



**THURBER** ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT  
HIGHWAY 11B  
CULVERT REPLACEMENT, 11+188 COLEMAN TWP  
NEW LISKEARD AREA  
G.W.P. 5421-04-00**

**GEOCRES Number: 31M-106**

**Report to**

**MMM GROUP LIMITED**

**5013-E-0031, Assignment 1**

Thurber Engineering Ltd.  
104, 2460 Lancaster Road  
Ottawa, Ontario  
K1B 4S5  
Phone: (613) 247-2121  
Fax: (613) 247-2185

February 6, 2015  
19-5161-208



## **TABLE OF CONTENTS**

### **PART 1 FACTUAL INFORMATION**

|     |  |   |
|-----|--|---|
| 1   | INTRODUCTION.....                          | 1 |
| 2   | SITE DESCRIPTION.....                      | 1 |
| 3   | SITE INVESTIGATION AND FIELD TESTING ..... | 2 |
| 4   | LABORATORY TESTING .....                   | 3 |
| 5   | DESCRIPTION OF SUBSURFACE CONDITIONS.....  | 3 |
| 5.1 | General.....                               | 3 |
| 5.2 | Pavement Structure .....                   | 3 |
| 5.3 | Embankment Fill.....                       | 4 |
| 5.4 | Fill.....                                  | 5 |
| 5.5 | Sand.....                                  | 5 |
| 5.6 | Bedrock .....                              | 6 |
| 5.7 | Groundwater Conditions .....               | 6 |
| 6   | MISCELLANEOUS.....                         | 7 |

### **PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS**

|     |  |    |
|-----|--|----|
| 7   | GENERAL.....                               | 8  |
| 8   | CULVERT ALTERNATIVES.....                  | 9  |
| 8.1 | General.....                               | 9  |
| 8.2 | Culvert Alternatives .....                 | 9  |
| 8.3 | Construction Methodology Alternatives..... | 11 |
| 8.4 | Recommended Approach .....                 | 12 |
| 9   | RECOMMENDATIONS .....                      | 13 |
| 9.1 | Excavation and Water Control .....         | 13 |
| 9.2 | Subgrade Preparation.....                  | 14 |
| 9.3 | Culvert Bedding and Cover.....             | 14 |
| 9.4 | Embankment Reinstatement.....              | 14 |
| 9.5 | Erosion Control.....                       | 15 |
| 9.6 | Lateral Earth Pressures .....              | 15 |
| 10  | CONSTRUCTION CONCERNS .....                | 16 |
| 11  | CLOSURE.....                               | 18 |



## **APPENDICES**

|            |  |
|------------|--|
| Appendix A | Borehole Locations and Soil Strata Drawing |
| Appendix B | Record of Borehole Sheets                  |
| Appendix C | Laboratory Test Results                    |
| Appendix D | Selected Photographs of Culvert Location   |
| Appendix E | Foundation Alternative Comparisons         |

**FOUNDATION INVESTIGATION AND DESIGN REPORT  
HIGHWAY 11B  
CULVERT REPLACEMENT, 11+188 COLEMAN TWP  
NEW LISKEARD AREA  
G.W.P. 5421-04-00**

**GEOCRES Number: 31M-106**

**PART 1: FACTUAL INFORMATION**

**1 INTRODUCTION**

This report presents the factual data obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) at a culvert replacement site on Highway 11B near Cobalt, Ontario.

No previous foundation investigation information near the subject culvert was available.

The purpose of this investigation was to obtain subsurface information at the site and, based on the data obtained, to provide a model of the subsurface conditions including borehole location plans, stratigraphic profiles, records of boreholes, laboratory test results and a written description of the subsurface conditions.

Thurber was retained by MMM Group Limited to carry out this foundation investigation under MTO Agreement Number 5013-E-0031.

**2 SITE DESCRIPTION**

The culvert site is located on Highway 11B, approximately 1.2 kilometres east of Highway 11 in the Township of Coleman. A 2.47 m span by 1.66 m rise by 30.7 m long concrete rigid box culvert is present at the site and covered with approximately 5.4 m of fill. The culvert conveys water under Highway 11B from north to south between two separated sections of Gillies Lake. The invert elevations are 288.1 m at the inlet on the north side and 287.9 m at the outlet on the south side, indicating an average gradient of approximately 0.7%.

The culvert is located within a fill section. The grade of the existing Highway 11B in the vicinity of the culvert is at 295.1 m geodetic. The cross-section includes two 3.3 m wide lanes and shoulders ranging in width from 2.9 m to 3.3 m. Three cable guide rail is present on both sides of the highway. The highway embankment is constructed with side slopes ranging from

approximately 1.5H:1V to 1.7H:1V. The slopes are sparsely vegetated with brush and small trees. Cobbles and boulders are also present on the slopes. No evidence of slope instability or erosion was noted during the field investigation.

The embankment fill height is approximately 7 m from culvert invert to roadway surface. The site is located in a rural area with lakes, forests, swamps, and creeks. Local topography is generally flat with rolling hills. Selected photographs of the culvert site are attached in Appendix D. The highway appears to have been re-aligned at some point in the past. The remnants of the old alignment appear to the north of the current highway.

The surficial geology of the area is typical of the Wisconsin glaciation. Soil cover consists primarily of organic soils, and glaciofluvial (sand and gravel) deposits.

### **3 SITE INVESTIGATION AND FIELD TESTING**

This borehole investigation and field testing program was carried out between September 30, 2014 and October 9, 2014. The program consisted of drilling and sampling six boreholes (numbered 14-1, 14-2, 14-3, 14-4, 14-5 and 14-6) to depths ranging from 8.2 to 15.8 m. Of these boreholes, one was located near the culvert inlet (14-1), one located near the culvert outlet (14-4), two (14-5 and 14-6) were located through the embankment (one within each shoulder) on opposite sides of the culvert, and two were located off the highway to the north (14-2 west of the culvert and 14-3 east of the culvert).

Prior to the start of drilling, the borehole locations were established in the field and utility clearances were obtained. The stationing with offsets and elevations of the as-drilled boreholes were subsequently surveyed by Thurber. The top of the right end of the box culvert at approximate Station 11+188 was used as a benchmark. Contract Drawings for 85-221 indicate the elevation at this location to be 289.51 m Geodetic.

A rubber track-mounted drill rig was used to drill and sample the boreholes on the roadway (14-5 and 14-6) as well as Boreholes 14-1 and 14-3, and a portable tripod drill rig was used to drill and sample the culvert inlet and outlet boreholes (14-2 and 14-4). Hollow stem augers and/or NW casing were used to advance the boreholes. Soil samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT). A Dynamic Cone was driven to extend Boreholes 14-2, 14-4 and 14-5 below the sampled depth.

Results of the field drilling and sampling are presented on the Record of Borehole sheets in Appendix B.

A member of Thurber's technical staff supervised the drilling and sampling operations on a full time basis. The supervisor logged the boreholes, secured the recovered soil samples in

labelled containers, and transported the samples to Thurber's laboratory for further examination and testing.

The boreholes were backfilled with soil cuttings mixed with bentonite and topped to surface with the existing granular material or, where required, 100 mm of premium cold patch asphalt.

#### **4 LABORATORY TESTING**

All recovered soil samples were subjected to Visual Identification and to Natural Moisture Content determination. Selected soil samples were subjected to Grain Size Distribution analyses (sieve). The results of this laboratory testing program are shown on the Record of Borehole sheets in Appendix B and on the Figures in Appendix C.

#### **5 DESCRIPTION OF SUBSURFACE CONDITIONS**

##### **5.1 General**

Reference is made to the Record of Borehole sheets in Appendix B for details of the soil stratigraphy encountered in the boreholes. A stratigraphic profile for the existing culvert alignment is presented on the Borehole Locations and Soil Strata Drawing in Appendix A for illustrative purposes. An overall description of the stratigraphy is given in the following paragraphs, however, the factual data presented in the record of boreholes governs any interpretation of the site conditions.

In general, the subsurface conditions encountered in the boreholes consist of granular embankment fill overlying sand deposits. More detailed descriptions of the individual strata are presented below.

##### **5.2 Pavement Structure**

One borehole was advanced through the old highway pavement structure (14-3). In this borehole 80 mm of asphalt was found at the surface. Beneath the old highway asphalt, a gravelly sand fill extended to a depth of 0.6 m or elevation 291.7 m. The moisture content of this material was 6%.

A layer of asphalt 80 mm in thickness was encountered at ground surface in Boreholes 14-5 and 14-6 which were drilled through the current highway shoulders.

Gravelly sand fill, likely placed as part of the pavement structure, extended to a depth of 1.4 m below surface (elevations 294.1 m and 293.7 m in Boreholes 14-5 and 14-6 respectively).

The moisture content of the pavement granulars sample ranged from 2% to 4%. The results of grain size analysis conducted on two samples of the granular material are presented on Fig. No 1 in Appendix C. The results are summarized in the following table.

| Soil Particles | %        |
|----------------|----------|
| Gravel         | 27 to 41 |
| Sand           | 48 to 64 |
| Silt and Clay  | 9 to 11  |

### 5.3 Embankment Fill

Embankment fill was encountered below the pavement granulars in Boreholes 14-5 and 14-6 and at ground surface in Boreholes 14-1 and 14-4. The thickness of the embankment fill in these boreholes ranged from 2.0 to 8.0 m. The base of the embankment fill was encountered at elevations ranging from 285.4 to 286.9 m.

The fill was observed to vary from silty sand to gravel and sand. The fill included cobbles at some intervals. Boulders were noted in Borehole 14-4. The upper 200 mm in thickness in Borehole 14-4, drilled near the outlet included roots and rootlets; the water content of one sample of this layer was 39%. Wood was noted at the base of the embankment fill in Borehole 14-1 and 14-5 and may be remnants of old cribwork.

The SPT N-value for the granular fill ranged from 3 to 86 blows per 0.3 m penetration, indicating a very loose to very dense state. The fill is generally in a compact state. The water content of the recovered embankment fill samples ranged between 3% and 34%. The colour of the embankment fill is brown.

The results of grain size analyses conducted on eight samples of the fill are presented on Fig. No 2 and 3 in Appendix C. The results are summarized in the following table.

| Soil Particles | %        |
|----------------|----------|
| Gravel         | 1 to 56  |
| Sand           | 43 to 90 |
| Silt and Clay  | 1 to 19  |

## 5.4 Fill

Fill was also noted in Boreholes 14-2 and 14-3 which were located to the north of the current highway alignment. The fill extended to depths of 2.9 m and 7.0 m in these two boreholes respectively, (elevation 287.9 m and 285.3 m).

The fill was observed to vary from sand to gravelly sand. The fill included cobbles at some intervals. Boulders were noted at a depth of approximately 2 m in Borehole 14-2; coring was required to advance the borehole through the boulder. Traces of organic material and wood were noted at the base of the fill in Borehole 14-3.

The SPT N-value for the fill ranged from 3 to 14 blows per 0.3 m penetration, indicating a very loose to compact state. The water content of the recovered fill samples ranged between 6% and 25%. The colour of the fill is brown.

The results of grain size analyses conducted on five samples of the fill are presented on Fig. No 4 in Appendix C. The results are summarized in the following table.

| Soil Particles | %        |
|----------------|----------|
| Gravel         | 9 to 32  |
| Sand           | 61 to 86 |
| Silt and Clay  | 3 to 9   |

## 5.5 Sand

Below the fill materials, a native sand deposit was encountered in all boreholes. All six boreholes were terminated within this deposit at depths ranging from 8.2 m to 15.8 m (elevation 281.0 m to 279.2 m). The SPT N-value for this deposit was weight-of-hammer (WH) to 25 blows per 0.3 m penetration, indicating a very loose to compact state. The water contents of the recovered samples ranged between 13% and 24%. The colour of this deposit is grey. Grain size analyses conducted on nine samples of the soil are presented on Fig. No 5 and 6 in Appendix C. These results are summarized in the following table.

| Soil Particles | %        |
|----------------|----------|
| Gravel         | 0 to 8   |
| Sand           | 33 to 99 |
| Silt and Clay  | 1 to 67  |



## **5.6 Bedrock**

Bedrock was not encountered within the depth of this investigation.

## **5.7 Groundwater Conditions**

At the time of drilling, free water was observed in Boreholes 14-1, 14-4, 14-5 and 14-6 at depths ranging from 0.39 m to 7.9 m. The elevation of the observed free water ranged from 287.2 m to 288.4 m. Water level in the lake was surveyed to be at elevation 288.5m near the culvert inlet and 287.7 m near the outlet on September 29, 2014.

It is noted during drilling that running sands were observed in all boreholes at elevations ranging from 282 m to 285 m.

