# FOUNDATION INVESTIGATION AND DESIGN REPORT
# BLEND CREEK BRIDGE
# HIGHWAY 587, DISTRICT OF THUNDER BAY
# G.W.P. 478-00-00, STRUCTURE No. 48C-46

**Geocres Number: 52A-149**

**Report to**
**McCormick Rankin Corporation**

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# TABLE OF CONTENTS

**Appendices**

# FOUNDATION INVESTIGATION AND DESIGN REPORT
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## PART 1: FACTUAL INFORMATION

### 1 INTRODUCTION

This report presents the factual findings obtained from a geotechnical investigation conducted at the location of a bridge carrying Highway 587 over the Blend Creek in the District of Thunder Bay, Ontario.

The purpose of the investigation was to explore the subsurface conditions at the bridge site and, based on the data obtained, provide a borehole location plan, borehole logs, stratigraphic profile, cross-sections, laboratory test results and a written description of the subsurface conditions.

Thurber carried out the investigation as a sub-consultant to McCormick Rankin Corporation under the Ministry of Transportation Ontario (MTO) Agreement Number 6010-E-0011.

### 2 SITE DESCRIPTION

The site is located on Highway 587 approximately 1.8 km south of the intersection with Highway 11/17 in the District of Thunder Bay, Ontario.

The existing structure consists of a three span bridge supported on timber pile bents. The length and width of the bridge are 16.6 m and 9.75 m, respectively. Highway 587 at the Blend Creek bridge crossing is constructed on an approximate 2.5 m to 3.0 m high embankment. The embankment slopes are grass covered. The surrounding lands are heavily wooded. The ground surface has a gently undulating topography.

At this location, the Blend Creek flows from north to south.

Photographs in Appendix C show views of the bridge and the general nature of the surrounding land.

The site lies within the Canadian Shield, characterized by low, rounded hills of Pre-Cambrian bedrock mantled by varying thicknesses of overburden. At this site, the overburden primarily consists of silty clay over sand. The underlying bedrock consists of schist.

## 3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out on July 18, 19, 21, 25, 26 and 28, 2011. A total of six sampled boreholes (numbered BC-1 to BC-6) were drilled through the existing highway embankments at the bridge location. Boreholes BC-2 and BC-3 were drilled near the west abutment and Boreholes BC-4 and BC-5 were drilled near the east abutment. Boreholes BC-1 and BC-6 were drilled at the west and east approaches, respectively. Boreholes were advanced to depths ranging from 11.3 m to 21.3 m (Elevations 182.6 to 192.8). Bedrock was proved in Boreholes BC-3 and BC-5 by NQ size diamond coring. Borehole BC-3 was advanced 3.1 m into bedrock and terminated at 18.0 m depth (Elevation 186.0). Borehole BC-5 was advanced 3.0 m into bedrock and terminated at 21.3 m depth (Elevation 182.6).

A Dynamic Cone Penetration Test (DCPT) was advanced adjacent to Borehole BC-4 from 10.6 m to 17.0 m depth.

The approximate locations of the boreholes and DCPT are shown on the Borehole Locations and Soil Strata Drawing in Appendix G. The coordinates and elevations of the boreholes are given on the drawings and on the individual Record of Borehole Sheets in Appendix A.

Prior to commencement of drilling, utility clearances were obtained for all borehole locations.

Hollow stem augers and wash-boring with casing were used to advance the boreholes. Samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT). In situ vane shear testing was carried out to assess the undrained shear strength of soft to firm cohesive deposits.

A member of Thurber's engineering staff supervised the drilling and sampling operations on a full time basis. The supervisor logged the boreholes, visually examined the recovered samples, and transported them to Thurber's laboratory for further examination and testing.

All rock cores were logged, and the Total Core Recovery (TCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined.

Groundwater conditions in the open boreholes were observed throughout the drilling operations.

Boreholes were grouted with bentonite/grout to 0.2 m or 0.3 m, concrete/Portland cement from 0.2 m or 0.3 m to 0.1m then asphalt cold patch to surface.

## 4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (sieve and hydrometer) and Atterberg Limits testing where appropriate. The results of this testing program are shown on the Record of Borehole sheets in Appendix A and on the figures contained in Appendix B.

Point load tests were carried out on selected samples of intact bedrock upon arrival at the laboratory to assist in evaluation of the compressive strength of the bedrock. Results of point load tests on the rock core samples are included in Appendix B and on the Record of Borehole sheets in Appendix A.

## 5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil and rock stratigraphy are presented in these sheets and on the "Borehole Locations and Soil Strata" drawing included in Appendix G. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond borehole locations.

The soil stratigraphy encountered at the borehole locations typically consists of an asphalt layer overlying sand and gravel fill, sand and silt fill and silty clay fill (embankment fill), underlain by native deposits of silty clay, silt to sandy silt, and fine sand. Fresh, grey schist bedrock was contacted below the sand/silty sand layers at depths ranging from 13.4 m to 18.3 m.

More detailed descriptions of the individual strata are presented below.

### 5.1 Asphalt

A 40 mm to 90 mm thick layer of asphalt was encountered in each borehole drilled on the travelled lanes of Highway 587.

### 5.2 Sand and Gravel Fill

The asphalt was underlain by fill consisting of reddish brown sand and gravel containing some silt, some clay and occasional cobbles. The thickness of the fill ranged from 1.3 m to 2.0 m.

The depth to the base of the sand and gravel fill varied from 1.3 m to 2.1 m (elevations 202.0 to 2002.8).

Layers of sand and silt fill containing some clay to clayey were encountered in Boreholes BC-3 and BC-4 at 1.5 m and 2.3 m depth (elevations 202.5 and 201.7), respectively. The thickness of the sand and silt fill was 1.5 m and 0.4 m.

SPT 'N' values in the sand and gravel fill and sand and silt fill typically decreased with depth. Within the upper 0.6 m of fill, the SPT 'N' values ranged from 28 to 38 blows per 0.3 m of penetration, indicating a compact to dense relative density. Below 0.6 m depth, the SPT 'N' values are lower, ranging from 3 to 22 blows per 0.3 m of penetration, indicating a very loose to compact relative density.

Moisture contents varied from 4% to 22%. A moisture content of 36% was measured in Borehole BC-4 near elevation 201.7.

Grain size distribution curves for samples of the sand and gravel fill and sand and silt fill are presented on the Record of Borehole sheets and on Figures B1 and B2 of Appendix B. The results of the laboratory tests are summarized as follows:

| Soil Particles | Sand and Gravel Fill (%) | Sand and Silt Fill (%) |
|---|---|---|
| Gravel | 46 | 7 |
| Sand | 42 | 32 |
| Silt | - | 34 |
| Clay | - | 27 |
| Silt & Clay | 12 | - |

## 5.3 Silty Clay Fill

A 800-mm thick layer of grey silty/sandy clay fill was contacted below the sand and gravel fill in Borehole BC-5, drilled at the east abutment.

A 200-mm thick layer of silty clay fill was contacted in Borehole BC-4 below the sand and gravel fill at 2.1 m depth (elevation 202.0).

The depths to the base of the silty clay fill were 2.3 m and 2.4 m (elevations 201.7 and 201.5).

The SPT 'N' values measured in the silty clay fill were 7 and 12 blows per 0.3 m of penetration, indicating a firm to stiff consistency.

Moisture contents of the silty clay fill were 20% and 37%.

## 5.4 Peat

Dark brown peat containing occasional roots and wood fibres was contacted below fill in Boreholes BC-3 to BC-5. The peat thickness ranged from 0.1m to 1.4 m.

The depth to the base of the peat ranged from 2.8 m to 4.1 m (elevation 199.9 to 201.2). The peat thickness may vary between and beyond the borehole locations.

SPT 'N' values recorded in the peat were 3 and 7 blows for 0.3 m of penetration, indicating a soft to firm consistency. Natural moisture contents in the peat ranged from 40% to 70%.

### 5.5 Sandy Silt

A layer of native grey sandy silt containing some clay to clayey and trace gravel was contacted below the sand and gravel fill at 1.5 m depth (elevation 202.5) in Borehole BC-2, drilled at the west abutment. The thickness of the sandy silt layer is 3.1 m.

The depth to the base of the sandy silt was 4.6 m (elevation 199.5).

SPT 'N' values in this layer decrease with depth, ranging from 15 to 2 blows per 0.3 m of penetration indicating a compact to very loose relative density.

Moisture contents varied from 21% to 33%.

A grain size distribution curve for a sample of the sandy silt is presented on the Record of Borehole sheets and on Figure B5 of Appendix B. The results of the laboratory tests are summarized as follows:

| Soil Particles | Sandy Silt (%) |
|---|---|
| Gravel | 1 |
| Sand | 32 |
| Silt | 44 |
| Clay | 23 |

### 5.6 Silty Clay

Native grey silty clay containing trace sand and sand seams was encountered below the fill in Boreholes BC-1 and BC-6, below the native sandy silt in Borehole BC-2 and below the peat in Boreholes BC-3 to BC-5. Occasional roots, shells and wood fibres were observed in the silty clay in Borehole BC-2.

The silty clay was contacted at depths ranging from 1.3 m to 4.6 m (elevations 199.5 to 202.8). The thickness of the silty clay ranged from 4.2 m to 7.5 m.

The depth to the base of the silty clay ranged from 8.7 m to 9.9 m (elevation 194.2 to 195.4).

SPT 'N' values recorded in the silty clay ranged from 0 to 9 blows for 0.3 m of penetration, indicating a very soft to sitff consistency. Typically, N-values in the native silty clay were 0 to 4 blows for 0.3 m penetration. In-situ Vane Shear Tests were also performed where low N-values were recorded. The shear strength of the silty clay ranges from 20 to 58 kPa.

The moisture content of samples collected from the silty clay layer generally varies between 23% and 79%.

Grain size distribution curves for selected silty clay samples are presented in Appendix B, Figures B3 and B4. The results are also summarized on the Record of Borehole sheets included in Appendix A. Atterberg Limits test results are presented in Figures B8 and B9 of Appendix B. The results of the laboratory tests are summarized as follows:

| Soil Particles | Percentage (%) |
|---|---|
| Gravel | 0 |
| Sand | 0 to 31 |
| Silt | 16 to 40 |
| Clay | 44 to 84 |

| Index Property | Percentage (%) |
|---|---|
| Liquid Limit | 39 to 71 |
| Plastic Limit | 18 to 24 |

The above results show that the silty clay is of medium to high plasticity with group symbols of CL-CH.

### 5.7 Silt to Sandy Silt

A layer of reddish brown to grey silt, trace sand, to sandy silt was contacted below the silty clay at depths of 8.7 to 9.9 m (elevation 194.2 to 195.4) in all boreholes drilled at the site. The thickness of the silt to sandy silt layer was 3.4 to 4.6 m in Boreholes BC-1 to BC-5. Borehole BC-6 was terminated within this deposit.

The depth to the base of the silt to sandy silt is 13.3 to 13.4 m (elevation 190.6 to 190.8).

SPT 'N' values ranging from 6 to 17 blows per 0.3 m of penetration were measured in the silt to sandy silt layer, indicating a loose to compact relative density.

The moisture content ranged from 17% to 25%, with one sample from Borehole BC-6 indicating 31%.

Grain size distribution curves for samples of the silt and sandy silt are presented on the Record of Borehole sheets and on Figures B5 and B6 of Appendix B. The results of the laboratory tests are summarized as follows:

| Soil Particles | Silt (%) | Sandy Silt (%) |
|---|---|---|
| Gravel | 0 | 0 |
| Sand | 3 to 9 | 39 |
| Silt | 78 to 90 | 58 |
| Clay | 5 to 13 | 3 |

### 5.8 Sand

Reddish brown to grey sand containing trace to some gravel and trace silt was contacted below the silt to sandy silt at 13.3 m depth (elevations 190.6 to 190.8) in Boreholes BC-2 to BC-5.

The thickness of the sand layer in Boreholes BC-2, BC-3 and BC-5 ranged from 1.3 to 5.0 m. The base of the sand was at 14.6 to 18.3 m depth (elevation 185.6 to 189.4). Borehole BC-4 was terminated within the sand layer at 16.8 m depth (elevation 187.3), indicating a thickness of at least 3.5 m.

In Boreholes BC-3 to BC-5, cobbles and boulders were encountered within the lower 0.6 to 1.6 m of this deposit, below depths of 14.3 to 16.7 m. Coring was required to penetrate the boulders in each borehole.

SPT 'N' values recorded in the sand ranged from 1 blow per 0.3 m of penetration (possible hydraulic disturbance), to 74 blows per 0.3 m of penetration indicating a very dense relative density. An SPT ' N' value of 50 blows per 0.15 m of penetration was obtained in Borehole BC-5 when a boulder was encountered.

The moisture content of the sand ranged from 9% to 23%.

A grain size distribution curve for a sample of the sand is presented on the Record of Borehole sheet and on Figure B7 of Appendix B. The results of the laboratory test are summarized as follows:

| Soil Particles | (%) |
|---|---|
| Gravel | 0 |
| Sand | 96 |
| Silt & Clay | 4 |

### 5.9 Bedrock

The overburden soils described above are underlain by dark grey, fresh schist bedrock. Occasional quartz interbeds, occasional mechanical breaks and sub-vertical fractures were noted throughout the bedrock cores.

