

**FOUNDATION INVESTIGATION AND DESIGN REPORTS  
PROPOSED WEST BEATON RIVER TRIBUTARY CULVERT REPLACEMENT  
HIGHWAY 631 NORTH OF HIGHWAY 17, ONTARIO  
WP 5079-09-01 SITE NO. 38N-013/C  
G.W.P. 5270-08-00  
MTO GEOCRES NO. 42C-26**

Prepared for:

**MCINTOSH PERRY CONSULTING ENGINEERS**

By:

**SPL CONSULTANTS LIMITED**

Project: 750-1001 (West Beaton)  
January 2013



**SPL Consultants Limited**  
Geotechnical Environmental Materials Hydrogeology

146 Colonnade Road  
Ottawa, Ontario K2E 7Y1  
Tel: 613.228.0065 Fax: 613.228.0045

**PART A**  
**FOUNDATION INVESTIGATION REPORT**  
**PROPOSED WEST BEATON RIVER TRIBUTARY CULVERT REPLACEMENT**  
**HIGHWAY 631 NORTH OF HIGHWAY 17, ONTARIO**  
**WP 5079-09-01 SITE NO. 38N-013/C**  
**G.W.P. 5270-08-00**  
**MTO GEOCRETS NO. 42C-26**

Prepared for:

**MCINTOSH PERRY CONSULTING ENGINEERS**

By:

**SPL CONSULTANTS LIMITED**

Project: 750-1001 (West Beaton)  
January 2013



146 Colonnade Road  
Ottawa, Ontario K2E 7Y1  
Tel: 613.228.0065 Fax: 613.228.0045

## Table of Contents

### PART A: FOUNDATION INVESTIGATION REPORT

|  |   |
|--|---|
| 1. INTRODUCTION .....                  | 1 |
| 2. SITE DESCRIPTION .....              | 1 |
| 3. INVESTIGATION PROCEDURES .....      | 1 |
| 3.1 Desktop Study .....                | 1 |
| 3.2 Field Investigation .....          | 2 |
| 3.3 Laboratory Testing .....           | 2 |
| 4. SUBSURFACE CONDITIONS .....         | 2 |
| 4.1 Soil Conditions .....              | 3 |
| 4.1.1 Asphalt .....                    | 3 |
| 4.1.2 Granular Fill .....              | 3 |
| 4.1.3 Native Silt and Sandy Silt ..... | 3 |
| 4.1.4 Bedrock and Auger Refusal .....  | 4 |
| 4.2 Groundwater Conditions .....       | 4 |
| 4.3 Summary .....                      | 4 |
| 5. Closure .....                       | 5 |

## Drawings

## No.

|                                      |   |
|--------------------------------------|---|
| Site Plan                            | 1 |
| Borehole Locations and Soil Strata   | 2 |
| Grain Size Distribution – Sandy Silt | 3 |
| Grain Size Distribution – Sandy      | 4 |
| Grain Size Distribution – Silt       | 5 |

## Appendices

Appendix A: Borehole Logs (Record of Borehole Sheets)

Appendix B: Chemical Test Results

Appendix C: Explanation of Terms used in Report

## **1. INTRODUCTION**

SPL Consultants Limited (SPL) was retained by McIntosh Perry Consulting Engineers to conduct a foundation investigation as part of the proposed culvert replacement at a tributary of the West Beaton River located on Highway 631 approximately 70.4 km north of Highway 17 between White River and Hornepayne, Ontario.

The terms of reference (TOR) for this investigation are outlined in the Request for Quotation (RFQ) issued by the Ministry of Transportation (MTO) under Agreement No. 5010-E-0001 dated April, 2010 and SPL's subsequent proposal No. P10.06.018 dated June, 2010. At the time of the foundation investigation (June 2011) the proposed culvert was to be located at the same location as the existing culvert. Subsequent to completion of the investigation the proposed culvert location was moved approximately 10 m to the west.

The purpose of the foundation investigation was to obtain subsurface information at the site by means of exploratory boreholes. This report presents the findings of the foundation investigation carried out at the site, as well as general comments and recommendations for the design and construction of the proposed culvert replacement.

As part of this project a geotechnical (pavement) investigation was also carried out at the site concurrent with the foundation investigation. The results of the pavement investigation are presented under separate cover.

## **2. SITE DESCRIPTION**

The site is located at a tributary of the West Beaton River, between White River and Hornpayne, ON on Highway 631 approximately 70.4 km north of Highway 17 (see Drawing 1). The existing structure is made up of a single plate Structural Plate Corrugated Steel Pipe (SPCSP) culvert with a width of 3.3 m, a height of 2.3 m, and an overall length of about 28 m. The fill cover is approximately 1.5 m in depth above the top of the culvert.

The elevation of natural ground in the general vicinity of the culvert crossing is approximately 324 m. The elevation of the highway (top of pavement) at the crossing is approximately 328.5 m (the embankment is approximately 4 m to 5 m high at the crossing).

## **3. INVESTIGATION PROCEDURES**

The foundation investigation was carried out in June, 2011. The scope of work for this assignment included a desk study, field investigations, laboratory testing, analysis and preparation of this report.

### **3.1 Desktop Study**

Surficial geology in the area comprises glacial till (silt sand and gravel as well as potentially cobbles and boulders), as well as glaciofluvial (sand and gravel) and glaciolacustrine (silt and sand) deposits.

Bedrock geology maps of the general area indicate the bedrock to be foliated to gneissic tonalite and granodiorite.

### **3.2 Field Investigation**

Field investigations were carried out on June 10 and 11, 2011 and included drilling a total of four boreholes at the crossing location (BH-1 through BH-4). As noted previously, additional shallow boreholes were advanced at the same time for the geotechnical (pavement) portion of the work; the results of those boreholes are submitted with the geotechnical (pavement) investigation report under separate cover.

The boreholes were advanced using a truck-mounted drill rig supplied and operated by George Downing Estate Drilling Limited of Hawkesbury, ON. The boreholes were drilled using hollow-stem auger drilling as well as dynamic cone penetration testing, to depths ranging from 5.4 m to 15.2 m below the existing ground surface. During drilling, sampling and in-situ testing [including Standard Penetration (SPT) Testing and Dynamic Cone Penetration (DCPT) Testing] were carried out.

A standpipe piezometer was installed in Borehole BH-2 to allow for subsequent measurement of stabilized groundwater levels at the site. All boreholes were backfilled with bentonite and soil cuttings and were sealed at the ground surface. All boreholes were drilled and abandoned in accordance with Ontario Regulation 903.

Borehole locations are shown in Drawing 2. Borehole logs are included in Appendix A.

### **3.3 Laboratory Testing**

During drilling and in-situ testing, soil samples were obtained for further examination and classification. A laboratory testing program, including determination of natural water content, grain size distribution (sieve and hydrometer) and chemical analyses, was carried out on selected representative soil samples.

The results of natural water content tests are included on the relevant borehole logs in Appendix A. The results of determination of grain size distribution are summarized on the individual borehole logs, and are also presented in Drawings 3 through 5.

Chemical testing to determine sulphate content, chloride content, pH and soil resistivity was carried out on selected soil samples obtained during drilling. The results of these tests are included in Appendix B.

## **4. SUBSURFACE CONDITIONS**

The subsurface conditions at the site are discussed in the following sections. Detailed descriptions of the soil and groundwater conditions encountered at each of the borehole locations are included in the individual borehole logs in Appendix A.

## **4.1 Soil Conditions**

### **4.1.1 Asphalt**

All boreholes drilled as part of this investigation were drilled on the shoulder of the existing highway. Boreholes BH-1 and BH-3 were drilled on a paved section of the shoulder and encountered a layer of asphalt 125 mm and 80 mm thick, respectively. Boreholes BH11-2 and BH11-4 were drilled on the unpaved shoulder and did not encounter any asphalt.

### **4.1.2 Granular Fill**

The asphalt is underlain by granular fill, which forms the pavement structure of the highway, as well as the existing highway embankment.

The uppermost portion of the granular fill was found to be sand and gravel, while the lower portions of the fill were primarily sand. The density of the fill material (as interpreted based on SPT and DCPT “N” values) typically ranged from loose to compact, with localized areas being very loose or dense.

The fill material extended to a depth of 3.1 m to 4.7 m below the existing road surface in the boreholes drilled as part of this investigation. This corresponds to elevations of 325 m to 323.9 m. In the two boreholes drilled adjacent to the existing culvert the fill material was found to be 4.6 m to 4.7 m thick (to elevation 323.7 m to 323.9 m).

A thin layer of peat was encountered at the base of the fill in BH-1 drilled near the existing culvert. This suggests the existing ground may not have been entirely stripped prior to constructing the existing embankment.

### **4.1.3 Native Silt and Sandy Silt**

The fill material was underlain by native soils which include a variable deposit of silt and sandy silt. The material generally ranges from silt with some clay and a trace of sand to sandy silt with a trace of clay. The density of native silt, sandy silt and sand (as interpreted on SPT “N” values and DCPT resistance values) is typically loose to compact. SPT “N” values and DCPT resistance values are presented on the borehole logs included in Appendix A as well as on the Soil Strata included in Drawing 2

A layer of compact gravelly sand was also encountered in BH-1. A layer of cobbles and boulders was encountered underlying the fill material in BH-3. Detailed descriptions of the soils encountered at each of the borehole locations are provided in the borehole records included in Appendix A.

The silty soils extended to the depth of drilling in BH1, BH-2 and BH-4. BH-3 encountered cobbles and boulders at a depth of 4.6 m, followed by refusal at 5.4 m depth.