Where surface water is present, the groundwater level should be assumed to coincide with the local surface water level. Local high water levels and the effects of precipitation must also be taken into consideration.

## 6 MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. The borehole locations and elevations were surveyed by Thurber

George Downing Estate Drilling Ltd. of Hawkesbury, Ontario, supplied and operated a track-mounted CME 45 drill rig as well as the portable tripod drill rig to carry out the drilling, sampling and in-situ testing operations. The drilling and sampling operations in the field were supervised on a full time basis by Mr. Justin Gray of Thurber. Laboratory testing was carried out by Thurber in its MTO-approved laboratory.

Overall project management and direction of the field program was provided by Dr. Fred Griffiths, P.Eng. Interpretation of the field data and preparation of this report was completed by Mr. Justin Gray and Dr. Fred Griffiths P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Justin Gray  
Geotechnical E.I.T.



Fred J. Griffiths, P.Eng.  
Associate, Senior Foundations Engineer



P. K. Chatterji, P.Eng.,  
Review Principal, Designated MTO Contact

**FOUNDATION INVESTIGATION AND DESIGN REPORT  
HIGHWAY 11B  
CULVERT REPLACEMENT, 11+188 COLEMAN TWP  
NEW LISKEARD AREA  
G.W.P. 5421-04-00**

**GEOCRES Number: 31M-106**

**PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS**

**7 GENERAL**

This report presents interpretation of the geotechnical data in the factual report and presents a foundation assessment and evaluation of methods for replacement of the Gillies Lake Culvert beneath Highway 11B, approximately 1.2 kilometres east of Highway 11 near Cobalt Ontario in the Township of Coleman.

A 2.47 m span by 1.66 m rise by 30.7 m long concrete rigid frame box culvert is present at the site and conveys water from north to south. The culvert invert elevations are approximately 288.1 m at the inlet on the north side and 287.9 m at the outlet on the south side, indicating an average gradient of approximately 0.7%. The top of pavement at the Highway 11B centreline above the culvert is at approximately elevation 295.1 m. The slopes of the existing embankment are inclined at approximately 1.5H:1V to 1.7H:1V and are approximately 7 m high from culvert invert to top of embankment. The cross-section includes two 3.3 m wide lanes and shoulders ranging in width from 2.9 m to 3.3 m. Three cable guide rail is present on both sides of the highway. The AADT is reported to be 1200 with 4% commercial traffic. Frost depth at this site is 2.3 m. Table A3.1.1 of the CHBDC indicates that the Zonal Acceleration Ratio for the study area is 0.10.

It is understood that the existing culvert is to be replaced as a part of a design-build contract, therefore a general arrangement drawing for the proposed culvert replacement was not available at the time of preparation of this report. It is noted that the existing culvert is considered a non-structural culvert and that the need for replacement was identified based on its current condition rather than a need to increase hydraulic capacity.

The discussions and recommendations presented in this report are based on our understanding of the project and on the factual data obtained during the course of this investigation.

## **8 CULVERT ALTERNATIVES**

### **8.1 General**

It is understood that the proposed invert for the replacement culvert would be set near the current invert elevation (288.1 m at the inlet and 287.9 m at the outlet).

The borehole information indicates that the base of the embankment fill near the existing culvert alignment ranges from 286.9 m to 285.4 m. Although the construction history was not available, it is likely that the highway embankment is constructed as a causeway filling a lower area linking the northern and southern portions of Gillies Lake. The excavation for a new culvert would therefore be within the embankment fill which was observed to consist of loose to dense sand to gravel and sand. Cobbles as well as boulders were noted in the fill. The native material observed immediately beneath the fill consisted of sand. It was typically compact. Groundwater levels at the time of the investigation were noted at an elevation ranging from 287.2 m to 288.4 m.

We have carried out an evaluation of the potential for liquefaction for the native sand layer and our evaluation indicates a low risk of liquefaction of this deposit. This is due to the low zonal acceleration ratio for this site.

The following sections address replacement of the existing culvert. Although, it has been assumed that the replacement culvert will be installed along the existing culvert alignment, it would be preferable to re-align the culvert to one side or the other to allow flow to continue through the existing culvert during construction of the replacement. The discussion and recommendations that follow are applicable regardless of minor culvert alignment shifts.

### **8.2 Culvert Alternatives**

This section presents discussions on alternate types of replacement culverts and foundation alternatives, and provides recommendations on feasible and/or preferred foundation options. Several common culvert and foundation types are listed below and a comparison based on their respective advantages and disadvantages, is included in Appendix E.

#### **Circular Pipes (Concrete, Steel, HDPE)**

From a foundation engineering standpoint, concrete, steel and HDPE pipes are technically feasible and likely the lowest cost alternative. The pipe diameter must be calculated based on a hydraulic analysis but a pipe diameter of approximately 2 m to 3 m is anticipated. Subgrade preparation should consist of excavation to the underside of the bedding layer. The exposed existing fill should be compacted and any soft material and organic materials must be removed and replaced with OPSS Granular A. The underside of the culvert bedding layer is expected to be at approximate elevation 287.8 to 287.6 m. Note that this is below the elevation of the lake

which was observed to be at 288.5 m near the culvert inlet and 287.7 m near the outlet on September 29, 2014. Subgrade preparation and bedding layer compaction must be carried out in the dry, therefore dewatering will be required. Given the presence of compact cohesionless materials at this site, water control will likely require a four sided enclosure with sheet pile coffer dams and a well point system pumping from within the sheet piles.

#### Concrete, Open Footing Culvert

Concrete, open footing culverts are not considered feasible at this site due to a low geotechnical resistance and anticipated construction difficulties with dewatering. The base of footing would be at approximately elevation 285.8 m at the inlet. This is within the loose to compact native sand layer and more than 2.5 m below the lake level on the north side. This option is not considered feasible.

#### Concrete Box (Closed) Culvert

Subgrade preparation should consist of excavation to the underside of the bedding layer. The exposed existing fill should be compacted and any soft or organic materials must be removed and replaced with OPSS Granular A. The underside of the culvert bedding layer is expected to be at approximate elevation 287.5 to 287.3 m. Note that this is below the elevation of the lake which was observed to be at 288.5 m near the culvert inlet and 287.7 m near the outlet on September 29, 2014. Subgrade preparation and bedding layer compaction must be carried out in the dry, therefore dewatering will be required. Given the presence of compact cohesionless materials at this site water control will likely require a four sided enclosure with sheet pile coffer dams and a well point system pumping from within the sheet piles.

The Factored Geotechnical Resistance at ULS for a 3.0 m wide box culvert founded at or higher than elevation 287.6 m is 165 kPa. The factored geotechnical resistance at ultimate limits states (ULS) includes a resistance factor of 0.5. The recommended Bearing Pressure at SLS is 110 kPa. The bearing pressure at serviceability limit states corresponds to the sustained pressure resulting in 25 mm of total settlement.

A concrete box (closed) culvert is considered feasible at this site.

#### Recommended Culvert

Replacement with a 2 to 3 m diameter CSP is both technically feasible and cost effective. The required diameter must be confirmed with a hydraulic analysis. Environmental concerns may also play a role in the selection of culvert shape. The report herein focuses on providing foundation recommendations related to the design and construction of a circular pipe culvert.

### **8.3 Construction Methodology Alternatives**

This section presents discussions on alternative construction methods for replacement of the culvert with a 2 to 3 m diameter CSP. Further comparison of these options is presented in tabular form in Appendix E.

All excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the embankment fill and native sand at this site are classified as Type 3 soil above the water level and Type 4 soil below the water level.

Excavations below the elevation of the lake which was observed to be at 288.5 m near the culvert inlet and 287.7 m near the outlet on September 29, 2014 are anticipated. Subgrade preparation and bedding layer compaction must be carried out in the dry, therefore dewatering will be required. Given the presence of compact cohesionless materials at this site, water control will likely require a four sided enclosure with sheet pile coffer dams and a well point system pumping from within the sheet piles.

#### Full Road Closure

Installation of new culvert during a full road closure is the preferred alternative from a foundations perspective. This option would allow for the quickest construction schedule and reduce costs associated with roadway protection, and avoid the need for platform widening. However, this alternative would have a significant impact on traffic (estimated AADT of 1200 for the site).

#### Staged Construction & Roadway Protection

There is insufficient existing platform width to replace the culvert as an open cut with staged construction (half and half) unless roadway protection is utilized.

#### Staged Construction & Platform Widening/Lowering

The geotechnical conditions are conducive to widening the existing platform to the north. Temporary platform lowering is also considered feasible. It is estimated that a 1.2 m grade lowering to elevation 294.0 m combined with an approximately 6 m platform widening at elevation 292.4 m would create sufficient platform width to allow replacement of the culvert in a half and half fashion, maintaining one lane of traffic without roadway protection.

A temporary extension of the culvert would be required. Installation of the culvert extension would need to occur within the four sided cofferdam enclosure, thus additional sheet pile is required for this option.

It is estimated that the placement of as much as 4 m of fill during the embankment widening stage will induce approximately 40 mm of settlement in the underlying soils. For this reason, the staging should be planned to ensure that the northern portion of the culvert is replaced first, as

the condition of the existing culvert may be compromised if it underwent that amount of settlement.

Given the need for a culvert extension and additional cofferdam length, this option presents no advantage over the more economical roadway protection option

#### Trenchless Options

Trenchless installations should be carried out in accordance with the requirements of the Non-Standard Special Provision (NSSP) "Pipe Installation by Trenchless Methods". Selection of an appropriate trenchless method is the responsibility of the Contractor and will depend on the relative costs and risks associated with each method. The experience of the Contractor is of primary importance for trenchless installation. Amongst the important issues discussed in the NSSP are maintenance of alignment, handling of obstructions and disposal of cuttings. Trenchless methods that are typically considered to install pipes under highways include: Jack and Bore, Pipe Ramming, Micro-Tunnelling, Hand Mining, Horizontal Directional Drilling and Pipe Bursting.

The anticipated diameter of the pipe is too large for jack and bore, pipe ramming and horizontal directional drilling. Given the box shape and condition of the existing culvert, pipe bursting is also not considered feasible.

A loose and saturated non-cohesive soils is present at the pipe invert level. It is anticipated that this material could lead to running conditions in open face tunnels, possibly compromising both the stability of the excavation and potentially the embankment. Hand mining is not considered to be feasible.

It is noted that Gillies Lake is present at the toe of the slope on the south side, thus preparation of an entry/exist pit would be problematic. This eliminates the micro-tunnelling option.

Although, a trenchless technique has the advantage of reducing disruption to traffic and would avoid an excavation through the existing highway embankment, it is not considered feasible for this site.

### **8.4 Recommended Approach**

If a full road closure is not possible due to other considerations, then staged construction with roadway protection is considered the best alternative. It presents an economic solution with minimal risk. The discussion and recommendations provided below are based on the culvert replacement consisting of a CSP culvert constructed in a half and half manner as facilitated by roadway protection.

## RECOMMENDATIONS

It is understood that the invert elevation of the replacement culvert will be similar to that of the existing culvert. Since the replacement culvert is non-structural and expected to consist of a circular pipe, the pipe design should be in accordance with the height of fill tables in the OPSD 800 series drawings. A hydraulic analysis is required to select pipe diameter. The possibility of raising the culvert invert should be considered during that analysis.

### 9.1 Excavation and Water Control

All excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the embankment fill and native sand at this site are classified as Type 3 soil above the water level and Type 4 soil below the water level.

Culvert construction and subgrade preparation must be carried out in the dry. This work should be carried out in accordance with OPSS 902. It is expected that groundwater and surface water will accumulate in the excavations during culvert construction. The groundwater level is expected to be largely governed by the water level in the lake and seasonal weather.

Excavations below the elevation of the lake, which was observed to be at 288.5 m near the culvert inlet and 287.7 m near the outlet on September 29, 2014, are anticipated. Given the presence of compact cohesionless materials at this site, water control will likely require a four sided enclosure with sheet pile coffer dams and a well point system pumping from within the sheet piles. Selection of the equipment and methodology to excavate and prepare the founding surface is the responsibility of the Contractor. The subgrade must be protected from disturbance. The Contractor must make provisions to control any groundwater seepage, surface runoff and ponding by measures including the use of sump pumps, cofferdams, and/or diversion and protection systems to maintain dry excavations during the course of construction.

Excavations for culvert replacement will typically be carried out through the existing embankment fill and extend into the underlying native soils. Protection systems will be required to facilitate the proposed construction staging. Protection systems should be designed by a licensed Professional Engineer experienced in such designs. OPSS 539 "Construction Specifications for Protection Systems" must be referenced in the contract documents. It is recommended that Performance Level 2, as per Clause 539.04.01.01 (maximum horizontal displacement of 25 mm), be specified for this culvert replacement site.