Bedrock was proved by coring at two boreholes. Table 5.1 summarizes depths and elevations to the top of bedrock and auger refusal on probable bedrock in the boreholes.

Core recovery in the bedrock was 75% in one core and 100% in the remaining cores. The RQD values ranged from 62% to 100%, indicating fair to excellent rock quality. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, was generally less than 4, except in Borehole BC-5 Run 1 where FI was greater than 20.

**Table 5.1 – Depths and Elevations of Bedrock and Probable Bedrock**

| Borehole | Top of Bedrock | |
|---|---|---|
| | Depth (m) | Elevation (m) |
| BC-1 | 13.4 | 190.7 |
| BC-2 | 14.6 | 189.5 |
| BC-3* | 14.9 | 189.1 |
| BC-4 | 16.8 | 187.3 |
| BC-5* | 18.3 | 185.6 |

* Bedrock proved by coring.

The estimated unconfined compressive strength of the rock cores ranged from 58 MPa to 161 to MPa, indicating a strong to very strong rock. Low unconfined compressive strength values ranging from 18 MPa to 28 MPa were measured in cores from Borehole BC-3, Run 1 and 2, indicating a weak rock. These estimated rock strength values are interpreted from point load tests that were conducted on rock cores recovered from the boreholes. A summary of the Point Load Test Results is presented in Appendix B.

### 5.10 Water Levels

Water levels were observed in the open boreholes upon completion of drilling operations. The water levels measured in the open boreholes, referenced to the ground surface, are summarized in Table 5.2.

**Table 5.2 – Water Level Measurements**

| Borehole | Date | Water Level (m) | | Comment |
|---|---|---|---|---|
| | | Depth | Elevation | |
| BC-1 | July 19, 2011 | 2.7 | 201.4 | Open borehole |
| BC-2 | July 19, 2011 | 0.2 | 203.9 | Open borehole |
| BC-3 | July 18, 2011 | -0.9* | 204.9* | Open borehole |
| BC-4 | July 28, 2011 | -0.6* | 204.7* | Open borehole |
| BC-5 | July 21, 2011 | -0.6* | 204.5* | Open borehole |
| BC-6 | July 25, 2011 | -0.1* | 204.2* | Open borehole |

*Indicates water level above ground surface, artesian conditions.

The groundwater level is 0.1 m to 0.9 m above ground surface (elevations 204.2 to 204.9), indicating artesian conditions at this site.

On the preliminary GA drawing, a water level at Elevation 202.2 is indicated in Blend Creek in May 2011.

The groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

## 6 MISCELLANEOUS

The borehole locations were established in the field by Thurber Engineering. The coordinates and ground surface elevations at the boreholes were subsequently determined by MMM Group Limited survey personnel.

Thurber obtained utility clearances for the borehole locations prior to drilling.

Eastern Ontario Diamond Drilling Ltd. supplied truck-mounted drilling equipment and conducted the drilling, sampling and in-situ testing operations for the boreholes drilled on the highway.

The field program was supervised on a full time basis by Ms. Eckie Siu and Mr. George Azzopardi of Thurber Engineering Ltd. Overall supervision of the field program was provided by Mr. Mark Farrant, P. Eng.

Interpretation of the data and preparation of the report was carried out by Ms. R. Palomeque Reyna, P.Eng. and Mr. Murray Anderson, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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## PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

## 7 INTRODUCTION

This report presents interpretation of the geotechnical data in the factual report and presents geotechnical recommendations for design of a new bridge to replace the existing bridge at Blend Creek in the District of Thunder Bay, Ontario.

The existing bridge is a three-span structure supported on timber bents with a concrete deck supported on timber bents. The length of the bridge is 16.6 m and the width is 9.75 m. It is understood that the existing concrete deck slab, timber deck panels, bent pile caps and piles, timber curbs and existing guiderail system will be removed in order to build the new bridge.

The proposed bridge consists of a single span structure supported on steel H-piles (refer to preliminary General Arrangement in Appendix F). A sheet pile wall will be installed immediately behind the row of H-piles to support the approach fill, in lieu of a conventional abutment. The new structure will have a span of 13.5 m and a width of 9.75 m. The existing Highway 587 grade will be raised about 200 mm at abutments.

The discussion and recommendations presented in this report are based on the information provided by McCormick Rankin Corporation and on the factual data obtained in the course of the investigations.

## 8 STRUCTURE FOUNDATIONS

In general terms, the stratigraphy encountered at the site generally consists of asphalt over very loose to dense cohesionless fill (sand, gravel and silt) and firm to stiff silty clay fill overlying native very soft to stiff silty clay. A 0.1-m to 1.4-m thick layer of peat was contacted below the fill in three boreholes at both abutments. A layer of compact to very loose silty sand was contacted below the fill at the west abutment. Loose to compact silt to sandy silt was contacted below the silty clay at 8.7 to 9.9 m depth, and this deposit was in turn underlain at 13.3 m depth by loose to very dense sand containing cobbles and boulders. The overburden soils are underlain by dark grey, fresh schist bedrock. The bedrock was encountered at 13.4 m to 14.9 m at the west abutment and at 16.8 m to 18.3 m at the east abutment.

Groundwater levels measured at this site range from 0.1 m to 0.9 m above ground surface (elevations 204.2 to 204.9), indicating artesian conditions. GA indicate water level in the Blend Creek at Elevation 202.2 in May 2011.

Geotechnical recommendations for design of the proposed H-pile foundation system are presented in the following sections. Foundation alternatives together with corresponding geotechnical design parameters for feasible options are also presented in the event that the foundation concept changes.

A comparison of the technical advantages and disadvantages of alternative foundation schemes (driven steel H-piles, spread footings on native soil, and caissons/drilled shafts) is presented in Appendix D. A foundation scheme preferred from a foundations perspective (driven steel H-piles) is recommended.

## 8.1 Driven Piles

The subsurface conditions at the west and east abutments are considered suitable for the design of foundations supported on steel H-piles driven to bedrock.

The elevations at which the piles are expected to encounter bedrock are given in Table 8.1. The anticipated pile lengths, assuming a pile cut-off at Elev. 203.3, are also presented in the table.

**Table 8.1– Estimated Pile Tip Elevation**

| Foundation Unit | Borehole | Anticipated Pile Length (m) | Anticipated Pile Tip Elevation on Bedrock |
|---|---|---|---|
| West Abutment | BC-2 | 13.9 | 189.4 |
| | BC-3 | 14.2 | 189.1 |
| East Abutment | BC-4 | 16.0 | 187.3 |
| | BC-5 | 17.7 | 185.6 |

The pile tip elevations shown in Table 8.1 should be used for estimating purposes only. The actual pile tip elevations will be controlled as described in Section 8.3.4 Pile Driving.

The GA indicates that the piles for the new abutments will be driven 1.6 m in front of the existing abutments which are supported on timber piles. The GA drawing also indicates that the existing bent pile caps will be removed.

In light of the artesian pressures noted in the boreholes at this site, it is recommended not to extract the existing timber piles to prevent upward flow of artesian water.

### 8.1.1 Axial Resistance

The axial, factored geotechnical resistance at Ultimate Limit States ($ULS_f$) for an H-Pile section 310x110 driven to refusal on bedrock at the elevations indicated in Table 8.1 is 2,000 kN.

The SLS condition will not govern for piles founded on the bedrock.

The structural resistance of the pile must be checked by the structural designer.

### 8.1.2 Pile Tips

The tips of all piles should be fitted with cast steel, H-section rock points from an approved manufacturer such as Titus Steel (Standard H-point) or approved equivalent.

The use of rock points is recommended as the piles will be driven into soil containing occasional cobbles and boulders immediately above the bedrock, which requires a higher level of protection than driving into soils containing only smaller particle sizes.

### 8.1.3 Pile Installation

Pile installation should be in accordance with OPSS 903.

The Contract Documents should contain a NSSP alerting the Bidders to the presence of cobbles and boulders in the native sand layer immediately above the bedrock. Suggested texts for NSSP's are included in Appendix F. The NSSP should require the QVE to terminate driving before the pile is damaged by overdriving.

### 8.1.4 Pile Driving

At the abutments, the piles should be driven to bedrock. The appropriate pile driving note is "Piles to be driven to bedrock".

We understand that the proposed bridge design may require that the deviation at the top of the pile be limited to 12 mm. To reduce the potential for misalignment resulting from hard driving to confirm bedrock, it is recommended that the pile driving note on the foundation drawing be modified as follows:

"Piles to be driven to bedrock. Upon initial contact with the bedrock:

1. Apply 10 blows at 10% of the hammer energy. Record the penetration.
2. Apply 10 blows at 50% of the hammer energy. If the penetration under 10 blows is less than 12.5 mm, the pile is set.
3. If the penetration under 10 blows is greater than 12.5 mm, refer the issue to the design team for resolution."

Use of a driving template or other means may also be required to achieve the specified maximum deviation.

### 8.1.5 Artesian Water Pressure

The groundwater level at this site is 0.1 m to 0.9 m above ground surface (elevations 204.2 to 204.9), indicating artesian conditions at this site. It is expected that the clay layer above the artesian zone will act as a seal to prevent artesian flow up along the pile shaft. If residual artesian flow is observed adjacent to the pile, the CA should refer this issue to the design team for resolution.

### 8.1.6 Downdrag

Since the highway grade revisions at the approaches and the abutments will be minimal, downdrag on the piles is not considered to be an issue at this site.

### 8.1.7 Lateral Resistance

The lateral resistance of the piles may be calculated using a value for the coefficient of horizontal subgrade reaction ($k_s$) and ultimate lateral resistance ($p_{ult}$) as follows:

$$k_s = n_h \, z / D \qquad (kN/m^3)$$

$$p_{ult} = 3 \,.\, \gamma \,.\, z \,.\, K_p \qquad (kPa)$$

where $z$ = depth of embedment of pile in metres
$D$ = pile width in metres
$n_h$ = value from Table 8.3
$\gamma$ = unit weight (Table 8.3)
$K_p$ = passive earth pressure coefficient (Table 8.3)

For cohesive soils, the lateral resistance of the piles may be calculated as follows:

$$k_s = 67 * S_u / D \qquad (kN/m^3)$$

$p_{ult}$ = $9 * S_u$ (kPa) at and below a depth of 3*D (m) reduced to zero at the ground surface

where

$D$ = pile width in metres
$S_u$ = undrained shear strength (kPa)

The above equations and recommended parameters may be used to analyze the interaction between a pile and the surrounding soil. The lateral pressures obtained from the analysis should not exceed the ultimate lateral resistance.

The spring constant, K, for analysis may be obtained by the expression, $K = k_s * L * D$ (kN/m), where $k_s$ is the coefficient of horizontal subgrade reaction ($kN/m^3$), D is the pile width (m) and L is the length (m) of the pile segment or element used in the analysis. The ultimate lateral resistance on any one segment of pile, $P_{ult}$, may be obtained from the expression, $P_{ult} = p_{ult}*L*D$. This represents the ultimate load at which the pile fails and will not support any additional load at greater displacements. It is recommended, however, that the total lateral resistance assumed in one pile be limited to no more than 120 kN at ULS and 50 kN at SLS.

Parameters for lateral pile resistance are shown in Table 8.3. The unit weights provided in the table for soils below the groundwater level are buoyant (effective) unit weights for use in the lateral resistance calculations.

**Table 8.3 – Parameters for Lateral Pile Resistance**

| Location | Elevation | $n_h$ ($kN/m^3$) | $S_u$ kPa | $K_p$ | Unit Weight ($kN/m^3$) | Soil Conditions |
|---|---|---|---|---|---|---|
| West Abutment | OGL to 202.0 | 6,000 | - | 3.0 | 21 | Sand and gravel, silt and sand, very loose to dense (FILL) |
| | 202.0 to 199.5 | 1,000 | - | 2.7 | 8* | Sandy silt fill, peat, native sandy silt, very loose/soft |
| | 199.5 to 195.0 | - | 25 | 2.7 | 10* | Silty clay, very soft to stiff |
| | 195.0 to 190.5 | 2,500 | - | 3.0 | 11* | Silt to sandy silt, loose to compact |
| East Abutment | OGL to 202.0 | 6,000 | - | 3.0 | 21 | Sand and gravel, occ. cobbles, dense to compact (FILL) |
| | 202.0 to 201.0 | 1,000 | - | 2.7 | 8* | Silty clay fill, firm to stiff, sand and silt fill, very loose, peat, soft |
| | 201.0 to 195.0 | - | 25 | 2.7 | 10* | Silty clay, very soft to firm |
| | 195.0 to 190.5 | 2,500 | - | 3.0 | 11* | Silt to sandy silt, very loose to compact |

*Buoyant unit weight below the water table.

For lateral soil/pile group interaction analysis, the modulus of subgrade reaction ($k_s$) may have to be reduced based on pile spacing.

