

# DRAFT FOUNDATION INVESTIGATION AND DESIGN REPORTS

PROPOSED CULVERT REPLACEMENT

CULVERT NO: CV-0002-0007-0001

HIGHWAY 7, DURHAM, ONTARIO

GEOCRES NO.

G.W.P. 2051-14-00

**WSP Project No.: 141-54753-00 (SPL No. 10000161)-2**  
**May 9, 2016**

© 2016 WSP Canada Inc.



# DRAFT REPORT ON FOUNDATION INVESTIGATION

PROPOSED CULVERT REPLACEMENT  
HIGHWAY 7, DURHAM, ONTARIO

CULVERT NO: CV-0002-0007-0001  
G.W.P. 2051-14-00

**Prepared For:**  
**D.M.Wills Associates Ltd**  
150 Jameson Drive, Peterborough ON K9J 0B9

WSP Project No: 141-54753-00 (SPL No. 10000161)-2  
Date: May 9, 2016

---

**WSP Canada Inc.**  
51 Constellation Court  
Toronto, ON M9W 1K4 Canada

Phone: +1 416-798-0065  
Fax: +1 416-798-0518  
**[www.wspgroup.com](http://www.wspgroup.com)**



# TABLE OF CONTENTS

<b>1</b>	<b>INTRODUCTION.....</b>	<b>1</b>
<b>2</b>	<b>GEOLOGICAL SETTING AND SITE DESCRIPTION .....</b>	<b>1</b>
2.1	GEOLOGICAL SETTING .....	1
2.2	PREVIOUS GROUND INVESTIGATIONS.....	1
2.3	SITE DESCRIPTION .....	2
<b>3</b>	<b>FIELD AND LABORATORY INVESTIGATIONS.....</b>	<b>2</b>
3.1	FIELD INVESTIGATIONS .....	2
3.2	LABORATORY INVESTIGATIONS.....	4
<b>4</b>	<b>SUBSURFACE CONDITIONS.....</b>	<b>5</b>
4.1	GENERAL .....	5
4.2	OVERVIEW.....	5
4.3	SUBSOIL CONDITIONS .....	6
4.3.1	TOPSOIL .....	6
4.3.2	PAVEMENT STRUCTURE .....	6
4.3.2.1	ASPHALT PAVEMENT .....	6
4.3.3.1	GRANULAR PAVEMENT FILL .....	6
4.3.3.2	EMBANKMENT FILL (UPPER) – SAND / SILTY SAND TO SILTY SANDY GRAVEL .....	7
4.3.3.3	EMBANKMENT FILL (LOWER) – CLAYEY SILT / SILTY CLAY FILL .....	7
4.3.4	CLAYEY SILT TILL .....	8
4.3.5	SILTY SAND/SANDY SILT TILL .....	10
<b>4.4</b>	<b>GROUNDWATER OBSERVATIONS.....</b>	<b>10</b>

## **DRAWING 1**

## **APPENDIX A: RECORD OF BOREHOLE SHEETS**

## **APPENDIX B: LABORATORY TEST RESULTS**

## **APPENDIX C: SITE PHOTOGRAPHS**

# **LIST OF TABLES**

TABLE 2-1 DETAILS OF CULVERT (CV-0002-0007-0001) UNDER HWY. 7 (BASED ON GA BY D.M.WILLS).....	2
TABLE 3-1 BOREHOLE DETAILS* .....	3
TABLE 3. 2 MONITORING WELL INSTALLATION DETAILS .....	4
TABLE 4-1 GRAIN SIZE DISTRIBUTION SUMMARY - PAVEMENT FILL .....	6
TABLE 4-2 GRAIN SIZE DISTRIBUTION SUMMARY - EMBANKMENT FILL (UPPER).....	7
TABLE 4-3 GRAIN SIZE DISTRIBUTION SUMMARY – EMBANKMENT FILL (LOWER) - CLAYEY SILT FILL ** .....	8
TABLE 4-4 GRAIN SIZE DISTRIBUTION SUMMARY - CLAYEY SILT TILL .....	9
TABLE 4-5 ATTERBERG LIMITS TEST RESULTS - CLAYEY SILT .....	9
TABLE 4-7 SUMMARY OF GROUNDWATER OBSERVATIONS .....	11

**DRAFT**  
**FOUNDATION INVESTIGATION REPORT**  
**PROPOSED CULVERT REPLACEMENT AT STATION**  
**Culvert No: CV-0002-0007-0001**  
**HIGHWAY 7, Durham, Ontario, G.W.P. 2051-14-00**

## 1 INTRODUCTION

WSP Canada Inc. (WSP), formerly SPL Consultants Ltd., was retained by D. M. Wills Associates Ltd. (Wills) to carry out foundation investigations to provide necessary geotechnical information and recommendations to replace the existing 1840 mm x 1410 mm open frame concrete culvert. This structure is located under on Highway 7, 1140 m east of the York Durham Line Interchange. This structure (Culvert No: CV-0002-0007-0001) is located within the Regional Municipality of Durham, and is under the jurisdiction of the Central Region of the Ministry of Transportation (MTO). This forms a part of four (4) non-structural culvert investigations that have been investigated by WSP under the present commission.

This report initially presents factual information concerning the subsurface conditions based on all the subsurface information at hand and is followed by an engineering discussion and recommendations for the replacement of the captioned culvert. WSP was informed by Wills that the replacement culvert will be a concrete rigid frame box (RFB) culvert, as shown on Drawing 1 (as per the General Arrangement (GA) Drawing prepared by Wills, dated March 23, 2016).

## 2 GEOLOGICAL SETTING AND SITE DESCRIPTION

### 2.1 GEOLOGICAL SETTING

According to Quaternary Geology of the Toronto and Surrounding Area Map (P2204; scale: 1:100 000), the project site lies within the Glacial ice deposits (Young Till), which has been characterized mainly as a clayey silt till and sandy silt till. According to the Bedrock geology of Ontario-Southern sheet (MNDM 2544, Scale 1:1 000 000), bedrock underlying the site comprises the Georgian Bay Formation (Shale, Limestone, Dolostone and Siltstone) from the Upper Ordovician.

### 2.2 PREVIOUS GROUND INVESTIGATIONS

We have not been able to locate any prior Foundation Investigation and Design Report at the subject site in the MTO Geocres library listings. However, Geocres 30M14-258 at Hwy 407/ Regional Road 30 underpass, located about 1.5 km south of this site, indicated that the interchange site is generally underlain by stiff to hard clayey silt to silty clay till deposit, extending to depths of about 1.5 m, which is further underlain by compact to very dense silty sand / sandy silt till. The measured groundwater level was varying from about 2.5 m to 6.5 m below existing ground surface at the underpass site.

## 2.3 SITE DESCRIPTION

The key plan of site location is shown on Drawing 1. The culvert site lies on a straight section of the highway visually on a fairly flat vertical alignment of the road. Farming nature of the surrounding landscape is observed in Photographs 1 to 8 (all photographs are in **Appendix C**) which give a general impression of the landscape including the conditions at the culvert ends. This is a 2-lane Highway with partially paved shoulders.

During our field investigation (March 14, 2016), it was observed that water flow in the inlet face of the culvert was slightly obstructed by a tree (see photo no. 7).

At this culvert site, the road embankment is approximately 3.7 m high and of Elevation 188.0 m on the road centerline (based on the GA drawing, by Wills). The side slopes of the road embankment at the culvert's inlet and outlet are approximately 1.9 H:1V and 2.7 H:1V (based on the GA drawing) respectively.

The water levels in the creek at the inlet and outlet ends were about 400 mm deep on May 6, 2016.

The geometry details of the existing and proposed culverts are given in **Table 2-1**.

**Table 2-1 Details of Culvert (CV-0002-0007-0001) under Hwy. 7 (Based on GA by D.M.Wills)**

	Existing Culvert	Proposed Culvert
<b>Culvert Type</b>	<b>Open Frame Concrete</b>	<b>Box Frame Concrete</b>
<b>Size (m)</b>	1840 mm x 1410mm	2400 mmx1800 mm
<b>Length (m)</b>	27.0	26.0
<b>Skew (degrees)</b>	0	0
<b>Cover on Road Centreline (m)</b>	1.6	1.4
<b>Inlet: Invert Elevation (m)</b>	184.82	184.82
<b>Outlet: Invert Elevation (m)</b>	184.73	184.73

## 3 FIELD AND LABORATORY INVESTIGATIONS

### 3.1 FIELD INVESTIGATIONS

The fieldwork undertaken by WSP consisted of carrying out four (4) boreholes and was undertaken on 14<sup>th</sup> and 15<sup>th</sup> March 2016. Table 3-1 presents the borehole details of the WSP field investigation program and the findings were used to develop the ground model. The borehole locations are shown on **Drawing 1**, following the text of the report.

Table 3-1 Borehole Details\*

BH No	Co-ordinates (m)	Ground Elevation (m)	Drilled Depth (m)	Remarks
<b>BH-16-2-1</b>	E 330779 N 4862581	187.9	9.4	NBS; Solid stem auger; sampling: auger sample/split spoon; terminated in the sandy silt till
<b>BH-16-2-2</b>	E 330767 N 4862589	187.9	9.3	SBS; Solid stem auger; sampling: auger sample/split spoon; terminated in the sandy silt till
<b>BH-16-2-3</b>	E 330772 N 4862567	185.0	10.1	Outlet side; Solid stem auger; sampling: split spoon; terminated in the sandy silt till and Dynamic Cone Penetration Test (DCPT)
<b>BH-16-2-4</b>	E 330758 N 4862590	187.2	6.7	Inlet side; Solid stem auger; sampling: split spoon; terminated in the clayey silt till

Notes\*:

1. Name of Drilling Company: Drilltech Drilling, Newmarket, Ontario
2. Type of Drilling rig Used: Rubber tired track mounted rig (MT-5 rig).
3. Drilling Supervision by: Atiqur Rahman, M.Eng., EIT; WSP staff
4. Borehole Survey: by the above WSP staff using a Differential GPS Survey Equipment made by Sokia
5. NBS - north bound shoulder; SBS – south bound shoulder
6. Co-ordinates: based on MTM NAD 83 Zone 10 coordinates

The WSP borehole drilling was carried out under full-time supervision of WSP engineering staff who directed the drilling and sampling operation, logged borehole data in accordance with MTO Soils Classification System and took custody of soil samples retrieved for subsequent laboratory testing and identification. Solid stem augers were used to advance the boreholes. The recovered soil samples were placed in labelled moisture-proof bags,

and returned to WSP's Vaughan laboratory for further assessment.

The soil stratigraphy was recorded by observing the quality and changes of augered materials which were withdrawn from the boreholes, and by sampling the soils at regular intervals of depth using a 50mm O.D. split spoon sampler, in accordance with the Standard Penetration Test (ASTM D 1586) method. This sampling method recovers samples from the soil strata, and the number of blows required to drive the sampler 300 mm depth into the undisturbed soil (SPT 'N'-values) gives an indication of the compactness condition or consistency of the sampled soil material. The SPT 'N' values are indicated on the Record of Borehole Sheets (Refer to **Appendix A**). Soil samples were visually classified in the field and later re-evaluated by a senior engineer in our laboratory.

In-situ shear vane tests were carried out within the cohesive soils when the consistency of such soils allowed to obtain an indication of the shear strength of the soil.

Field Dynamic Cone Penetration Test (DCPT) was performed in BH 16-2-3 at depths ranging between 8.23m and 10.1m below grade on March 15, 2016. The results of these tests are shown on the Record of Borehole Sheet.

Groundwater conditions in the boreholes were observed during and on completion of drilling in the open boreholes. A 50 mm monitoring well was installed in Borehole BH 16-2-1 upon its completion to enable long term groundwater monitoring, **Table 3. 2**. The rest of the boreholes were grouted using a cement/bentonite mixture as per MTO procedures. As part of the construction, the monitoring well needs to be decommissioned in accordance with Ontario Regulation 903 (amended by Ontario Regulation 372/07).

**Table 3. 2 Monitoring Well Installation Details**

BH ID	Ground Surface Elevation (m)	Borehole Bottom		Well Screen Depth Interval (m)		Well Screen Elevation Interval (m)	
		Depth (m)	Elevation (m)	From	To	From	To
BH 16-2-1	187.9	9.4	178.5	4.6	6.1	183.3	181.8

### 3.2 LABORATORY INVESTIGATIONS

Visual examination and classification were undertaken on the soil samples returned to the laboratory. A laboratory testing program consisting of natural water content tests, Atterberg Limits tests and grain size analyses, including hydrometer testing, was performed on selected, representative samples. The results of the laboratory tests are presented on the appropriate Record of Borehole Sheets in **Appendix A**, and also in **Appendix B**.



## 4 SUBSURFACE CONDITIONS

### 4.1 GENERAL

The subsurface conditions encountered at the culvert location are described in the following sections. For purposes of soil description, the MTO soil classification manual was generally followed.

**Drawing 1** at the end of the text shows a borehole location plan with a subsurface profile. It should be noted that the subsurface conditions might vary in between and beyond the borehole locations. **Drawing 1** that presents an inferred stratigraphic profile at the culvert location is based on the borehole data. The strata boundaries shown should not be interpreted as exact planes of geological change but rather as inferred transitions from one soil type to another.

The soil descriptions are based on visual and tactile observations, and complemented by the results of field and laboratory soil test results. It should be noted that the subsurface conditions and the topsoil thicknesses encountered might vary in between and beyond the borehole locations.

An overview of subsurface conditions is described below. All depths quoted are below existing ground surface. It is to be noted that based on the borehole data, the elevations (El.) reported for strata boundaries are from the shallowest occurrence to the deepest occurrence.