The grain size distributions of representative samples of the native soils are presented in Table 1 below. The grain size distribution curves are also included in Drawings 3 through 5.

**Table 1 – Results of Grain Size Analyses for Native Soils**

| Borehole No. | Sample No. | Grain Size Distribution |        |        |        |
|--------------|------------|-------------------------|--------|--------|--------|
|              |            | % Gravel                | % Sand | % Silt | % Clay |
| BH-1         | SS-7       | 40                      | 42     | 15     | 3      |
| BH-1         | SS-8       | 0                       | 8      | 63     | 27     |
| BH-2         | SS-8       | 0                       | 1      | 85     | 14     |
| BH-3         | SS-5       | 10                      | 38     | 45     | 7      |
| BH-4         | SS-5       | 0                       | 6      | 76     | 18     |
| BH-4         | SS-8       | 0                       | 1      | 85     | 14     |

#### 4.1.4 Auger Refusal

Auger refusal was encountered in all of the boreholes, with the exception of BH-4. Auger refusal may represent the bedrock surface in some of the locations (at BH-3 south of the culvert the hole was attempted at three locations, and all three attempts met with refusal at roughly the same depth). It may, however, also represent cobbles and boulders which could not be augered through. At the culvert location DCPT testing could be continued more than 5 m past the point of auger refusal in BH-2.

## 4.2 Groundwater Conditions

Groundwater was encountered during drilling in all of the boreholes. A standpipe piezometer was installed in BH-2 adjacent to the existing culvert. The groundwater level at the site was measured the day after completion of drilling and found to be at an elevation of 326.9 m in the piezometer.

It should be noted that the groundwater levels can vary and are subjected to seasonal fluctuations as well as fluctuations in response to major weather events, and in particular for this site, in response to changes in the level of the creek. If construction is carried out at a time when the creek level is higher than the level in June, 2011 a corresponding increase in groundwater levels should be anticipated.

## 4.3 Summary

A summary of the soil and groundwater conditions encountered at the West Beaton River Tributary crossing location is presented in Table 2 below.



Table 2 – Simplified Stratigraphy and Groundwater Elevations

| Borehole No. | Ground Surface Elevation | Simplified Stratigraphy (Depth) |                          | Measured Groundwater Elevation | Notes  |
|--------------|--------------------------|---------------------------------|--------------------------|--------------------------------|--|
|              |                          | Granular Fill                   | Native Silt & Sandy Silt |                                |  |
| BH-1         | 328.5                    | 0.0 – 4.6 m                     | 4.6 – 10.7 m             | --                             | Auger refusal at 9.8 m; DCPT continued to 10.7 m |
| BH-2         | 328.4                    | 0.0 – 4.7 m                     | 4.7 – 15.2 m             | 326.9                          | Auger refusal at 9.8 m; DCPT continued to 15.2 m |
| BH-3         | 329.0                    | 0.0 – 3.1 m                     | 3.1 – 5.4 m              | ---                            | Auger refusal at 5.4 m                           |
| BH-4         | 328.1                    | 0.0 – 3.1 m                     | 3.1 – 9.8 m              | ---                            | --   |

## 5. CLOSURE

The field investigations were supervised by Mr. Naeem Ehsan, P.Eng. This report was prepared by Mr. Chris Hendry, P.Eng. Mr. Fanyu Zhu, P.Eng., SPL's designated MTO contact and Mr. Shaheen Ahmad, P.Eng., SPL's project quality control auditor, provided independent review and quality control of the technical aspects of this report.

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

### SPL CONSULTANTS LIMITED



Chris Hendry, M.Eng., P.Eng.





Fanyu Zhu, Ph.D., P.Eng.



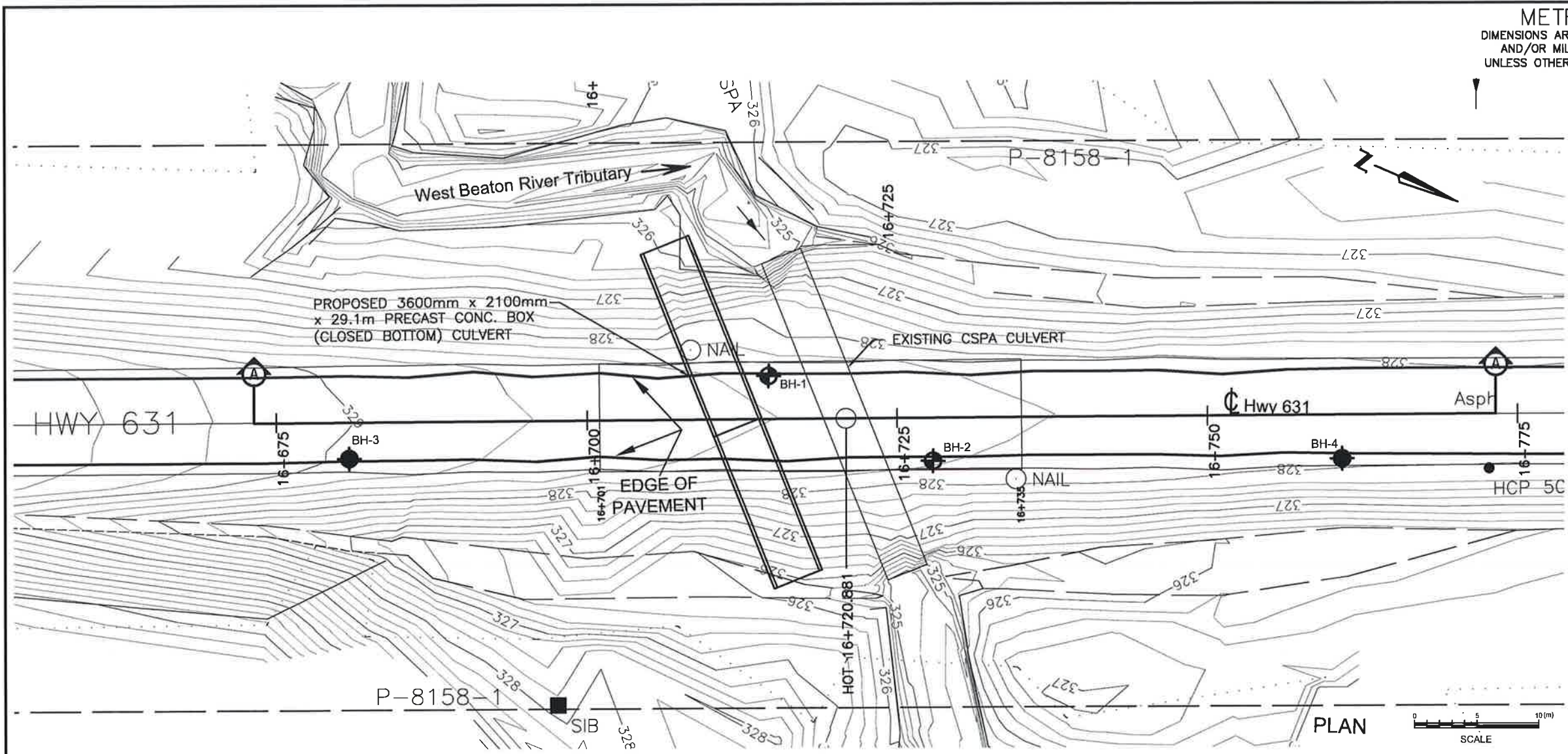

Shaheen Ahmad, M.A.Sc., P.Eng.

# Drawings



|   |             |   |          |
|---|-------------|---|----------|
| Client: McIntosh Perry Consulting Engineers |             | Title: SITE PLAN  |          |
| Project#:                                   | 750-1001    | DWG #:  | 1        |
| Drawn:                                      | NT          | Approved:   | CH       |
| Date:                                       | AUG 26-2011 | Scale:  | N. T. S. |
| Size:                                       | Letter      | Rev:  | 0        |
|   |             |  <b>SPL Consultants Limited</b><br>Geotechnical Environmental Materials Hydrogeology |          |



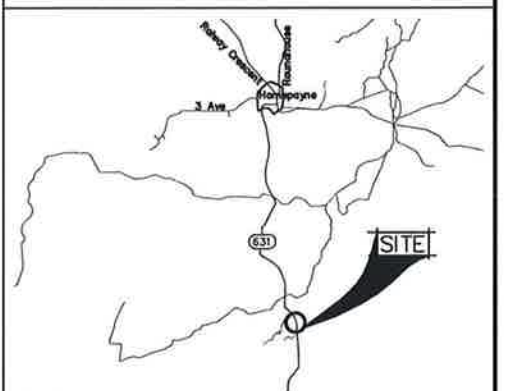


METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No  
WP No 5079-09-01

WEST BEATON RIVER  
TRIBUTARY CULVERT-HWY 631  
BORE HOLE LOCATIONS & SOIL STRATA

SPL Consultants Limited  
Geotechnical • Environmental • Materials • Hydrogeology