Where a pile group is oriented ***perpendicular*** to the direction of loading, group action may be considered by reducing values for $k_s$ by a reduction factor R as follows:

| Pile Spacing Perpendicular to Direction of Loading | Horizontal Subgrade Reaction Reduction Factor, R |
|---|---|
| 4 D* | 1.00 |
| 1 D* | 0.50 |

* D is the width of the pile, and spacing is measured centre to centre

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Where a pile group is oriented ***parallel*** to the direction of loading, group action may be considered by reducing values for $k_s$ by a reduction factor R as follows:

| Pile Spacing Parallel to Direction of Loading | Horizontal Subgrade Reaction Reduction Factor, R |
|---|---|
| 8 D | 1.00 |
| 6 D | 0.70 |
| 4 D | 0.40 |
| 3 D | 0.25 |

Intermediate values may be obtained by interpolation.

### 8.2 Sheet Pile Walls

A sheet pile wall (EZ-88 or approved alternative) is proposed to be installed at each abutment to a tip elevation of 200.5.

The lateral resistance of sheet piles may be computed using the lateral earth pressure distribution and parameters presented in Section 14. The potential exists that occasional cobbles may be encountered in the embankment fill. Based on the borehole data, it is anticipated that sheet piles will penetrate or push aside these obstructions if encountered.

### 8.3 Spread Footings on Native Soils

Spread footings founded on native soils are not recommended at this site due to the following reasons:

- Low geotechnical capacities are present at this site in much of the overburden soils above the bedrock.
- Relatively large settlements under footing loads will occur if footings are placed on the native soils.
- Groundwater levels are high and artesian conditions are also present at the site. Unwatering/groundwater control will be difficult for construction of footings.

### 8.4 Augered Caissons (Drilled Shafts)

Augered caisson foundations were also considered for the support of the new abutments. However, the overburden soils are not considered suitable for caisson support and the caissons must be founded on the bedrock at depths ranging from 13.4 m to 18.3 m below original ground surface. In addition, artesian and high water level conditions are present at the site. The caissons will have to be installed through cohesionless soils under a high hydrostatic head.

The permeable nature of the sand and the presence of boulders above the bedrock would make it difficult to seal the bottom of the caisson liner into the founding stratum to exclude groundwater. Unwatering of the caissons would be impractical and attempts to do so might result in continued flow of fines into the caisson excavation.

Installation of caissons to bedrock is also expected to be a more expensive option than driven piles.

For these reasons, the use of a caisson foundation is not recommended.

### 8.5 Recommended Foundation

From a geotechnical perspective and based on the subsurface conditions, steel H-piles driven to refusal on bedrock for supporting the east and west abutments are recommended at this site.

### 8.6 Frost Cover

The design depth of frost penetration at this site is 2.3 m.

Frost protection should be provided for the undersides of all pile caps, if employed, and should consist of a minimum of 2.3 m of soil cover.

## 9 EXCAVATION

If earth excavation is required, it must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the native soils within the probable depth of excavation at this site may be classed as Type 3 soils above the water table and Type 4 soils below the water table.

The excavation must be carried out in accordance with OPSS 902.

Excavation below the groundwater level without prior dewatering is not recommended since the inflow of groundwater will cause boiling and sloughing of the soil below the water table making it difficult to maintain a dry, sound base on which to work.

## 10 UNWATERING

The groundwater level measured in piezometers is 0.1 m to 0.9 m above ground surface (elevations 204.2 to 204.9 m), indicating artesian conditions at this site. The water level in the creek was elevation 202.2 m in January 2011.

Based on the preliminary GA for the bridge structure and the use of pile foundations, it is expected that work at the abutments will not require excavation below the groundwater level.

If removal of existing timber bent pile caps at the abutments involves excavation below the creek water level, dewatering will be required. The design of the dewatering system should be the responsibility of the Contractor and the Contract Documents should alert him to this responsibility.

## 11 APPROACH EMBANKMENTS

Currently, the embankment slopes in the approach areas of the Blend Creek bridge are generally at an inclination of 2.5H:1V and approximately 2.5 m to 3.0 m high. The foundation soils governing stability of the approach embankments consist generally of native very loose to compact sandy silt and very soft to stiff silty clay. Layers of peat were observed at the abutments below the embankment fill.

### 11.1 Settlement

It is understood that the existing Highway 587 grade will be raised up to 200 mm at the abutments.

The settlement induced by the placement of new fill is considered minimal.

### 11.2 Stability

The global, internal and surficial stability of the approach embankment fills depends on the slope geometry and also to a large degree on the material used to construct the embankments.

An evaluation of the slope stability of the approach embankments was conducted for the proposed highway grade and embankment slope. The stability of the embankments was not checked under seismic loading as the zonal acceleration at this site is 0.0g. The computed factors of safety are as shown in Table 11.1. Slope stability computation output is included in Appendix E.

**Table 11.1 Computed Factor of Safety**

| Material | Height (1) (m) | Slope (2) | Factor of Safety | Figure (Appendix E) |
|---|---|---|---|---|
| Earth Fill | 3.2 | 2H:1V | 1.4 | 1 |

(1) Including proposed 200 mm of fill to raise the highway grade
(2) Proposed slope 2H:1V indicated in the GA

The factor of safety against global failure was 1.4. This factor of safety is considered to be acceptable for the proposed embankment bearing on cohesive soil.

If placement of new fill is required, the existing slope surfaces should be appropriately benched, as per OPSD 208.010, after stripping of vegetation, topsoil, organics, soft soils or otherwise unsuitable overburden materials.

## 12 EROSION PROTECTION

In general, earth fill embankment slopes must be provided with erosion protection in accordance with OPSS 804.

Erosion protection must be provided at the toe of any embankment slopes that are potentially in contact with the river flow. We understand that the existing creek banks are not to be disturbed during construction.

## 13 BACKFILL TO ABUTMENTS

Backfill to the abutment if required, must consist of granular material.

Backfill to the abutments should consist of Granular A or Granular B Type II material meeting the requirements of Special Provision 110S13. The backfill must be in accordance with OPSS 902, and placed to the extents shown in OPSD 3101.150.

All new embankment earth fill should be placed in uniform lifts and be compacted in accordance with OPSS 501. Also, compaction equipment to be used adjacent to retaining structures must be restricted in accordance OPSS 501.

## 14 EARTH PRESSURE

Earth pressures acting on the structure may be assumed to be triangular and to be governed by the characteristics of the abutment backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC but generally are given by the expression:

$$p_h = K^*(\gamma h + q)$$

Where:

$p_h$ = horizontal pressure on the wall at depth h (kPa)

K = earth pressure coefficient (see Table 14.1)

$\gamma$ = unit weight of retained soil (see Table 14.1)

h = depth below top of fill where pressure is computed (m)

q = value of any surcharge (kPa)

In accordance with Clause 6.9.3 of the CHBDC, a compaction surcharge should be added. The magnitude should be 12 kPa at the top of fill and decreasing to 0 kPa at a depth of 2.0 m for Granular B Type I or 1.7 m for Granular A or Granular B Type II.

Earth pressure coefficients for backfill to the abutment wall are dependent on the material used as backfill. Typical values are shown in Table 14.1. Earth pressure parameters for the native soil deposits for assessment and design of the sheet pile walls are also included in Table 14.1.

**Table 14.1 – Earth Pressure Coefficients (K) for Horizontal Ground Surface**

| Condition | Earth Pressure Coefficient (K) | | | | |
|---|---|---|---|---|---|
| | **OPSS Granular A or OPSS Granular B Type II** $\phi = 35°$ $\gamma = 22.8\ kN/m^3$ | **OPSS Granular B Type I** $\phi = 32°$ $\gamma = 21.2\ kN/m^3$ | **Existing Sand Fill** $\phi = 30°$ $\gamma = 21 kN/m^3$ | **Silty Clay** $\phi = 27°$ $\gamma = 18\ kN/m^3$ | **Native Sand and Silt** $\phi = 32°$ $\gamma = 21\ kN/m^3$ |
| Active (Unrestrained Wall) | 0.27 | 0.31 | 0.33 | 0.37 | 0.31 |
| At rest (Restrained Wall) | 0.43 | 0.47 | 0.5 | 0.55 | 0.47 |
| Passive (Movement Towards Soil Mass) | 3.7 | 3.3 | 3.0 | 2.7 | 3.3 |

Below the water level, use the buoyant unit weight = $\gamma' = \gamma - 9.8\ kN/m^3$

In conventional design, the use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) might be preferred as it results in lower earth pressures acting on the wall.

The factors in Table 14.1 are "ultimate" values and require certain movements for the respective conditions to be mobilized. The values to use in design can be estimated from Figure C6.9.1 (a) in the Commentary to the Canadian Highway Bridge Design Code.

## 15 ROADWAY PROTECTION

The bridge construction will be done in stages in order to keep at least one highway lane operational. Roadway protection will have to be implemented to facilitate staging of removals and support the existing Highway 587 adjacent to the excavation.

Roadway protection must be provided in accordance with OPSS 539 and designed for Performance Level 2. Continuous sheet pile walls or conventional steel soldier pile and timber lagging walls are possible options for roadway protection. Timber lagging boards should be installed as soon as the soil face is exposed and properly prepared.

The following parameters apply for design of the temporary shoring system.

| | | | |
|---|---|---|---|
| $\gamma$ | = | $20\ kN/m^3$ | (bulk unit weight) |
| $\gamma_w$ | = | $10\ kN/m^3$ | (submerged unit weight under groundwater table) |
| $K_a$ | = | 0.33 | (Active pressure coefficient for road embankment fill) |
| | = | 0.37 | (Active pressure coefficient for silty clay) |
| $K_p$ | = | 3.0 | (Passive pressure coefficient for road embankment fill) |
| | = | 2.7 | (Passive pressure coefficient for silty clay) |
| $h_w$ | = | 0 | (assuming that the groundwater is maintained below the base of the excavation and that there is no hydrostatic pressure build-up behind a presumably permeable wall, soldier pile and lagging) |
| $h_w$ | = | 202.2 | (elevation for hydrostatic pressure build-up behind sheet piles) |

The actual pressure distribution acting on the shoring system is a function of the construction sequence and the relative flexibility of the wall and these factors must be considered when designing the shoring system.

Temporary groundwater and surface water control measures will be required during construction.

The design of roadway protection should be the responsibility of the Contractor. All shoring systems should be designed by a Professional Engineer experienced in such designs, who will determine an appropriate support system.

## 16 SEISMIC CONSIDERATIONS

The following seismic parameters should be used for design:

- Velocity Related Seismic Zone 0
- Zonal Velocity Ratio 0.0
- Acceleration Related Seismic Zone 0
- Zonal Acceleration Ratio 0.0
- Peak Horizontal Acceleration 0.02

The soil profile type at this site has been classified as Type I. Therefore, according to Table 4.4.6.1 of the CHBDC, a Site Coefficient "S" (ground motion amplification factor) of 1.0 should be used in seismic design.

In accordance with Clause 4.6.4 of the CHBDC, retaining structures should be designed using active ($K_{AE}$) and passive ($K_{PE}$) earth pressure coefficients that incorporate the effects of earthquake loading. The coefficients of horizontal earth pressure for seismic loading presented in Table 16.1 may be used:

**Table 16.1 – Earth Pressure Coefficients for Earthquake Loading**

| Condition | Earth Pressure Coefficient (K) | | | | |
|---|---|---|---|---|---|
| | **OPSS Granular A or OPSS Granular B Type II** $\phi = 35°$ $\gamma = 22.8$ kN/m$^3$ | **OPSS Granular B Type I** $\phi = 32°$ $\gamma = 21.2$ kN/m$^3$ | **Existing Sand Fill** $\phi = 30°$ $\gamma = 21$kN/m$^3$ | **Silty Clay** $\phi = 27°$ $\gamma = 18$ kN/m$^3$ | **Native Sand and Silt** $\phi = 32°$ $\gamma = 21$ kN/m$^3$ |
| Active ($K_{AE}$)* | 0.28 | 0.32 | 0.34 | 0.38 | 0.32 |
| Passive ($K_{PE}$) | 3.7 | 3.2 | 2.9 | 2.6 | 3.2 |
| At Rest ($K_{OE}$)** | 0.45 | 0.50 | 0.52 | 0.57 | 0.49 |

* After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall.
** After Woods

The site overlies very soft to firm cohesive soils deposits and a high water table. A review of the subsurface conditions indicates the site is not susceptible for liquefaction under current conditions.

## 17 CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to:

- The potential exists for encountering occasional cobbles in the embankment fill during sheet pile and H-pile installation.
- An artesian condition was encountered at this site. If artesian groundwater flow is observed adjacent to the piles, the contractor or QVE must immediately advise the CA. The CA should refer this issue to the design team.
- Evidence of occasional cobbles and boulders was noted during drilling immediately above the bedrock. It is possible that a pile will achieve refusal at a higher elevation than anticipated due to encountering a boulder. If it is suspected that this is happening, the QVE must immediately bring it to the attention of the CA. If the CA cannot resolve the issue, it must be referred to the design team for resolution.
- It is anticipated that removal of the existing abutment pile caps will not require excavation blow the creek water level. However if required, excavation below the water level will involve lowering of the groundwater level below the excavation base to maintain a reasonably dry excavation.
- Roadway protection must be provided to maintain traffic during construction. Temporary shoring systems should be properly designed by a Professional Engineer experienced in such designs.

The successful performance of the bridge will depend largely upon good workmanship and quality control during construction. Pile driving supervision should be carried out by qualified geotechnical personnel during construction to confirm that foundation recommendations are correctly implemented and material specifications are met.