### 4.2 OVERVIEW

As an overview, the encountered subsurface conditions at the culvert location consisted of a pavement structure overlying an embankment fill whose upper horizon consisted of a cohesionless fill and underlain by a cohesive fill in boreholes BH16-2-1, BH16-2-2 and BH16-2-4. At borehole BH 16-2-3, no embankment fill was contacted whilst in borehole BH 16-2-4, there was a thin layer of topsoil overlying the embankment fill.

At all borehole locations, a native clayey silt till was contacted either under the embankment fill or below topsoil, and borehole BH 16-2-4 was terminated within this deposit. The remaining boreholes were terminated in an underlying sandy silt till deposit.

The native soil stratigraphy observed at this site is in broad agreement with the geological setting and what was reported in a nearby site as described under Sections 2.1 and 2.2 respectively.

The glacial tills reported in this investigation can be expected to contain cobbles and boulders in view of their mode of deposition.

The factual data presented on the Record of Borehole Sheets would govern any interpretation of the site conditions.

The following paragraphs are intended to give more detailed descriptions of the data documented on the Record of Borehole Sheets (**Appendix A**).

## 4.3 SUBSOIL CONDITIONS

### 4.3.1 TOPSOIL

Topsoil (0.45 m and 0.60 m thick) was contacted at ground surface in BH 16-2-3 and 16-2-4, and the boreholes BH 16-2-3 and 16-2-4 were in the vicinity of the outlet and inlet locations respectively. These topsoil thicknesses should not be relied upon for any quantity estimation.

Based on our experience, the thickness of topsoil could frequently vary in between and beyond borehole locations, especially in depressed areas and near watercourses.

### 4.3.2 PAVEMENT STRUCTURE

#### 4.3.2.1 ASPHALT PAVEMENT

Asphalt was contacted at the ground surface in boreholes BH16-2-1 and BH16-2-2 with thicknesses of 80 mm and 70 mm respectively overlying a granular pavement fill.

### 4.3.3 FILL

#### 4.3.3.1 GRANULAR PAVEMENT FILL

BH 16-2-1 and 16-2-2 were undertaken from the pavement shoulders of Hwy 7. A granular base (sand and gravel) with a 400 mm thickness was contacted.

The grain-size distributions of one (1) sample (BH 16-2-/AS1) from the granular base/subbase fill was determined in the laboratory and gave the grain-size distribution shown in **Table 4-1**. Based on the grain size information, the pavement fill can be classified as cohesionless soil (**SW**).

**Drawing B-1** shows that when compared to gradation specifications outlined in OPSS1010, the existing pavement granular fill material from this borehole does not meet the requirements for Granular 'A' and 'B' Type I materials.

Measured moisture contents of the pavement granular fill were reported as 6% and 9% by weight, indicative of a generally moist condition (based on two (2) samples).

As auger samples were retrieved from the pavement fill, no SPT 'N' results are available to characterise compactness.

Note that the pavement fill thickness may vary beyond the borehole locations. Further, this information will not be sufficient for quantity estimation.

**Table 4-1 Grain Size Distribution Summary - Pavement Fill**

Samples Tested	Size Fraction	% Passing by Weight	Remarks
BH 16-2-	Gravel	37%	Shown as <b>Figure B-1, Appendix B</b> ;

Samples Tested	Size Fraction	% Passing by Weight	Remarks
2/AS	Sand	49%	Summarized on the relevant Record of Borehole Sheet
	Fines (silt & clay):	14%	Based on the grain size information, the sample can be classified as cohesionless ( <b>SW</b> )

#### 4.3.3.2 EMBANKMENT FILL (UPPER) – SAND / SILTY SAND TO SILTY SANDY GRAVEL

Sand / silty sand to silty sandy gravel fill was encountered in embankment boreholes (BH 16-2-1, BH 16-2-2 and BH 16-2-4). The fill contained trace to some clay. The thickness of this layer ranged from 0.7 m to 1.8 m and the elevations of the base of the unit varied between El. 186.7 m (BH 16-2-2) and El. 184.9 m (BH 16-2-4). A thin (0.3 m thick) veneer of clayey silt fill material was sandwiched between the topsoil and embankment fill material in borehole BH 16-2-4.

The grain size distributions of two (2) samples from the embankment fill was determined in the laboratory and gave the grain size distribution shown in **Table 4-2**.

**Table 4-2 Grain Size Distribution Summary - Embankment Fill (Upper)**

Samples Tested	Size Fraction	% Passing by weight	Remarks
BH 16-2-1/SS3 BH 16-2-4/SS3	Gravel	6% to 36%	Shown as <b>Figure B-2, Appendix B</b> ;
	Sand	30% to 55%	Summarized on the relevant Record of Borehole Sheet
	Silt	28% to 30%	Based on the grain size information, the samples can be classified as cohesionless ( <b>SM/GM</b> )
	Clay	6% to 9%	

Based on the grain size information, the embankment fill (Upper) can be classified as a cohesionless soil (**SM/GM**) but depending on the amount of clay present, some cohesiveness can be expected and was confirmed by tactile observation.

The moisture content based on five (5) samples recovered from this layer ranged from 8% to 19% indicative of a moist condition.

SPT testing carried out in the boreholes gave SPT 'N' values ranging from 4 blows/300 mm to 20 blows/300 mm (based on 5 SPT results) which indicate generally a loose to compact relative density.

#### 4.3.3.3 EMBANKMENT FILL (LOWER) – CLAYEY SILT / SILTY CLAY FILL

Brown to dark brown, clayey silt to silty clay fill was encountered underlying the cohesionless embankment fill in

all boreholes except in borehole BH 16-2-3. The fill contained traces of organics, sand and gravel. A cohesionless seam was identified in borehole BH 16-2-4 towards the base of this unit. The thickness of this layer ranged from 1.5 m to 2.6 m and the elevations of the base of the unit varied between and El. 184.1 m (BH 16-2-1 and BH 16-2-2) and El. 182.7m (BH 16-2-4).

The grain size distribution of one (1) sample from this embankment fill was determined in the laboratory and gave the grain size distribution shown in **Table 4-3**.

**Table 4-3 Grain Size Distribution Summary – Embankment Fill (Lower) - Clayey Silt Fill\*\***

Samples Tested	Size Fraction	% Passing by weight	Remarks
BH 16-2-4/SS6	Gravel	27%	Shown as <b>Figure B-3, Appendix B</b> ; Summarized on the relevant Record of Borehole Sheet
	Sand	29%	
	Silt	32%	
	Clay	12%	

Note: \*\* The grading results shown above is not representative of the cohesive fill and indicative of a cohesionless seam.

The moisture content based on five (5) samples recovered from this layer ranged from 15% to 30% indicative of a moist to wet condition.

SPT testing carried out in the boreholes gave SPT 'N' values ranging from 3 blows/300 mm to 5 blows/300 mm (based on 5 SPT results) which indicate a soft to firm consistency. A Field Shear Vane Test in BH16-2-2 gave undrained shear strength of 55 kPa which indicates a stiff consistency. Thus, the fill can be described as typically of firm consistency.

#### 4.3.4 CLAYEY SILT TILL

A brown to grey, clayey silt till native deposit was contacted in all boreholes. The deposit contained trace to some sand and gravel. The thickness of this deposit varied between 2.2 m and 4.9 m and the elevations of the base of the unit varied between El. 181.8 m (BH 16-2-1) and El. 179.2 m (BH 16-2-2). BH 16-2-4 was terminated with depths of 6.7 m (El.180.5 m) in clayey silt till deposit.

The grain size distributions of five (5) samples from the till deposit were determined in the laboratory and gave the grain size distribution shown in **Table 4-4**.

**Table 4-4 Grain Size Distribution Summary - Clayey Silt Till**

Samples Tested	Size Fraction	% Passing by weight	Remarks
BH 16-2-1/SS6	Gravel	3% to 11%	Shown as <b>Figure B-4, Appendix B</b> ; Summarized on the relevant Record of Borehole Sheets
BH 16-2-2/SS6	Sand	23% to 35%	
BH 16-2-2/SS8	Silt	41% to 46%	
BH 16-2-3/SS4	Clay	12% to 26%	

An Atterberg Limits test was performed on two (2) samples from this deposit. This test indicates the following index values.

**Table 4-5 Atterberg Limits Test Results - Clayey Silt**

Samples Tested	Liquid Limit (w <sub>L</sub> ) %	Plastic Limit (w <sub>P</sub> ) %	Plasticity Index (I <sub>P</sub> ) %	Remarks
BH 16-2-1 SS7	18	12	6	Shown as <b>Figure B-4a, Appendix B</b> ; Summarized on the relevant Record of Borehole Sheets
BH 16-2-2 SS5	21	14	7	

Based on the grain size information and Atterberg limits, the soil can be classified as a cohesive soil of low plasticity (**CL-ML**).

The moisture content based on thirteen (13) samples recovered from this layer ranged from 8% to 16% indicative of a moist condition.

SPT testing carried out in the boreholes, gave SPT 'N' values ranging from 9 blows/300 mm to 33 blows/300 mm (based on 13 SPT results) which indicate a stiff to hard consistency.

The glacial till can be expected to contain cobbles and boulders in view of their mode of deposition.

#### 4.3.5 SILTY SAND/SANDY SILT TILL

A basal grey silty sand till to sandy silt till was contacted in all boreholes in which the drilling was terminated with depths ranging from 9.3 m (BH 16-2-2) to 10.1 m (BH 16-2-3), except in BH 16-2-4. The deposit contained trace to some clay and gravel. The elevations of the unit on termination varied between El. 178.5 m (BH 16-2-1 and BH 16-2-2) and El. 175.0 m (BH 16-2-3). The explored thickness of this deposit varied between 0.7 m (BH 16-2-2) and 5.5 m (BH 16-2-3).

The grain size distributions of two (2) samples from the till deposit were determined in the laboratory and gave the grain size distribution shown in **Table 4-6**.

**Table 4-6 Grain Size Distribution Summary – Silty Sand Till to Sandy Silt Till**

Samples Tested	Size Fraction	% Passing by weight	Remarks
BH 16-2-1/SS9	Gravel	8% to 14%	Shown as <b>Figure B-4, Appendix B</b> ; Summarized on the relevant Record of Borehole Sheets
BH 16-2-3/SS9	Sand	36% to 41%	
	Silt	34% to 41%	
	Clay	11% to 15%	

The grading results shown above indicate the deposit to be generally cohesionless (SM/ML) but depending on the amount of clay present, some cohesiveness can be expected and was confirmed by tactile observation.

Moisture content based on seven (7) samples recovered from this deposit ranged from 7% to 10% indicative of a moist condition.

SPT tests carried out gave SPT 'N' values that ranged from 18 blows/300 mm to >100 blows/300 mm (in the seating drive) (based on 7 SPT results). The recorded SPT 'N' values typically indicate a compact to very dense relative density.

DCPT testing was continued below elevation El. 176.8 m in borehole BH 16-2-3 and recorded equivalent SPT 'N' values between 30 to 100 with increasing depth.

The glacial till can be expected to contain cobbles and boulders in view of their mode of deposition.

#### 4.4 GROUNDWATER OBSERVATIONS

Groundwater levels were encountered in all boreholes and were noted upon completion of drilling. A monitoring well was installed in borehole BH 16-2-1 only. The screen was located entirely within the clayey silt till. All the water level observations are shown on the individual Record of Borehole Sheets in **Appendix A** and the observations are summarized in **Table 4-7**.

Groundwater levels measured on completion are not considered to have stabilized and may not necessarily represent the groundwater level at the site. The table below summarizes the ground water observations.

**Table 4-7 Summary of Groundwater Observations**

BH No	Ground Surface Elevation (m)	Water Level Measurements		Remarks
		Depth of water (m)	Elevation (m)	
BH-16-2-1	187.9	3.1	184.8	BH completion on 15 March 2016; Reading taken on 23 March 2016 caved-in @ 6.1 m/El. 181.8 m ; wet spoon @ 3.8 m/ El. 184.1 m
		2.7	185.2	8 April 2016
BH-16-2-2	187.9	4.3*	183.6	Upon completion: 15 March 2016; caved-in @ 8.2 m/El. 179.7 m; wet spoon @ 4.6 m/ El. 183.3 m
BH-16-2-3	185.0	0.3*	184.7	Upon completion: 15 March 2016; caved-in @ 6.1 m / El.178.9 m; wet spoon @ 0.8 m/El. 184.2 m
BH-16-2-4	187.2	0.3*	186.9	Upon completed: 14 March 2016; caved-in @ 6.1m / El.181.1 m; wet spoon @ 0.8 m/ El. 184.4 m

Note: \* Unstabilized water levels

In BH 16-2-1, the monitoring well slotted screen along with the filter pack straddled both glacial till units. Based on the monitoring well readings, it is noted that the piezometric head was about 1.1 m above clayey silt till layer, which is indicative of sub-artesian pressure.

It should be pointed out that the groundwater levels would be subject to seasonal fluctuations in response to major weather events. The groundwater levels at the site could also be influenced by the water level in the creek.

## SIGNATURES

We trust that the information contained in this foundation investigation report is satisfactory. Should you have any questions, please do not hesitate to contact this office.