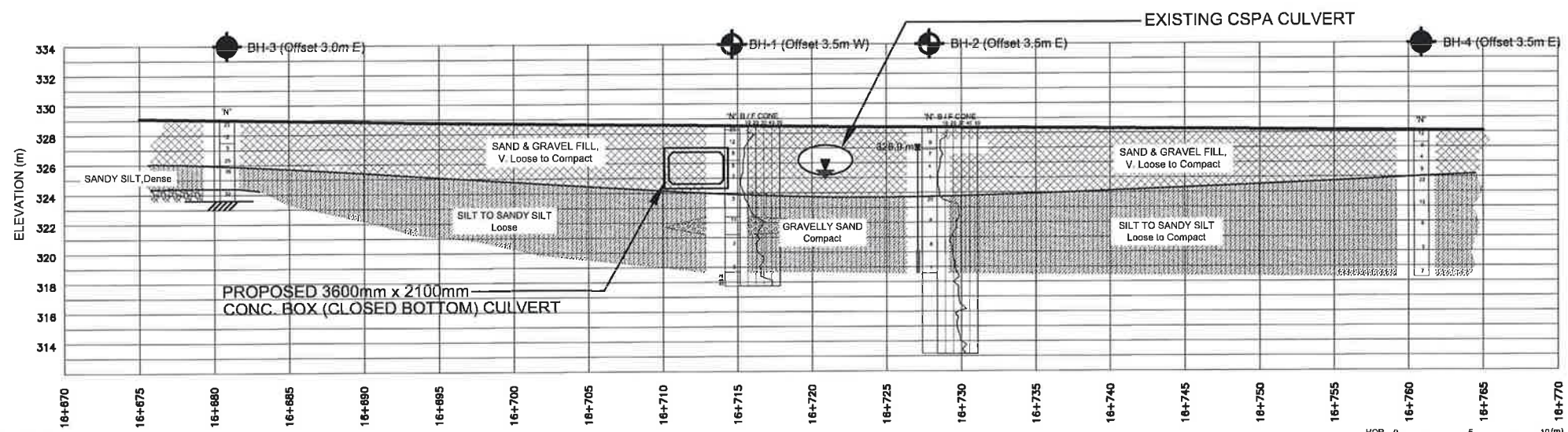
KEY PLAN  
NOT TO SCALE

- LEGEND
- Bore Hole
  - Bore Hole & Cone
  - N Blows/0.3m (Std Pen Test, 475 J/blow)
  - CONE Blows/0.3m (60' Cone, 475 J/blow)
  - WL at time of investigation July 2011
  - WL in Piezometer
  - Piezometer

| No   | ELEVATION | STATION  | OFFSET |
|------|-----------|----------|--------|
| BH-1 | 328.5     | 16+714.6 | 3.5m W |
| BH-2 | 328.4     | 16+727.9 | 3.5m E |
| BH-3 | 329.0     | 16+680.9 | 3.0m E |
| BH-4 | 328.1     | 16+760.9 | 3.5m E |

NOTES

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



LICENCED PROFESSIONAL ENGINEER  
C. G. HENDRY  
100011328  
JAN 28/13  
PROVINCE OF ONTARIO

LICENCED PROFESSIONAL ENGINEER  
F. ZHU  
Jan 28/13  
PROVINCE OF ONTARIO

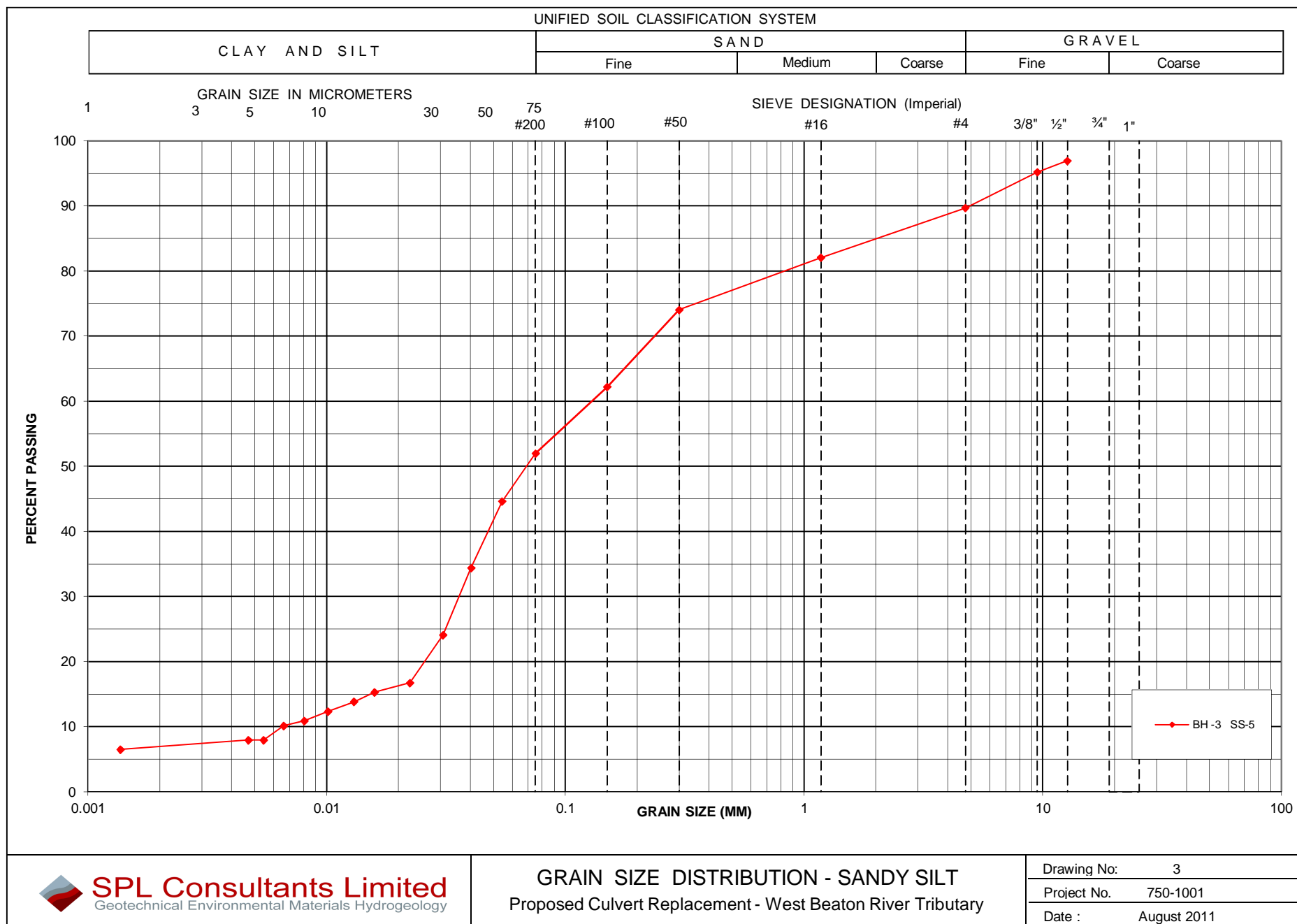
- SOIL STRATA SYMBOLS
- SAND & GRAVEL FILL
  - GRAVELLY SAND
  - COBBLE & BOULDER
  - SILT & SANDY SILT
  - AUGER REFUSAL

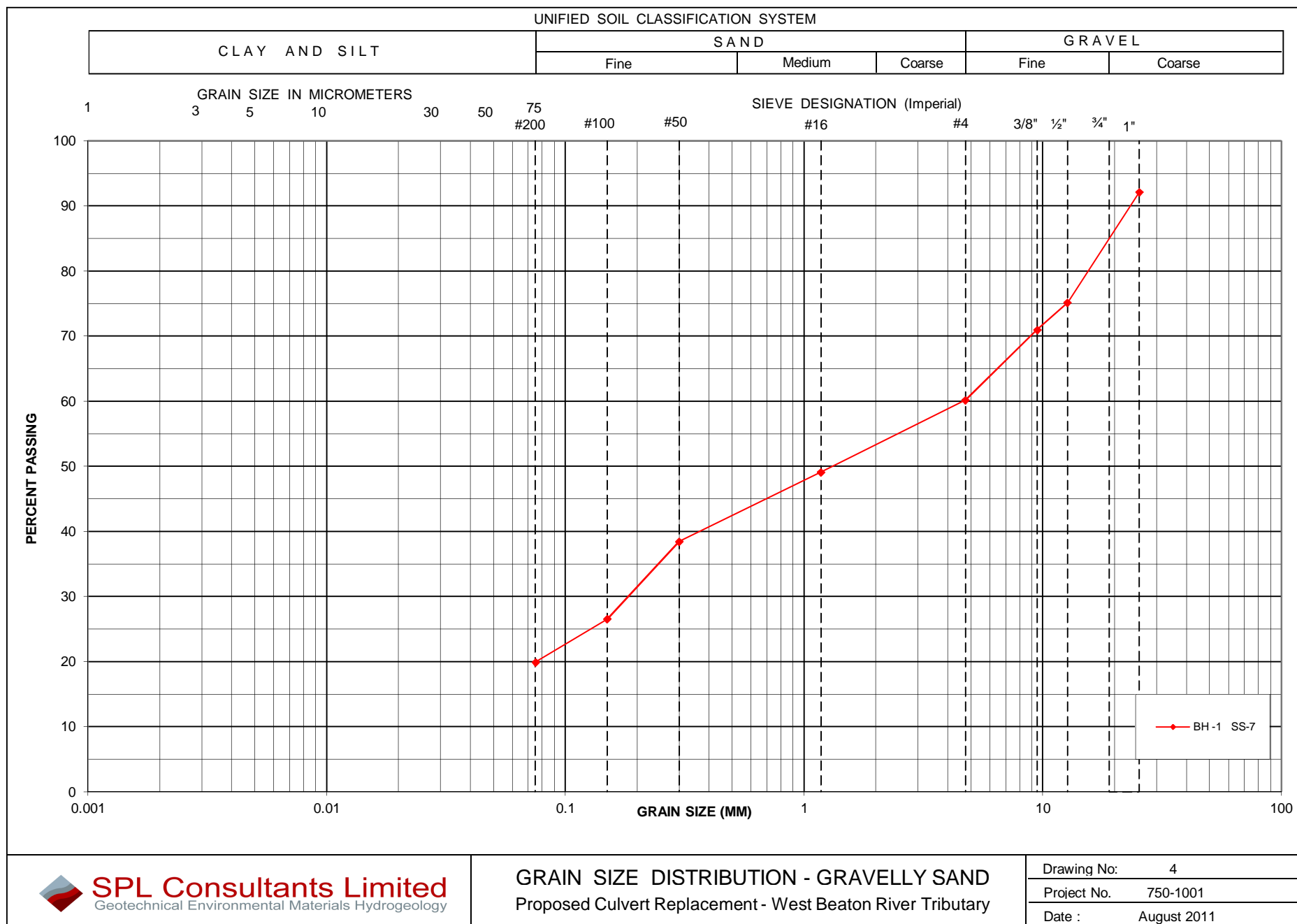
CROSS-SECTION A-A'

| REVISIONS | DATE | BY | DESCRIPTION    |
|-----------|------|----|----------------|
| Aug 15/12 | TJC  |    | Final Revision |
| Feb 16/12 | TJC  |    | Revision 1     |
|           |      |    |                |
|           |      |    |                |

