)

Appendix D

Explanation of Terms Used in Report

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

C_u (kPa)	0 – 12	12 – 25	25 – 50	50 – 100	100 – 200	>200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

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

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

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

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

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

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

JOINT AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICALL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

P_s	kg/m ³	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
j_s	kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
P_w	kg/m ³	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
j_w	kN/m ³	UNIT WEIGHT OF WATER	s_r	%	DEGREE OF SATURATION	D_n	mm	N PERCENT – DIAMETER
P	kg/m ³	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
j	kN/m ³	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
P_d	kg/m ³	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m ³ /s	RATE OF DISCHARGE
j_d	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $(W_L - W_p) / I_p$	v	m/s	DISCHARGE VELOCITY
P_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $(W - W_p) / I_p$	i	1	HYDAULIC GRADIENT
j_{sat}	kN/m ³	UNIT WEIGHT OF SATURATED SOIL	I_c	1	CONSISTENCY INDEX = $(W_L - W) / 1_p$	k	m/s	HYDRAULIC CONDUCTIVITY
P'	kg/m ³	DENSITY OF SUBMERED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m ³	SEEPAGE FORCE
j'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						