**WSP Canada Inc.**



Miao Wang, MSc., EIT  
Geotechnical Department



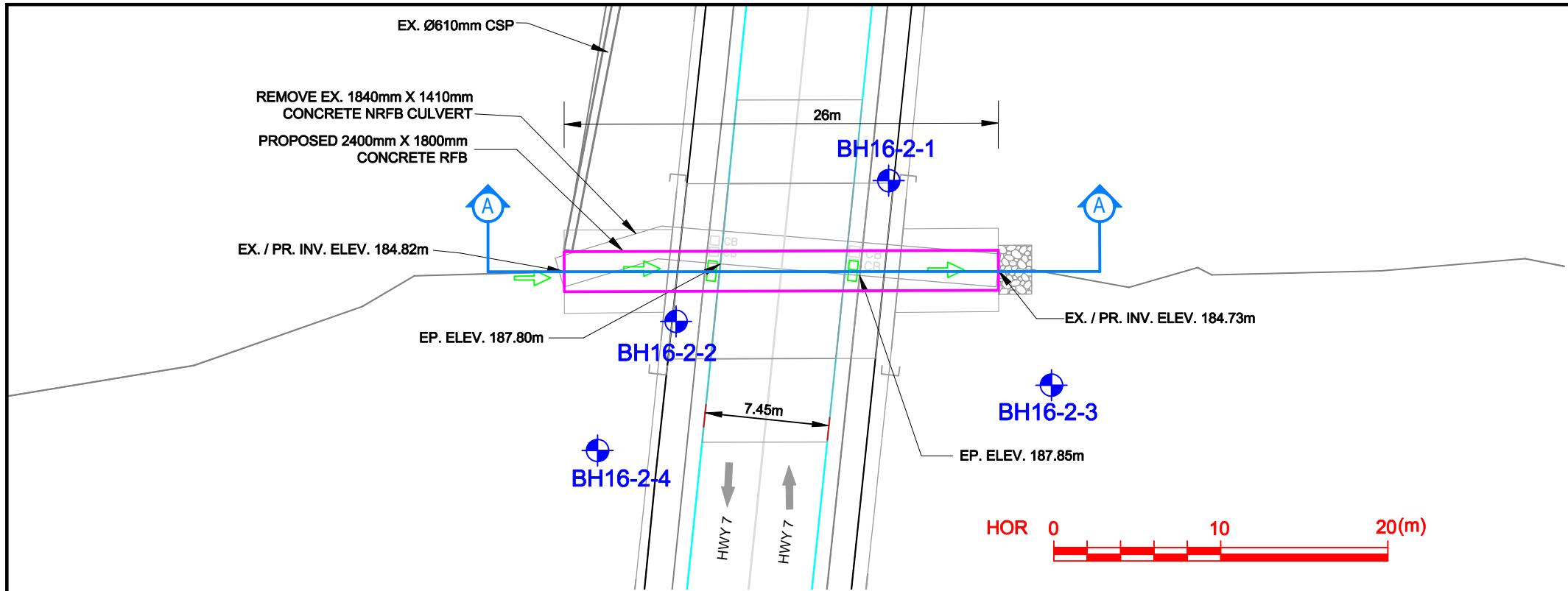
Mani Patchayappan, M.Eng., P.Eng  
Intermediate Geotechnical Engineer



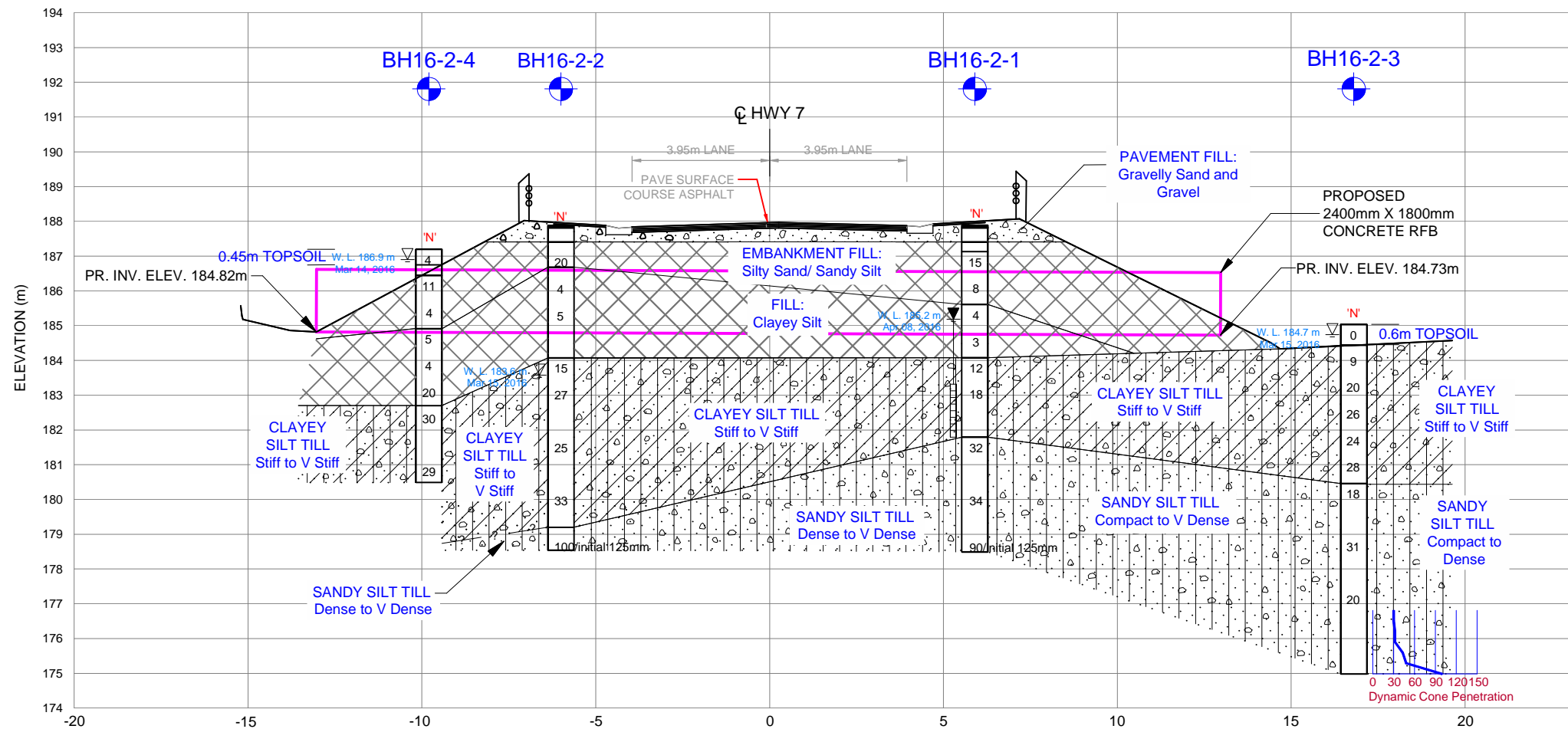
Vasantha Wijeyakulasuriya, M.Eng., P.Eng  
Senior Technical Director, Geotechnical  
MTO Designated Contact



# Drawing 1



PLAN



CROSS SECTION A-A

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

CONT No: 2016-2019  
WP : 2051-14-00

CV-0002-0007-0001  
CULVERT REPLACEMENT  
LOCUST HILL MARKHAM, ONTARIO  
BOREHOLE LOCATIONS & SOIL STRATA

WSP 51 Constellation Court  
Toronto, Ontario  
M9W 1K4



KEY PLAN  
NOT TO SCALE

LEGEND

- Borehole drilled by WSP
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- WL upon completion
- WL in Monitoring Well
- Monitoring Well

SOIL STRATA SYMBOLS

- Topsoil
- Pavement Fill
- Fill
- Clayey Silt Till
- Sandy Silt Till

BH No.	APPROX. ELEV. (m)	MTM NAD83 ZONE 10 CO-ORDINATES	
		NORTH (m)	EAST (m)
BH16-2-1	187.9	4862581	330779
BH16-2-2	187.9	4862589	330767
BH16-2-3	185.0	4862567	330772
BH16-2-4	187.2	4862590	330758

NOTES

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

Borehole Location plan and profile are based on drawing "01-Contract 4" received on March 23, 2016.

REVISIONS				
	May 6/16	ZMO	Submission for MTO review	
	DATE	BY	DESCRIPTION	
GEOCRES No : -				
HWY No 7			DIST -	
SUBM'D		CHECKED MP	DATE May 6, 2016	
DRAWN ZMO		CHECKED MP	APPROVED RM	DWG 1

## **Appendix A: Record of Borehole Sheets**

# RECORD OF BOREHOLE No BH16-2-1

METRIC 1 OF 2

W.P. 2051-14-00 LOCATION CV-0002-0007-0001, E 330779, N 4862581 ORIGINATED BY AR  
 DIST HWY 7 BOREHOLE TYPE Solid Stem Auger COMPILED BY MW  
 DATUM Geodetic DATE Mar/15/2016 to Mar/15/2016 CHECKED BY RM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT		POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m <sup>3</sup> )	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>p</sub>	W	W <sub>L</sub>	W <sub>L</sub>			
187.9	ASPHALT: 80mm																	GR SA SI CL
187.8	GRANULAR BASE/SUBBASE: 400 mm, sand and gravel, brown, moist.		1	AS			Cement											
187.4	FILL: sand, some silt, trace gravel, brown, moist.																	
187.1	FILL: silty sand, trace gravel, trace clay, brown to reddish brown, moist, loose to compact.		2	SS	15		187											
185.6			3	SS	8		186											6 55 30 9
185.6	FILL: silty clay to clayey silt, trace gravel, trace sand, trace organics, dark brown, moist, soft to firm.		4	SS	4		Bentonite											
184.1																		
184.1	CLAYEY SILT TILL: sandy, trace gravel, brown, moist, stiff to very stiff.		6	SS	12		184											wet spoon
181.8			7	SS	18		183											9 31 44 16
181.8	SILTY SAND TILL TO SANDY SILT TILL: trace to some clay, trace gravel, grey, moist, dense to very dense.		8	SS	32		182											
							181											
			9	SS	34		180											8 36 41 15

Continued Next Page

## GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

+ 3, X 3: Numbers refer to Sensitivity ○ 3% Strain at Failure

141-54753-00

ON-MTO-2015 10000161-LOG-16-2 MAY GP J ON MOT GDT 5/12/16

# RECORD OF BOREHOLE No BH16-2-1

METRIC 2 OF 2

W.P. 2051-14-00 LOCATION CV-0002-0007-0001, E 330779, N 4862581 ORIGINATED BY AR  
 DIST HWY 7 BOREHOLE TYPE Solid Stem Auger COMPILED BY MW  
 DATUM Geodetic DATE Mar/15/2016 to Mar/15/2016 CHECKED BY RM

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT CONTENT			POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)								
						20	40	60	80	100	20	40	60	80	100	10	20	30			
	SILTY SAND TILL TO SANDY SILT TILL: trace to some clay, trace gravel, grey, moist, dense to very dense. (continued)																				
178.5			10	SS	90/ initial 125mm																
9.4	END OF BOREHOLE Notes: 1) Caved-in at 6.1 m 2) 50 mm monitoring well installed upon completion of drilling. 3) Water Level Readings: Date Depth (m) Elevation (m) Mar. 23, 2016 3.1 184.8 Apr. 08, 2016 2.7 185.2																				

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

+ 3, X 3: Numbers refer to  
Sensitivity

○ 3% Strain at Failure

141-54753-00

# RECORD OF BOREHOLE No BH16-2-2

METRIC 1 OF 2

W.P. 2051-14-00 LOCATION CV-0002-0007-0001, E 330767, N 4862589 ORIGINATED BY AR  
 DIST HWY 7 BOREHOLE TYPE Solid Stem Auger COMPILED BY MW  
 DATUM Geodetic DATE Mar/15/2016 to Mar/15/2016 CHECKED BY RM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m <sup>3</sup> )	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40						
187.9	ASPHALT: 70 mm														
187.4	GRANULAR BASE/SUBBASE: 400 mm, sand and gravel, trace to some silt, brown, moist.		1	AS											37 49 (14)
187.4	FILL: sand, some silt, trace gravel, brown, moist, compact.														
186.7	FILL: clayey silt, trace sand, brown, moist, firm.		2	SS	20										
186.7															
186.7			3	SS	4										
186.7															
186.7			4	SS	5										
186.7															
186.7				VANE											
186.7															
184.1	CLAYEY SILT TILL: sandy, trace gravel, brown to grey, moist, stiff to hard.		5	SS	15										
184.1															
184.1			6	SS	27										10 35 43 12
184.1															
184.1															
184.1			7	SS	25										
184.1															
184.1															
184.1			8	SS	33										3 25 46 26
184.1															

Continued Next Page

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

+ 3, X 3: Numbers refer to Sensitivity ○ 3% Strain at Failure

141-54753-00

ON-MTO-2015 10000161-LOG-16-2 MAY.GPJ ON MOT.GDT 5/12/16

# RECORD OF BOREHOLE No BH16-2-2

METRIC 2 OF 2

W.P. 2051-14-00 LOCATION CV-0002-0007-0001, E 330767, N 4862589 ORIGINATED BY AR  
 DIST HWY 7 BOREHOLE TYPE Solid Stem Auger COMPILED BY MW  
 DATUM Geodetic DATE Mar/15/2016 to Mar/15/2016 CHECKED BY RM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m <sup>3</sup> )	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 20 40 60 80 100					WATER CONTENT (%) 10 20 30							
179.2	CLAYEY SILT TILL: sandy, trace gravel, brown to grey, moist, stiff to hard. (continued)																	
8.7	SILTY SAND TILL TO SANDY SILT TILL: trace to some clay, trace gravel, grey, moist, very dense.																	
178.5	END OF BOREHOLE		9	SS	100/ initial 25mm													
9.3	Notes: 1) Borehole caved in at 8.2m and water level was at 4.3m upon completion of drilling.																	