GEORES No 42C-26

|            |            |                   |                |
|------------|------------|-------------------|----------------|
| HWY No 631 | CHECKED CH | DATE Aug 13, 2012 | SITE 38N-013/C |
| SUBM'D CH  | CHECKED CH | APPROVED FZ       | DWG 2          |





**SPL Consultants Limited**  
Geotechnical Environmental Materials Hydrogeology

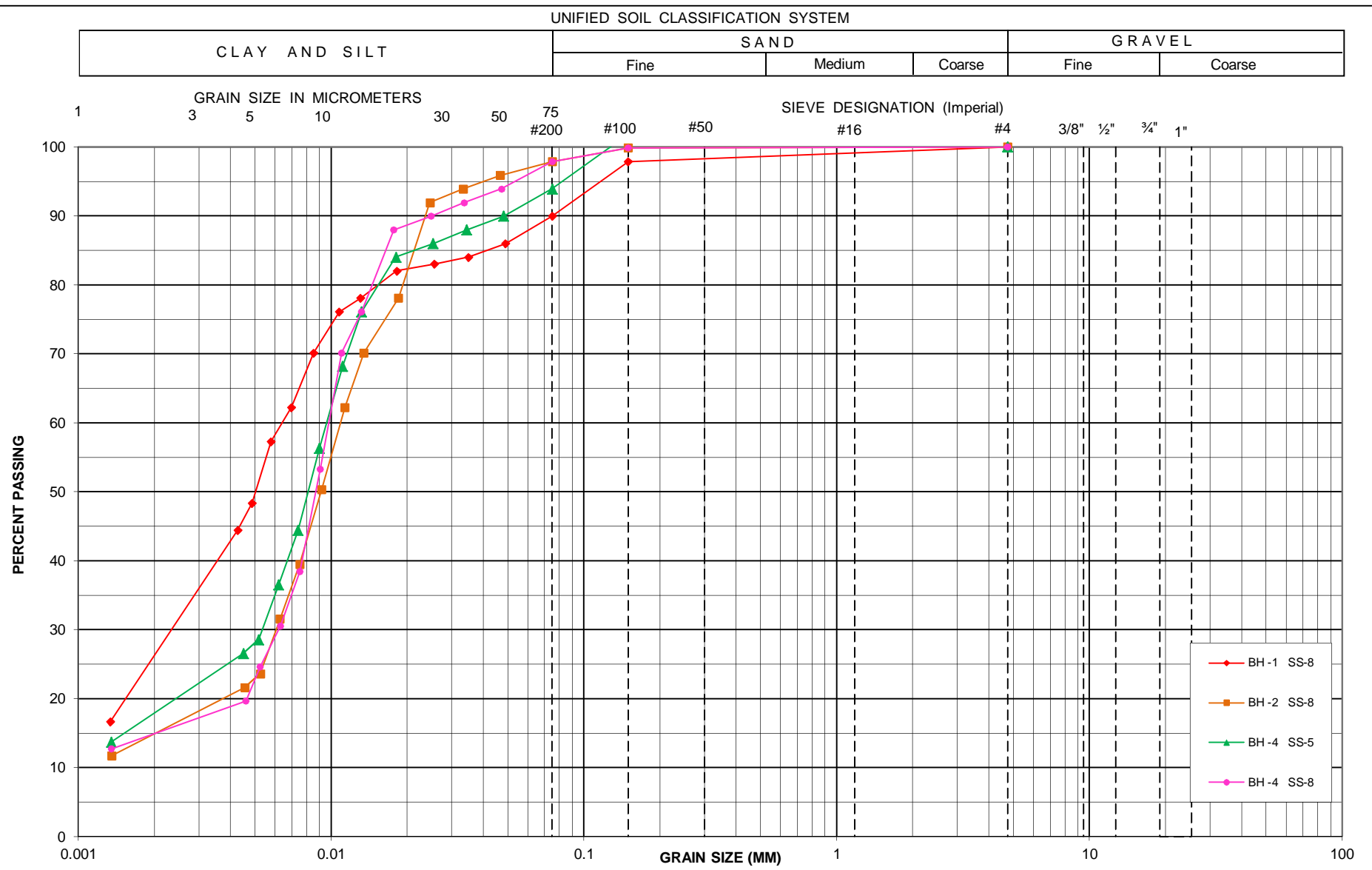
**GRAIN SIZE DISTRIBUTION - GRAVELLY SAND**

Proposed Culvert Replacement - West Beaton River Tributary

Drawing No: 4

Project No. 750-1001

Date : August 2011





# Appendix A

## Borehole Logs (Record of Borehole Sheets)



**RECORD OF BOREHOLE No BH-1**

1 OF 1

**METRIC**

W.P. 5079-09-01 LOCATION See Borehole Location Plan ORIGINATED BY NE  
DIST Algoma HWY 631 BOREHOLE TYPE Hollow Stem Augers COMPILED BY NE  
DATUM Geodetic DATE 11/06/2011 CHECKED BY CH

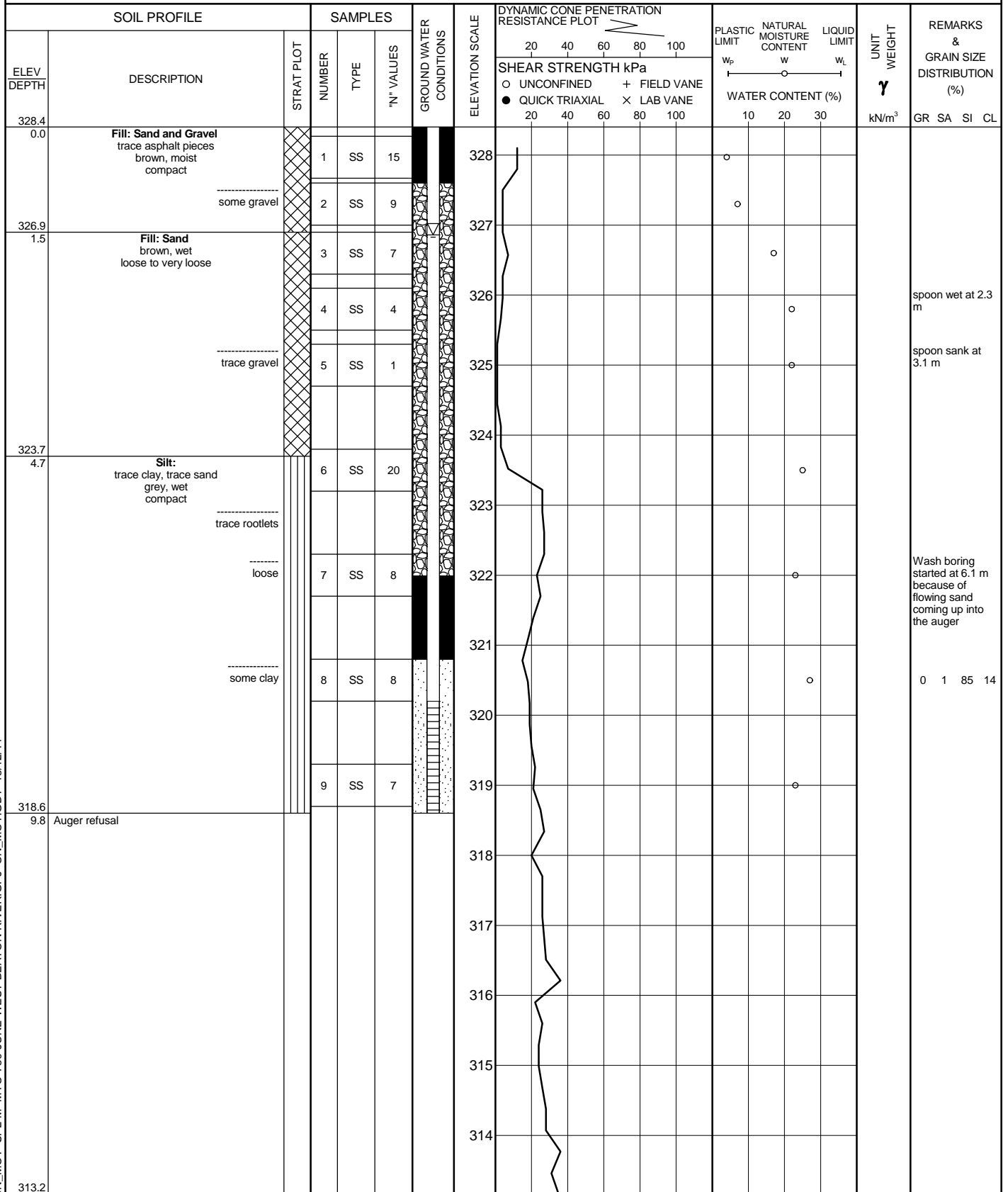
| SOIL PROFILE  |   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  | PLASTIC<br>LIMIT<br>W <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>W | LIQUID<br>LIMIT<br>W <sub>L</sub> | UNIT<br>WEIGHT<br>γ<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |
|---------------|---|------------|---------|------|------------|----------------------------|-----------------|---|--|------------------------------------|-------------------------------------|-----------------------------------|--|---|
| ELEV<br>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                             |  |                                    |                                     |                                   |  |   |
| 328.5         |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
| 0.1           | ASPHALT: 125 mm                           |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               | Fill: Sand and Gravel                     |            | 1       | SS   | 23         |                            | 328             |   |  |                                    |                                     |                                   |  |   |
|               | brown, moist                              |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               | compact                                   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               | trace gravel                              |            | 2       | SS   | 12         |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               | loose                                     |            | 3       | SS   | 8          |                            | 327             |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
| 326.2         |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
| 2.3           | Fill: Sand                                |            | 4       | SS   | 6          |                            | 326             |   |  |                                    |                                     |                                   |  |   |
|               | brown, wet                                |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               | loose to very loose                       |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               | trace gravel                              |            | 5       | SS   | 3          |                            | 325             |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
| 323.9         |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
| 324.8         | Peat: dark brown, moist                   |            |         |      |            |                            | 324             |   |  |                                    |                                     |                                   |  |   |
| 4.7           | Sandy Silt:                               |            | 6       | SS   | 3          |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               | trace clay, trace rootlets, some organics |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               | grey, wet                                 |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               | very loose                                |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
| 322.4         |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
| 6.1           | Gravelly Sand:                            |            | 7       | SS   | 11         |                            | 322             |   |  |                                    |                                     |                                   |  |   |
|               | some silt, trace clay                     |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               | grey, wet                                 |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               | compact                                   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
| 321.2         |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
| 7.3           | Silt:                                     |            | 8       | SS   | 7          |                            | 321             |   |  |                                    |                                     |                                   |  |   |
|               | trace sand, trace to some clay            |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               | grey, wet                                 |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               | firm                                      |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |
|               |   |            |         |      |            |                            |                 |   |  |                                    |                                     |                                   |  |   |