## 18 CLOSURE

Engineering analysis and preparation of the foundation design report were carried out by Ms. R. Palomeque Reyna and Mr. Murray Anderson, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

**Thurber Engineering Ltd.**

Murray R. Anderson, P.Eng., M.Eng.
Senior Foundations Engineer


P.K. Chatterji, P.Eng., Ph.D.
Review Principal

# Appendix A

## 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[1] '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 $W_L < 50\%$ | 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. ($W_L < 30\%$). |
| | | CI | Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$). |
| | | OL | Organic silts and organic silty-clays of low plasticity. |
| | SILTS AND CLAYS $W_L > 50\%$ | 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

## ROCK WEATHERING CLASSIFICATION

| | |
|---|---|
| **Fresh (FR)** | No visible signs of weathering. |
| **Fresh Jointed (FJ)** | Weathering limited to the surface of major discontinuities. |
| **Slightly Weathered (SW)** | Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material. |
| **Moderately Weathered (MW)** | Weathering extends throughout the rock mass, but the rock material is not friable. |
| **Highly Weathered (HW)** | Weathering extends throughout the rock mass and the rock is partly friable. |
| **Completely Weathered (CW)** | Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved. |

## SYMBOLS

CLAYSTONE

SILTSTONE

SANDSTONE

COAL

Bedrock (general)

## DISCONTINUITY SPACING

| **Bedding** | **Bedding Plane Spacing** |
|---|---|
| Very thickly bedded | Greater than 2m |
| Thickly bedded | 0.6 to 2m |
| Medium bedded | 0.2 to 0.6m |
| Thinly bedded | 60mm to 0.2m |
| Very thinly bedded | 20 to 60mm |
| Laminated | 6 to 20mm |
| Thinly Laminated | Less than 6mm |

## TERMS

| | |
|---|---|
| Total Core Recovery: (TCR) | Core recovered as a percentage of total core run length. |
| Solid Core Recovery: (SCR) | Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run. |
| 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. |
| Uniaxial Compressive Strength (UCS) | Axial stress required to break the specimen |
| Fracture Index: (FI) | Frequency of natural fractures per 0.3m of core run. |

## STRENGTH CLASSIFICATION

| **Rock Strength** | **Approximate Uniaxial Compressive Strength** | | **Field Estimation of Hardness*** |
|---|---|---|---|
| | **(MPa)** | **(psi)** | |
| Extremely Strong | Greater than 250 | Greater than 36,000 | Specimen can only be chipped with a geological hammer |
| Very Strong | 100-250 | 15,000 to 36,000 | Requires many blows of geological hammer to break |
| Strong | 50-100 | 7,500 to 15,000 | Requires more than one blow of geological hammer to break |
| Medium Strong | 25.0 to 50.0 | 3,500 to 7,500 | Breaks under single blow of geological hammer. |
| Weak | 5.0 to 25.0 | 750 to 3,500 | Can be peeled by a pocket knife with difficulty |
| Very Weak | 1.0 to 5.0 | 150 to 750 | Can be peeled by a pocket knife, crumbles under firm blows of geological pick. |
| Extremely Weak (Rock) | 0.25 to 1.0 | 35 to 150 | Indented by thumbnail |

THURBER

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# RECORD OF BOREHOLE No BC-1



METRIC

| | | | |
|---|---|---|---|
| W.P. 465-00-00 | LOCATION Blend Creek Bridge N 5 384 405.7 E 395 972.6 | ORIGINATED BY GA |
| HWY 17 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY AN |
| DATUM Geodetic | DATE 2011.07.19 - 2011.07.19 | CHECKED BY MRA |

## SOIL PROFILE

| ELEV / DEPTH | DESCRIPTION |
|---|---|
| 204.1 | |
| 0.0 | **ASPHALT:** (50mm) |
| | **SAND** and **GRAVEL**, some clay, some silt<br>Compact<br>Reddish Brown<br>(FILL) |
| 202.8 / 1.3 | Silty **CLAY**, occasional sand seams<br>Stiff to Soft<br>Grey |
| 195.3 / 8.8 | **SILT**, trace sand, trace clay<br>Compact<br>Reddish Brown/Grey<br>Wet |

## SAMPLES

| NUMBER | TYPE | "N" VALUES | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|
| 1 | SS | 28 | |
| 2 | SS | 17 | 46 42 12 (SI+CL) |
| 3 | SS | 9 | |
| 4 | SS | 7 | |
| 5 | SS | 4 | 0 0 21 79 |
| 6 | SS | 4 | |
| 7 | SS | 2 | 0 0 16 84 |
| 8 | SS | 6 | |
| 9 | SS | 13 | |

GROUND WATER CONDITIONS: water level symbol shown at approx. elev. 201.6 (sample 4).

ELEVATION SCALE: 204, 203, 202, 201, 200, 199, 198, 197, 196, 195

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE — 20 40 60 80 100

Field vane: + (3.5) at approx. elev. 200.0; + (3) at approx. elev. 197.0

PLASTIC LIMIT $w_P$ — NATURAL MOISTURE CONTENT $w$ — LIQUID LIMIT $w_L$

WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m³

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 1197.GPJ 1/25/12

# RECORD OF BOREHOLE No BC-1



METRIC

W.P. 465-00-00 LOCATION Blend Creek Bridge N 5 384 405.7 E 395 972.6 ORIGINATED BY GA

HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2011.07.19 - 2011.07.19 CHECKED BY MRA

| ELEV DEPTH | SOIL PROFILE: DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa | WATER CONTENT (%) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Continued From Previous Page | | | | | | | | | | |
| | **SILT**, trace sand, trace clay<br>Compact<br>Reddish Brown/Grey<br>Wet | | | | | | 194 | | | | |
| | | | 10 | SS | 10 | | | | ○ | | 0 4 89 7 |
| | | | | | | | 193 | | | | |
| | | | | | | | 192 | | | | |
| | Sandy | | 11 | SS | 17 | | | | ○ | | |
| | | | | | | | 191 | | | | |
| 190.7<br>13.4 | END OF BOREHOLE AT 13.4m UPON AUGER REFUSAL ON PROBABLE BEDROCK.<br>BOREHOLE OPEN TO 13.4m AND WATER LEVEL AT 2.7m.<br>BOREHOLE BACKFILLED WITH HOLEPLUG FROM 13.4m TO 0.3m, CONCRETE FROM 0.3m TO 0.1m, THEN ASPHALT COLD PATCH TO SURFACE. | | | | | | | | | | |

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE, 20 40 60 80 100; PLASTIC LIMIT $w_P$, NATURAL MOISTURE CONTENT $w$, LIQUID LIMIT $w_L$; WATER CONTENT (%) 20 40 60

$+^3, \times^3$: Numbers refer to Sensitivity    20 / 15-5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

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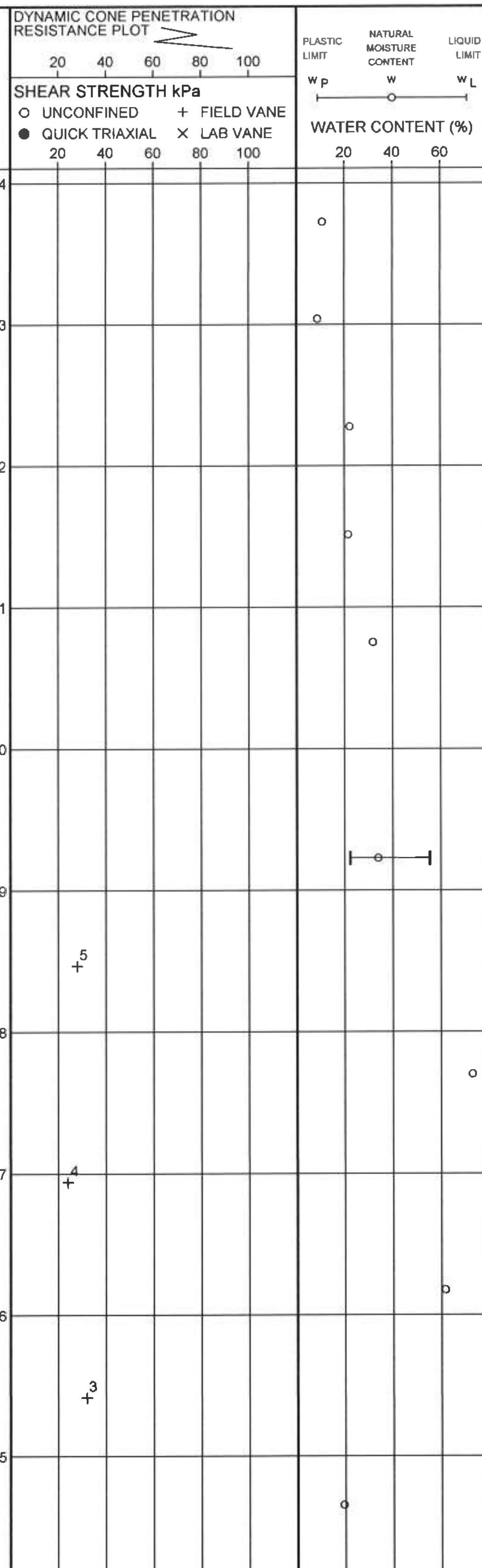
# RECORD OF BOREHOLE No BC-2



**METRIC**

| | | | |
|---|---|---|---|
| W.P. 465-00-00 | LOCATION Blend Creek Bridge N 5 384 406.4 E 395 980.6 | | ORIGINATED BY GA |
| HWY 17 | BOREHOLE TYPE Hollow Stem Augers | | COMPILED BY AN |
| DATUM Geodetic | DATE 2011.07.19 - 2011.07.19 | | CHECKED BY MRA |

| ELEV / DEPTH | DESCRIPTION | NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|
| 204.1 / 0.0 | **ASPHALT:** (50mm) | | | | ▽ | |
| | **SAND and GRAVEL** Dense to Compact Reddish Brown Dry (FILL) | 1 | SS | 36 | | |
| | | 2 | SS | 16 | | |
| 202.5 / 1.5 | Sandy **SILT**, some clay to clayey, trace gravel Very Loose Grey Wet | 3 | SS | 15 | | |
| | | 4 | SS | 2 | | 1 32 44 23 |
| | | 5 | SS | 2 | | |
| 199.5 / 4.6 | Silty **CLAY**, trace sand, occassional roots, shells, and wood fibres Very Soft to Firm Grey Wet | 6 | SS | 2 | | 0 7 26 67 |
| | | 7 | SS | 1 | | |
| | | 8 | SS | 4 | | |
| 195.2 / 8.8 | **SILT**, trace sand to sandy, trace clay Loose to Compact Reddish Brown/Grey Wet | 9 | SS | 8 | | |




Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No BC-2



**METRIC**

| | | | |
|---|---|---|---|
| W.P. 465-00-00 | LOCATION Blend Creek Bridge N 5 384 406.4 E 395 980.6 | ORIGINATED BY GA |
| HWY 17 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY AN |
| DATUM Geodetic | DATE 2011.07.19 - 2011.07.19 | CHECKED BY MRA |

Column headings: SOIL PROFILE (ELEV/DEPTH; DESCRIPTION; STRAT PLOT); SAMPLES (NUMBER; TYPE; "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT $w_P$, NATURAL MOISTURE CONTENT $w$, LIQUID LIMIT $w_L$, WATER CONTENT (%) (20 40 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)

Continued From Previous Page

| ELEV / DEPTH | DESCRIPTION | NUMBER | TYPE | "N" VALUES | ELEVATION SCALE | GR | SA | SI | CL |
|---|---|---|---|---|---|---|---|---|---|
| | **SILT**, trace sand to sandy, trace clay<br>Loose to Compact<br>Grey<br>Wet | | | | 194 | | | | |
| | | 10 | SS | 7 | 193 | 0 | 3 | 90 | 7 |
| | | 11 | SS | 11 | 192 | | | | |
| 190.8 / 13.3 | **SAND**, fine, trace to some gravel, trace silt<br>Loose to Compact<br>Grey<br>Wet | | | | 191 | | | | |
| | | 12 | SS | 10 | 190 | | | | |
| 189.4 / 14.6 | END OF BOREHOLE AT 14.6m UPON AUGER REFUSAL. BOREHOLE OPEN TO 14.6m AND WATER LEVEL AT 0.2m. BOREHOLE BACKFILLED WITH HOLEPLUG FROM 14.6m TO 0.3m, CONCRETE FROM 0.3m TO 0.1m, THEN ASPHALT COLD PATCH TO SURFACE. | | | | | | | | |



$+^3, \times^3$: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No BC-3



METRIC

| | | | | | |
|---|---|---|---|---|---|
| W.P. | 465-00-00 | LOCATION | Blend Creek Bridge N 5 384 402.9 E 395 978.3 | ORIGINATED BY | GA |
| HWY | 17 | BOREHOLE TYPE | Hollow Stem Augers/NQ Coring | COMPILED BY | AN |
| DATUM | Geodetic | DATE | 2011.07.18 - 2011.07.18 | CHECKED BY | MRA |

| ELEV / DEPTH | DESCRIPTION | SAMPLE NUMBER | TYPE | "N" VALUES | ELEVATION SCALE | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|
| 204.0 / 0.0 | **ASPHALT:** (50mm) | | | | 204 | * 0.9m above ground surface |
| | **SAND and GRAVEL** Dense to Compact, Reddish Brown, Dry (FILL) | 1 | SS | 31 | | |
| | | 2 | SS | 20 | 203 | |
| 202.5 / 1.5 | **SAND and SILT**, clayey, trace gravel. Loose to Very Loose, Reddish Brown to Grey, Wet (FILL) | 3 | SS | 10 | | 7 32 34 27 |
| | | 4 | SS | 3 | 202 | |
| 201.0 / 3.0 | **PEAT** Soft, Dark Brown, Wet | 5 | SS | 3 | 201 | |
| 199.9 / 4.1 | Silty **CLAY**, occasional sand seams. Soft to Firm, Grey, Wet | | | | 200 | |
| | | 6 | SS | 2 | 199 | 0 1 39 60 |
| | | 7 | SS | 2 | 198, 197 | |
| | | 8 | SS | 2 | 196 | |
| 195.0 / 9.0 | **SILT**, trace sand to sandy, trace clay. Loose to Compact, Reddish Brown, Wet | 9 | SS | 7 | 195 | |

Field vane shear strength values plotted with sensitivity: 3.5 (at approx. elev. 198.1), 4 (at approx. elev. 196.9).