As cobbles and boulders were observed in the boreholes, it is recommended that the contract include an NSSP alerting bidders to their presence. We suggest the following wording: *"Installation of cofferdams and roadway protection systems could encounter obstructions may impede sheet pile installation and prohibit the sheet piles from reaching the design depth of*



*installation. The contractor shall be prepared to remove, drill through and/or penetrate these obstructions and extend the sheet piles to the design depth.”*

## **9.2 Subgrade Preparation**

Trace organic material and wood were encountered at the base of the fill in Boreholes 14-1, 14-3 and 14-5. After excavation to the design founding elevation (underside of bedding), the exposed surface must be inspected during compaction to confirm that the subgrade is suitable and uniformly competent. Any remaining fill, wood, topsoil, organics, lake bed deposits, soft/loose areas, disturbed soils and any deleterious materials within the culvert replacement footprint must be further sub-excavated to undisturbed, competent native soils. The sub-excavated area should be replaced with well compacted granular fill consisting of OPSS 1010 Granular A material as soon as practicable and the subgrade protected from disturbance during construction.

Culvert construction and subgrade preparation must be carried out in the dry. This work should be carried out in accordance with OPSS 902.

## **9.3 Culvert Bedding and Cover**

It is recommended that the limits of excavation and backfill be in accordance with the applicable OPSD 800-series of drawings (dependent on culvert type).

Culvert bedding and cover material should consist of free-draining granular material conforming to OPSS Granular A specifications.

The cover should be placed and compacted in simultaneous, equal lifts on both sides of the culvert. Heavy compaction equipment should not be used adjacent to the culvert. Compaction should be carried out in accordance with OPSS 501.

## **9.4 Embankment Reinstatement**

The existing embankment is sloped at approximately 1.5H:1V to 1.7H:1V and exhibits no signs of instability. Embankment reconstruction, after culvert replacement, should be carried out in accordance with OPSS 206. The embankment material should consist of imported Granular B Type II material. Excavated granular fill may also be reused as backfill provided there is no organics in the excavated fill and there is sufficient space to stockpile on site and control the moisture content within acceptable limits for compaction

Provided the subgrade is prepared as outline in Section 9.2 and embankment fill is placed as recommended herein, an embankment slope inclination of 2H:1V, or flatter will remain stable. Slope stability analyses carried out with Slide indicate a minimum Factor of Safety in excess of 1.3. As this is a culvert replacement project, minimal embankment settlement is anticipated.

## 9.5 Erosion Control

Erosion protection should be provided at the culvert inlet and outlet areas. Design of the erosion protection measures must consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field. Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact. Treatment at the outlets should be in accordance with OPSP 810.010. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS 804.

It is recommended that a clay seal or a concrete cut-off wall be used to minimize the potential for erosion near the inlet area. The clay seal should extend a minimum of 0.3 m above the high water level and laterally for the width of the granular material, and have a minimum thickness of 0.5 m. The material requirements should be in accordance with OPSS 1205. A geosynthetic clay liner may be used as a clay seal.

## 9.6 Lateral Earth Pressures

In general, earth pressures acting on shoring used as coffer dams or roadway protection may be assumed to impose a triangular distribution governed by the characteristics of the backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC but generally are given by the expression:

$$p = K (\gamma h + q)$$

where:  $p$  = horizontal pressure on the wall at depth  $h$  (kPa)  
 $K$  = earth pressure coefficient (see Table 10.1)  
 $\gamma$  = bulk unit weight of retained soil (see Table 10.1)  
 $h$  = depth below top of fill where pressure is computed (m)  
 $q$  = value of any surcharge (kPa)

Earth pressure coefficients for backfill are dependent on the material used as backfill. Recommended unfactored values are shown in Table 9.1. Active earth pressures should be used for design of unrestrained walls. For braced walls the at-rest coefficient should be used to assess the lateral earth pressures.

**Table 9.1 – Geotechnical design parameters for static lateral earth pressures**

| Parameter                                    | Existing Embankment Fill and Native Sand | Granular B Types I and III | Granular A and Granular B Type II |
|--|--|----------------------------|-----------------------------------|
| <b><i>Soil Parameters</i></b>                |  |                            |                                   |
| Soil Unit weight (kN/m <sup>3</sup> )        | 20.0                                     | 21.2                       | 22.8                              |
| Angle of Internal friction, $\phi$           | 30°                                      | 32°                        | 35°                               |
| <b><i>Walls with Horizontal Backfill</i></b> |  |                            |                                   |
| Coefficient of earth pressure at-rest, $K_0$ | 0.50                                     | 0.47                       | 0.43                              |
| Coefficient of active earth pressure, $K_a$  | 0.33                                     | 0.31                       | 0.27                              |
| Coefficient of passive earth pressure, $K_p$ | 3.0                                      | 3.3                        | 3.7                               |
| <b><i>Walls with 2H:1V Backfill</i></b>      |  |                            |                                   |
| Coefficient of active earth pressure, $K_a$  | 0.54                                     | 0.47                       | 0.39                              |

In accordance with Clause 6.9.3 of the CHBDC, a compaction surcharge should be added. The design of the walls must incorporate measures such as weepholes or subdrains to permit drainage of the backfill, or alternatively the walls should be designed to withstand the potential build-up of hydrostatic pressures behind the walls.

## 10 CONSTRUCTION CONCERNS

The planned construction methodology includes staged construction with roadway protection in order to maintain traffic flow through the culvert area. Potential construction concerns include, but are not necessarily limited to, the following:

- Impact of excavation on the existing pavement surface. Daily visual inspection of the pavement surface must be carried out in the vicinity of the culvert construction. If cracks form in the pavement or settlement is observed to occur, these matters must immediately


be brought to the attention of the C.A. for determining the level of remedial action that is required.

- Implementation of an adequate and effective surface water management and dewatering plan to construct the replacement culvert and subgrade in the dry.
- Removal of organics and soft soils from the culvert subgrade and from beneath the new culvert footprint.
- Confirmation that the culvert backfill is adequately placed and compacted to specifications.

The successful performance of the culvert will depend largely upon good workmanship and quality control during construction. Observation of the excavation and backfilling operations by the QVE will be required during construction to confirm that the foundation recommendations are correctly implemented and material specifications are met.

## 11 CLOSURE

Preparation of this foundation design report was carried out by Mr. Justin Gray, and Dr. Fred Griffiths P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng.



Justin Gray  
Geotechnical E.I.T.



Fred J. Griffiths, P.Eng.  
Associate, Senior Foundations Engineer



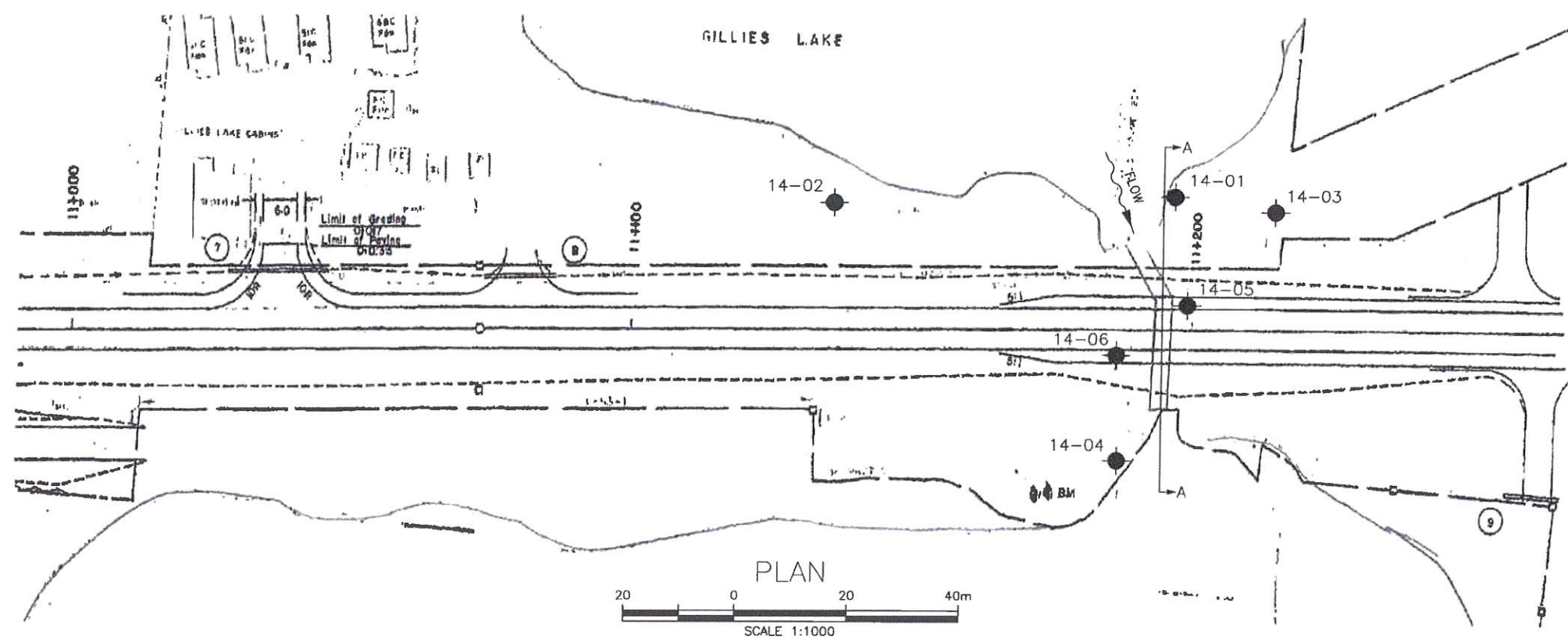
P.K. Chatterji, P.Eng.  
Principal, Designated MTO Contact

## **Appendix A**

### **Borehole Locations and Soil Strata Drawings**

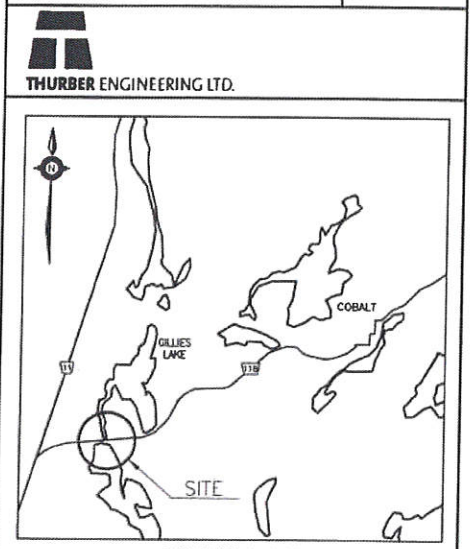


MINISTRY OF TRANSPORTATION, ONTARIO



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

|   |       |
|---|-------|
| CONT No   | SHEET |
| WP No   |       |
| HIGHWAY 11B<br>CULVERT<br>REPLACEMENT<br>BOREHOLE LOCATIONS AND SOIL STRATA |       |