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

+ 3, × 3: Numbers refer to Sensitivity ○ 6=3% Strain at Failure

141-54753-00

# RECORD OF BOREHOLE No BH16-2-3

METRIC 1 OF 2

W.P. 2051-14-00 LOCATION CV-0002-0007-0001, E 330772, N 4862567 ORIGINATED BY AR  
 DIST HWY 7 BOREHOLE TYPE Solid Stem Auger COMPILED BY MW  
 DATUM Geodetic DATE Mar/15/2016 to Mar/15/2016 CHECKED BY RM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			POCKET PEN. (C <sub>u</sub> ) (kPa)	NATURAL UNIT WT (kN/m <sup>3</sup> )	REMARKS & GRAIN SIZE DISTRIBUTION (%)									
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>						
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL							× LAB VANE					
185.0	0.0 TOPSOIL: 600 mm		1	SS	0		185							γ	GR SA SI CL							
184.4	0.6 CLAYEY SILT TILL:sandy, trace gravel, brown, moist, stiff to very stiff.		2	SS	9		W. L. 184.7 m Mar 15, 2016						55			wet spoon  11 30 41 18						
			3	SS	20		184						75				9 23 45 23					
			4	SS	26		183						150					250				
			5	SS	24		182												181			
			6	SS	28		180													179		
			7	SS	18		178														177	
			8	SS	31																	176
			9	SS	20																	
													174									
														173								
															172							
																171						
																	170					
																		169				
																			168			
																				167		
																					166	
													165									
														164								
															163							
																162						
																	161					
																		160				
																			159			
																				158		
																					157	
													156									
														155								
															154							
																153						
																	152					
																		151				
																			150			
																				149		
																					148	
													147									
														146								
															145							
																144						
																	143					
																		142				
																			141			
																				140		
																					139	
													138									
														137								
															136							
																135						
																	134					
																		133				
																			132			
																				131		
																					130	
													129									
														128								
															127							
																126						
																	125					
																		124				
																			123			
																				122		
																					121	
													120									
														119								
															118							
																117						
																	116					
																		115				
																			114			
																				113		
																					112	
													111									
														110								
															109							
																108						
																	107					
																		106				
																			105			
																				104		
																					103	
													102									
														101								
															100							
																99						
																	98					
																		97				
																			96			
																				95		
																					94	
													93									
														92								
															91							
																90						
																	89					
																		88				
																			87			
																				86		
																					85	
													84									
														83								
															82							
																81						
																	80					
																		79				
																			78			
																				77		
																					76	
													75									
														74								
															73							
																72						
																	71					
																		70				
																			69			
																				68		
																					67	
													66									
														65								
															64							
																63						
																	62					
																		61				
																			60			
																				59		
																					58	
													57									
														56								
															55							
																54						
																	53					
																		52				
																			51			
																				50		
																					49	
													48									
														47								
															46							
																45						
																	44					
																		43				
																			42			
																				41		
																					40	
													39									
														38								
															37							
																36						
																	35					
																		34				
																			33			
																				32		
																					31	
													30									
														29								
															28							
																27						
																	26					
																		25				
																			24			
																				23		
																					22	
													21									
														20								
															19							
																18						
																	17					
																		16				
																			15			
																				14		
																					13	
													12									
														11								
															10							
																9						
																	8					

Continued Next Page

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

+ 3, X 3: Numbers refer to Sensitivity ○ 3% Strain at Failure

141-54753-00

ON-MTO-2015 10000161-LOG-16-2 MAY.GPJ ON MOT.GDT 5/12/16



# RECORD OF BOREHOLE No BH16-2-3

METRIC 2 OF 2

W.P. 2051-14-00 LOCATION CV-0002-0007-0001, E 330772, N 4862567 ORIGINATED BY AR  
 DIST HWY 7 BOREHOLE TYPE Solid Stem Auger COMPILED BY MW  
 DATUM Geodetic DATE Mar/15/2016 to Mar/15/2016 CHECKED BY RM

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m <sup>3</sup> )	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE									
176.8 8.2						177	<p>SHEAR STRENGTH kPa                      ○ UNCONFINED + FIELD VANE                      ● QUICK TRIAXIAL × LAB VANE</p> <p>WATER CONTENT (%)                      10 20 30</p>						DCPT starts at 8.23
176						176							
175.0 10.1	END OF BOREHOLE					175							
Notes: 1) Borehole caved in at 6.1m and water level was at 0.3m upon completion of drilling.													

ON-MTO-2015 10000161-LOG-16-2 MAY.GPJ ON\_MOT.GDT 5/12/16

141-54753-00

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

+ 3, × 3: Numbers refer to Sensitivity ○ 3% Strain at Failure

# RECORD OF BOREHOLE No BH16-2-4

METRIC 1 OF 1

W.P. 2051-14-00 LOCATION CV-0002-0007-0001, E 330758, N 4862590 ORIGINATED BY AR  
 DIST HWY 7 BOREHOLE TYPE Solid Stem Auger COMPILED BY MW  
 DATUM Geodetic DATE Mar/14/2016 to Mar/14/2016 CHECKED BY RM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m <sup>3</sup> )	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100			
187.2 0.0	TOPSOIL: 450 mm		1	SS	4		187								GR SA SI CL
186.8 0.5	FILL: clayey silt, trace to some sand, brown, moist, firm.						W. L. 186.9 m Mar 14, 2016								
186.4 0.8	FILL: silty sandy gravel, trace clay, brown, moist, loose to compact.		2	SS	11		186								wet spoon
184.9 2.3	FILL: clayey silt, sandy, some gravel, trace organics, brown to grey, moist, firm to very stiff.		3	SS	4		185								36 30 28 6
			4	SS	5										
			5	SS	4		184								spoon recovery 11%
			6	SS	20		183								spoon recovery 22% 27 29 32 12
182.7 4.5	CLAYEY SILT TILL: trace sand, trace gravel, grey, moist, very stiff.		7	SS	30		182								
			8	SS	29		181								
180.5 6.7	END OF BOREHOLE Notes: 1) Borehole caved in at 6.1m and water level was at 0.3m upon completion of drilling.														

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

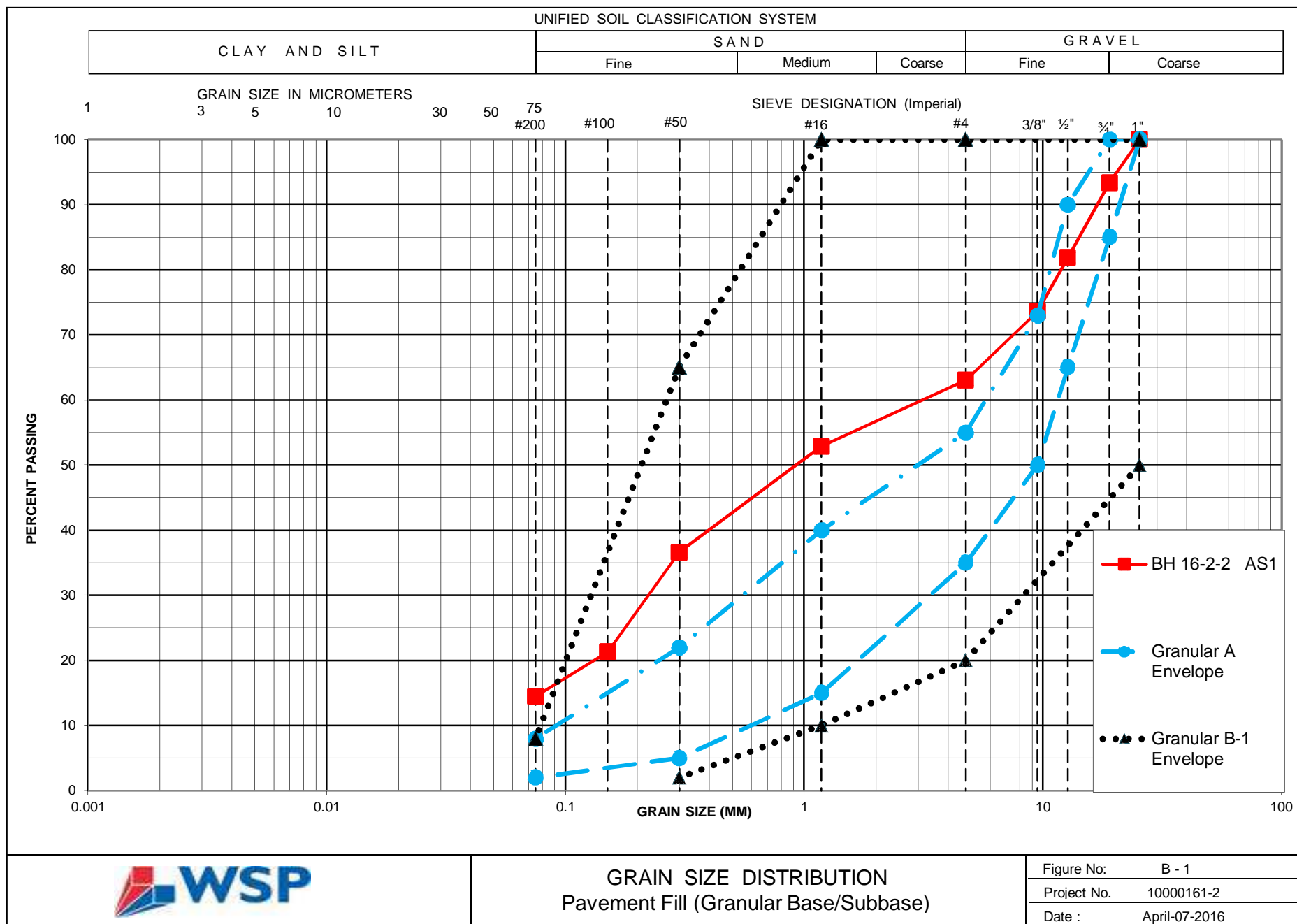
+ 3, X 3: Numbers refer to Sensitivity

○ 3% Strain at Failure

141-54753-00

ON-MTO-2015 10000161-LOG-16-2 MAY.GPJ ON MOT.GDT 5/12/16

## **Appendix B: Laboratory Test Results**



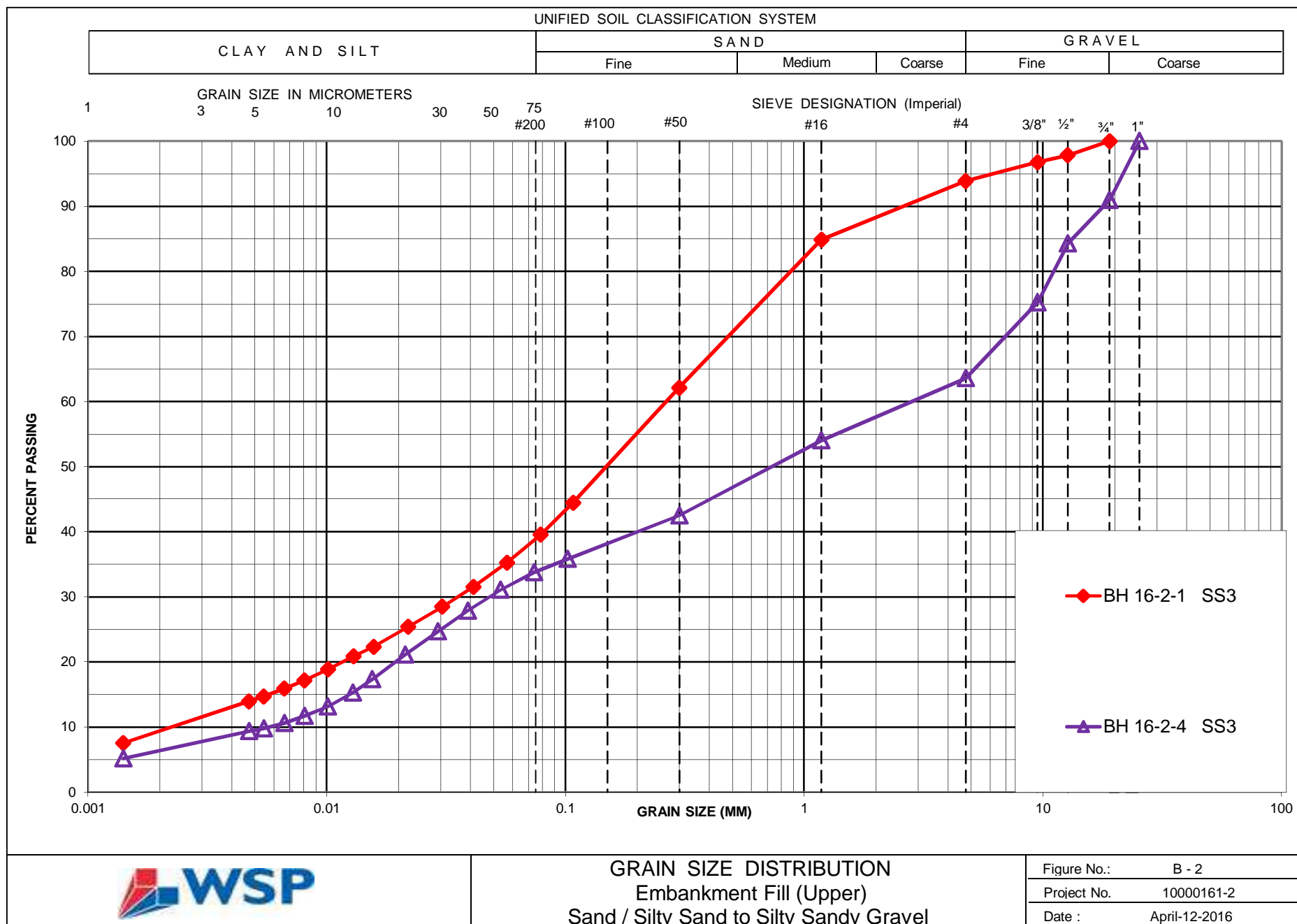
**GRAIN SIZE DISTRIBUTION**

Pavement Fill (Granular Base/Subbase)