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100
PLASTIC LIMIT $w_P$ — NATURAL MOISTURE CONTENT $w$ — LIQUID LIMIT $w_L$
WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ kN/m³

Continued Next Page

+³, ×³: Numbers refer to Sensitivity    20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 1197.GPJ 1/25/12

# RECORD OF BOREHOLE No BC-3



**METRIC**

| | | | |
|---|---|---|---|
| W.P. 465-00-00 | LOCATION Blend Creek Bridge N 5 384 402.9 E 395 978.3 | ORIGINATED BY GA | |
| HWY 17 | BOREHOLE TYPE Hollow Stem Augers/NQ Coring | COMPILED BY AN | |
| DATUM Geodetic | DATE 2011.07.18 - 2011.07.18 | CHECKED BY MRA | |

Continued From Previous Page

| ELEV DEPTH | DESCRIPTION | NUMBER | TYPE | "N" VALUES | ELEVATION SCALE | WATER CONTENT (%) (w) | UNIT WEIGHT / FI | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|
| | **SILT**, trace sand to sandy, trace clay<br>Loose to Compact<br>Reddish Brown<br>Wet | | | | 194 | | | |
| | | 10 | SS | 13 | 193 | ~19 | | |
| | | | | | 192 | | | |
| | | 11 | SS | 6 | | ~20 | | 0 39 58 3 |
| 190.7 | | | | | 191 | | | |
| 13.3 | **SAND**, some gravel, trace silt<br>Compact<br>Grey<br>Wet | | | | | | | |
| | | 12 | SS | 18 | 190 | ~22 | | |
| | Cored through 200mm boulder | | | | | | | |
| 189.1 | | | | | | | FI | |
| 14.9 | **BEDROCK**, fresh, layered, weak to strong, dark grey, black slate/schist, occasional quartz seams | | | | 189 | | 0 | RUN #1<br>TCR=100%<br>SCR=100%<br>RQD=100%<br>UCS=70MPa<br>(Average) |
| | | | | | | | 0 | |
| | | 1 | RUN | | | | 1 | |
| | Sub-horizontal joints at 15.9m, 16.0m and 17.2m | | | | 188 | | 3 | |
| | | | | | | | 0 | |
| | | | | | | | 0 | RUN #2<br>TCR=100%<br>SCR=100%<br>RQD=95%<br>UCS=54MPa<br>(Average) |
| | | | | | 187 | | 0 | |
| | | 2 | RUN | | | | 2 | |
| | | | | | | | 0 | |
| 186.0 | | | | | | | 0 | |
| 18.0 | END OF BOREHOLE AT 18.0m.<br>BOREHOLE OPEN TO 18.0m AND ARTESIAN PRESSURE AT 0.9m ABOVE GROUND SURFACE.<br>BOREHOLE BACKFILLED WITH HOLEPLUG FROM 18.0m TO 0.3m, CONCRETE FROM 0.3m TO 0.1m, THEN ASPHALT COLD PATCH TO SURFACE. | | | | | | | |

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE, 20 40 60 80 100; PLASTIC LIMIT $w_P$, NATURAL MOISTURE CONTENT w, LIQUID LIMIT $w_L$, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL.

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 ◆ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

# RECORD OF BOREHOLE No BC-4



**METRIC**

W.P. 465-00-00 | LOCATION Blend Creek Bridge N 5 384 395.6 E 396 001.1 | ORIGINATED BY ES

HWY 17 | BOREHOLE TYPE Hollow Stem Augers/Casing | COMPILED BY AN

DATUM Geodetic | DATE 2011.07.26 - 2011.07.28 | CHECKED BY RPR

| ELEV / DEPTH | DESCRIPTION | NUMBER | TYPE | "N" VALUES | ELEVATION SCALE | REMARKS (GR SA SI CL) |
|---|---|---|---|---|---|---|
| 204.1 | | | | | | * 0.6m above ground surface |
| 0.0 | **ASPHALT:** (90mm) | | | | 204 | |
| 0.1 | **SAND** and **GRAVEL**, Compact, Reddish Brown, Damp (FILL) | 1 | GS | | | |
| | Occasional cobbles | 1 | SS | 17 | 203 | |
| | | 2 | SS | 12 | | |
| 202.0 / 2.1 | Silty **CLAY**, some sand, Stiff, Reddish Brown (FILL) | | | | 202 | |
| 201.7 / 2.3 | **SAND** and **SILT**, some clay, Very Loose, Reddish Brown, Wet (FILL) | 3 | SS | 3 | | |
| 201.3 / 2.7 | **PEAT**, some sand, Soft, Dark Brown | | | | | |
| 201.2 / 2.8 | Silty **CLAY**, some sand, Very Soft to Firm, Grey | 4 | SS | 2 | 201 | 0 20 29 51 |
| | | | | | 200 | |
| | | 5 | SS | 0 | 199 | |
| | | | | | 198 | |
| | | 6 | SS | 0 | 197 | |
| | | 7 | SS | 1 | 196 | |
| | | | | | 195 | |
| | | 8 | SS | 0 | | 0 0 24 76 |
| 194.2 | | | | | | |

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT $w_P$, NATURAL MOISTURE CONTENT $w$, LIQUID LIMIT $w_L$; WATER CONTENT (%) (20 40 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Shear strength plot values: +5 (approx. 198.5), + (approx. 197.0), +3 (approx. 195.4)

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No BC-4



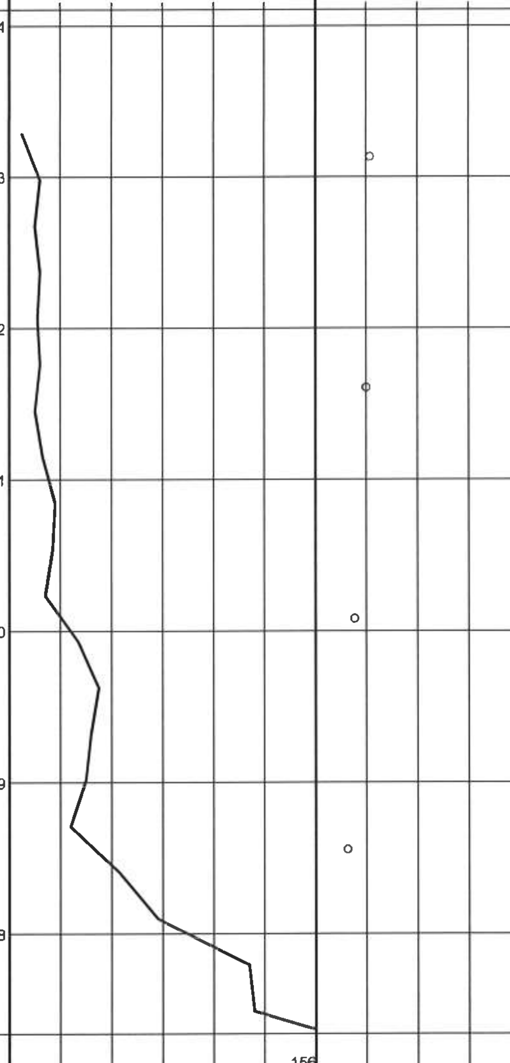
**METRIC**

| | | | |
|---|---|---|---|
| W.P. 465-00-00 | LOCATION Blend Creek Bridge N 5 384 395.6 E 396 001.1 | | ORIGINATED BY ES |
| HWY 17 | BOREHOLE TYPE Hollow Stem Augers/Casing | | COMPILED BY AN |
| DATUM Geodetic | DATE 2011.07.26 - 2011.07.28 | | CHECKED BY RPR |

SOIL PROFILE | SAMPLES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100) | SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE (20, 40, 60, 80, 100) | PLASTIC LIMIT $w_P$, NATURAL MOISTURE CONTENT w, LIQUID LIMIT $w_L$ — WATER CONTENT (%) (20, 40, 60) | UNIT WEIGHT γ kN/m3 | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued From Previous Page

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | GR | SA | SI | CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9.9 | **SILT**, trace sand<br>Loose to Compact<br>Reddish Brown<br>Wet | | | | | | 194 | | | | |
| | | | 9 | SS | 12 | | 193 | | | | |
| | | | | | | | 192 | | | | |
| | | | 10 | SS | 7 | | | 0 | 6 | 89 | 5 |
| 190.8 / 13.3 | **SAND**, trace gravel, trace silt<br>Loose to Very Loose<br>Reddish Brown<br>Wet | | | | | | 191 | | | | |
| | | | 11 | SS | 8 | | 190 | | | | |
| | | | | | | | 189 | | | | |
| | | | 12 | SS | 1 | | | | | | |
| | Cobbles and boulders (cored) | | | | | | 188 | | | | |
| 187.3 / 16.8 | END OF BOREHOLE AT 16.8m.<br>WATER AT 0.6m ABOVE GROUND SURFACE UPON COMPLETION.<br>BOREHOLE BACKFILLED WITH PORTLAND CEMENT TO 6.7m, HOLEPLUG TO 3.9m, PORTLAND CEMENT TO 0.1m, THEN ASPHALT TO SURFACE. | | | | | | | | | | |




+ 3, × 3 : Numbers refer to Sensitivity

15 ⊕ 5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

# RECORD OF BOREHOLE No BC-5



**METRIC**

W.P. 465-00-00 | LOCATION Blend Creek Bridge N 5 384 390.2 E 396 000.8 | ORIGINATED BY GA

HWY 17 | BOREHOLE TYPE Hollow Stem Augers/NQ Coring | COMPILED BY AN

DATUM Geodetic | DATE 2011.07.21 - 2011.07.21 | CHECKED BY MRA

| ELEV / DEPTH | DESCRIPTION | NUMBER | TYPE | "N" VALUES | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|
| 203.9 | | | | | * 0.6m above ground surface |
| 0.0 | **ASPHALT:** (40mm) | | | | |
| | **SAND** and **GRAVEL**, trace clay, Dense to Compact, Reddish Brown (FILL) | 1 | SS | 38 | |
| | | 2 | SS | 22 | |
| 202.3 / 1.6 | Silty **CLAY**, sandy, Firm, Grey (FILL) | 3 | SS | 7 | |
| 201.5 / 2.4 | **PEAT**, occasional rootlets and wood fibres, Loose, Dark Brown, Wet | 4 | SS | 7 | |
| 200.9 / 3.0 | Silty **CLAY**, trace sand, Soft to Very Soft, Grey | 5 | SS | 4 | 0 1 23 76 |
| | | 6 | SS | 2 | |
| | | 7 | SS | 2 | |
| | Sand seams | 8 | SS | 2 | 0 1 40 59 |
| 195.1 / 8.8 | **SILT**, trace sand to sandy, Compact, Reddish Brown, Wet | 9 | SS | 13 | |

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT $w_P$, NATURAL MOISTURE CONTENT $w$, LIQUID LIMIT $w_L$; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³.