KEYPLAN

LEGEND

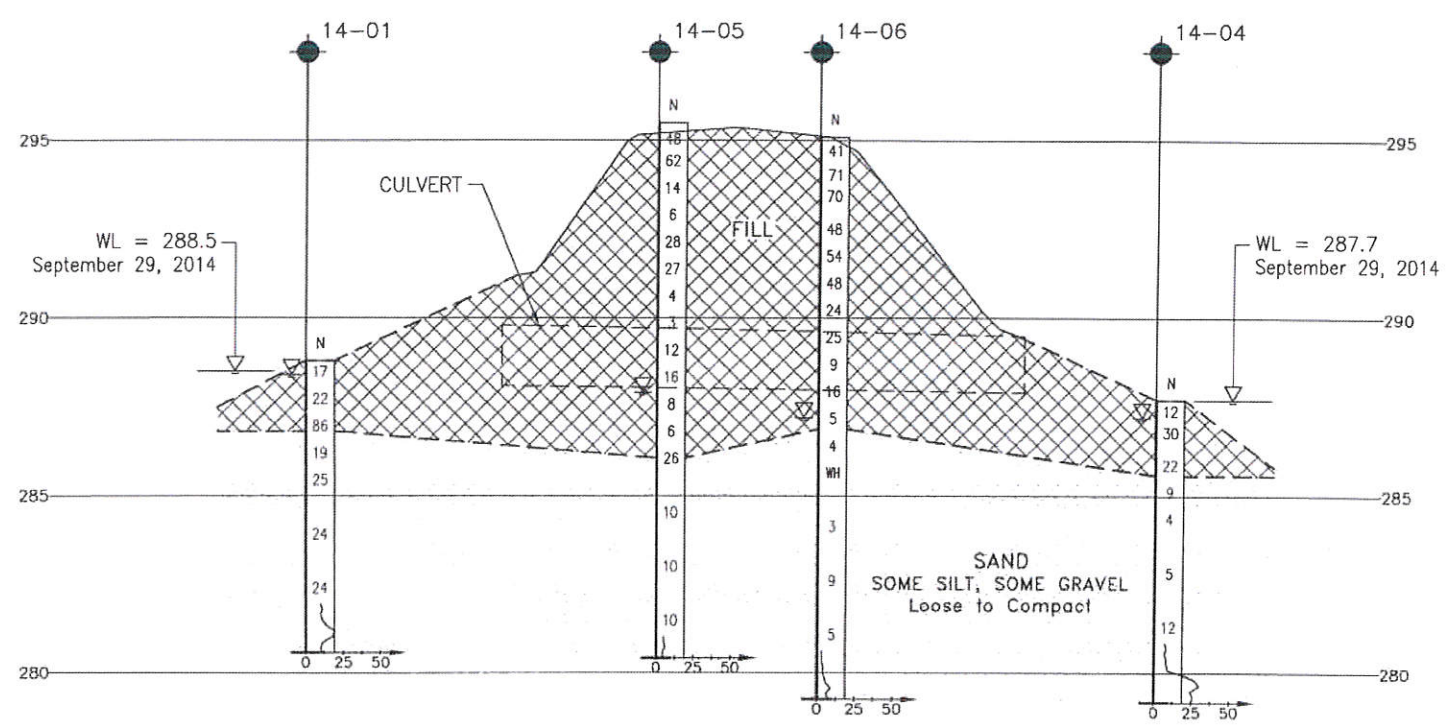
- Borehole
- Borehole and Cone
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60° Cone, 475J/blow)
- PH Pressure, Hydraulic
- Water Level
- Head Artesian Water
- Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

| NO    | ELEVATION | CHAINAGE | OFFSET |
|-------|-----------|----------|--------|
| 14-01 | 288.8     | 11+194   | 23L    |
| 14-02 | 290.8     | 11+135   | 22L    |
| 14-03 | 292.3     | 11+212   | 21L    |
| 14-04 | 287.7     | 11+187   | 24R    |
| 14-05 | 295.5     | 11+199   | 3.7L   |
| 14-06 | 295.1     | 11+186   | 3.6R   |

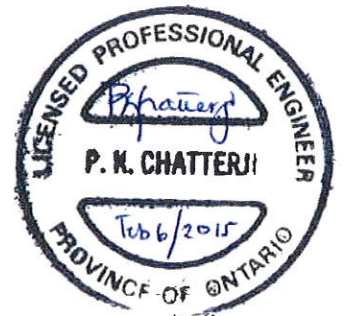
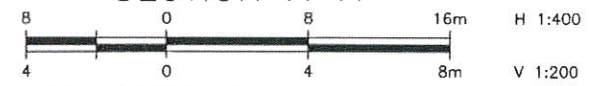
-NOTES-

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

GEOCRES No. 31M-106



SECTION A-A



| REVISIONS | DATE   | BY   | DESCRIPTION |
|-----------|--------|------|-------------|
| DESIGN    | JG     | CHK  | PC          |
| DRAWN     | MFA    | CHK  | JG          |
| CODE      | LOAD   | DATE | FEB 2015    |
| SITE      | STRUCT | DWG  | 1           |

FILENAME: H:\Projects\15151\208\_NER\_DE\_Retainer\Design 1 Hwy 11B\CA\15-02-02\1508-PlanProfile.dwg  
PLOTDATE: 2/2/2015 1:15 PM

## **Appendix B**

### **Record of Borehole Sheets**



## SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

### 1. TEXTURAL CLASSIFICATION OF SOILS

| CLASSIFICATION | PARTICLE SIZE      | VISUAL IDENTIFICATION                               |
|----------------|--------------------|---|
| Boulders       | Greater than 200mm | same  |
| Cobbles        | 75 to 200mm        | same  |
| Gravel         | 4.75 to 75mm       | 5 to 75mm   |
| Sand           | 0.075 to 4.75mm    | Not visible particles to 5mm                        |
| Silt           | 0.002 to 0.075mm   | Non-plastic particles, not visible to the naked eye |
| Clay           | Less than 0.002mm  | Plastic particles, not visible to the naked eye     |

### 2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

| TERMINOLOGY                     | PROPORTION    |
|---------------------------------|---------------|
| Trace or Occasional             | Less than 10% |
| Some                            | 10 to 20%     |
| Adjective (e.g. silty or sandy) | 20 to 35%     |
| And (e.g. sand and gravel)      | 35 to 50%     |

### 3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

| DESCRIPTIVE TERM | UNDRAINED SHEAR STRENGTH (kPa) | APPROXIMATE SPT <sup>(1)</sup> 'N' VALUE |
|------------------|--------------------------------|--|
| Very Soft        | 12 or less                     | Less than 2                              |
| Soft             | 12 to 25                       | 2 to 4                                   |
| Firm             | 25 to 50                       | 4 to 8                                   |
| Stiff            | 50 to 100                      | 8 to 15                                  |
| Very Stiff       | 100 to 200                     | 15 to 30                                 |
| Hard             | Greater than 200               | Greater than 30                          |

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer


### 4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

| DESCRIPTIVE TERM | SPT "N" VALUE   |
|------------------|-----------------|
| Very Loose       | Less than 4     |
| Loose            | 4 to 10         |
| Compact          | 10 to 30        |
| Dense            | 30 to 50        |
| Very Dense       | Greater than 50 |

### 5. LEGEND FOR RECORDS OF BOREHOLES

|   |   |  |                        |
|---|---|--|------------------------|
| SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE | SS Split Spoon Sample                     | WS Wash Sample                         | AS Auger (Grab) Sample |
|   | TW Thin Wall Shelby Tube Sample           | TP Thin Wall Piston Sample             |                        |
|   | PH Sampler Advanced by Hydraulic Pressure | PM Sampler Advanced by Manual Pressure |                        |
|   | WH Sampler Advanced by Self Static Weight | RC Rock Core                           | SC Soil Core           |

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

 Water Level


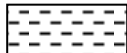



$C_{pen}$  Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value      Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT      Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

# UNIFIED SOILS CLASSIFICATION

| MAJOR DIVISIONS      |                                 | GROUP SYMBOL | TYPICAL DESCRIPTION   |
|----------------------|---------------------------------|--------------|---|
| COARSE GRAINED SOILS | GRAVEL AND GRAVELLY SOILS       | GW           | Well-graded gravels or gravel-sand mixtures, little or no fines.  |
|                      |                                 | GP           | Poorly-graded gravels or gravel-sand mixtures, little or no fines.  |
|                      |                                 | GM           | Silty gravels, gravel-sand-silt mixtures.   |
|                      |                                 | GC           | Clayey gravels, gravel-sand-clay mixtures.  |
|                      | SAND AND SANDY SOILS            | SW           | Well-graded sands or gravelly sands, little or no fines.  |
|                      |                                 | SP           | Poorly-graded sands or gravelly sands, little or no fines.  |
|                      |                                 | SM           | Silty sands, sand-silt mixtures.  |
|                      |                                 | SC           | Clayey sands, sand-clay mixtures.   |
| FINE GRAINED SOILS   | SILTS AND CLAYS<br>$W_L < 50\%$ | ML           | Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.     |
|                      |                                 | CL           | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.<br>( $W_L < 30\%$ ). |
|                      |                                 | CI           | Inorganic clays of medium plasticity, silty clays.<br>( $30\% < W_L < 50\%$ ).  |
|                      |                                 | OL           | Organic silts and organic silty-clays of low plasticity.  |
|                      | SILTS AND CLAYS<br>$W_L > 50\%$ | MH           | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.                                    |
|                      |                                 | CH           | Inorganic clays of high plasticity, fat clays.  |
|                      |                                 | OH           | Organic clays of medium to high plasticity, organic silts.  |
| HIGHLY ORGANIC SOILS |                                 | Pt           | Peat and other highly organic soils.  |
| CLAY SHALE           |                                 |              |   |
| SANDSTONE            |                                 |              |   |
| SILTSTONE            |                                 |              |   |
| CLAYSTONE            |                                 |              |   |
| COAL                 |                                 |              |   |

## EXPLANATION OF ROCK LOGGING TERMS

| <u>ROCK WEATHERING CLASSIFICATION</u> |   | <u>SYMBOLS</u>  |                   |
|---------------------------------------|---|---|-------------------|
| <b>Fresh (FR)</b>                     | No visible signs of weathering.   |   |                   |
| <b>Fresh Jointed (FJ)</b>             | Weathering limited to the surface of major discontinuities.   |  | CLAYSTONE         |
| <b>Slightly Weathered (SW)</b>        | Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material. |  | SILTSTONE         |
| <b>Moderately Weathered (MW)</b>      | Weathering extends throughout the rock mass, but the rock material is not friable.                            |  | SANDSTONE         |
| <b>Highly Weathered (HW)</b>          | Weathering extends throughout the rock mass and the rock is partly friable.                                   |  | COAL              |
| <b>Completely Weathered (CW)</b>      | Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.       |  | Bedrock (general) |

| <u>DISCONTINUITY SPACING</u> |                       | <u>STRENGTH CLASSIFICATION</u> |   |                     |   |
|------------------------------|-----------------------|--------------------------------|---|---------------------|---|
| Bedding                      | Bedding Plane Spacing | Rock Strength                  | Approximate Uniaxial Compressive Strength |                     | Field Estimation of Hardness*                             |
|                              |                       |                                | (MPa)                                     | (psi)               |   |
| Very thickly bedded          | Greater than 2m       | Extremely Strong               | Greater than 250                          | Greater than 36,000 | Specimen can only be chipped with a geological hammer     |
| Thickly bedded               | 0.6 to 2m             |                                |   |                     |   |
| Medium bedded                | 0.2 to 0.6m           | Very Strong                    | 100-250                                   | 15,000 to 36,000    | Requires many blows of geological hammer to break         |
| Thinly bedded                | 60mm to 0.2m          | Strong                         | 50-100                                    | 7,500 to 15,000     | Requires more than one blow of geological hammer to break |
| Very thinly bedded           | 20 to 60mm            |                                |   |                     |   |
| Laminated                    | 6 to 20mm             | Medium Strong                  | 25.0 to 50.0                              | 3,500 to 7,500      | Breaks under single blow of geological hammer.            |
| Thinly Laminated             | Less than 6mm         |                                |   |                     |   |





| <u>TERMS</u>                        |  |                       |             |              |  |
|-------------------------------------|--|-----------------------|-------------|--------------|--|
| Total Core Recovery: (TCR)          | Core recovered as a percentage of total core run length.   | Weak                  | 5.0 to 25.0 | 750 to 3,500 | Can be peeled by a pocket knife with difficulty                                |
| Solid Core Recovery: (SCR)          | Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run. | Very Weak             | 1.0 to 5.0  | 150 to 750   | Can be peeled by a pocket knife, crumbles under firm blows of geological pick. |
| Rock Quality Designation: (RQD)     | Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.        | Extremely Weak (Rock) | 0.25 to 1.0 | 35 to 150    | Indented by thumbnail  |
| Uniaxial Compressive Strength (UCS) | Axial stress required to break the specimen  |                       |             |              |  |
| Fracture Index: (FI)                | Frequency of natural fractures per 0.3m of core run.   |                       |             |              |  |

# RECORD OF BOREHOLE No 14-1

1 OF 1

METRIC

19-5161-208 LOCATION 11+194 23 LT CL ORIGINATED BY JG  
HWY 11B BOREHOLE TYPE Casing COMPILED BY JG  
DATUM geodetic DATE 2014.10.07 - 2014.10.08 CHECKED BY FG

| 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><br>$\gamma$<br><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                          |    |    |    |     | WATER CONTENT (%)   |   |                |   | GR  | SA | SI                 | CL |
|               |   |   |         |      |            |   |                 | 20  | 40 | 60 | 80 | 100 | W <sub>P</sub>  | W | W <sub>L</sub> |   |   |    |                    |    |
| 288.8         |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
| 0.0           | Gravelly <b>SAND</b><br>Compact<br>Brown<br><b>(FILL)</b> |  | 1       | SS   | 17         |  |                 |   |    |    |    |     |   |   |                |   |   |    | 41 53 6<br>(SI+CL) |    |
|               | random cobbles between 0 to 1.5m                          |   | 2       | SS   | 22         |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
| 286.8         | <b>Wood</b>   |  | 3       | SS   | 86         |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
| 2.0           | <b>SAND</b><br>Compact<br>Grey                            |  |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   | 4       | SS   | 19         |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   | 5       | SS   | 25         |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |
|               |   |   |         |      |            |   |                 |   |    |    |    |     |   |   |                |   |   |    |                    |    |