Figure No: B - 1

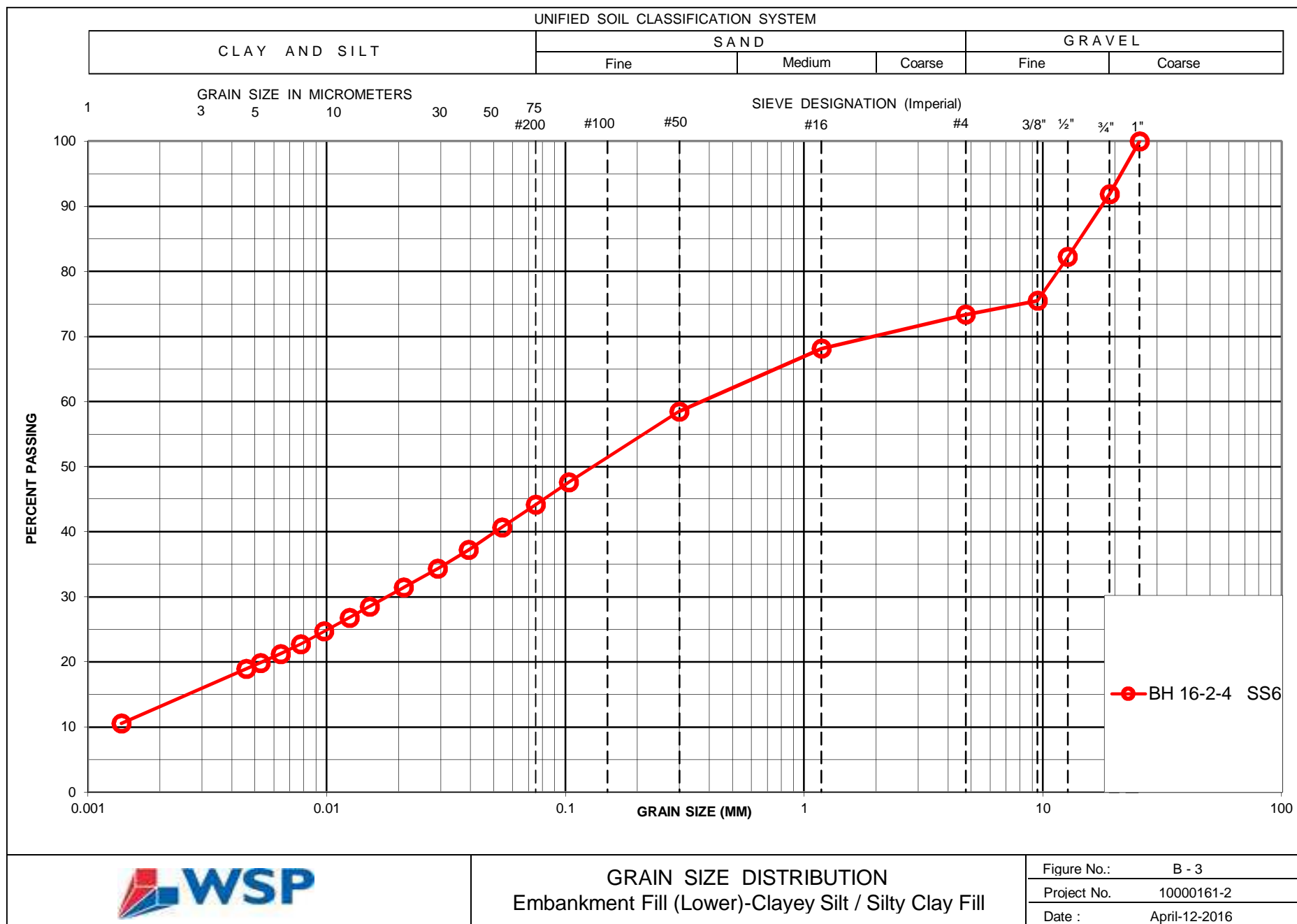
Project No. 10000161-2

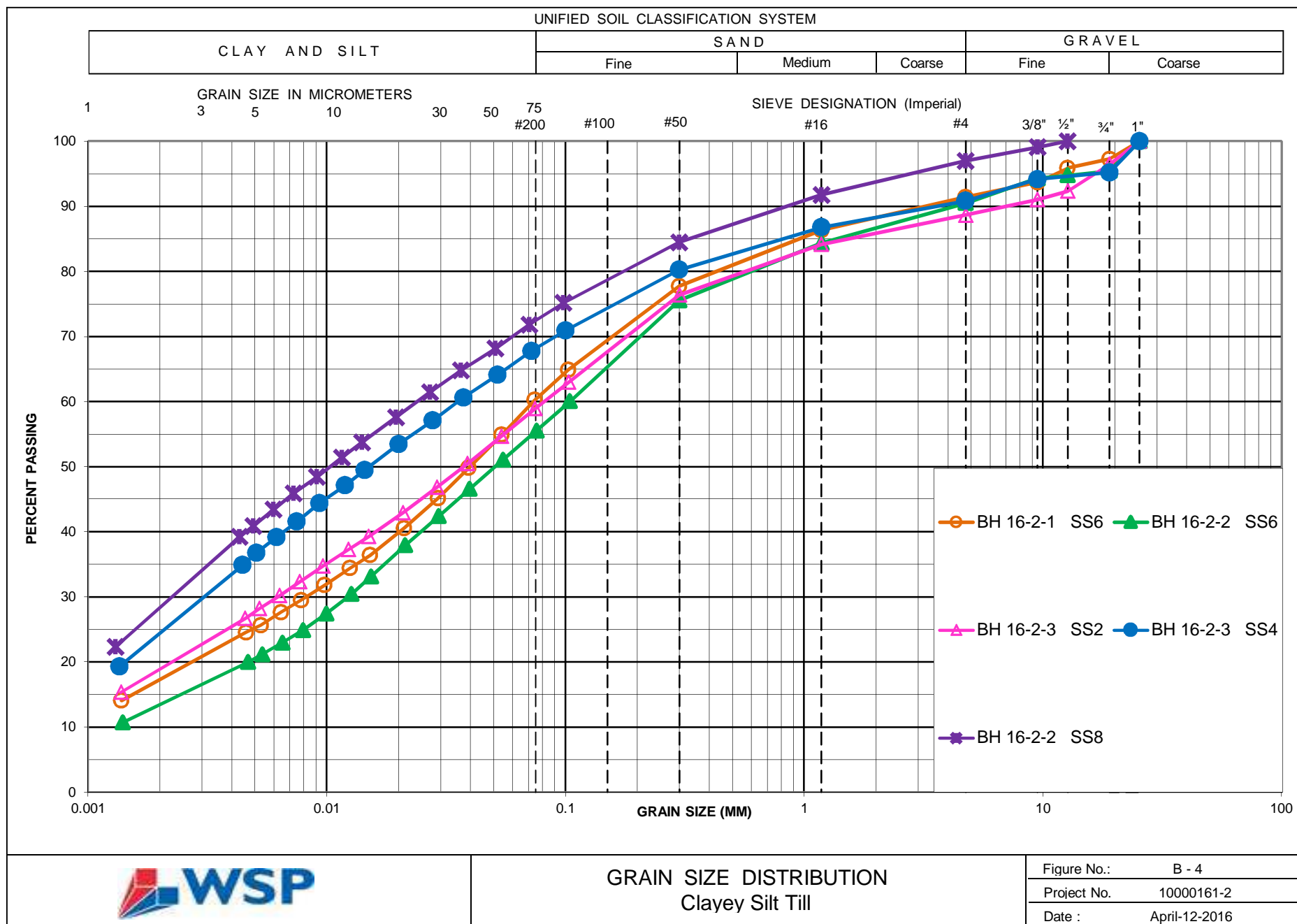
Date : April-07-2016



**GRAIN SIZE DISTRIBUTION**  
 Embankment Fill (Upper)  
 Sand / Silty Sand to Silty Sandy Gravel

Figure No.:	B - 2
Project No.	10000161-2
Date :	April-12-2016



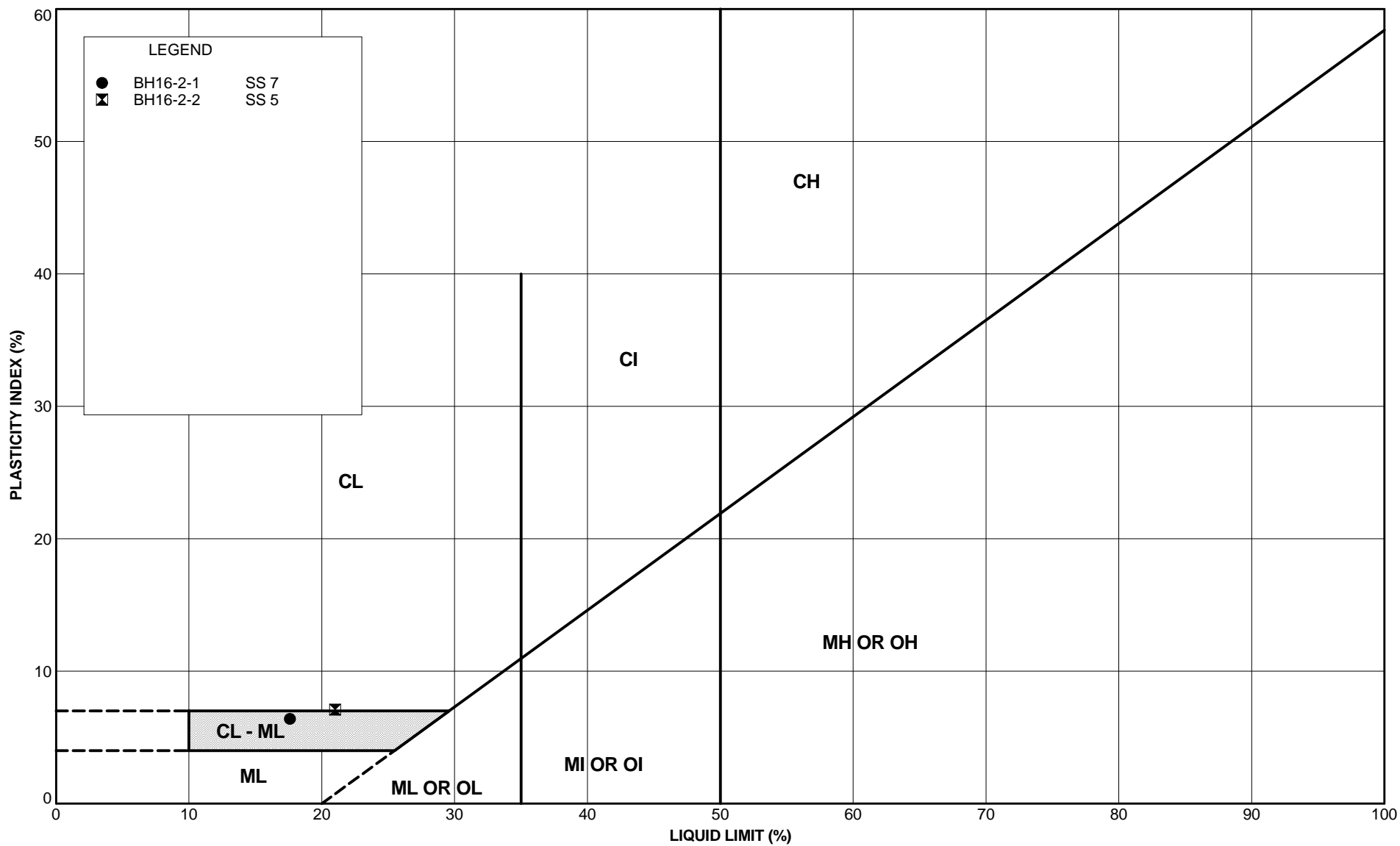


**GRAIN SIZE DISTRIBUTION**  
Clayey Silt Till

Figure No.: B - 4

Project No. 10000161-2

Date : April-12-2016



PLASTICITY CHART  
Clayey Silt Till

FIGURE NO.	B - 4a
JOB NO.	10000161
DATE	May 2016





## **Appendix C: Site Photographs**



Photo 1: Facing West, Highway 7 near culvert



Photo 2: Facing East, Highway 7 near culvert





Photo 3: Facing East, Southside of culvert (BH16-2-1 location)



Photo 4: Facing West, Northside of culvert (BH16-2-2 location)





Photo 5: Facing North, Southside of culvert (BH16-2-3 location)



Photo 6: Facing East, Northside of culvert (BH16-2-4 location)





Photo 7: Facing Southeast, Northside of culvert



Photo 8: Facing Northeast, Southside of culvert

# DRAFT REPORT ON FOUNDATION DESIGN

PROPOSED CULVERT REPLACEMENT  
HIGHWAY 7, DURHAM, ONTARIO

CULVERT NO: CV-0002-0007-0001

GEOCRES NO:

G.W.P. 2051-14-00

**Prepared For:**

**D.M.Wills Associates Ltd**

150 Jameson Drive, Peterborough ON K9J 0B9

WSP Project No: 141-54753-00 (SPL No. 10000161)-2  
Date: May 9, 2016

---

**WSP Canada Inc.**

51 Constellation Court  
Toronto, ON M9W 1K4 Canada

Phone: +1 416-798-0065

Fax: +1 416-798-0518

**[www.wspgroup.com](http://www.wspgroup.com)**



# TABLE OF CONTENTS

<b>5</b>	<b>DISCUSSION AND RECOMMENDATIONS.....</b>	<b>13</b>
<b>5.1</b>	<b>GENERAL .....</b>	<b>13</b>
<b>5.2</b>	<b>GEOTECHNICAL CHARACTERISATION.....</b>	<b>13</b>
5.2.1	OVERVIEW OF SUBSURFACE CONDITIONS .....	13
5.2.2	GEOTECHNICAL MODEL.....	14
5.2.2.1	GEOTECHNICAL STRENGTH MODEL .....	14
5.2.2.2	FROST DEPTH/SUSCEPTIBILITY .....	15
<b>5.3</b>	<b>GEOTECHNICAL CONSIDERATIONS FOR REPLACEMENT CULVERT .....</b>	<b>15</b>
5.3.1	GENERAL .....	15
5.3.2	PROPOSED FOUNDING LEVELS .....	15
5.3.3	BEARING RESISTANCE/SETTLEMENTS/SLIDING RESISTANCE .....	16
<b>5.4</b>	<b>OPEN CUT EXCAVATION FOR CULVERT REPLACEMENT.....</b>	<b>16</b>
5.4.1	GEOTECHNICAL DESIGN PARAMETERS FOR SHORING SUPPORT.....	16
<b>5.5</b>	<b>CONSTRUCTION CONSIDERATIONS .....</b>	<b>17</b>
5.5.1	DEWATERING AND DRAINAGE ISSUES.....	17
5.5.2	BEARING SUBGRADE .....	18
5.5.3	BEDDING AND COVER .....	18
5.5.4	BACKFILL .....	18
5.5.5	EMBANKMENT RECONSTRUCTION .....	19
5.5.6	OPEN CUT EXCAVATIONS.....	19
5.5.7	SOIL DISPOSAL ISSUES .....	20
<b>5.6</b>	<b>INLET AND OUTLET .....</b>	<b>20</b>
5.6.1	HEAD WALL/WING WALL DESIGN CONSIDERATIONS .....	20
5.6.2	EROSION PROTECTION.....	21