Elevation scale: 203, 202, 201, 200, 199, 198, 197, 196, 195, 194

Field vane sensitivity values: 3 (approx. elev. 198.4), 3 (approx. elev. 196.9)

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No BC-5



**METRIC**

| | | | | | |
|---|---|---|---|---|---|
| W.P. | 465-00-00 | LOCATION | Blend Creek Bridge N 5 384 390.2 E 396 000.8 | ORIGINATED BY | GA |
| HWY | 17 | BOREHOLE TYPE | Hollow Stem Augers/NQ Coring | COMPILED BY | AN |
| DATUM | Geodetic | DATE | 2011.07.21 - 2011.07.21 | CHECKED BY | MRA |

Continued From Previous Page

| ELEV / DEPTH | DESCRIPTION | SAMPLE NUMBER | TYPE | "N" VALUES | ELEVATION SCALE | WATER CONTENT (%) | UNIT WEIGHT / FI | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|
| | **SILT**, trace sand to sandy<br>Compact<br>Reddish Brown<br>Wet | | | | | | | |
| | | 10 | SS | 12 | 193 | o | | |
| | | | | | 192 | | | |
| | | 11 | SS | 10 | | o | | |
| | | | | | 191 | | | |
| 190.6 / 13.3 | **SAND**, fine, trace gravel, trace silt<br>Dense to Very Dense<br>Reddish Brown<br>Wet | | | | | | | |
| | | 12 | SS | 30 | 190 | o | | 0 96 4 (SI+CL) |
| | | | | | 189 | | | |
| | | 13 | S | 74 | | o | | |
| | Occasional cobbles and boulders | | | | 188 | | | |
| | | 14 | SS | 50/0.150 | 187 | | | |
| | Cored 300mm boulder | | | | | | | |
| | | | | | 186 | | FI | |
| 185.6 / 18.3 | **BEDROCK**, fresh, weak to strong, dark grey, schist, occasional mechanical breaks<br><br>Highly broken zone from 18.8m to 19.1m<br><br>Sub-vertical joint at 18.2m, 18.4m and 18.6m | 1 | RUN | | 185 | | 4<br>>10<br>>20<br>0<br>0 | RUN #1<br>TCR=100%<br>SCR=78%<br>RQD=62%<br>UCS=140MPa<br>(Average)<br><br>RUN #2 |
| | | | | | 184 | | | |

Continued Next Page

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE (20 40 60 80 100); PLASTIC LIMIT $w_P$, NATURAL MOISTURE CONTENT w, LIQUID LIMIT $w_L$; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m3; GROUND WATER CONDITIONS; STRAT PLOT.

$+^3, \times^3$: Numbers refer to Sensitivity    20 / 15 ⌖ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No BC-5



**METRIC**

| | | | | | |
|---|---|---|---|---|---|
| W.P. | 465-00-00 | LOCATION | Blend Creek Bridge N 5 384 390.2 E 396 000.8 | ORIGINATED BY | GA |
| HWY | 17 | BOREHOLE TYPE | Hollow Stem Augers/NQ Coring | COMPILED BY | AN |
| DATUM | Geodetic | DATE | 2011.07.21 - 2011.07.21 | CHECKED BY | MRA |

| ELEV / DEPTH | DESCRIPTION (Continued From Previous Page) | STRAT PLOT | NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa | WATER CONTENT (%) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **BEDROCK**, fresh, strong, dark grey, schist, occasional mechanical breaks | | 2 | RUN | | | | | | 0<br>0<br>0 | TCR=75%<br>SCR=75%<br>RQD=75%<br>UCS=123MPa<br>(Average) |
| | Horizontal joints at 19.9m and 20.4m | | | | | | 183 | | | 0 | |
| 182.6 | | | | | | | | | | 0 | |
| 21.3 | END OF BOREHOLE AT 21.3m. WATER AT 0.6m ABOVE GROUND SURFACE UPON COMPLETION. BOREHOLE BACKFILLED WITH HOLEPLUG FROM 21.3m TO 0.3m, PELTONITE FROM 0.3m TO 0.2m, CONCRETE FROM 0.2m TO 0.1m THEN ASPHALT COLD PATCH TO SURFACE. | | | | | | | | | | |

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100. PLASTIC LIMIT $w_P$, NATURAL MOISTURE CONTENT $w$, LIQUID LIMIT $w_L$; WATER CONTENT (%) 20 40 60.

$+^3, \times^3$: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

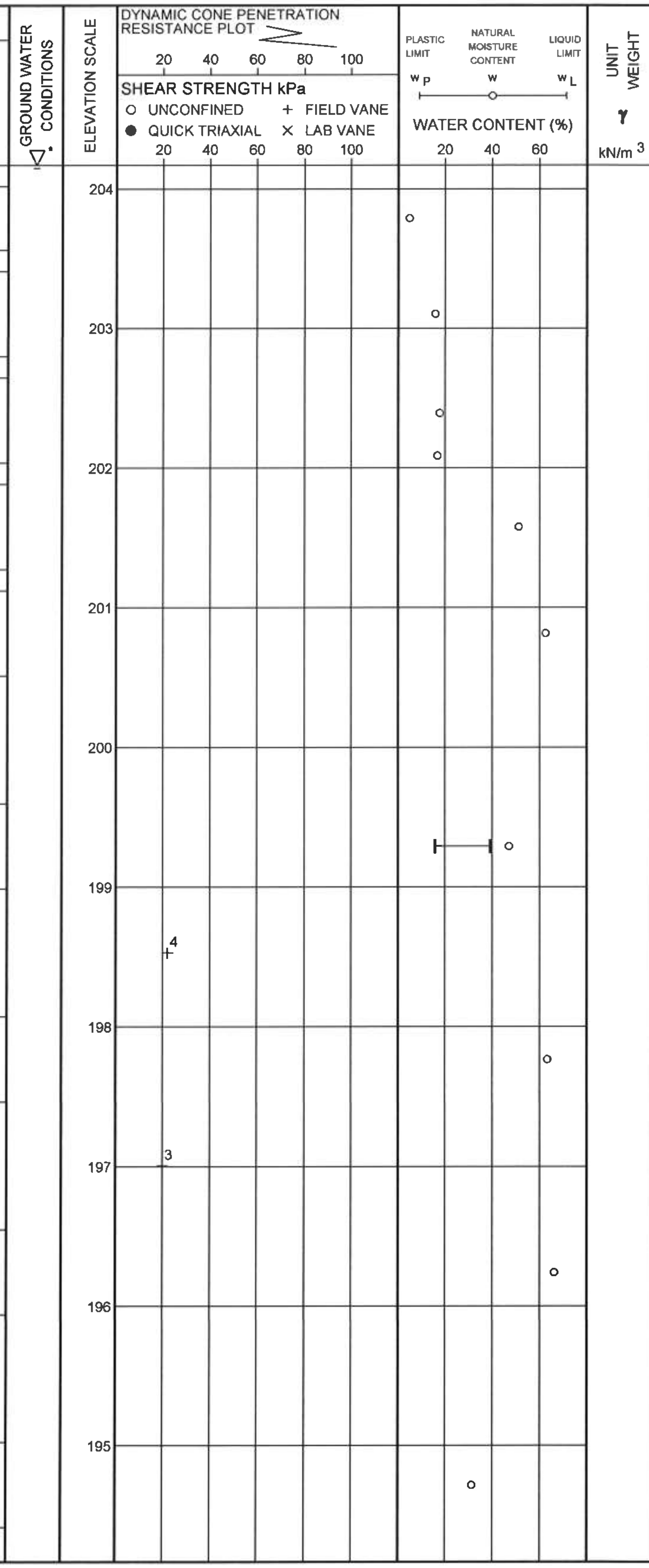
# RECORD OF BOREHOLE No BC-6



**METRIC**

| | | | | | |
|---|---|---|---|---|---|
| W.P. | 465-00-00 | LOCATION | Blend Creek Bridge N 5 384 394.3 E 396 007.8 | ORIGINATED BY | ES |
| HWY | 17 | BOREHOLE TYPE | Hollow Stem Augers/Casing | COMPILED BY | AN |
| DATUM | Geodetic | DATE | 2011.07.25 - 2011.07.25 | CHECKED BY | RPR |

| ELEV / DEPTH | SOIL PROFILE – DESCRIPTION | SAMPLE NUMBER | TYPE | "N" VALUES | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|
| 204.1 / 0.0 | **ASPHALT:** (50mm) | | | | * 0.1m above ground surface |
| | **SAND** and **GRAVEL**<br>Compact to Loose<br>Reddish Brown<br>Damp<br>(FILL) | 1 | GS | | |
| | Occasional cobbles | 1 | SS | 12 | |
| | | 2 | SS | 4 | |
| 202.1 / 2.0 | Silty **CLAY**, sandy<br>Soft to Very Soft<br>Brown | 3 | SS | 4 | |
| | Grey<br>Occasional sand seams | 4 | SS | 2 | |
| | | 5 | SS | 1 | 0 31 25 44 |
| | | 6 | SS | 0 | |
| | | 7 | SS | 0 | |
| 195.4 / 8.7 | **SILT**, some clay, trace sand to sandy<br>Loose to Compact<br>Reddish Brown<br>Wet | 8 | SS | 8 | 0 9 78 13 |




Continued Next Page

+³, ×³: Numbers refer to Sensitivity

20 / 15 / 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

# RECORD OF BOREHOLE No BC-6



METRIC

| | | | | | |
|---|---|---|---|---|---|
| W.P. | 465-00-00 | LOCATION | Blend Creek Bridge N 5 384 394.3 E 396 007.8 | ORIGINATED BY | ES |
| HWY | 17 | BOREHOLE TYPE | Hollow Stem Augers/Casing | COMPILED BY | AN |
| DATUM | Geodetic | DATE | 2011.07.25 - 2011.07.25 | CHECKED BY | RPR |

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa | WATER CONTENT (%) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Continued From Previous Page | | | | | | | | | | |
| | **SILT**, some clay, trace sand to sandy<br>Loose to Compact<br>Reddish Brown<br>Wet | | | | | | 194 | | | | |
| | | | 9 | SS | 15 | | | | w ≈ 20 | | |
| 192.8<br>11.3 | END OF BOREHOLE AT 11.3m.<br>WATER AT 0.1m ABOVE GROUND SURFACE.<br>BOREHOLE BACKFILLED WITH PELTONITE TO 10.0m, PORTLAND CEMENT TO 7.0m, BENTONITE TO 0.1m, SAND AND GRAVEL TO 0.04m, THEN ASPHALT TO SURFACE. | | | | | | 193 | | | | |

Legend: SHEAR STRENGTH kPa — O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE. Scales 20 40 60 80 100. Water content: PLASTIC LIMIT $w_P$, NATURAL MOISTURE CONTENT $w$, LIQUID LIMIT $w_L$; scale 20 40 60.