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 14-2

1 OF 2

METRIC

19-5161-208 LOCATION 11+135 22 LT CL ORIGINATED BY JG  
 HWY 11B BOREHOLE TYPE Hollow Stem Auger COMPILED BY JG  
 DATUM geodetic DATE 2014.10.01 - 2014.10.02 CHECKED BY FG

| SOIL PROFILE  |             |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |  |  |  | UNIT<br>WEIGHT<br>$\gamma$<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                          |  |  |  |  |   |   | WATER CONTENT (%)   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|               |             |            |         |      |            |                            |                 | 20 40 60 80 100                             |  |  |  |  |   |   | PLASTIC LIMIT<br>NATURAL MOISTURE CONTENT<br>LIQUID LIMIT |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 290.8         |             |            |         |      |            |                            |                 |   |  |  |  |  |   |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

## METRIC

| SOIL PROFILE                 |             | SAMPLES    |        | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT                                    |            | PLASTIC LIMIT     |    | NATURAL<br>MOISTURE<br>CONTENT |    | LIQUID<br>LIMIT |                | UNIT<br>WEIGHT<br><br>γ<br><br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |                |    |    |    |
|------------------------------|-------------|------------|--------|----------------------------|-----------------|--|------------|-------------------|----|--------------------------------|----|-----------------|----------------|--|---|----------------|----|----|----|
| ELEV<br>DEPTH                | DESCRIPTION | STRAT PLOT | NUMBER |                            |                 | TYPE   | "N" VALUES | 20                | 40 | 60                             | 80 | 100             | W <sub>P</sub> |  | W   | W <sub>L</sub> | 20 | 40 | 60 |
| Continued From Previous Page |             |            |        |                            |                 |  |            |                   |    |                                |    |                 |                |  |   |                |    |    |    |
|                              |             |            |        |                            |                 | SHEAR STRENGTH kPa<br>○ UNCONFINED + FIELD VANE<br>● QUICK TRIAXIAL × LAB VANE |            | WATER CONTENT (%) |    |                                |    |                 |                | GR SA SI CL                                      |   |                |    |    |    |

[illegible]

# RECORD OF BOREHOLE No 14-3

1 OF 2

METRIC

19-5161-208 LOCATION 11+212 21 LT CL ORIGINATED BY JG  
HWY 11B BOREHOLE TYPE Hollow Stem Auger COMPILED BY JG  
DATUM geodetic DATE 2014.10.01 - 2014.10.01 CHECKED BY FG

| SOIL PROFILE  |                            |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |  |  |  | UNIT<br>WEIGHT<br><br>$\gamma$<br><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                             |  |  |  |  |   |   |
| 292.3         |                            |            |         |      |            |                            |                 |   |  |  |  |  |   |   |
| 0.0           | 80mm ASPHALT (old highway) |            |         |      |            |                            |                 |   |  |  |  |  |   |   |
|               | Gravelly SAND              |            | 1       | SS   | 10         |                            | 292             |   |  |  |  |  |   |   |
| 291.7         | Compact                    |            |         |      |            |                            |                 |   |  |  |  |  |   |   |
| 0.6           | Brown (FILL)               |            |         |      |            |                            |                 |   |  |  |  |  |   |   |
|               | SAND                       |            | 2       | SS   | 8          |                            |                 |   |  |  |  |  |   | 9 85 6 (SI+CL)                                    |
|               | Very loose to compact      |            |         |      |            |                            | 291             |   |  |  |  |  |   |   |
|               | Brown (FILL)               |            |         |      |            |                            |                 |   |  |  |  |  |   |   |
|               |                            |            | 3       | SS   | 11         |                            |                 |   |  |  |  |  |   |   |
|               |                            |            |         |      |            |                            | 290             |   |  |  |  |  |   |   |
|               |                            |            | 4       | SS   | 5          |                            |                 |   |  |  |  |  |   |   |
|               |                            |            |         |      |            |                            |                 |   |  |  |  |  |   |   |
|               |                            |            | 5       | SS   | 4          |                            | 289             |   |  |  |  |  |   |   |
|               |                            |            |         |      |            |                            |                 |   |  |  |  |  |   |   |
|               |                            |            | 6       | SS   | 3          |                            | 288             |   |  |  |  |  |   |   |
|               |                            |            |         |      |            |                            |                 |   |  |  |  |  |   |   |
|               |                            |            | 7       | SS   | 7          |                            |                 |   |  |  |  |  |   |   |
|               |                            |            |         |      |            |                            | 287             |   |  |  |  |  |   |   |
|               | becoming gravelly          |            | 8       | SS   | 7          |                            |                 |   |  |  |  |  |   | 30 63 7 (SI+CL)                                   |
|               |                            |            |         |      |            |                            |                 |   |  |  |  |  |   |   |
|               | trace organic material     |            | 9       | SS   | 6          |                            | 286             |   |  |  |  |  |   | 11 86 3 (SI+CL)                                   |
|               | trace wood                 |            |         |      |            |                            |                 |   |  |  |  |  |   |   |
| 285.3         |                            |            |         |      |            |                            |                 |   |  |  |  |  |   |   |
| 7.0           | SAND                       |            |         |      |            |                            | 285             |   |  |  |  |  |   |   |
|               | Very loose to loose        |            | 10      | SS   | 4          |                            |                 |   |  |  |  |  |   |   |
|               | Grey                       |            |         |      |            |                            | 284             |   |  |  |  |  |   |   |
|               |                            |            |         |      |            |                            |                 |   |  |  |  |  |   |   |
|               | running sands              |            | 11      | SS   | 5          |                            | 283             |   |  |  |  |  |   |   |
|               |                            |            |         |      |            |                            |                 |   |  |  |  |  |   |   |

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 14-3

2 OF 2

METRIC

19-5161-208 LOCATION 11+212 21 LT CL ORIGINATED BY JG  
HWY 11B BOREHOLE TYPE Hollow Stem Auger COMPILED BY JG  
DATUM geodetic DATE 2014.10.01 - 2014.10.01 CHECKED BY FG

| 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>(%)<br>GR SA SI CL |
|---------------|---|------------|---------|------|------------|----------------------------|-----------------|---|--|--|--|--|------------------------------------|-------------------------------------|-----------------------------------|--|--|
| ELEV<br>DEPTH | DESCRIPTION   | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa                          |  |  |  |  |                                    |                                     |                                   |  |  |
|               | Continued From Previous Page  |            |         |      |            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |  |  |
| 281.0         | <b>SAND</b><br>Very loose to loose<br>Grey  |            | 12      | SS   | 7          |                            | 282             |   |  |  |  |  |                                    |                                     |                                   |  |  |
| 11.3          | END OF BOREHOLE AT 11.28m<br>BOREHOLE BACKFILLED WITH<br>DRILL CUTTINGS AND BENTONITE |            |         |      |            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |  |  |



# RECORD OF BOREHOLE No 14-4

1 OF 1

METRIC

19-5161-208

LOCATION

11+187 24 RT CL

ORIGINATED BY JG

HWY 11B

BOREHOLE TYPE Casing

COMPILED BY JG

DATUM geodetic

DATE

2014.10.08 - 2014.10.09

CHECKED BY FG

| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |    |    |    | PLASTIC      NATURAL      LIQUID<br>LIMIT      MOISTURE      LIMIT<br>CONTENT |                |   | UNIT<br>WEIGHT<br><br>γ<br><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                          |    |    |    | WATER CONTENT (%)   |                |   |  | GR  | SA | SI | CL |              |  |
|               |  |            |         |      |            |                            |                 | 20  | 40 | 60 | 80 | 100   | W <sub>P</sub> | W |  | W <sub>L</sub>                                    |    |    |    |              |  |
| 287.7         |  |            |         |      |            |                            |                 |   |    |    |    |   |                |   |  |   |    |    |    |              |  |
| 0.0           | <b>SAND</b> with organics, roots and rootlets<br>Compact<br>Blackish brown<br>Moist<br><br>Gravelly <b>SAND</b> to <b>GRAVEL and SAND</b> , frequent cobbles and boulders<br>Compact to loose<br>Brown<br><b>(FILL)</b><br>a few random cobbles and boulders between 0.3 and 1.2m  |            | 1       | SS   | 12         |                            |                 |   |    |    |    |   |                |   |  |   |    | 43 | 51 | 6<br>(SI+CL) |  |
| 0.2           |  |            | 2       | SS   | 30         |                            |                 |   |    |    |    |   |                |   |  |   |    |    |    |              |  |
|               |  |            | 3       | SS   | 22         |                            |                 |   |    |    |    |   |                |   |  |   |    |    |    |              |  |
| 285.4         |  |            |         |      |            |                            |                 |   |    |    |    |   |                |   |  |   |    |    |    |              |  |
| 2.3           | <b>SAND</b><br>Very loose to compact<br>Brown to grey<br>Wet<br><br><br><br><br><br><br><br><br><br>changes to grey in colour<br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br>< |            |         |      |            |                            |                 |   |    |    |    |   |                |   |  |   |    |    |    |              |  |

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 14-5

1 OF 2

METRIC

19-5161-208 LOCATION 11+199 3.7 LT CL ORIGINATED BY JG  
 HWY 11B BOREHOLE TYPE Hollow Stem Auger COMPILED BY JG  
 DATUM geodetic DATE 2014.09.30 - 2014.09.30 CHECKED BY FG

| 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><br>γ<br><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   |  |  |  |  | WATER CONTENT (%)                                       |   |  |  | GR  | SA | SI                     | CL |  |
|               |             |  |         |      |            |                            |                 | 20   40   60   80   100                                      |  |  |  |  | w <sub>p</sub> w   w <sub>L</sub>                       |   |  |  |   |    |                        |    |  |
|               |             |  |         |      |            |                            |                 | ○ UNCONFINED   + FIELD VANE<br>● QUICK TRIAXIAL   × LAB VANE |  |  |  |  |   |   |  |  |   |    |                        |    |  |
| 295.5         |             |  |         |      |            |                            |                 |  |  |  |  |  |   |   |  |  |   |    |                        |    |  |
| 0.0           |             | 80mm ASPHALT SHOULDER  |         |      |            |                            |                 |  |  |  |  |  |   |   |  |  |   |    |                        |    |  |
|               |             | Gravelly SAND<br>Dense<br>Brown<br>(FILL)                            |         | 1    | SS         | 48                         |                 |  |  |  |  |  |   | ○ |  |  |   |    |                        |    |  |
|               |             |  |         | 2    | SS         | 62                         |                 |  |  |  |  |  |   | ○ |  |  |   |    | 27   64   9<br>(SI+CL) |    |  |
| 294.1         |             |  |         |      |            |                            |                 |  |  |  |  |  |   |   |  |  |   |    |                        |    |  |
| 1.4           |             | Silty SAND, occasional cobble<br>Loose to compact<br>Brown<br>(FILL) |         | 3    | SS         | 14                         |                 |  |  |  |  |  |   | ○ |  |  |   |    |                        |    |  |
|               |             |  |         |      |            |                            |                 |  |  |  |  |  |   |   |  |  |   |    |                        |    |  |
|               |             |  |         | 4    | SS         | 6                          |                 |  |  |  |  |  |   | ○ |  |  |   |    |                        |    |  |
|               |             |  |         |      |            |                            |                 |  |  |  |  |  |   |   |  |  |   |    |                        |    |  |
|               |             |  |         | 5    | SS         | 28                         |                 |  |  |  |  |  |   | ○ |  |  |   |    |                        |    |  |
|               |             |  |         |      |            |                            |                 |  |  |  |  |  |   |   |  |  |   |    |                        |    |  |
|               |             |  |         | 6    | SS         | 27                         |                 |  |  |  |  |  |   |   |  |  |   |    |                        |    |  |
|               |             | a few random cobbles between 3.0<br>and 4.6m                         |         |      |            |                            |                 |  |  |  |  |  |   |   |  |  |   |    |                        |    |  |
|               |             |  |         | 7    | SS         | 4                          |                 |  |  |  |  |  |   | ○ |  |  |   |    |                        |    |  |
|               |             |  |         |      |            |                            |                 |  |  |  |  |  |   |   |  |  |   |    |                        |    |  |
|               |             |  |         | 8    | SS         | 3                          |                 |  |  |  |  |  |   | ○ |  |  |   |    | 5   81   14<br>(SI+CL) |    |  |
|               |             |  |         |      |            |                            |                 |  |  |  |  |  |   |   |  |  |   |    |                        |    |  |
|               |             |  |         | 9    | SS         | 12                         |                 |  |  |  |  |  |   | ○ |  |  |   |    |                        |    |  |
|               |             |  |         |      |            |                            |                 |  |  |  |  |  |   |   |  |  |   |    |                        |    |  |
|               |             |  |         | 10   | SS         | 16                         |                 |  |  |  |  |  |   | ○ |  |  |   |    |                        |    |  |
|               |             |  |         |      |            |                            |                 |  |  |  |  |  |   |   |  |  |   |    |                        |    |  |
|               |             |  |         | 11   | SS         | 8                          |                 |  |  |  |  |  |   | ○ |  |  |   |    |                        |    |  |
|               |             |  |         |      |            |                            |                 |  |  |  |  |  |   |   |  |  |   |    |                        |    |  |
|               |             |  |         | 12   | SS         | 6                          |                 |  |  |  |  |  |   |   |  |  |   |    |                        |    |  |
|               |             |  |         |      |            |                            |                 |  |  |  |  |  |   |   |  |  |   |    |                        |    |  |
|               |             | Trace organics, wood   |         |      |            |                            |                 |  |  |  |  |  |   |   |  |  |   |    |                        |    |  |
| 286.1         |             |  |         | 13   | SS         | 26                         |                 |  |  |  |  |  |   | ○ |  |  |   |    | 11   83   6<br>(SI+CL) |    |  |
| 9.4           |             | Sandy SILT to SAND<br>Compact<br>Grey                                |         |      |            |                            |                 |  |  |  |  |  |   | ○ |  |  |   |    | 0   33   67<br>(SI+CL) |    |  |