## APPENDIX D: STAGGING PLAN

## APPENDIX E: LIST OF OPSSS, OPSDS AND NSSPS

## APPENDIX F: LIMITATIONS



## LIST OF TABLES

TABLE 5-1 GEOTECHNICAL STRENGTH MODEL .....	14
TABLE 5-2 GEOTECHNICAL DESIGN PARAMETERS (UNFACTORED) - FOR TEMPORARY SHORING .....	16
TABLE 5-3 INTERPRETED OSHA REQUIREMENTS FOR OPEN CUT EXCAVATIONS ....	19
TABLE 5-4 COEFFICIENTS OF LATERAL EARTH PRESSURE.....	20

**DRAFT  
FOUNDATION DESIGN REPORT  
PROPOSED CULVERT REPLACEMENT AT STATION  
Culvert No: CV-0002-0007-0001  
HIGHWAY 7, Durham, Ontario, G.W.P. 2051-14-00**

## 5 DISCUSSION AND RECOMMENDATIONS

### 5.1 GENERAL

WSP Canada Inc. (WSP), formerly SPL Consultants Ltd., was retained by D. M. Wills Associates Ltd. (Wills) to carry out foundation investigations to provide necessary geotechnical information and recommendations to replace the existing 1840 mm x 1410 mm open frame concrete culvert. This structure is located under Highway 7, approximately 1140 m east of the York Durham Line Interchange. This structure (Culvert No: CV-0002-0007-0001) is located within the Regional Municipality of Durham, and is under the jurisdiction of the Central Region of the Ministry of Transportation (MTO). This forms a part of four (4) non-structural culvert investigations being investigated by WSP under the present commission.

WSP was informed by Wills that the replacement culvert will be a 2400 mm x 1800 mm concrete RFB (rigid frame box) culvert, as shown on Drawing 1 (as per the General Arrangement (GA) Drawing prepared by Wills, dated March 23, 2016). The proposed box culvert is 26 m long with invert elevation at the inlet, El. 184.82 m and at the outlet, the invert elevation will be El. 184.73 m. Both invert elevations of the proposed culvert are the same as those of the existing. On plan, the alignment of the proposed culvert will be almost the same as that of the existing.

As the main thrust of this report, focus will be made on the geotechnical aspects associated with the design and construction issues with the replacement structure and will address staging and road protection issues. It is our understanding that no widening of the embankment or road pavement grade raise will be involved.

### 5.2 GEOTECHNICAL CHARACTERISATION

#### 5.2.1 OVERVIEW OF SUBSURFACE CONDITIONS

At the proposed culvert site, the road embankment is approximately 3.7 m high and of El. 188.0 m on the road centerline (based on the GA). The side slopes of the road embankment are approximately 1.9 H: 1V on the north side (inlet side) and 2.7 H:1V on the south side (outlet side).

As an overview, the encountered subsurface conditions at the culvert location consisted of a pavement structure overlying an embankment fill whose upper horizon consisted of a cohesionless fill and underlain by a cohesive fill in boreholes BH16-2-1, BH16-2-2 and BH16-2-4. At borehole BH 16-2-3, no embankment fill was contacted.

The upper cohesionless embankment fill was found to be of loose to compact relative density. The lower cohesive embankment fill was typically of firm consistency. At all borehole locations, a native clayey silt till was contacted either under the embankment fill or below topsoil, and borehole BH 16-2-4 was terminated within this deposit. The remaining boreholes were terminated in an underlying sandy silt till deposit. The clayey silt till

deposit was found to be of stiff to hard consistency whilst the underlying cohesionless till had a compact to very dense relative density.

The native soil stratigraphy observed at this site is in broad agreement with the geological setting and what was reported in a nearby site as described under Sections 2.1 and 2.2 respectively.

The unstabilized water levels (on completion) ranged from El. 183.6 m to El. 186.9 m, respectively and the groundwater level in the monitoring well installed in BH 16-2-1 indicated the groundwater level at El. 185.2 m (or at 2.7 m depth below existing ground surface) as at April 8, 2016, indicative of sub-artesian conditions.

## 5.2.2 GEOTECHNICAL MODEL

### 5.2.2.1 GEOTECHNICAL STRENGTH MODEL

The geotechnical model as shown in **Table 5-1** was developed based on the stratigraphic model discussed in Section 4 and on engineering judgement. The purpose of the geotechnical model is to enable the addressing of box culvert bearing issues and global stability issues associated with the proposed road protection.

**Table 5-1 Geotechnical Strength Model**

Thickness Range (m)	Material/Deposit	Plasticity Index ( $I_p$ )	Moisture Content %	SPT 'N' Average	Unit Weight ( $\text{kN/m}^3$ )	Phi' (deg) $C' = 0$ kPa	Undrained Strength, $S_u$ (kPa)
0.4	Pavement Fill		6 & 9	NA	22	32	NA
0.7 – 1.8	Embankment Fill- Sand/silty sand to sand and gravel		8 to 19	10	20	30	NA
1.5-2.6	Embankment Fill - Clayey silt/Silty clay		15 to 30	4	18	28	40
2.3-4.9	Clayey Silt Till	6 - 7	8 to 16	23	21	32	125
0.7-5.5*	Sandy Silt/Silty Sand Till		7 to 10	27	22.5	36	NA

Note \*: Explored thickness; Design groundwater table can be considered at El. 185.0

The subject site for the proposed structures can be classified as 'Class D' for seismic site response according to Table 4.1.8.4.A of OBC 2012, based on the borehole information and our review of the general subsurface conditions in the area.

### 5.2.2.2 FROST DEPTH/SUSCEPTIBILITY

The frost depth for the project site is 1.4 m. The soils at the proposed culvert site have low frost susceptibility based on the MTO Frost Susceptibility Classification.

## 5.3 GEOTECHNICAL CONSIDERATIONS FOR REPLACEMENT CULVERT

### 5.3.1 GENERAL

According to the GA, the replacement culvert will be 2400 mmx1800 mm RFB (rigid frame box). Stiffness and configuration of the soil around the culvert box can affect culvert box performance limits. In the case of a rigid frame box, however, the relative soil stiffness affects only material failure. The replacement culvert alignment both in plan and in terms of invert elevations is almost the same as the existing open frame culvert. However, the replacement culvert has a higher rise and being a box has a larger bearing area compared to the existing. This would imply that in terms of net loading on the founding subgrade, the replacement culvert will induce a net load reduction on the bearing subgrade. However, the existing culvert will need to be exhumed to facilitate the placement of the replacement culvert. This would invariably cause some disturbance as the footings of the existing culvert will be deeper below the invert levels. It is also our understanding that the founding levels of the existing open frame culvert footings are unknown.

### 5.3.2 PROPOSED FOUNDING LEVELS

It is most likely that the existing open frame culvert footings are founded on or within the native clayey silt till. The top of the clayey silt layer was contacted approximately slightly above elevation 184.0 m, except in borehole BH 16-2-4, at El. 182.7. After carefully excavating and removing the existing footings, it is prudent to further sub-excavate a minimum of 300 mm into the native clayey silt assuming the underside of the existing footings are on or into the native clayey silt deposit until relatively undisturbed bearing subgrade is contacted. In the unlikely scenario, if the underside of the existing footing is above the till deposit in the fill (based on the offset borehole BH16-2-4 conditions; more likely towards the inlet end of the existing culvert), then excavation down to El. 183.5 m or 100 mm into the native till deposit whichever occurs earlier should be undertaken. On plan, the excavation should be extended a minimum of 0.5 m on either side of the proposed culvert span, i.e. 2400 mm span, to an overall width of 3.4 m.

Upon inspection and approval of the subgrade by a geotechnical engineer who is familiar with the findings of this investigation, replace the excavated material with engineered OPSS 1010 granular "A" to 100 % of SPMDD, to the elevation of the underside of the bedding layer supporting the box frame culvert base. Alternatively, subject to structural designer's approval, the box culvert can be founded on this engineered granular pad.

Assuming the bases of the existing culvert footings are at least 1 m below the invert levels, i.e. say, at El. 183.7 m, then a further sub-excavation to remove any suspected disturbed material, say, a minimum of 0.3 m would bring the excavation bottoms to at least El. 183.4 at the very least. Based on the wet spoon observations during drilling, they were observed as high as El. 184.2 m within the clayey silt till layer, notwithstanding any higher perched water.

To produce dry working conditions and enable effective compaction, it will require dewatering to be undertaken and the groundwater table lowered at least 1.0 m below the lowest elevation of excavation. Section 5.5.1 further

discusses dewatering and construction issues. Further, after inspecting and approving the subgrade, to minimize fines from the founding subgrade contaminating the granular bedding, a geotextile separator should be placed over the finished subgrade without delay.

### 5.3.3 BEARING RESISTANCE/SETTLEMENTS/SLIDING RESISTANCE

Recommended SLS under the box culvert base bearing on the engineered granular pad is 150 kPa (for total settlements not exceeding 25 mm and differential settlements to be less than 19 mm) with factored ULS of 225 kPa. An unfactored friction angle of 30 degrees can be used to check sliding friction. Sliding is unlikely to pose a problem as the major horizontal earth pressure thrust on the culvert is along the road axis, which subject to proper backfill placement with regard to differential height control as discussed in Section 5.5.4, should not pose an issue. Construction considerations to ensure the integrity of the subgrade are discussed in Section 5.5.2 and bedding and cover issues are discussed in Section 5.5.3.

## 5.4 OPEN CUT EXCAVATION FOR CULVERT REPLACEMENT

### 5.4.1 GEOTECHNICAL DESIGN PARAMETERS FOR SHORING SUPPORT

Table 5-2 gives recommended unfactored design parameters for design of temporary shoring. The shoring system should be designed so that the lateral movement of the portion of the 'roadway protection system' will not exceed the established criterion for the structure performance level. In this case, the required Performance Level is considered to be 2. The presence of potential cobbles and boulders within the embankment fill and in the basal till layers should be taken into consideration in deciding means and methods for shoring support. A Professional Engineer experienced in this type of work should carry out the shoring design.

**Table 5-2 Geotechnical Design Parameters (Unfactored) - For Temporary Shoring**

Layer Number	Material	Relative Density/ Consistency (Typical)	Unit weight $\gamma'$ (kN/m <sup>3</sup> )	Effective Stress Parameters*					Total Shear Strength Parameters*
				$c'$ (kPa)	$\Phi'$ (deg)	$K_a$	$K_p$	$K_o$	$S_u$ (kPa)
1	Pavement Structure		22	0	32	0.31	3.26	0.47	NA
2	Embankment Fill- Cohesionless	Loose to Compact	20	0	30	0.33	3.0	0.5	NA

Layer Number	Material	Relative Density/ Consistency (Typical)	Unit weight $\gamma'$ (kN/m <sup>3</sup> )	Effective Stress Parameters*					Total Shear Strength Parameters*
				$c'$ (kPa)	$\Phi'$ (deg)	$K_a$	$K_p$	$K_o$	$S_u$ (kPa)
3	Embankment Fill - Cohesive	Soft to firm	18	0	28	0.36	2.78	0.53	40
4	Clayey Silt Till	Stiff to Hard	21	0	32	0.31	3.26	0.47	125
5	Sandy Silt Till	Compact to very dense	22.5	0	36	0.26	3.85	0.41	NA

Notes:

$C'$  = Effective Cohesion;  $\Phi'$  = Effective Friction Angle;  $K_a$  = Active Earth Pressure Coefficient

$K_p$  = Passive Earth Pressure Coefficient;  $K_o$  = At-Rest Earth Pressure Coefficient;

$S_u$  = Undrained Shear Strength

- 1 A factor of safety of 2 shall be applied for computing passive resistance to lateral loads. Disregard any passive resistance within the frost depth.
- 2 Adequate allowance should be made for surcharge loads such as traffic with a minimum of 12 kPa surcharge
- 3 Earth pressure coefficients given in the table are for horizontal backfill and level surface in front. Any departures from this should be taken into account.
- 4 El. 185.0 m can be assumed as the design groundwater level
- 5 Sub-artesian groundwater conditions should be noted by the shoring designer

WSP should be consulted to ensure the shoring designs are compliant with the geotechnical design assumptions and to carry out global stability assessments, once the shoring designs are finalized.

## 5.5 CONSTRUCTION CONSIDERATIONS

### 5.5.1 DEWATERING AND DRAINAGE ISSUES

Dewatering should be undertaken to lower the piezometric head at least 1.0 m below the lowest excavation level. Wet spoon conditions were observed on entry into the clayey silt till. In addition, creek flows need to be diverted. This could consist of a temporary cofferdam say with sand bags.

The dewatering is not expected to be significant. This is likely to consist of gravity drainage in shallow perimeter

ditches and pumping from strategically placed deep filtered sumps and well-pointseductors. Specialist contractor input should be sought to decide on the optimum system based on the time of construction in the year and prevailing groundwater levels. This dewatering should be maintained during culvert installation until compaction operations are not compromised by groundwater impact. A PTTW is not considered a requirement. Any dewatering shall conform to OPSS 517.