$+^3, \times^3$: Numbers refer to Sensitivity

20 / 15 ◆ 5 / 10 (%) STRAIN AT FAILURE

# Appendix B

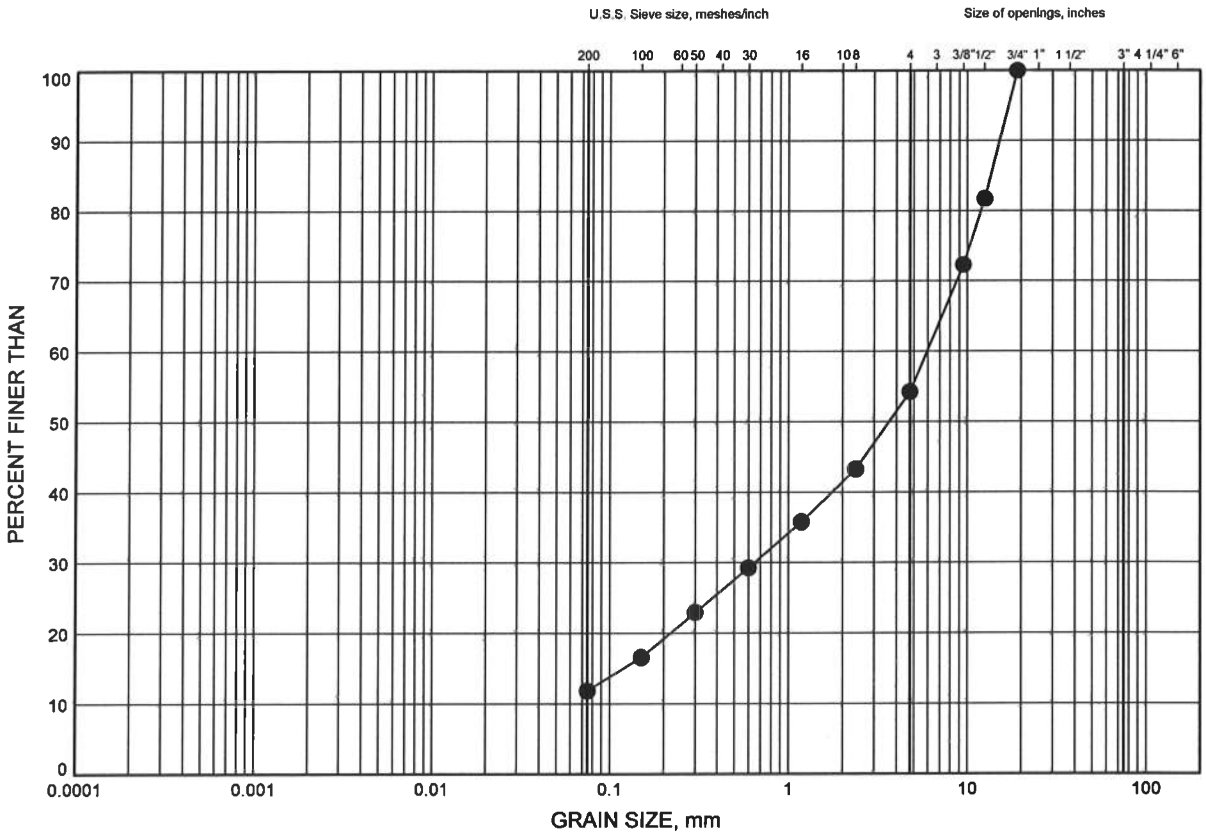
# Laboratory Test Results

NWR 32 Rehabs

# GRAIN SIZE DISTRIBUTION

FIGURE B1

## SAND & GRAVEL FILL




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

## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | BC-1 | 1.07 | 203.04 |

W.P.# 478-00-00

Prepared By AN

Checked By RPR

THURBER

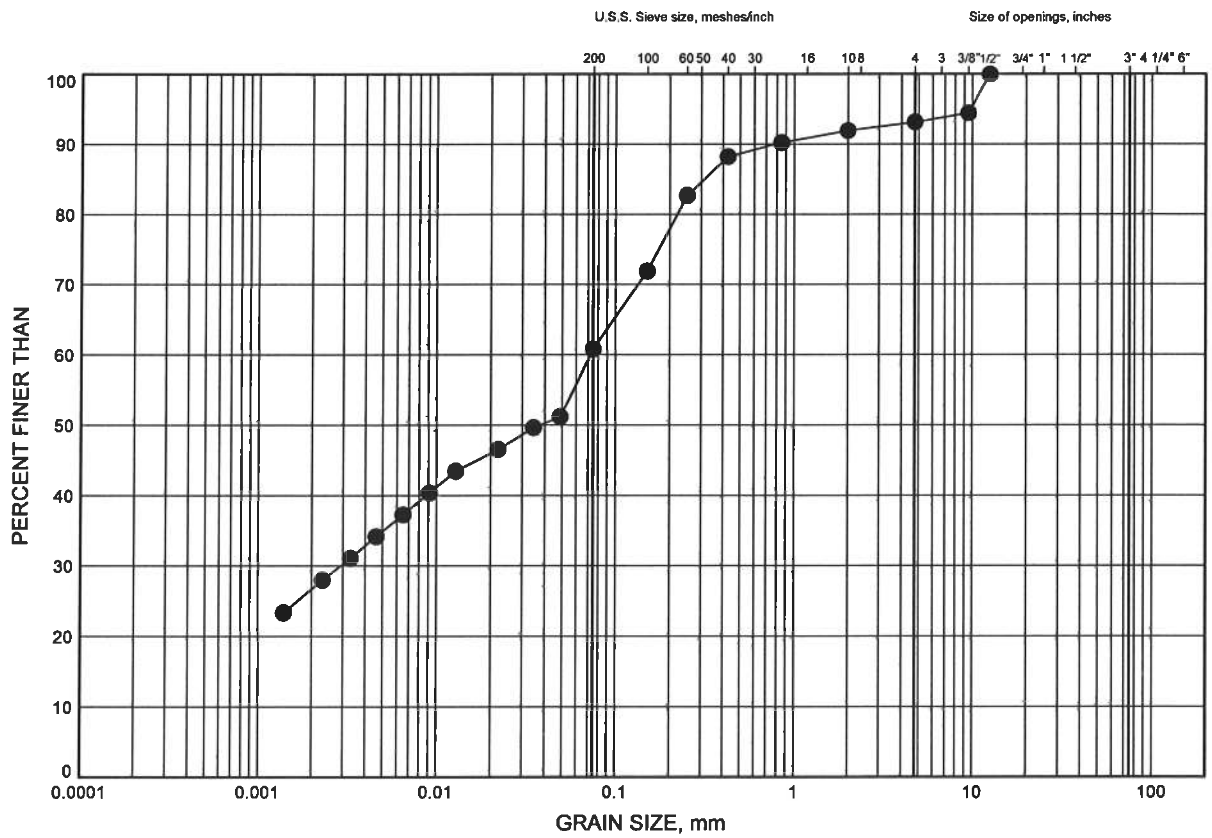
GRAIN SIZE DISTRIBUTION - THURBER 1197.GPJ 8/9/11

NWR 32 Rehabs

# GRAIN SIZE DISTRIBUTION

FIGURE B2

## SAND & SILT FILL




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

## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | BC-3 | 1.83 | 202.18 |

THURBER

W.P.# 478-00-00

Prepared By AN

Checked By RPR

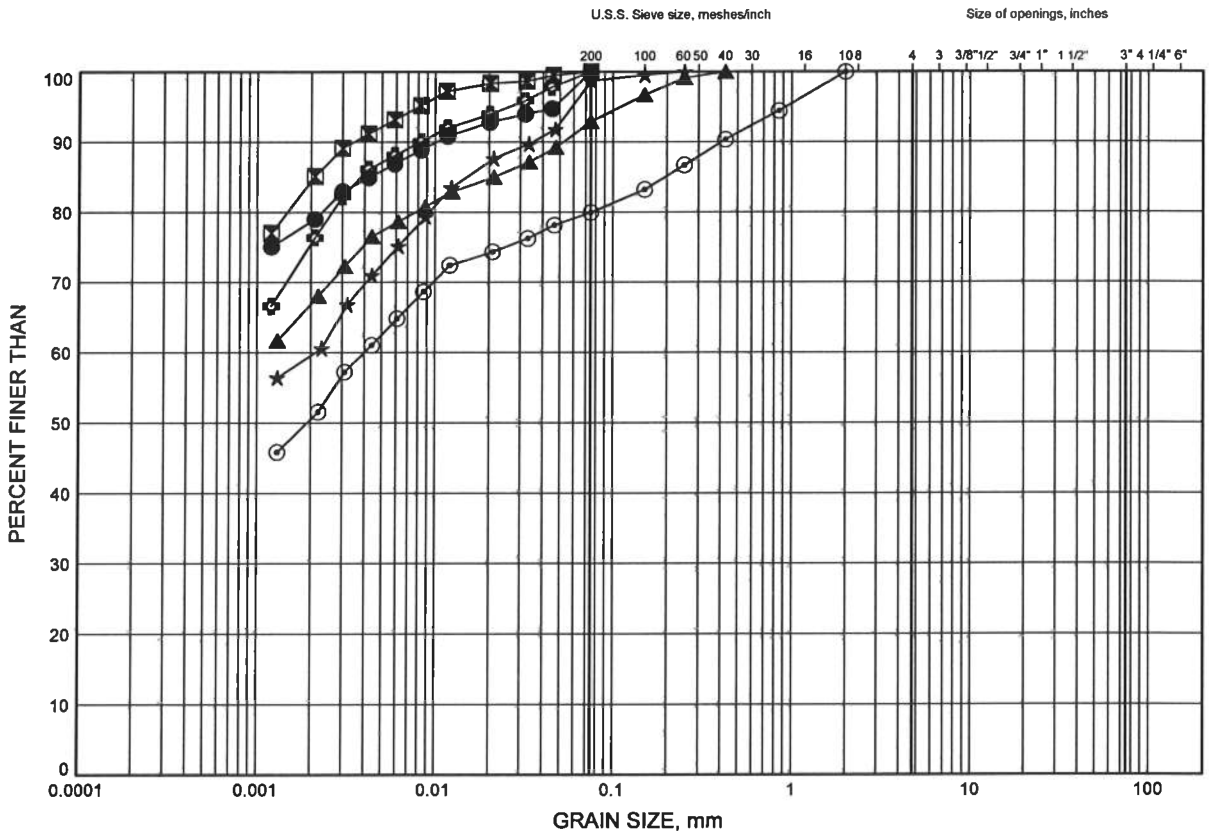
GRAIN SIZE DISTRIBUTION - THURBER 1197.GPJ 8/9/11

NWR 32 Rehabs

# GRAIN SIZE DISTRIBUTION

FIGURE B3

## SILTY CLAY




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

## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | BC-1 | 3.35 | 200.75 |
| ⊠ | BC-1 | 6.40 | 197.70 |
| ▲ | BC-2 | 4.88 | 199.18 |
| ★ | BC-3 | 4.88 | 199.14 |
| ⊙ | BC-4 | 3.35 | 200.70 |
| ✪ | BC-4 | 9.45 | 194.61 |

W.P.# 478-00-00

Prepared By AN

Checked By RPR

THURBER

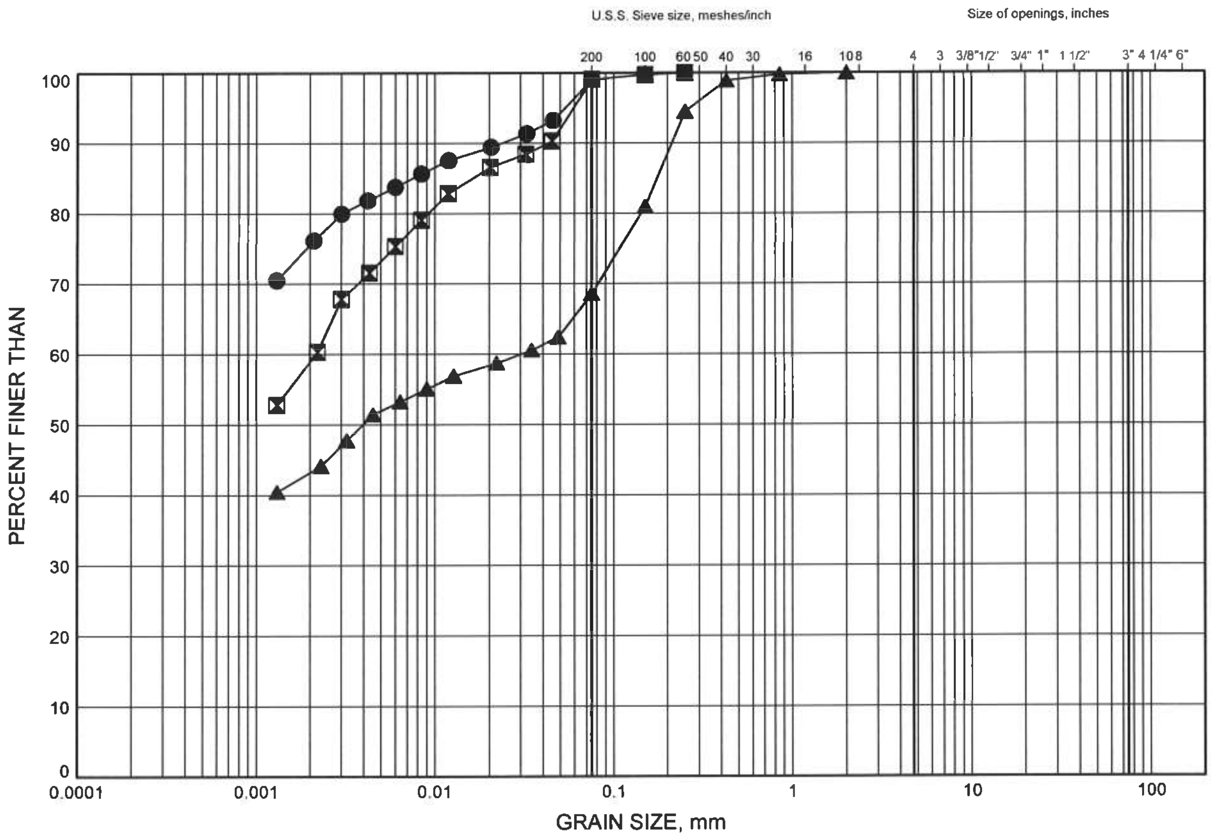
GRAIN SIZE DISTRIBUTION - THURBER 1197.GPJ 8/9/11

NWR 32 Rehabs

# GRAIN SIZE DISTRIBUTION

FIGURE B4

## SILTY CLAY




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

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | BC-5 | 3.35 | 200.57 |
| ⊠ | BC-5 | 7.92 | 196.00 |
| ▲ | BC-6 | 4.88 | 199.24 |

W.P.# 465-00-00

Prepared By MFA

Checked By MRA

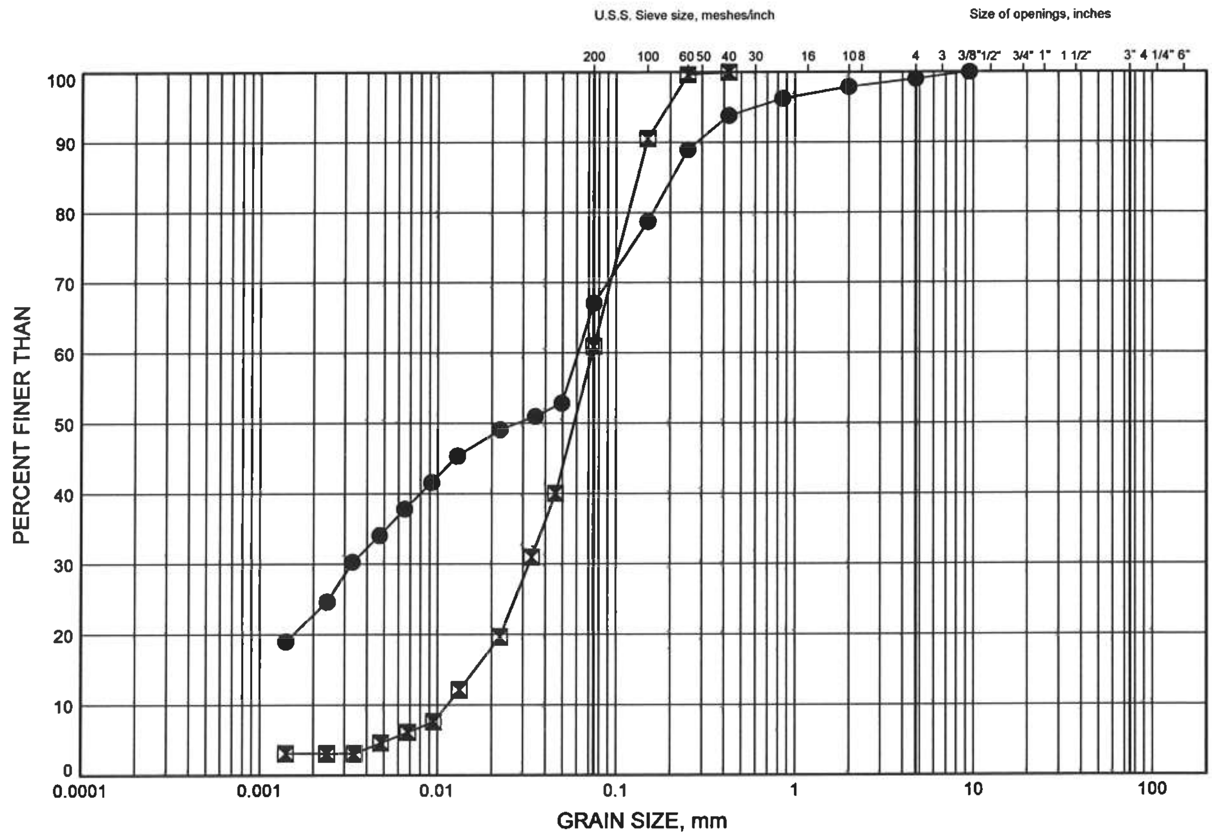
THURBER

NWR 32 Rehabs

# GRAIN SIZE DISTRIBUTION

FIGURE B5

## SANDY SILT




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

## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | BC-2 | 2.59 | 201.46 |
| ⊠ | BC-3 | 12.50 | 191.52 |