**RECORD OF BOREHOLE No BH-2**

1 OF 2

**METRIC**

W.P. 5079-09-01 LOCATION See Borehole Location Plan ORIGINATED BY NE  
DIST Algoma HWY 631 BOREHOLE TYPE Hollow Stem Augers COMPILED BY NE  
DATUM Geodetic DATE 10/06/2011 CHECKED BY CH



Continued Next Page

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

**RECORD OF BOREHOLE No BH-2**

2 OF 2

**METRIC**

W.P. 5079-09-01 LOCATION See Borehole Location Plan ORIGINATED BY NE  
DIST Algoma HWY 631 BOREHOLE TYPE Hollow Stem Augers COMPILED BY NE  
DATUM Geodetic DATE 10/06/2011 CHECKED BY CH

| SOIL PROFILE  |  | SAMPLES    |        |      | GROUND WATER<br>CONDITIONS | ELEVATION SCALE  | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |                    |    |     |                                     | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT |                   |  | UNIT<br>WEIGHT<br>$\gamma$<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br>GR SA SI CL |
|---------------|--|------------|--------|------|----------------------------|--|---|--------------------|----|-----|-------------------------------------|---|-------------------|--|---|--|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER | TYPE |                            |  | "N" VALUES                                  | SHEAR STRENGTH kPa |    |     |                                     |   | WATER CONTENT (%) |  |   |  |
|               |  |            |        |      |                            | ○ UNCONFINED + FIELD VANE<br>● QUICK TRIAXIAL × LAB VANE |   |                    |    |     | W <sub>p</sub> — W — W <sub>L</sub> |   |                   |  |   |  |
|               |  |            |        |      |                            | 20   | 40  | 60                 | 80 | 100 |                                     |   |                   |  |   |  |
| 15.2          | <b>End of Borehole</b><br>Notes:<br>1. Auger drilling ended at 9.8 m and dynamic cone test ended at 15.2 m.<br>2. Water level at 2.3 m during drilling.<br>3. Water level at 7 m upon completion.<br>4. 19 mm dia. piezometer was installed to a depth of 9.8 m.<br>5. water level in piezometer<br><u>Date</u> <u>Depth (m)</u> <u>Elevation (m)</u><br>June 11, 2011 1.54 326.86 |            |        |      |                            |  |   |                    |    |     |                                     |   |                   |  |   |  |

ONL\_MOT SPL-M-MTO-750-JUNE-WEST BEATON RIVER.GPJ ON\_MOT.GDT 15/12/11

**RECORD OF BOREHOLE No BH-3**

1 OF 1

**METRIC**

W.P. 5079-09-01 LOCATION See Borehole Location Plan ORIGINATED BY NE  
DIST Algoma HWY 631 BOREHOLE TYPE Hollow Stem Augers COMPILED BY NE  
DATUM Geodetic DATE 10/06/2011 CHECKED BY CH

| SOIL PROFILE  |   |            | SAMPLES |      |             | GROUND WATER<br>CONDITIONS       | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    | PLASTIC<br>LIMIT<br>w <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>w | LIQUID<br>LIMIT<br>w <sub>L</sub> | UNIT<br>WEIGHT<br><br>γ | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |                   |  |  |  |
|---------------|---|------------|---------|------|-------------|----------------------------------|-----------------|---|----|------------------------------------|-------------------------------------|-----------------------------------|-------------------------|---|-------------------|--|--|--|
| ELEV<br>DEPTH | DESCRIPTION   | STRAT PLOT | NUMBER  | TYPE | "N" VALUES  |                                  |                 | SHEAR STRENGTH kPa                          |    |                                    |                                     |                                   |                         |   | WATER CONTENT (%) |  |  |  |
|               |   |            |         |      |             |                                  |                 | ○ UNCONFINED      + FIELD VANE              |    |                                    |                                     |                                   |                         |   |                   |  |  |  |
|               |   |            |         |      |             | ● QUICK TRIAXIAL      × LAB VANE |                 |   |    |                                    |                                     |                                   |                         |   |                   |  |  |  |
| 329.0         |   |            |         |      |             |                                  |                 | 20  | 40 | 60                                 | 80                                  | 100                               |                         |   |                   |  |  |  |
| 328.9         | <b>ASPHALT:</b> 80 mm<br><b>Fill: Sand and Gravel</b><br>trace asphalt pieces, brown, moist<br>compact  |            | 1       | SS   | 23          |                                  |                 |   |    |                                    |                                     |                                   |                         |   |                   |  |  |  |
|               | trace gravel  |            | 2       | SS   | 12          |                                  |                 |   |    |                                    |                                     |                                   |                         |   |                   |  |  |  |
| 327.5         |   |            |         |      |             |                                  |                 |   |    |                                    |                                     |                                   |                         |   |                   |  |  |  |
| 1.5           | <b>Fill: Sand</b><br>brown, very moist<br>loose   |            | 3       | SS   | 5           |                                  |                 |   |    |                                    |                                     |                                   |                         |   |                   |  |  |  |
|               | some silt to silty, some organics, moist to wet,<br>compact   |            | 4       | SS   | 25          |                                  |                 |   |    |                                    |                                     |                                   |                         |   |                   |  |  |  |
| 325.9         |   |            |         |      |             |                                  |                 |   |    |                                    |                                     |                                   |                         |   |                   |  |  |  |
| 3.1           | <b>Sandy Silt:</b> trace clay, trace gravel, trace<br>sandstone fragments, wet sand seams, dense  |            | 5       | SS   | 36          |                                  |                 |   |    |                                    |                                     |                                   |                         |   |                   |  |  |  |
|               |   |            |         |      |             |                                  |                 |   |    |                                    |                                     |                                   |                         |   |                   |  |  |  |
| 324.4         |   |            |         |      |             |                                  |                 |   |    |                                    |                                     |                                   |                         |   |                   |  |  |  |
| 4.6           | <b>Cobble &amp; Boulder</b> (possibly Bedrock)  |            | 6       | SS   | 50/<br>25mm |                                  |                 |   |    |                                    |                                     |                                   |                         |   |                   |  |  |  |
| 323.6         |   |            | 7       | SS   | 50/<br>0mm  |                                  |                 |   |    |                                    |                                     |                                   |                         |   |                   |  |  |  |
| 5.4           | <b>End of Borehole</b><br>Notes:<br>1. Borehole was drilled 50 m North of rock cut<br>area and got auger refusal at 5.4 m on<br>possible cobble/boulder or possible bedrock.<br>2. Redrilled three times by moving the<br>borehole 2 to 3 m North and South of the<br>original borehole location and got auger<br>refusal at 5.4 m on possible cobble/boulder or<br>possible bedrock.<br>3. Water level at 3.6 m upon completion. |            |         |      |             |                                  |                 |   |    |                                    |                                     |                                   |                         |   |                   |  |  |  |