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 14-5

2 OF 2

METRIC

19-5161-208 LOCATION 11+199 3.7 LT CL ORIGINATED BY JG  
 HWY 11B BOREHOLE TYPE Hollow Stem Auger COMPILED BY JG  
 DATUM geodetic DATE 2014.09.30 - 2014.09.30 CHECKED BY FG

| 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><br>γ<br><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                          |    |                                      |    |     | WATER CONTENT (%)   |   |  |  | GR  | SA | SI | CL                   |  |
| Continued From Previous Page |   |            |         |      | ○ UNCONFINED      + FIELD VANE<br>● QUICK TRIAXIAL      × LAB VANE |                            |                 |   |    | w <sub>p</sub> w      w <sub>L</sub> |    |     |   |   |  |  |   |    |    |                      |  |
|                              |   |            |         |      |  |                            |                 | 20  | 40 | 60                                   | 80 | 100 |   |   |  |  |   |    |    |                      |  |
|                              | <b>SAND</b><br>Compact<br>Grey  |            |         |      |  |                            | 285             |   |    |                                      |    |     |   |   |  |  |   |    |    |                      |  |
|                              |   |            | 14      | SS   | 10   |                            |                 |   |    |                                      |    |     |   | ○ |  |  |   |    | 3  | 95      2<br>(SI+CL) |  |
|                              |   |            |         |      |  |                            | 284             |   |    |                                      |    |     |   |   |  |  |   |    |    |                      |  |
|                              | running sands   |            |         |      |  |                            |                 |   |    |                                      |    |     |   |   |  |  |   |    |    |                      |  |
|                              |   |            | 15      | SS   | 10   |                            | 283             |   |    |                                      |    |     |   | ○ |  |  |   |    | 3  | 91      6<br>(SI+CL) |  |
|                              |   |            |         |      |  |                            | 282             |   |    |                                      |    |     |   |   |  |  |   |    |    |                      |  |
|                              |   |            | 16      | SS   | 10   |                            |                 |   |    |                                      |    |     |   | ○ |  |  |   |    |    |                      |  |
|                              |   |            |         |      |  |                            | 281             |   |    |                                      |    |     |   |   |  |  |   |    |    |                      |  |
| 280.4                        |   |            |         |      |  |                            |                 |   |    |                                      |    |     |   |   |  |  |   |    |    |                      |  |
| 15.1                         | Dynamic cone penetration testing from 14.33 to 15.09m.<br>END OF BOREHOLE AT 15.1m<br>BOREHOLE BACKFILLED WITH<br>DRILL CUTTINGS AND BENTONITE<br>UPON COMPLETION WATER LEVEL<br>RECORDED AT 7.6m |            |         |      |  |                            |                 |   |    |                                      |    |     |   |   |  |  |   |    |    |                      |  |

ONTMT4S 19-5161-208.GPJ 2012TEMPLATE(MTO).GDT 5/2/15

# RECORD OF BOREHOLE No 14-6

1 OF 2

METRIC

19-5161-208 LOCATION 11+186 3.6 RT CL ORIGINATED BY JG  
HWY 11B BOREHOLE TYPE Hollow Stem Auger COMPILED BY JG  
DATUM geodetic DATE 2014.10.01 - 2014.10.01 CHECKED BY FG

| 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><br>$\gamma$<br><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   |    |    |     |  | W P      W      W L   |   |  |   | GR  | SA | SI | CL |               |
|               |             |   |         |      |            |                            |                 | 20   40   60   80   100  |    |    |     |  | 20   40   60  |   |  |   |   |    |    |    |               |
|               |             |   |         |      |            |                            |                 | ○ UNCONFINED      + FIELD VANE<br>● QUICK TRIAXIAL      × LAB VANE |    |    |     |  | WATER CONTENT (%)   |   |  |   |   |    |    |    |               |
| 295.1         |             |   |         |      |            |                            | 20              | 40   | 60 | 80 | 100 |  |   |   |  |   |   |    |    |    |               |
| 0.0           |             | 80mm ASPHALT SHOULDER   |         |      |            |                            |                 |  |    |    |     |  |   |   |  |   |   |    |    |    |               |
|               |             | Gravelly SAND<br>Dense to very dense<br>Brown<br>(FILL)   |         | 1    | SS         | 41                         |                 |  |    |    |     |  | ○   |   |  |   |   |    |    |    |               |
|               |             |   |         |      |            |                            |                 |  |    |    |     |  |   | ○ |  |   |   |    |    |    |               |
|               |             |   |         | 2    | SS         | 71                         |                 |  |    |    |     |  |   |   |  |   |   |    | 41 | 48 | 11<br>(SI+CL) |
| 293.7         |             |   |         |      |            |                            |                 |  |    |    |     |  |   |   |  |   |   |    |    |    |               |
| 1.4           |             | Gravelly SAND to Gravelly SAND<br>some Silt, frequent cobbles<br>Compact to very dense<br>Brown<br>(FILL) |         | 3    | SS         | 70                         |                 |  |    |    |     |  |   |   |  |   |   |    |    |    |               |
|               |             |   |         |      |            |                            |                 |  |    |    |     |  |   |   |  |   |   |    |    |    |               |
|               |             |   |         | 4    | SS         | 48                         |                 |  |    |    |     |  | ○   |   |  |   |   |    | 26 | 65 | 9<br>(SI+CL)  |
|               |             |   |         |      |            |                            |                 |  |    |    |     |  |   |   |  |   |   |    |    |    |               |
|               |             |   |         | 5    | SS         | 54                         |                 |  |    |    |     |  | ○   |   |  |   |   |    |    |    |               |
|               |             |   |         |      |            |                            |                 |  |    |    |     |  |   |   |  |   |   |    |    |    |               |
|               |             | a few random cobbles throughout   |         | 6    | SS         | 48                         |                 |  |    |    |     |  | ○   |   |  |   |   |    |    |    |               |
|               |             |   |         |      |            |                            |                 |  |    |    |     |  |   |   |  |   |   |    |    |    |               |
|               |             |   |         | 7    | SS         | 24                         |                 |  |    |    |     |  | ○   |   |  |   |   |    | 28 | 53 | 19<br>(SI+CL) |
|               |             |   |         |      |            |                            |                 |  |    |    |     |  |   |   |  |   |   |    |    |    |               |
|               |             |   |         | 8    | SS         | 25                         |                 |  |    |    |     |  | ○   |   |  |   |   |    |    |    |               |
|               |             |   |         |      |            |                            |                 |  |    |    |     |  |   |   |  |   |   |    |    |    |               |
| 289.0         |             |   |         |      |            |                            |                 |  |    |    |     |  |   |   |  |   |   |    |    |    |               |
| 6.1           |             | SAND<br>Loose to compact<br>Brown<br>(FILL)   |         | 9    | SS         | 9                          |                 |  |    |    |     |  | ○   |   |  |   |   |    |    |    |               |
|               |             |   |         |      |            |                            |                 |  |    |    |     |  |   |   |  |   |   |    |    |    |               |
|               |             |   |         | 10   | SS         | 16                         |                 |  |    |    |     |  | ○   |   |  |   |   |    | 1  | 90 | 9<br>(SI+CL)  |
|               |             |   |         |      |            |                            |                 |  |    |    |     |  |   |   |  |   |   |    |    |    |               |
|               |             |   |         | 11   | SS         | 5                          |                 |  |    |    |     |  | ○   |   |  |   |   |    |    |    |               |
| 286.9         |             |   |         |      |            |                            |                 |  |    |    |     |  |   |   |  |   |   |    |    |    |               |
| 8.2           |             | SAND<br>Very loose to compact<br>Grey   |         |      |            |                            |                 |  |    |    |     |  |   |   |  |   |   |    |    |    |               |
|               |             |   |         | 12   | SS         | 4                          |                 |  |    |    |     |  | ○   |   |  |   |   |    |    |    |               |
|               |             |   |         |      |            |                            |                 |  |    |    |     |  |   |   |  |   |   |    |    |    |               |
|               |             |   |         | 13   | SS         | WH                         |                 |  |    |    |     |  | ○   |   |  |   |   |    | 1  | 95 | 4<br>(SI+CL)  |
|               |             |   |         |      |            |                            |                 |  |    |    |     |  |   |   |  |   |   |    |    |    |               |

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 14-6

2 OF 2

METRIC

19-5161-208 LOCATION 11+186 3.6 RT CL ORIGINATED BY JG  
 HWY 11B BOREHOLE TYPE Hollow Stem Auger COMPILED BY JG  
 DATUM geodetic DATE 2014.10.01 - 2014.10.01 CHECKED BY FG

| 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><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 (%)                                   |  |                   |                         |   |
|                              |   |            |         |      |            |                            |                 | 20 40 60 80 100                             | ○ UNCONFINED + FIELD VANE   | W <sub>P</sub> W W <sub>L</sub> |   |  |                   |                         |   |
| Continued From Previous Page |   |            |         |      |            |                            |                 | 20 40 60 80 100                             | ● QUICK TRIAXIAL × LAB VANE |                                 |   |  | kN/m <sup>3</sup> | GR SA SI CL             |   |
| 279.3<br>15.8                | <b>SAND</b><br>Compact<br>Grey<br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br>< |            |         |      |            |                            |                 |   |                             |                                 |   |  |                   |                         |   |

ONTMT4S 19-5161-208.GPJ 2012TEMPLATE(MTO).GDT 5/2/15

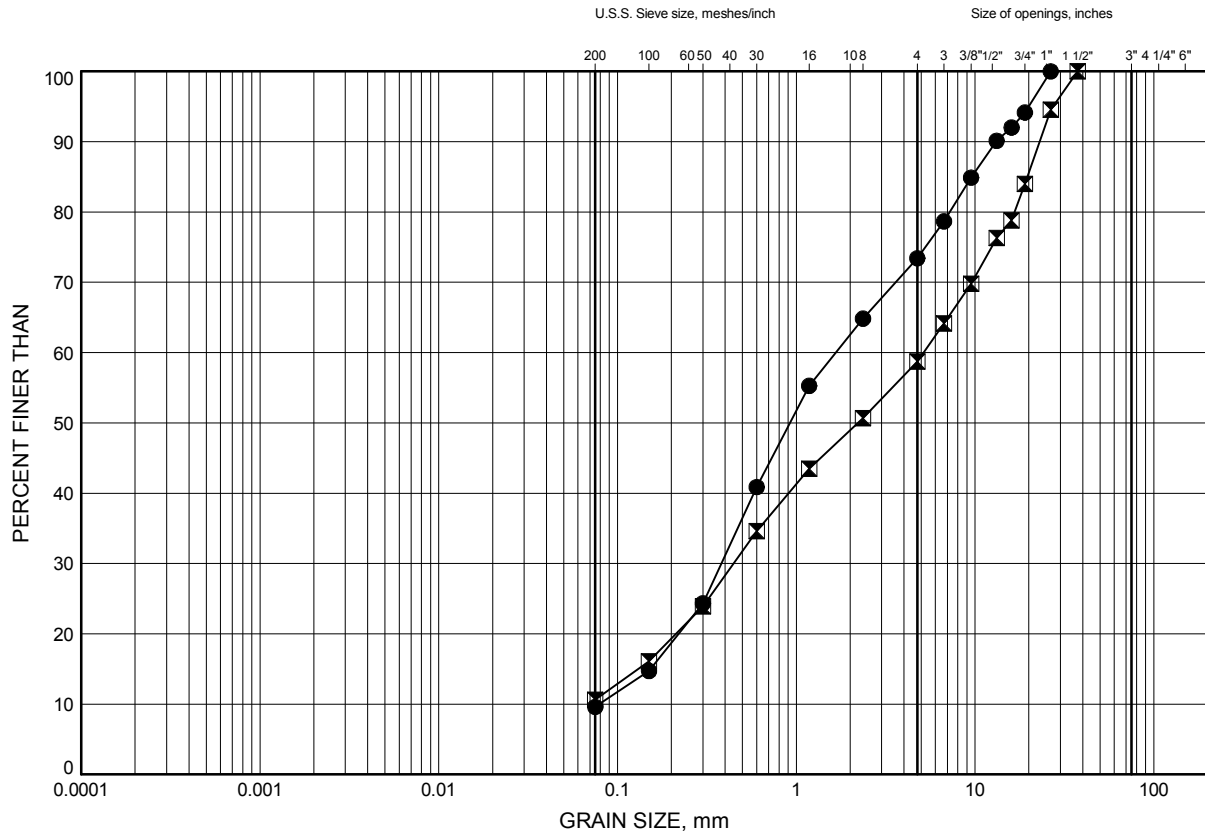
## **Appendix C**

### **Laboratory Test Results**

# GRAIN SIZE DISTRIBUTION

FIGURE 1

## Pavement Granulars



|               |      |        |        |        |        |             |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE   | COARSE | COBBLE SIZE |
| FINE GRAINED  | SAND |        |        | GRAVEL |        |             |