### 5.5.2 BEARING SUBGRADE

Excavations to remove the existing culvert footings need to be carried out with constraint to limit potential disturbance to the bearing sub-grade. Further, after inspecting and approving the subgrade, to minimize fines from the founding subgrade contaminating the granular pad through migration of fines, a geotextile separator should be placed over the finished native subgrade without delay. An NSSP should be included in the contract to address this and suggested wording is included for reference in **Appendix D**.

The transportation and placement of the culvert elements will need to proceed with caution to ensure the newly constructed bedding and/or the underlying subgrade are not disturbed or subjected to rutting failure.

A geotechnical engineer who is familiar with the findings of this investigation should evaluate all bearing surfaces prior to placement of mud mat to confirm that the founding conditions are consistent with the recommendations given in the report. All organic, loose/soft/disturbed or otherwise unsuitable soils should be removed prior to pouring the concrete.

### 5.5.3 BEDDING AND COVER

The bedding thicknesses in excess of 300 mm should be avoided. Any requirement for thicker bedding due to prevailing subgrade conditions at the time of construction should be managed through stabilizing the subgrade by lowering groundwater level as discussed under Section 5.5.1 and control of surface water flow.

Uniform bedding conditions should be provided below the rigid frame box to prevent localized concentrated foundation support which can lead to possible distress at invert and haunches.

The bedding and cover material should consist of a well-graded granular material and use of OPSS 1010, Granular 'A' is recommended. The bedding material should be placed as soon as practicable after the preparation of the subgrade, its inspection and approval. The placement and compaction should follow OPSS 401, OPSD 803.010. The level difference between opposite sides, at any time during compaction, must conform to Clause 401.07.10.03.

### 5.5.4 BACKFILL

Backfill can consist of excavated non-cohesive embankment fill free of cobbles and boulders. Placement and compaction should follow OPSS 401.

Any organic, excessively wet, compressible or otherwise deleterious materials should be discarded from being used for backfilling. Any material shortfall should be met with approved materials and backfilling must conform to OPSS 401 and site restoration to OPSS 492.

### 5.5.5 EMBANKMENT RECONSTRUCTION

Embankment must be reconstructed to restore side batters to existing slopes as stated in Section 5.2.1. Excavated non-cohesive embankment fill free of cobbles and boulders can be used for borrow and compaction shall conform to OPSS 501.

### 5.5.6 OPEN CUT EXCAVATIONS

All excavations should be carried out in accordance with the Province's Occupational Health and Safety Act (OHSA), O. Reg. 213/91, as well as OPSS.PROV 539 Construction Specification for Temporary Protection Systems.

In accordance with the Province's Safety Regulation, the following soil classification would be applicable for open cut as shown in **Table 5-3**.

**Table 5-3 Interpreted OHSA Requirements for Open Cut Excavations**

Material/Deposit	Compactness/ Consistency	Groundwater	OHSA Classification
<b>Granular Pavement Fill</b>	Compact*	NA	Not steeper than 1H:1V
<b>Embankment Fill</b>	Loose to Compact	NA	Not steeper than 1.5H:1V
<b>Embankment Fill- Clayey Fill</b>	Soft to firm	Above groundwater level	Not steeper than 2H:1V
		Below groundwater level	Not steeper than 3H:1V
<b>Clayey Silt Till</b>	Stiff to Hard	Above groundwater level	Not applicable
		Below groundwater level	Not steeper than 2H:1V
<b>Sandy Silt Till</b>	Compact to very dense	Above groundwater level	Not applicable
		Below groundwater level	Not steeper than 2H:1V



Note: \* Based on grain size information and being a thin layer; Sub-artesian ground water impacts on excavation stability cannot be ruled out and hence geotechnical input to excavation design is recommended, unless carried out under dewatering control.

These temporary slopes for the above soil types as per OHSA are only as guidelines for temporary excavation slopes to be used for a short duration. We also recommend that these slopes be visually monitored for any movement especially if workers are present at the toe of the slopes.

All excavations should be undertaken with care to minimize disturbance especially to slopes below the water table and the saturated foundation subgrade.

Excavations should be possible in the above soil types using equipment such as a hydraulic excavator. Cobbles and boulders in the embankment fill and in the native glacial deposits cannot be ruled out. It is also important to note that sub-artesian ground water conditions were observed in the glacial till deposits.

### 5.5.7 SOIL DISPOSAL ISSUES

The excavated materials from the construction should be stockpiled. It should be checked for contamination prior to removal/disposal off-site, in order to determine which disposal option is best for the excavated materials (OPSS 180).

## 5.6 INLET AND OUTLET

### 5.6.1 HEAD WALL/WING WALL DESIGN CONSIDERATIONS

Computation of earth pressures acting against rigid culvert walls and wing walls should be in accordance with the Canadian Highway Bridge Design Code, S6-06: (CHBDC) 2006. For design purposes, the following properties can be assumed for backfill.

Compacted Granular 'A' or Granular 'B' Type II with less than 5% passing the 200 sieve.

Angle of Internal Friction  $\phi = 35^\circ$  (unfactored), Unit weight = 22 kN/m<sup>3</sup>

**Table 5-4 Coefficients of Lateral Earth Pressure**

Level Backfill	Backfill Sloping at 3H:1V	Backfill Sloping at 2H:1V
<b>K<sub>a</sub>=0.27</b>	K <sub>a</sub> =0.34	K <sub>a</sub> =0.40
<b>K<sub>o</sub>=0.43</b>	K <sub>o</sub> =0.56	K <sub>o</sub> =0.62

Note: K<sub>a</sub> is the coefficient of active earth pressure

K<sub>o</sub> is the coefficient of earth pressure at-rest

These values are based on the assumption that the backfill behind the retaining structure is free-draining granular material and adequate drainage is provided.

The earth pressure coefficient adopted will depend on whether the retaining structure is restrained or some

movement can occur such that the active state of earth pressure can develop. Allowance should be made for compaction induced stresses in the selection of the appropriate earth pressure coefficients, and reference should be made to Clause 6.9.3 of CHBDC (S6-06). The use of vibratory compaction equipment behind the retaining walls should be restricted in size as per current MTO practice and although native basal sand is free draining, great caution should be exercised with any vibratory equipment close to the saturated native sand.

### 5.6.2 EROSION PROTECTION

Typically, a wing wall on the inlet end can prevent any water flow through the embankment (typically granular material) around the culvert and it protects/retains the embankment. Riprap protection should be provided at the culvert's inlet and outlet ends and should be generally followed by OPSD 810.010 and any specific recommendations in the hydrology report. Riprap placed up to 1.5H: 1V without an underlying geotextile will be stable. Consideration can be also given to a low permeability clay seal/GCL (OPSS 1205/OPSD 802.095) at the inlet.

These erosion/scour protection systems should be designed by a specialist River Engineer/Scientist (as erosion and scour largely depend on the hydraulic energy, i.e. velocity of water in the watercourse and its regime and the erodible nature of stream bed material).

---

## CLOSURE

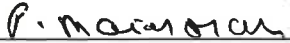
The "Limitations of Report" as presented in Appendix G are an integral part of this report.

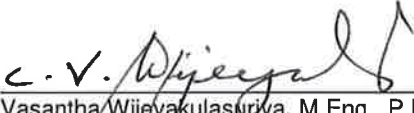
---

## SIGNATURES

We trust that the information contained in this foundation design report is satisfactory. Should you have any questions, please do not hesitate to contact this office.

**WSP Canada Inc.**

  
\_\_\_\_\_  
Mani Patchayappan, M.Eng., P.Eng  
Intermediate Geotechnical Engineer

  
\_\_\_\_\_  
Vasantha Wijeyakulasuriya, M.Eng., P.Eng  
Senior Technical Director, Geotechnical  
MTO Designated Contact

## REFERENCES

Canadian Highway Bridge Design Code (CHBDC) and Commentary on CAN/CSA S6-06. 2006. CSA Special Publication, S6.1 06. Canadian Standards Association.

Canadian Geotechnical Society, 2006. Canadian Foundation Engineering Manual, 4<sup>th</sup> Edition. The Canadian Geotechnical Society c/o BiTech Publisher Ltd, British Columbia.

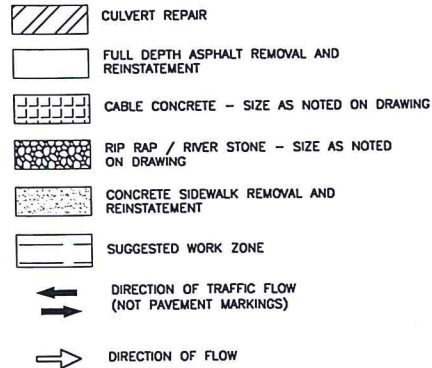
## **Appendix D: Staging Plan**



DRAWING NAME: \\DWFILE\Data\4000\4000-4489\4489 - Culverts Various Highways Central Region\02 Drawings\Current Drawings\Contract 4 MTO\01 CONTRACT 4 - JAN 20\COMPLETE\DWG  
CREATED: Wednesday, January 20, 2010 10:00 AM

88-55  
PR-3-707  
MINISTRY OF TRANSPORTATION, ONTARIO

## LEGEND



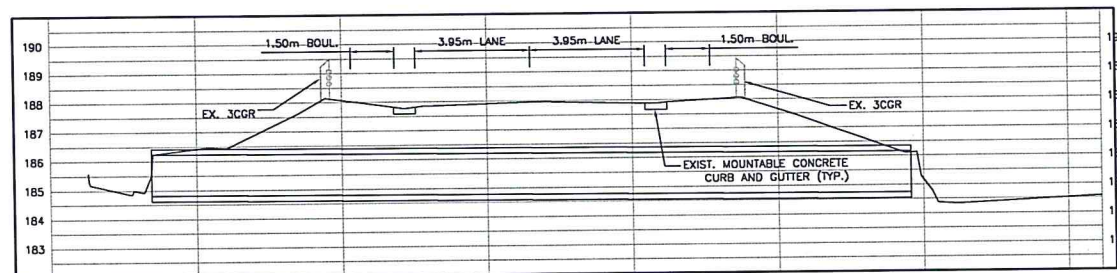
## ENVIRONMENTAL CONSIDERATIONS

1. ESC MEASURES SHALL BE INSTALLED, MAINTAINED, AND REPAIRED AT THIS SITE AS DESCRIBED ELSEWHERE IN THE CONTRACT.
2. IN WATER WORK IS ONLY PERMITTED FROM JULY 1ST TO SEPTEMBER 15TH AS DIRECTED BY THE MNRF.
3. THE WORK AREA MUST BE ISOLATED FROM THE NATURAL WATERCOURSE BY USE OF COFFERDAMS WHEN COMPLETING IN-WATER WORK. COFFERDAM REQUIREMENTS AND DETAILS ARE SPECIFIED ELSEWHERE IN THE CONTRACT. ALL REQUIRED WORK IS TO BE COMPLETED IN THE DRY.
4. NATURAL WATERCOURSE FLOWS DOWNSTREAM MUST BE MAINTAINED AT ALL TIMES WHILE IN-WATER WORKS ARE BEING COMPLETED. SCREENING SHALL BE PLACED OVER THE PUMP INTAKE TO PREVENT THE ENTRAINMENT OF FISH IN THE PUMP MACHINERY.
5. FISH STRANDED WITHIN THE WORK AREA MUST BE RELOCATED TO SUITABLE HABITAT DOWNSTREAM OF THE WORK AREA. THIS WORK IS TO BE COMPLETED BY OBTAINING A LICENCE TO COLLECT FISH FOR SCIENTIFIC PURPOSES FROM MNRF.
6. ANY DEWATERING FROM THE WORK AREA MUST BE DIRECTED TO A STABLE AND VEGETATED AREA AT LEAST 30m FROM THE WATERCOURSE OR TO A SUITABLE SEDIMENT FILTRATION MEASURES.
7. FOLLOWING CONSTRUCTION, ALL DISTRIBUTED AREAS RESULTING FROM THE WORK SHALL BE RESTORED AS STABILIZED AS DESCRIBED ELSEWHERE IN THE CONTRACT.

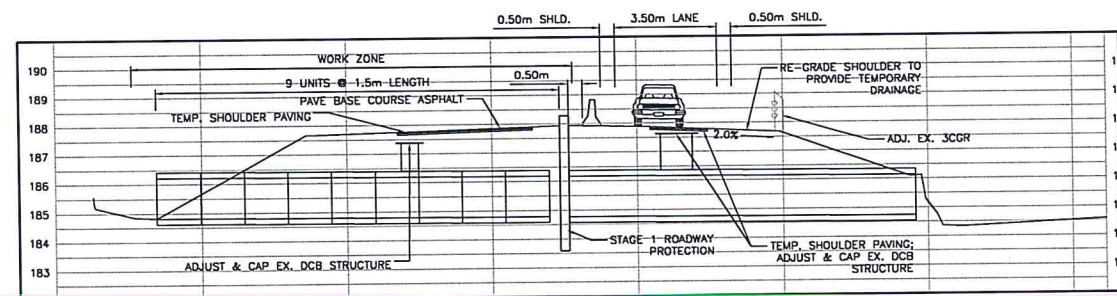
## NOTE:

ALL TRAFFIC CONTROL REQUIRED TO PERFORM THE WORK SHALL BE CARRIED OUT IN ACCORDANCE WITH ONTARIO TRAFFIC MANUAL BOOK 7.