**RECORD OF BOREHOLE No BH-4**

1 OF 1

**METRIC**

W.P. 5079-09-01 LOCATION See Borehole Location Plan ORIGINATED BY NE  
DIST Algoma HWY 631 BOREHOLE TYPE Hollow Stem Augers COMPILED BY NE  
DATUM Geodetic DATE 10/06/2011 CHECKED BY CH

| SOIL PROFILE  |   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION<br>SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |              |     |  | PLASTIC<br>LIMIT<br>w <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>w | LIQUID<br>LIMIT<br>w <sub>L</sub> | UNIT<br>WEIGHT<br><br>γ | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |                   |  |            |
|---------------|---|------------|---------|------|------------|----------------------------|--------------------|---|----|--------------|-----|--|------------------------------------|-------------------------------------|-----------------------------------|-------------------------|---|-------------------|--|------------|
| ELEV<br>DEPTH | DESCRIPTION   | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                    | SHEAR STRENGTH kPa                          |    |              |     |  |                                    |                                     |                                   |                         |   | WATER CONTENT (%) |  |            |
|               |   |            |         |      |            |                            |                    | ○ UNCONFINED                                |    | + FIELD VANE |     |  |                                    |                                     |                                   |                         |   | ● QUICK TRIAXIAL  |  | × LAB VANE |
| 328.1         |   |            |         |      |            |                            | 20                 | 40  | 60 | 80           | 100 |  |                                    |                                     |                                   |                         |   |                   |  |            |
| 0.0           | Fill: Sand and Gravel<br>trace asphalt pieces<br>brown, moist<br>compact  |            | 1       | SS   | 12         |                            |                    |   |    |              |     |  |                                    |                                     |                                   |                         |   |                   |  |            |
| 327.3         |   |            | 2       | SS   | 9          |                            |                    |   |    |              |     |  |                                    |                                     |                                   |                         |   |                   |  |            |
| 0.8           | Fill: Sand<br>brown, moist<br>loose to very loose   |            | 3       | SS   | 4          |                            |                    |   |    |              |     |  |                                    |                                     |                                   |                         |   |                   |  |            |
|               | -----<br>wet  |            | 4       | SS   | 9          |                            |                    |   |    |              |     |  |                                    |                                     |                                   |                         |   |                   |  |            |
|               | -----<br>loose, some silt to silty, some organics   |            |         |      |            |                            |                    |   |    |              |     |  |                                    |                                     |                                   |                         |   |                   |  |            |
| 325.0         |   |            |         |      |            |                            |                    |   |    |              |     |  |                                    |                                     |                                   |                         |   |                   |  |            |
| 3.1           | Silt:<br>some clay<br>grey, moist<br>stiff  |            | 5       | SS   | 22         |                            |                    |   |    |              |     |  |                                    |                                     |                                   |                         |   |                   |  |            |
|               |   |            |         |      |            |                            |                    |   |    |              |     |  |                                    |                                     |                                   |                         |   |                   |  |            |
|               |   |            | 6       | SS   | 15         |                            |                    |   |    |              |     |  |                                    |                                     |                                   |                         |   |                   |  |            |
|               | -----<br>wet  |            |         |      |            |                            |                    |   |    |              |     |  |                                    |                                     |                                   |                         |   |                   |  |            |
|               |   |            | 7       | SS   | 8          |                            |                    |   |    |              |     |  |                                    |                                     |                                   |                         |   |                   |  |            |
|               |   |            |         |      |            |                            |                    |   |    |              |     |  |                                    |                                     |                                   |                         |   |                   |  |            |
|               |   |            | 8       | SS   | 5          |                            |                    |   |    |              |     |  |                                    |                                     |                                   |                         |   |                   |  |            |
|               |   |            |         |      |            |                            |                    |   |    |              |     |  |                                    |                                     |                                   |                         |   |                   |  |            |
|               | -----<br>clay seams, wet seams of sand  | 9          | SS      | 7    |            |                            |                    |   |    |              |     |  |                                    |                                     |                                   |                         |   |                   |  |            |
| 318.3         |   |            |         |      |            |                            |                    |   |    |              |     |  |                                    |                                     |                                   |                         |   |                   |  |            |
| 9.8           | End of Borehole<br>Notes:<br>1. Water level at 4.6 m during drilling.<br>2. Water level at 8.8 m upon completion. |            |         |      |            |                            |                    |   |    |              |     |  |                                    |                                     |                                   |                         |   |                   |  |            |

ONL\_MOT\_SPL-M-MTO-750-JUNE-WEST BEATON RIVER.GPJ ON\_MOT\_GDT 15/12/11

# Appendix B

## Chemical Test Results

Client: **SPL Consultants Ltd.**  
 146 Colonnade Rd., Unit 17

Ottawa, ON  
 K2E 7Y1

Attention: **Mr. Neem Tavakkoli**

Report Number: 1118694  
 Date: 2011-08-19  
 Date Submitted: 2011-08-15

Project: 750-1001

P.O. Number: VISA  
 Matrix: Soil


Chain of Custody Number: 145782

|                         |        |       | LAB ID:      | 903424         | 903425         |  |  |  | GUIDELINE |       |       |
|-------------------------|--------|-------|--------------|----------------|----------------|--|--|--|-----------|-------|-------|
|                         |        |       | Sample Date: | 2011-06-11     | 2011-06-11     |  |  |  |           |       |       |
|                         |        |       | Sample ID:   | BH11-WB-1/SS-9 | BH11-WB-2/SS-6 |  |  |  |           |       |       |
| PARAMETER               | UNITS  | MRL   |              |                |                |  |  |  | TYPE      | LIMIT | UNITS |
| Chloride                | %      | 0.002 |              | <0.002         | <0.002         |  |  |  |           |       |       |
| Electrical Conductivity | mS/cm  | 0.05  |              | 0.09           | 0.12           |  |  |  |           |       |       |
| pH                      |        |       |              | 8.8            | 8.8            |  |  |  |           |       |       |
| Resistivity             | ohm-cm | 1     |              | 11100          | 8330           |  |  |  |           |       |       |
| Sulphate                | %      | 0.01  |              | 0.04           | 0.04           |  |  |  |           |       |       |

MRL = Method Reporting Limit INC = Incomplete AO = Aesthetic Objective OG = Operational Guideline MAC = Maximum Allowable Concentration IMAC = Interim Maximum Allowable Concentration

Comment:

Methods references and/or additional QA/QC information available on request.

APPROVAL:   
 Lorna Wilson  
 Inorganic Lab Supervisor

# Appendix C

## 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 63.5 kg, 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           |
| $\sigma$                             | kPa | TOTAL NORMAL STRESS           |
| $\sigma'$                            | kPa | EFFECTIVE NORMAL STRESS       |
| $\tau$                               | kPa | SHEAR STRESS                  |
| $\sigma_1, \sigma_2, \sigma_3$       | kPa | PRINCIPAL STRESSES            |
| $\epsilon$                           | %   | LINEAR STRAIN                 |
| $\epsilon_1, \epsilon_2, \epsilon_3$ | %   | PRINCIPAL STRAINS             |
| E                                    | kPa | MODULUS OF LINEAR DEFORMATION |
| G                                    | kPa | MODULUS OF SHEAR DEFORMATION  |
| $\mu$                                | 1   | COEFFICIENT OF FRICTION       |

### MECHANICAL PROPERTIES OF SOIL

|                |                       |                                      |
|----------------|-----------------------|--------------------------------------|
| $m_v$          | $\text{kPa}^{-1}$     | COEFFICIENT OF VOLUME CHANGE         |
| $c_c$          | 1                     | COMPRESSION INDEX                    |
| $c_e$          | 1                     | SWELLING INDEX                       |
| $c_a$          | 1                     | RATE OF SECONDARY CONSOLIDATION      |
| $c_v$          | $\text{m}^2/\text{s}$ | COEFFICIENT OF CONSOLIDATION         |
| H              | m                     | DRAINAGE PATH                        |
| $T_v$          | 1                     | TIME FACTOR                          |
| U              | %                     | DEGREE OF CONSOLIDATION              |
| $\sigma'_{vo}$ | kPa                   | EFFECTIVE OVERBURDEN PRESSURE        |
| $\sigma'_p$    | kPa                   | PRECONSOLIDATION PRESSURE            |
| $\tau_f$       | kPa                   | SHEAR STRENGTH                       |
| $c'$           | kPa                   | EFFECTIVE COHESION INTERCEPT         |
| $\Phi$         | -°                    | EFFECTIVE ANGLE OF INTERNAL FRICTION |
| $c_u$          | kPa                   | APPARENT COHESION INTERCEPT          |
| $\Phi_u$       | -°                    | APPARENT ANGLE OF INTERNAL FRICTION  |
| $\tau_R$       | kPa                   | RESIDUAL SHEAR STRENGTH              |
| $\tau_r$       | kPa                   | REMOULDED SHEAR STRENGTH             |
| $S_t$          | 1                     | SENSITIVITY = $c_u / \tau_r$         |

### PHYSICAL PROPERTIES OF SOIL

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

**PART B**  
**FOUNDATION DESIGN REPORT**  
**PROPOSED WEST BEATON RIVER TRIBUTARY CULVERT REPLACEMENT**  
**HIGHWAY 631 NORTH OF HIGHWAY 17, ONTARIO**  
**WP 5079-09-01 SITE NO. 38N-013/C**  
**G.W.P. 5270-08-00**  
**MTO GEOCRES NO. 42C-26**

Prepared for:

**MCINTOSH PERRY CONSULTING ENGINEERS**

By:

**SPL CONSULTANTS LIMITED**

Project: 750-1001 (West Beaton)  
January 2013



**SPL Consultants Limited**  
Geotechnical Environmental Materials Hydrogeology

146 Colonnade Road  
Ottawa, Ontario K2E 7Y1  
Tel: 613.228.0065 Fax: 613.228.0045

## Table of Contents

### PART B: FOUNDATION DESIGN REPORT

|  |           |
|--|-----------|
| <b>6. DISCUSSION AND RECOMMENDATIONS .....</b> | <b>6</b>  |
| 6.1 General .....                              | 6         |
| 6.2 Frost Protection .....                     | 6         |
| 6.3 Seismic Performance.....                   | 6         |
| 6.4 Foundations Design.....                    | 7         |
| 6.4.1 Foundation Options .....                 | 7         |
| 6.4.2 Bearing Resistance .....                 | 7         |
| 6.4.3 Sliding Resistance .....                 | 7         |
| 6.5 Bedding, Cover and Backfill.....           | 7         |
| 6.6 Earth Pressures .....                      | 8         |
| 6.7 Embankment Widening .....                  | 10        |
| 6.8 Erosion Protection .....                   | 10        |
| 6.9 Construction Considerations.....           | 11        |
| 6.10 Corrosion and Cement Type .....           | 12        |
| <b>7. CLOSURE .....</b>                        | <b>13</b> |
| <b>8. REFERENCES .....</b>                     | <b>14</b> |

## **6. DISCUSSION AND RECOMMENDATIONS**

### **6.1 General**

The proposed new culvert structure is a 3.6 m wide by 2.1 m high closed bottom concrete box culvert. The invert new culvert will be approximately 324.4 m to 324.8 m (which is lower than the existing culvert). The new culvert will be approximately 10 m west of the existing culvert. The current design does not include any change in the final embankment height.