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 14-5     | 1.07      | 294.43    |
| ◻      | 14-6     | 0.91      | 294.19    |

Date December 2014  
19-5161-208

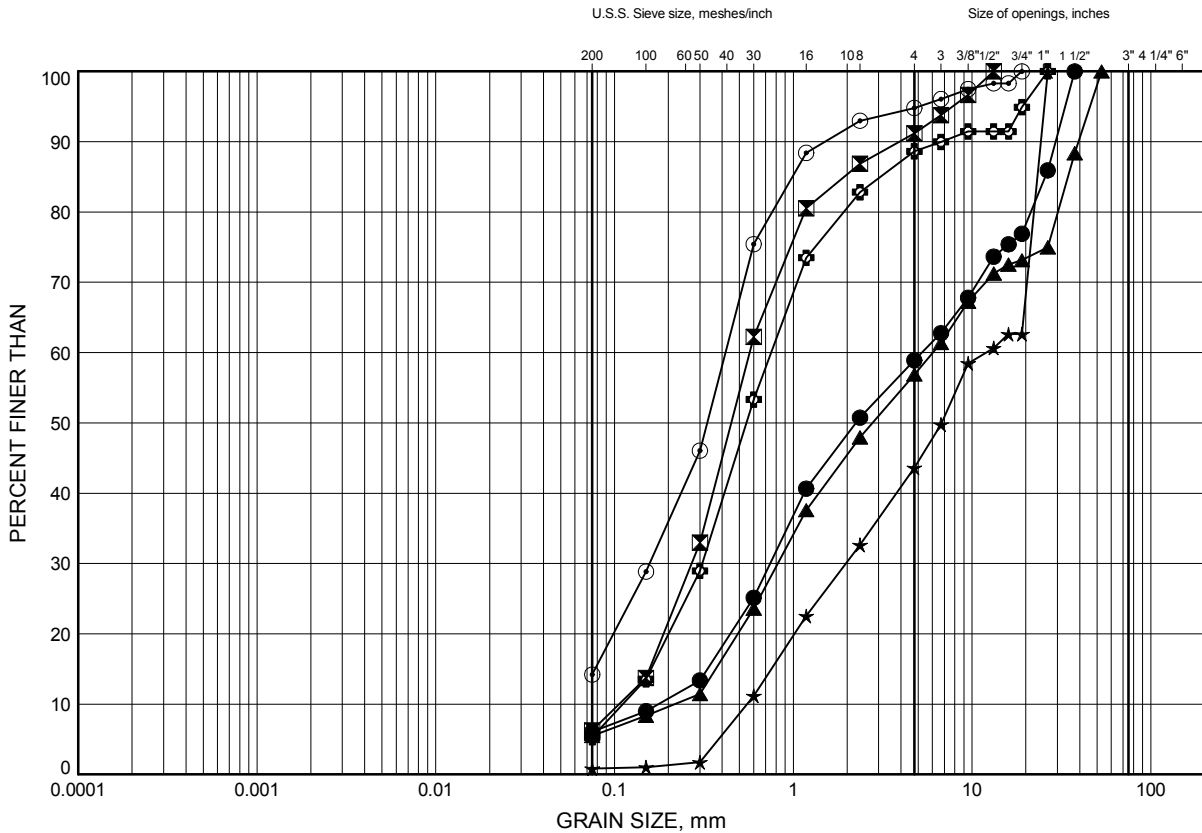


Prep'd JG  
Chkd. FG

# GRAIN SIZE DISTRIBUTION

FIGURE 2

## Embankment Fill



|               |      |        |        |        |        |             |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE   | COARSE | COBBLE SIZE |
| FINE GRAINED  | SAND |        |        | GRAVEL |        |             |

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 14-1     | 0.30      | 288.50    |
| ⊠      | 14-3     | 1.07      | 291.23    |
| ▲      | 14-4     | 0.41      | 287.29    |
| ★      | 14-4     | 1.83      | 285.87    |
| ⊙      | 14-5     | 5.64      | 289.86    |
| ⊞      | 14-5     | 9.30      | 286.20    |

Date December 2014  
19-5161-208



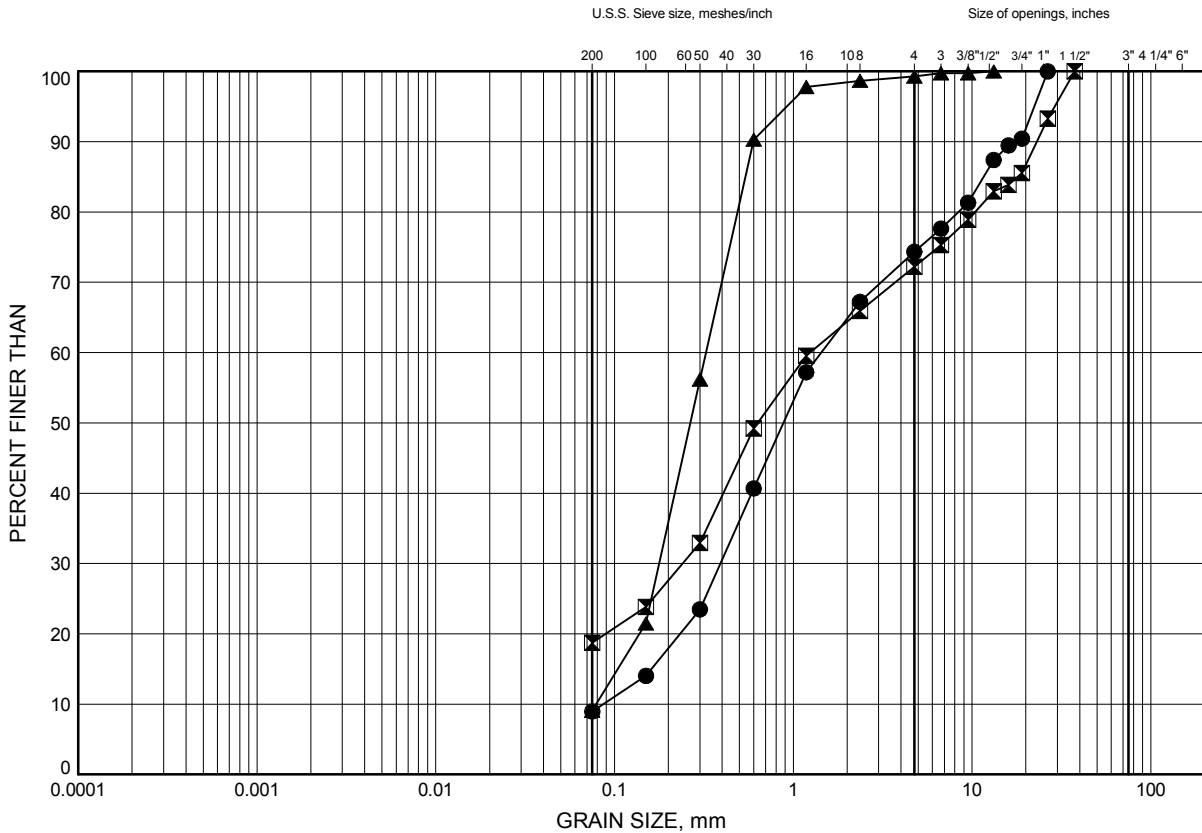
Prep'd JG  
Chkd. FG



# GRAIN SIZE DISTRIBUTION

FIGURE 3

## Embankment Fill



|               |      |        |        |        |        |             |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE   | COARSE | COBBLE SIZE |
| FINE GRAINED  | SAND |        |        | GRAVEL |        |             |

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 14-6     | 2.59      | 292.51    |
| ⊠      | 14-6     | 4.88      | 290.22    |
| ▲      | 14-6     | 7.16      | 287.94    |

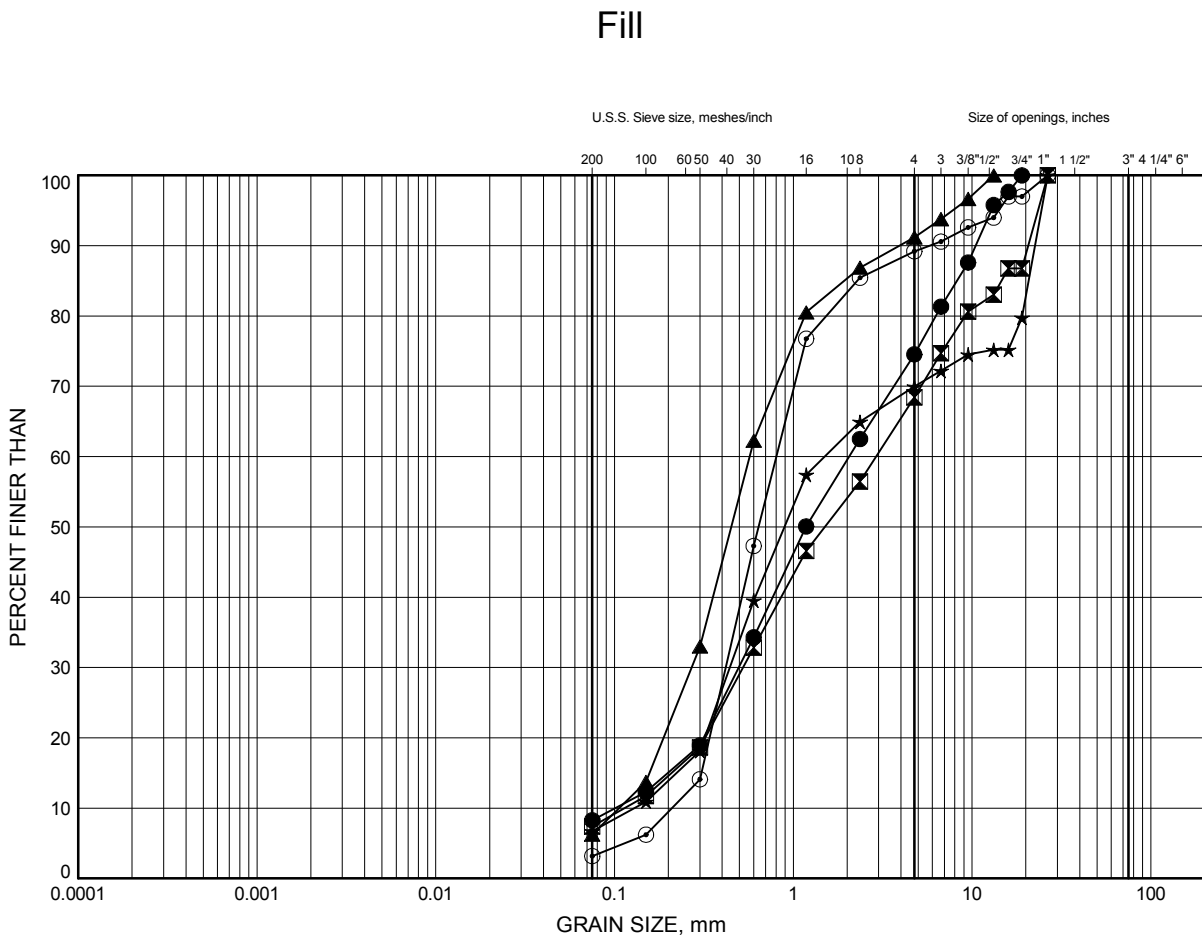
Date December 2014  
19-5161-208



Prep'd JG  
Chkd. FG

# GRAIN SIZE DISTRIBUTION

FIGURE 4



|               |      |        |        |        |        |             |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE   | COARSE | COBBLE SIZE |
| FINE GRAINED  | SAND |        |        | GRAVEL |        |             |

## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 14-2     | 0.30      | 290.50    |
| ⊠      | 14-2     | 2.59      | 288.21    |
| ▲      | 14-3     | 1.07      | 291.23    |
| ★      | 14-3     | 5.64      | 286.66    |
| ⊙      | 14-3     | 6.40      | 285.90    |

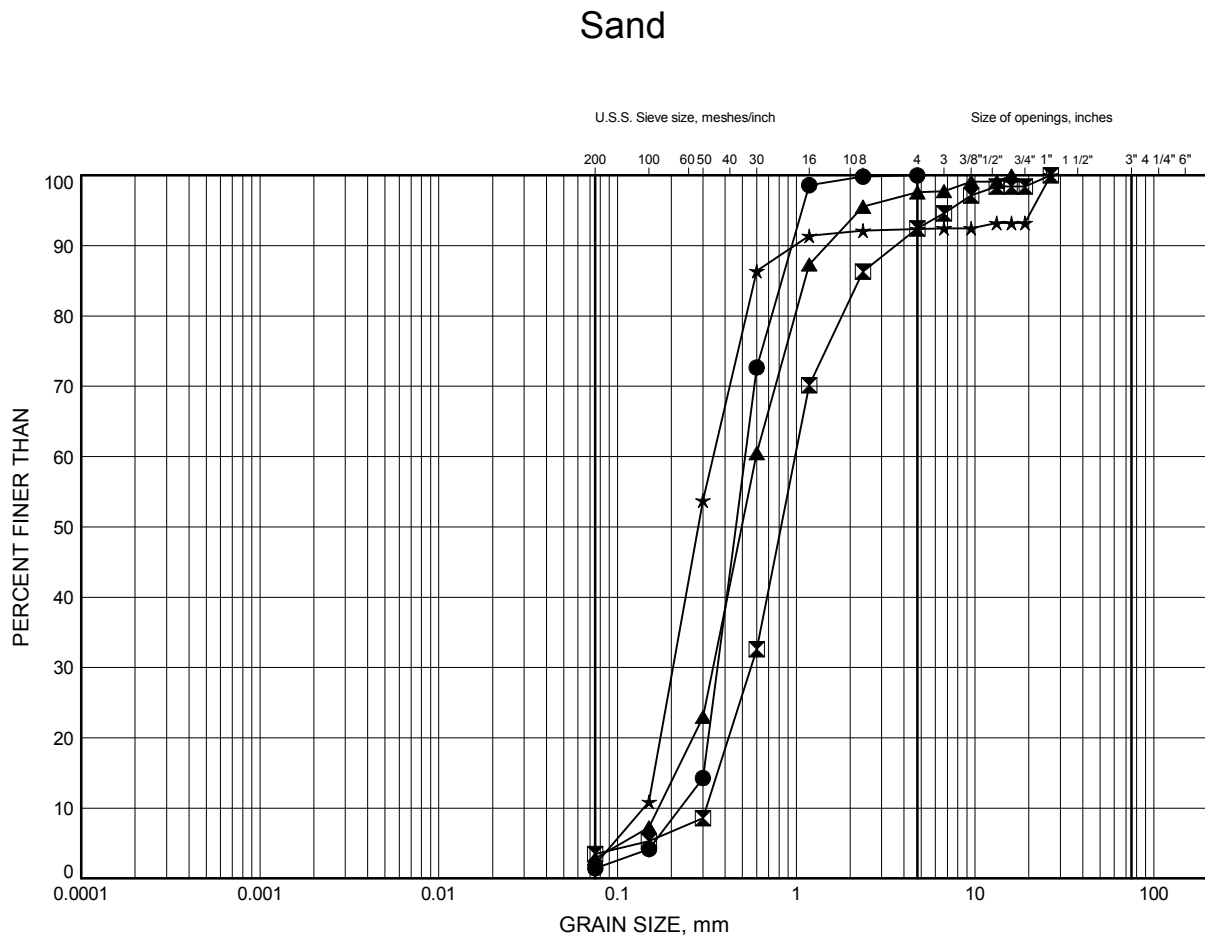
Date December 2014  
19-5161-208



Prep'd JG  
Chkd. FG

# GRAIN SIZE DISTRIBUTION

FIGURE 5



|               |      |        |        |        |        |             |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE   | COARSE | COBBLE SIZE |
| FINE GRAINED  | SAND |        |        | GRAVEL |        |             |

## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 14-1     | 4.88      | 283.92    |
| ⊠      | 14-2     | 4.11      | 286.69    |
| ▲      | 14-2     | 9.45      | 281.35    |
| ★      | 14-4     | 4.88      | 282.82    |

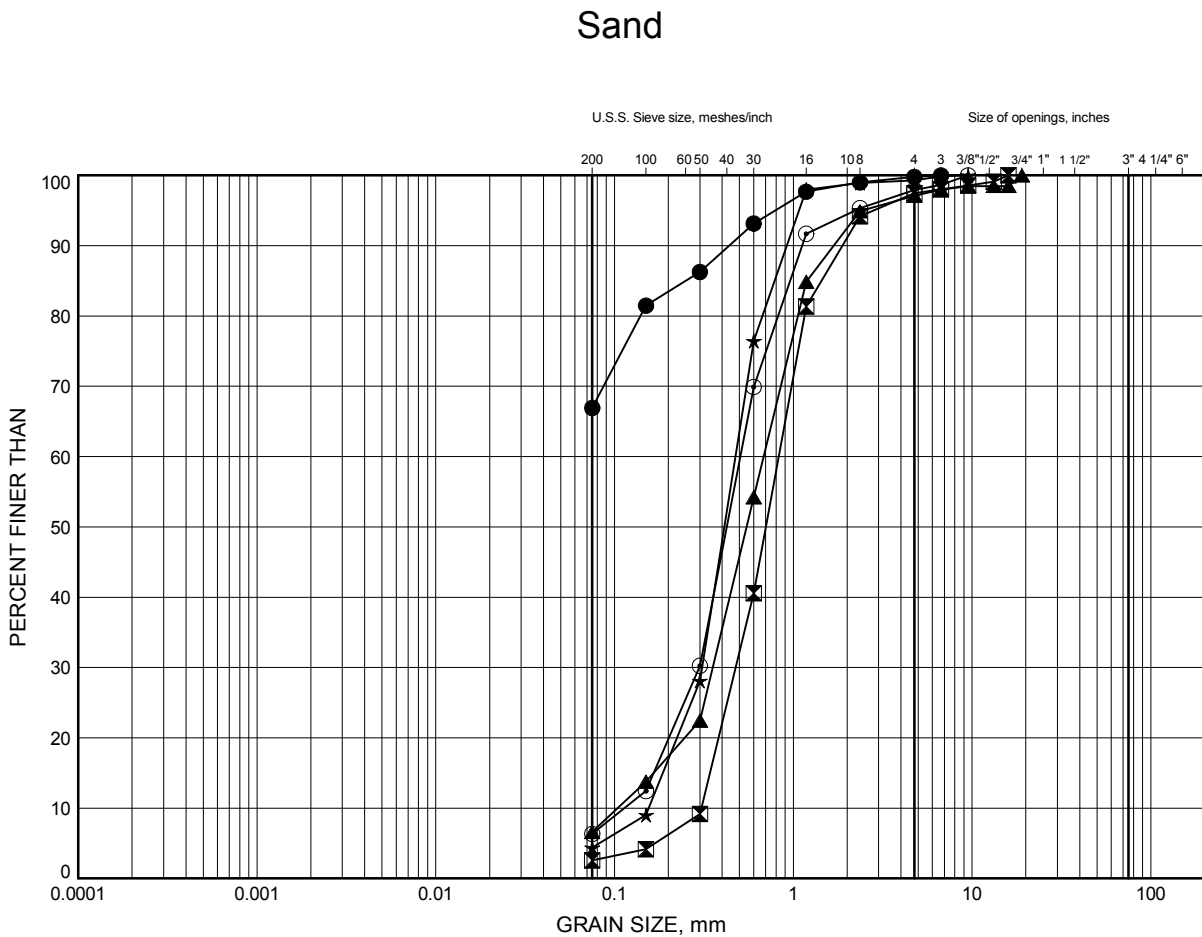
Date December 2014  
19-5161-208



Prep'd JG  
Chkd. FG

# GRAIN SIZE DISTRIBUTION

FIGURE 6



|               |      |        |        |        |        |             |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE   | COARSE | COBBLE SIZE |
| FINE GRAINED  | SAND |        |        | GRAVEL |        |             |

## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 14-5     | 9.60      | 285.90    |
| ⊠      | 14-5     | 10.97     | 284.53    |
| ▲      | 14-5     | 12.50     | 283.00    |
| ★      | 14-6     | 9.45      | 285.65    |
| ⊙      | 14-6     | 14.02     | 281.08    |

Date December 2014  
19-5161-208



Prep'd JG  
Chkd. FG

## **Appendix D**

### **Selected Photographs**



**Photo 1: Looking east along Hwy 11B, (above Culvert 1)**



**Photo 2: Looking west along Hwy 11B (above Culvert 1)**





**Photo 3: Culvert 1 inlet (north embankment)**



**Photo 4: Culvert 1 outlet (south embankment)**

## **Appendix E**

### **Foundation Alternatives Comparisons**



**COMPARISON OF CULVERT ALTERNATIVES**

| <b>Comment</b>                   | <b>Circular Pipe</b>  | <b>Concrete - Open Footing Culvert</b>  | <b>Concrete Box (closed) Culvert</b>  |
|----------------------------------|---|---|---|
| <b><i>Advantages</i></b>         | Quick installation particularly with a CSP.<br>Simple construction  | Improved durability   | Improved durability<br>Quick installation procedure due to use of pre-cast sections         |
| <b><i>Disadvantages</i></b>      | Less durable product  | Additional excavation depth<br>Additional dewatering<br>Lowest Geotechnical Resistance<br>Longest construction duration<br>Less flexible, so differential settlement could cause issues | Low Geotechnical Resistance<br>Less flexible, so differential settlement could cause issues |
| <b><i>Risks/Consequences</i></b> | Water infiltration during preparation of subgrade/Reduce risk with coffer dams<br>Durability of culvert/use coating to protect steel if necessary | Higher risk of water infiltration during preparation of subgrade as footings are deeper/increase in costs and additional construction time  | Water infiltration during preparation of subgrade/Reduce risk with coffer dams              |
| <b><i>Relative Cost</i></b>      | lowest  | high  | moderate  |
|                                  | <b>RECOMMENDED</b>  | <b>NOT FEASIBLE</b>   | <b>FEASIBLE</b>   |

**COMPARISON OF CONSTRUCTION METHODOLOGY OPTIONS**

| <b>Comment</b>                   | <b>Staged, with Roadway Protection</b>  | <b>Staged, with embankment widening/lowering</b>  | <b>Trenchless</b>   |
|----------------------------------|---|---|---|
| <b><i>Advantages</i></b>         | Quick installation particularly with a CSP.<br>Simple construction<br>More localized construction | Quick installation particularly with a CSP.<br>Simple construction  | Does not require staging – minimal traffic impact<br>Relatively well known technology and readily available.<br>Permits installation of a sleeve on line and grade. |
| <b><i>Disadvantages</i></b>      | Traffic impacts<br>Requires roadway protection<br>Requires water/groundwater control              | Traffic impacts<br>Requires temporary extensions to culvert<br>Requires additional water/groundwater control as culvert is longer<br>Extends limits of construction | Pipe diameter limits feasible techniques.<br>No room for exit pit due to presence of lake<br>High mobilization costs<br>Requires water/groundwater control          |
| <b><i>Risks/Consequences</i></b> |   | Pockets of organics within footprint of embankment widening/ increase in subgrade preparation costs   | Presence of cobbles & boulders in fill/difficulty advancing.  |
| <b><i>Relative Cost</i></b>      | low   | low   | high  |
|                                  | <b>RECOMMENDED</b>  | <b>FEASIBLE</b>   | <b>NOT FEASIBLE</b>   |