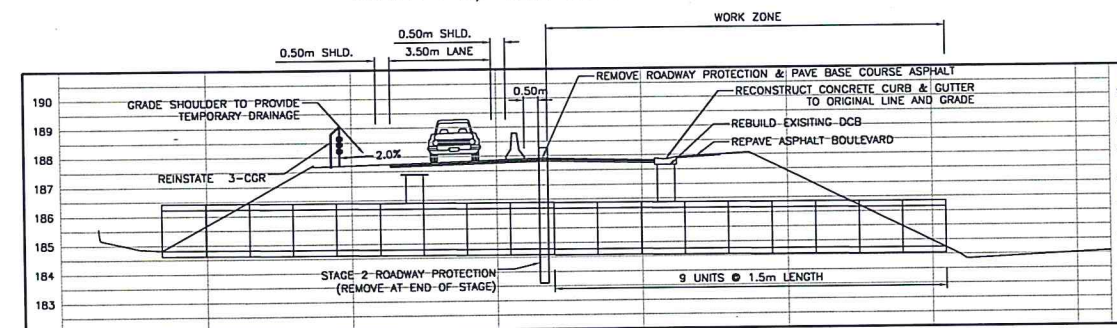
LOCATION  
LATITUDE: 43.90289  
LONGITUDE: -79.17675



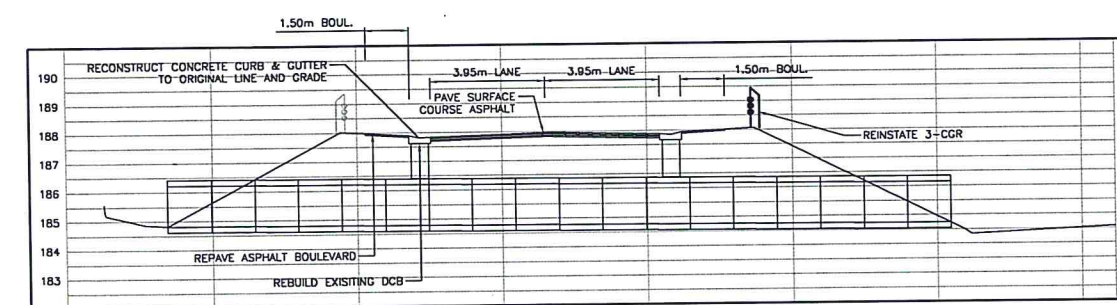
EXISTING CONFIGURATION



STAGE 1 W/ TEMPORARY TRAFFIC SIGNALS



STAGE 2 W/ TEMPORARY TRAFFIC SIGNALS



STAGE 3/FINAL CONFIGURATION  
(DAYTIME SINGLE LANE CLOSURES)

## CITY OF PICKERING REGIONAL MUNICIPALITY OF DURHAM

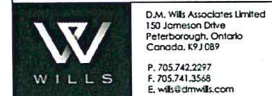
METRIC

DIMENSION ARE IN  
METRES AND/OR  
MILLIMETRES UNLESS  
OTHERWISE SHOWN

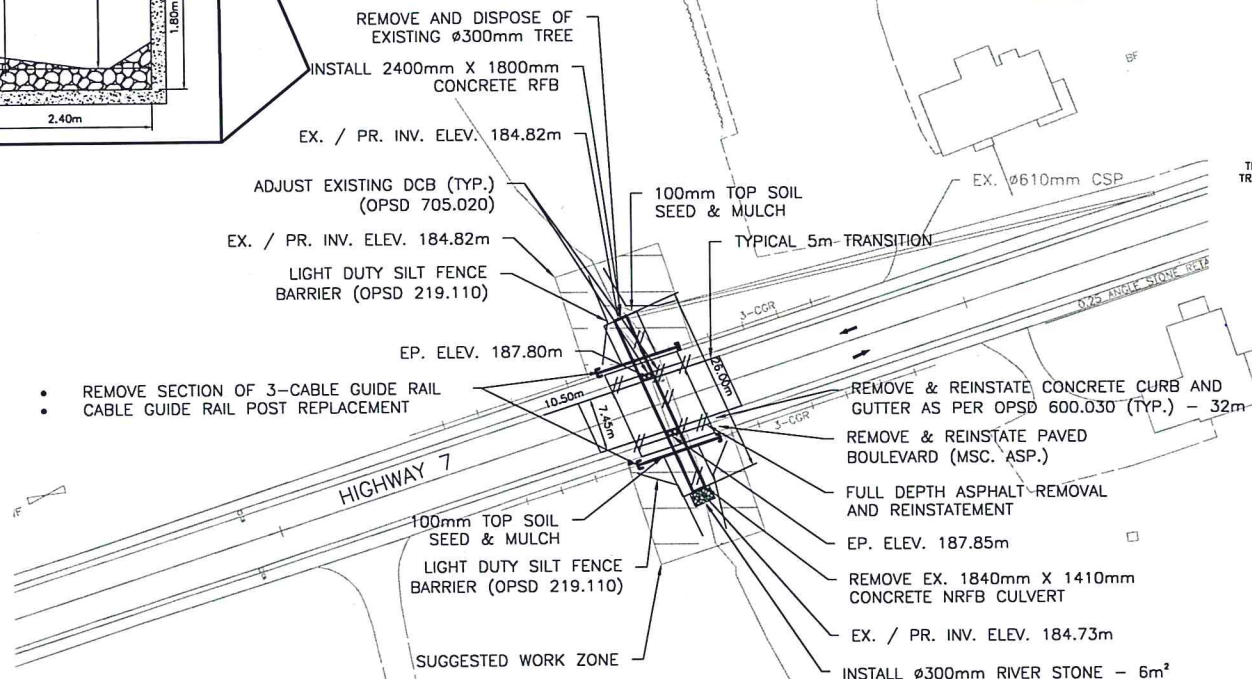
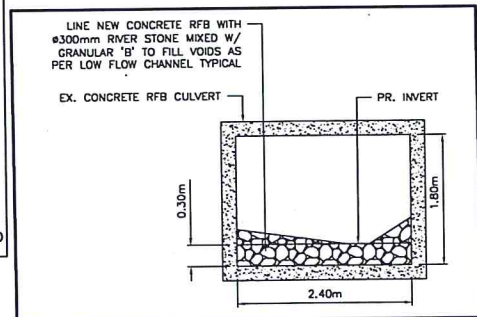


PLATE No  
CONT 2016-2019  
WP 2051-14-00

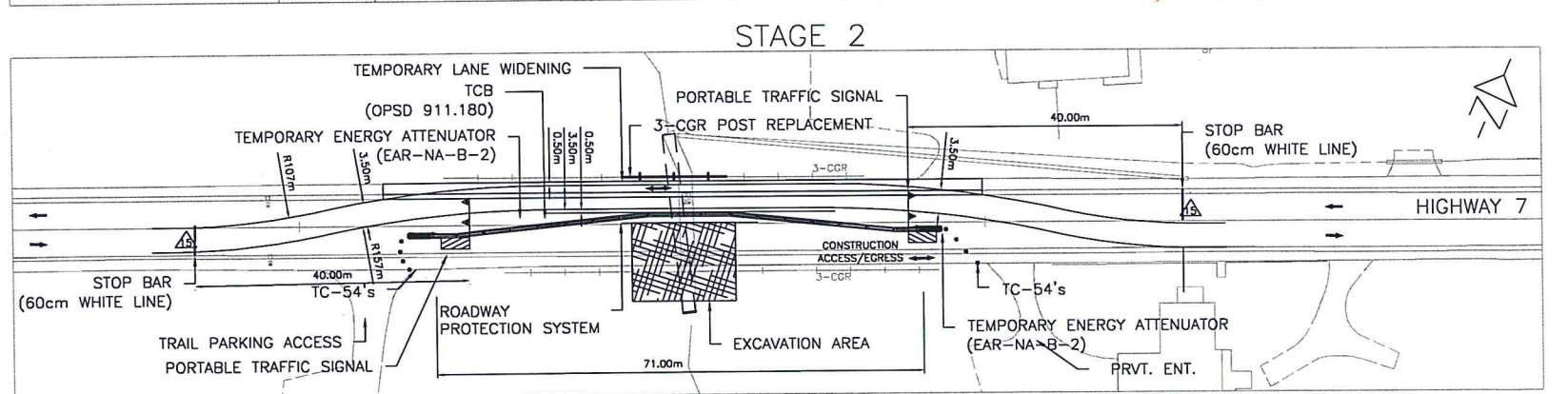
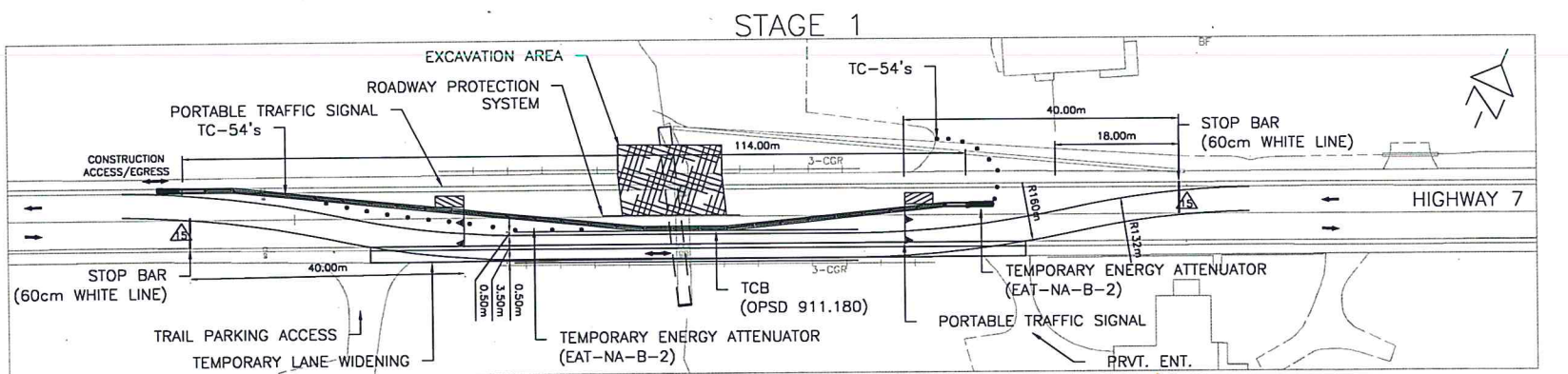
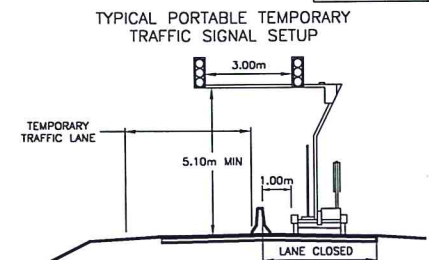
CV-0002-0007-0001  
STA TO STA  
Survey Revised



SHEET  
09



- REMOVE SECTION OF 3-CABLE GUIDE RAIL
- CABLE GUIDE RAIL POST REPLACEMENT



## **Appendix E: List of OPSSs, OPSDs and NSSPs**



## List of OPSSs, OPSDs and NSSPs referenced in the Report

NSSP		SEPARATOR
OPSD	810.01	GENERAL RIP-RAP LAYOUT FOR SEWER AND CULVERT OUTLETS
OPSD	3090.101	FROST PENETRATION DEPTHS - SOUTHERN ONTARIO
OPSD	803.010	BACKFILL AND COVER FOR CONCRETE CULVERTS WITH SPANS LESS THAN OR EQUAL TO 3.0 M
OPSS	180	GENERAL SPECIFICATION FOR THE MANAGEMENT OF EXCESS MATERIALS
OPSS	401	CONSTRUCTION SPECIFICATION FOR TRENCHING, BACKFILLING, AND COMPACTING
OPSS	422	CONSTRUCTION SPECIFICATION FOR PRECAST REINFORCED CONCRETE BOX CULVERTS AND BOX SEWERS IN OPEN CUT
OPSS	492	CONSTRUCTION SPECIFICATION FOR SITE RESTORATION FOLLOWING INSTALLATION OF PIPELINES, UTILITIES, AND ASSOCIATED STRUCTURES
OPSS	501	CONSTRUCTION SPECIFICATION FOR COMPACTING
OPSS	517	CONSTRUCTION SPECIFICATION FOR DEWATERING OF PIPELINE, UTILITY, AND ASSOCIATED STRUCTURE EXCAVATION
OPSS	803	CONSTRUCTION SPECIFICATION FOR SODDING
OPSS	804	CONSTRUCTION SPECIFICATION FOR SEED AND COVER
OPSS.PROV	539	CONSTRUCTION SPECIFICATION FOR TEMPORARY PROTECTION SYSTEMS
OPSS.PROV	1010	MATERIAL SPECIFICATION FOR PAVING AND BACKFILL
OPSS.PROV	1205	MATERIAL SPECIFICATION FOR CLAY SEAL



## **Geosynthetic Separator**

### **Non-Standard Special Provision**

#### ***Scope***

As part of the work under the above tender item, the Contractor shall supply and install a geosynthetic separator between the approved natural subgrade and granular bedding.

#### ***References***

**OPSS 1860 – MATERIAL SPECIFICATION FOR GEOTEXTILES**

#### ***Materials***

Class II Non-Woven Geotextile Separator

#### ***Basis of Payment***

Payment at the Contract Price for the above tender item shall be full compensation for all labour, equipment and material to do the work.

## **Appendix F: Limitations**

## **LIMITATIONS OF REPORT**

This report is intended solely for the Client named. The material in it reflects our best judgment in light of the information available to WSP Canada Inc. at the time of preparation. Unless otherwise agreed in writing by WSP Canada Inc., it shall not be used to express or imply warranty as to the fitness of the property for a particular purpose. No portion of this report may be used as a separate entity, it is written to be read in its entirety.

The conclusions and recommendations given in this report are based on information determined at the test hole locations. The information contained herein in no way reflects on the environment aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the test holes may differ from those encountered at the test hole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the test hole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of test holes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. WSP Canada Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

We accept no responsibility for any decisions made or actions taken as a result of this report unless we are specifically advised of and participate in such action, in which case our responsibility will be as agreed to at that time.