The subsurface conditions encountered in the boreholes drilled at the site include a layer of granular fill approximately 4.6 m to 4.7 m deep at the existing culvert, which forms the road structure, embankment and backfill around the existing culvert.

The fill layer is underlain by native soils consisting primarily of silt and sandy silt, and in some locations gravel as well as cobbles and boulders. The native granular soils extended to the depth of drilling and DCPT testing at the culvert location (approximately 15 m below the existing ground surface, and 12 m below the culvert invert).

The groundwater level at the site was found to be at approximately elevation 326.9 m, and would be expected to vary seasonally and with the level of the creek.

Based on the borehole information, the culvert and bedding will be founded on loose to compact silt and sandy silt, and potentially some granular fill (the proposed culvert invert is approximately at the transition between the fill and the native soils). Either the existing granular fill or the native granular soils are expected to be adequate to support the proposed culvert.

### **6.2 Frost Protection**

The depth of frost penetration for the West Beaton River Tributary site is 2.4 m. The existing fill material within the frost depth is predominantly sand and silty sand and is considered to have a low susceptibility to frost heave. As such, frost tapers are not required for new construction.

### **6.3 Seismic Performance**

The site is located in an area of relatively low seismic activity. The Peak Horizontal Ground Acceleration (PHA) for an earthquake with a 10% chance of exceedance in 50 years (475 year return period event) is 0.011 g. Based on the Canadian Highway Bridge Design Code (CHBDC) this corresponds to a Seismic Performance Zone 1 (assuming the crossing would be classified as an Emergency Route Bridge), and Zonal Acceleration Ratio of  $A = 0$  (CHBDC Section 4.4).

For the purposes of assessing the effects of site conditions under seismic conditions, the site may be assumed to be Soil Profile Type III, which corresponds to a Site Coefficient  $S = 1.5$  (CHBDC Section 4.4.6).

## **6.4 Foundations Design**

### **6.4.1 Foundation Options**

MTO has selected a pre-cast concrete box culvert as the preferred replacement option. The sub-surface conditions at the site are considered to be adequate for the founding of the preferred replacement structure (pre-cast box culvert) on normal foundations (granular bedding placed over native soils or granular fill).

Deep foundations are technically feasible, but are not required as conventional shallow foundations will provide sufficient bearing resistance and settlement performance for the proposed culvert.

### **6.4.2 Bearing Resistance**

The bedding for the new culvert structure will be placed on the native silty soils (or possibly on the existing fill in some areas).

For the new culvert which is 3.6 m wide and will be founded at an elevation of approximately 324.4 m to 324.8 m, the unfactored geotechnical bearing resistance at Ultimate Limit States (ULS) can be taken as 400 kPa. A resistance factor of 0.5 should be applied to this value, yielding a factored bearing resistance of 200 kPa at ULS. This value is for a concentrically loaded foundation. Eccentric loads (if present) should be accounted for by considering an effective bearing area as outlined in the CHBDC.

The geotechnical resistance at the Serviceability Limit State (SLS) can be taken as 150 kPa.

Provided that the subgrade is not disturbed during construction the total and differential settlements associated with the above SLS resistance values are expected to be less than 25 mm and 20 mm, respectively. It is expected that for this level of settlement the new culverts will not require a camber.

### **6.4.3 Sliding Resistance**

For the purposes of evaluating sliding resistance (Section 6.7.5 of the CHBDC) of either the native soils or the granular fill below the foundation the effective cohesion,  $c'$ , should be assumed to be zero. The effective friction angle ( $\phi'$ ) for the silty, sandy native soils may be assumed to be  $30^\circ$ . These values are unfactored values. A resistance factor of 0.8 should be applied to the resulting resistance to obtain the factored sliding resistance as per the CHBDC.

## **6.5 Bedding, Cover and Backfill**

Bedding, cover and backfill details for the new culvert should be as per MTOD 803.021. Bedding for the new culvert may consist of either:

- 500 mm of compacted Granular A or Granular B Type II; or

- 300 mm of compacted Granular A or Granular B Type II placed over a lean concrete working slab.

If constructed properly, either bedding treatment is considered adequate from a foundations perspective.

A 75 mm levelling course of additional Granular A or fine aggregate should also be provided between the bedding and the culvert. In order to minimize the potential for piping and undermining of the culvert foundations the bedding should be wrapped in a non-woven geotextile which meets the requirements of OPSS 1860.

Cover for the new culverts should be a minimum of 300 mm thick as per MTOD 803.021 and may include either Granular A or Granular B with a maximum particle size of 75 mm (as per OPSS 422 and Special Provision 422S01).

Granular backfill may consist of either imported Granular A or B material, or salvageable portions of the existing soils (Granular A or B is preferred for fills below the water table as well as immediately below the pavement structure). Portions of the fill which forms the embankment meet the requirements of OPSS 1010 Granular B Type I. Other portions of the fill meet the requirements of OPSS 1010 for SSM. The excavated soils should be reviewed as excavated and suitable portions may be stockpiled for re-use as backfill (if a cost-effective stockpile location is available). Material from below the water table, as well as the native soils, is unlikely to be suitable for use as granular backfill and there will be a net import of granular fill required for construction.

All bedding, cover and backfill should be placed in lifts not exceeding 200 mm and in accordance with OPSS 206. All fill material should be compacted in accordance with OPSS 422 (as amended by SP422S01), OPSS 501 and OPSS 902.

Heavy equipment should not be used behind the culvert and any other structures within the restricted zone as outlined in OPSS 501.

## 6.6 Earth Pressures

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

### **Compacted Granular 'A' or Granular 'B' Type II**

Angle of Internal Friction ( $\phi$ ) = 35 degrees (unfactored)

Unit Weight = 22 kN/m<sup>3</sup>

**Coefficients of Lateral Earth Pressure:**

| Earth Pressure<br>Coefficient | Level Backfill | Sloping Backfill<br>3H:1V | Sloping Backfill<br>2H:1V |
|-------------------------------|----------------|---------------------------|---------------------------|
| $K_a$                         | 0.27           | 0.34                      | 0.40                      |
| $K_b$                         | 0.35           | 0.44                      | 0.50                      |
| $K_0$                         | 0.43           | 0.56                      | 0.62                      |
| $K^*$                         | 0.45           | 0.60                      | 0.66                      |

**Compacted Granular 'B' Type I**

Angle of Internal Friction ( $\phi$ ) = 32 degrees (unfactored)

Unit Weight = 21 kN/m<sup>3</sup>

**Coefficients of Lateral Earth Pressure:**

| Earth Pressure<br>Coefficient | Level Backfill | Sloping Backfill<br>3H:1V | Sloping Backfill<br>2H:1V |
|-------------------------------|----------------|---------------------------|---------------------------|
| $K_a$                         | 0.30           | 0.38                      | 0.47                      |
| $K_b$                         | 0.38           | 0.48                      | 0.57                      |
| $K_0$                         | 0.47           | 0.61                      | 0.69                      |
| $K^*$                         | 0.51           | 0.67                      | 0.76                      |

**Notes:**

$K_a$  is the coefficient of active earth pressure;

$K_b$  is the coefficient of active earth pressure for an unrestrained structure including compaction efforts;

$K_0$  is the coefficient of earth pressure at rest;

$K^*$  is the coefficient of earth pressure at rest for a fully restrained structure including compaction efforts.

The above values assume that the backfill behind the structure is free-draining granular fill, and that proper drainage is provided. Water pressures must also be accounted for in areas below the water table.

The appropriate earth pressure coefficient for design will depend upon whether the retaining structure is restrained or some movement can occur such that the active earth pressure state can develop. The effect of compaction should also be taken into account when selecting the appropriate earth pressure coefficients.

In accordance with the method outlined in the CHBDC and Commentaries Section 4.6.4, for a Zonal Acceleration Ratio of  $A = 0$  the earth pressure under the design seismic event is equal to the earth

pressure under static conditions (the horizontal seismic coefficient,  $k_h$  is 0.5 or 1.5 times the Zonal Acceleration Ratio, and for the design earthquake  $A = 0$ ).

## **6.7 Embankment Widening**

It is understood that the existing roadway embankment may be widened on the west side to facilitate a detour around the construction site, and that this widening would likely be of similar height as the embankment. Based on the conditions encountered in the boreholes, foundation failures are not anticipated for the proposed embankment widening with normal (2H:1V or flatter) slopes, assuming that all organic or unsuitable materials are removed as per normal MTO standards and procedures for stripping and benching prior to placing the embankment fills.

All unsuitable materials should be removed and the approved embankment subgrade should be proofrolled. The construction of the new embankment widening may require dewatering and/or groundwater control as discussed in Section 6.9 below where the base of the embankment is below the water table.

The sides of the existing embankment should be benched prior to placing fill material for the embankment widening, as per OPSD 208.01. Fill material should be placed in lifts not exceeding 300 mm in thickness and compacted to 95% SPMD as per OPSS 206 and OPSS 501. Borrow material should consist of select suitable inorganic earth, free of objectionable inclusions such as cobbles, boulders, frozen materials, organic soils, etc. The existing fill material may be suitable for this purpose. Borrow material for the proposed embankment widening should be approved prior to installation from both a geotechnical and environmental standpoint.

Based on the subsurface conditions present, it is expected that the settlement at the surface of the embankment will be less than 50 mm (including settlement of the fill itself as well as the underlying soils) most of which will occur within approximately 6 weeks of construction (assuming predominantly granular fill is used for the embankment). These estimated settlements are typical of this type of construction and considered within acceptable limits.

All embankment construction (including review of exposed subgrade, approval of fill materials, etc.) should be carried out under the review and supervision of a qualified person.

## **6.8 Erosion Protection**

The native soils at the site are expected to be susceptible to erosion. Erosion and scour protection such as rip rap treatment similar to OPSD 810.919) will be required at the culvert inlets and outlets. The sizing of erosion protection should be carried out by a specialist who is familiar with the site hydraulics and the findings of this investigation.

The current culvert design includes upstream and downstream cut-off walls on the new culverts. These walls should extend to below the base of the bedding and levelling course to prevent flow of water below the walls through the permeable bedding layer. It is also recommended that the bedding and



levelling course be enclosed in a non-woven geotextile (OPSS 1860) in order to reduce the potential for piping and erosion of the culvert bedding.

## **6.9 Construction Considerations**

### Construction Dewatering

The groundwater level at the site was found to be approximately equal to the level of the water in the creek at the time of the investigation. The groundwater level is expected to be sensitive to changes in the water level in the creek, and for this reason it is recommended that if possible the rehabilitation be carried out in a dry period when the creek would be expected to be at its lowest level. It is also recommended that where possible the water flow in the existing watercourse be diverted away from the construction zone, and the existing culvert remain in place to be used as a by-pass structure, to maintain sufficiently dry conditions for construction.

The replacement will involve excavations below the groundwater table, and even with the above measures, dewatering will likely be required to stabilize the native soils, to maintain a dry working area and to minimize disturbance of the foundation soils during construction. Depending upon the creek level and groundwater conditions at the time of construction, closely spaced filtered sumps may be used for excavations which extend only a short distance below the groundwater table (say 0.5 m or so). The creek level was at approximately 325.5 m at the time of the site survey, and the groundwater level measured in the native soils was at approximately 326.9 m. Excavation will be required to below 324 m elevation when accounting for the culvert itself as well as bedding (1.5 m to 3 m below the likely groundwater level) will be required to accommodate the culvert, bedding, levelling course, etc. These deeper excavations will likely require an active dewatering system including well points and/or deep wells to maintain a dry excavation.

In addition to groundwater control, it is expected that an above-ground diversion (coffer dam and diversion of the existing water course around the site), and an underground impervious barrier (such as a sheet pile wall; the choice of protection systems and cut-off walls will ultimately be the responsibility of the contractor) will also need to be constructed to control groundwater flows into the excavation.

### Temporary Excavations

All excavations should be carried out in accordance with the most recent Occupational Health and Safety Act (OHSA). Part III of Ontario Regulation 213/91 deals with excavations. In addition, the following Ontario Provincial Standard Specifications (OPSS) also deal with temporary excavations:

OPSS 539 – Construction Specification for Temporary Protection Systems

OPSS 902 – Construction Specification for Excavating and Backfilling - Structures

The soils at the site include granular fill in the pavement structure and embankment, underlain by loose to compact native silty soils. Both granular fill and granular native soils can be classified as Type 3 soil above the water table and Type 4 soil below the water table.

Temporary excavations above the water table are likely feasible using sloped excavations in the granular fill. Excavations below the water table will require some form of protection system. It is also noted that the preliminary staging will require excavation in close proximity to the travelled lanes of the highway which will preclude the use of sloped excavations in some areas (as there is not sufficient space).

Temporary shoring would typically consist of soldier piles and timber lagging or interlocking sheet piles. It should be noted that cobbles and boulders were encountered during the investigation. This should be considered when selecting shoring systems and installation methods.

#### Foundation Excavations

The bearing capacities provided in Section 6.4 above assume that the subgrade is not excessively disturbed during construction. Given the fact that the foundations for any new structures will be below the groundwater table in loose to compact sand and silt, it will require careful construction control to achieve this condition. Installation and operation of an adequate dewatering system, as discussed above, will be critical to the construction of the foundations.

A layer of lean concrete working slab (mud slab) on foundation bearing surfaces can also be included in the design (see Section 6.5 above). If used, the working slab should be placed immediately after excavation and inspection (before placement of bedding and levelling layers) to minimize foundation disturbance. If excavation conditions are found to be better than anticipated then the requirement for the lean concrete mud slab may be waived at the time of construction. All excavated surfaces should be kept free of frost, water, etc. during the course of construction.

All excavated surfaces should be inspected prior to foundation construction by a qualified individual who is familiar with the findings of this investigation and the design and construction of similar structures.

#### **6.10 Corrosion and Cement Type**

Two soil samples were submitted to Exova Accutest for testing related to soil corrosivity and potential exposure of concrete elements to sulphate attack. The results of these tests are included in Appendix B.

The test results indicate that the sulphate content of the native soils is relatively low, and sulphate-resistant Portland cement is not required.

Soil resistivity and acidity test results indicate that there is a low to moderate potential for corrosion of buried steel elements. Appropriate care should be taken in designing the corrosion protection system for any buried steel structures.

## 7. CLOSURE

The field investigations were supervised by Mr. Naeem Ehsan, P.Eng. This report was prepared by Mr. Chris Hendry, P.Eng. Mr. Fanyu Zhu, P.Eng., SPL's designated MTO contact and Mr. Shaheen Ahmad, P.Eng., SPL's project quality control auditor, provided independent review and quality control of the technical aspects of this report.

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

### SPL CONSULTANTS LIMITED

Chris Hendry, M.Eng., P.Eng.



Fanyu Zhu, Ph.D., P.Eng.



Shaheen Ahmad, M.A.Sc., P.Eng.

## 8. REFERENCES

The following section provides a general list of references, as well as a list of Ontario Provincial Standard Specifications which are expected to be relevant to the Foundations portion of the proposed work.

### General References

CAN/CSA-S6-06 Canadian Highway Bridge Design Code, 2011

Canadian Foundation Engineering Manual, 2006. 4<sup>th</sup> Edition. Canadian Geotechnical Society

### Relevant Ontario Provincial Standard Specifications

| OPSS NO. | TITLE   |
|----------|---|
| 128      | Supply of Pre-Qualified Materials and Products                                    |
| 182      | Environmental Protection for Construction in Waterbodies and on Waterbody banks.  |
| 201      | Clearing, Close Cut Clearing, Grubbing, and Removal of Surface and Piled Boulders |
| 206      | Grading   |
| 401      | Trenching, Backfilling, and Compacting  |
| 404      | Support Systems   |
| 422      | Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut               |
| 501      | Compacting  |
| 504      | Preservation, Protection and Reconstruction of Existing Facilities                |
| 506      | Dust Suppressants   |
| 510      | Removals  |
| 511      | Rip-Rap, Rock Protection, and Granular Sheeting                                   |
| 514      | Trenching, Backfilling, and Compacting  |
| 518      | Control of Water from Dewatering Operations                                       |
| 539      | Temporary Protection Systems  |
| 805      | Temporary Erosion and Sediment Control Measures                                   |
| 902      | Excavating and Backfilling – Structures   |
| 1001     | Aggregates - General  |
| 1010     | Aggregates – Base, Subbase, Select Subgrade, and Backfill Material                |
| 1860     | Geotextiles   |

### Relevant CDED Special Provisions

| Provision No. | Title   |
|---------------|---|
| 100S60        | Amendment to MTO General Conditions of Contract, April 2010 – use of unlicensed vehicles... |
| 104S04        | Amendment to OPSS 401, November 2010  |
| 105S21        | Amendment to OPSS 501, November 2010  |
| 110S13        | Amendment to OPSS 1010, April 2004  |
| 199S55        | Record Drawings for Structures and Foundations  |
| 422S01        | Precast Concrete Box Culvert  |
| 511S01        | Rip Rap   |
| 539S02        | Protection System – Amendment to OPSS 512, April 2011                                       |
| 805F01        | Light-Duty Sediment Barriers, etc.  |

### Relevant OPSD's

| OPSD No. | Title   |
|----------|---|
| 803.010  | Backfill and Cover for Concrete Culverts with Spans Less Than or Equal to 3 m |
| 810.010  | Rip-Rap Treatment for Sewer and Culvert Inlets                                |
| 810.020  | Rip-Rap Treatment for Ditch Inlets  |
| 3090.100 | Foundation, Frost Penetration Depths for Northern Ontario                     |

### Relevant MTOD's

| MTOD No. | Title  |
|----------|--|
| 803.021  | Bedding and Backfill for Precast Concrete Box Culverts |