W.P.# 478-00-00

Prepared By AN

Checked By RPR

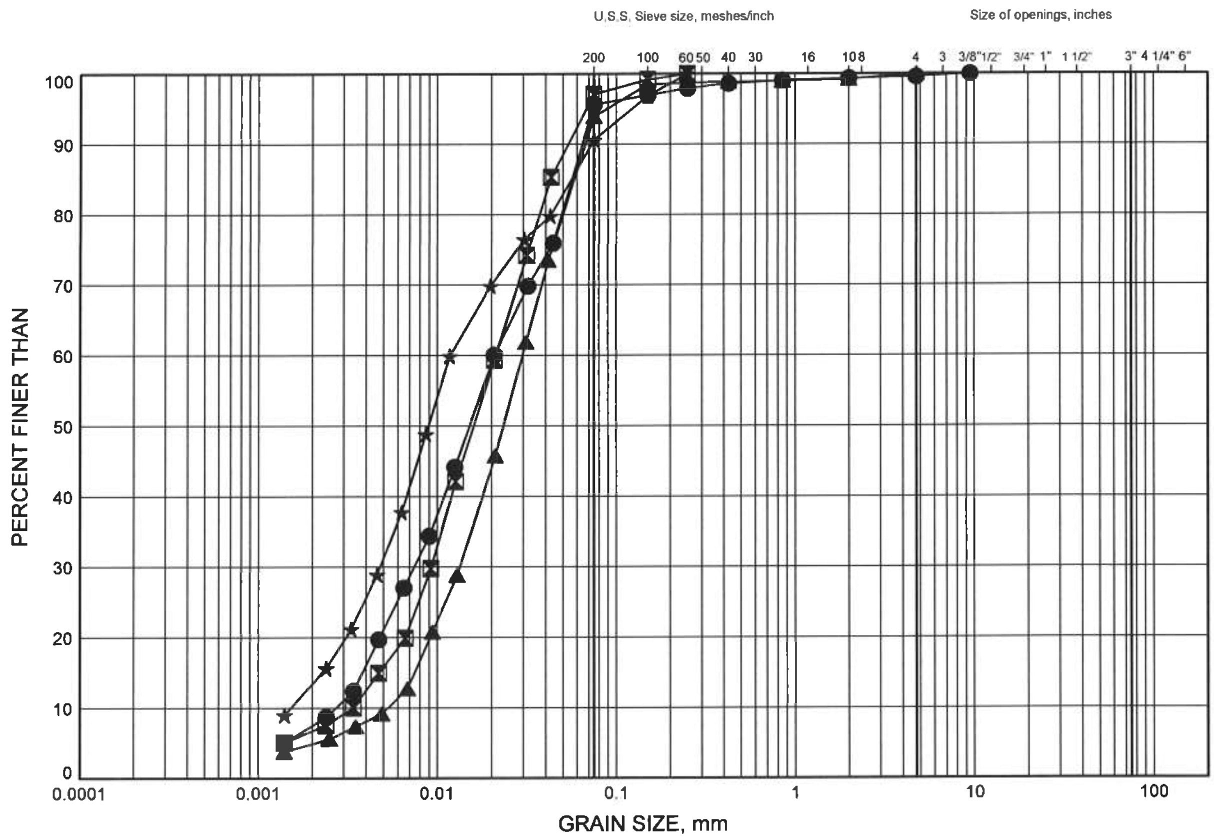
THURBER

GRAIN SIZE DISTRIBUTION - THURBER 1197.GPJ 8/9/11

NWR 32 Rehabs
# GRAIN SIZE DISTRIBUTION

FIGURE B6

## SILT




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

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | BC-1 | 10.97 | 193.13 |
| ⊠ | BC-2 | 10.97 | 193.08 |
| ▲ | BC-4 | 12.50 | 191.56 |
| ★ | BC-6 | 9.45 | 194.67 |

W.P.# 465-00-00

Prepared By MFA

Checked By MRA

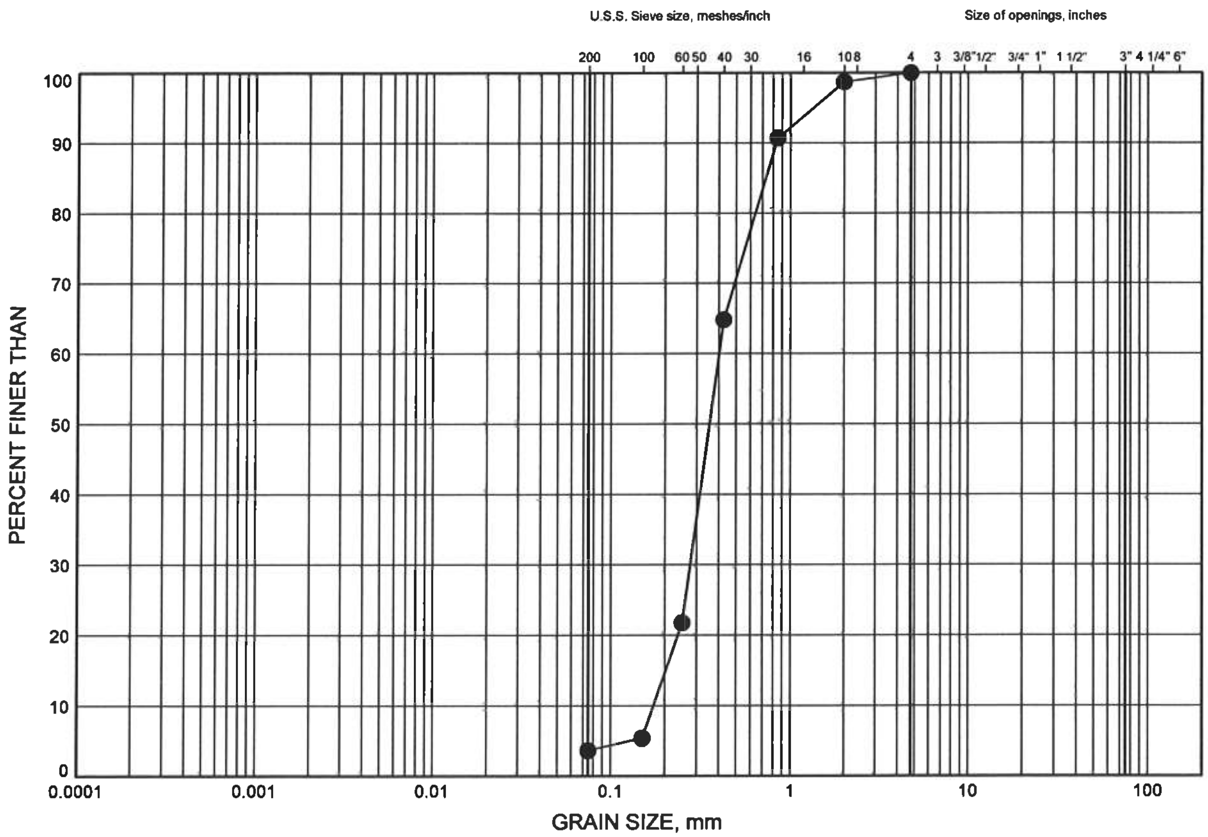
THURBER

NWR 32 Rehabs

# GRAIN SIZE DISTRIBUTION

FIGURE B7

## SAND




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

## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | BC-5 | 14.02 | 189.90 |

GRAIN SIZE DISTRIBUTION - THURBER 1197.GPJ 8/9/11

W.P.# 478-00-00

Prepared By AN

Checked By RPR

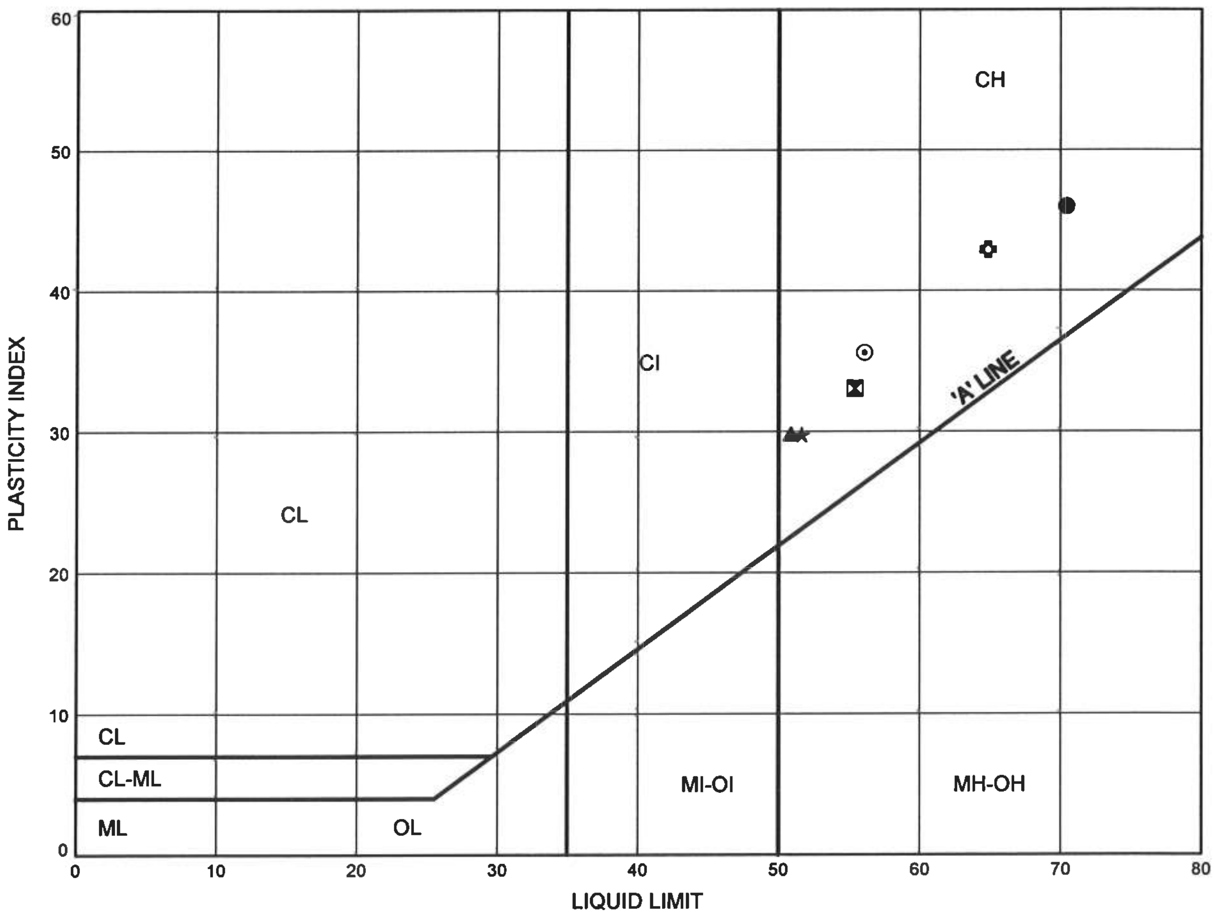
THURBER

NWR 32 Rehabs

# ATTERBERG LIMITS TEST RESULTS

FIGURE B8

## SILTY CLAY




| SYMBOL | BH | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | BC-1 | 6.40 | 197.70 |
| ⊠ | BC-2 | 4.88 | 199.18 |
| ▲ | BC-3 | 4.88 | 199.14 |
| ★ | BC-4 | 9.45 | 194.61 |
| ⊙ | BC-5 | 3.35 | 200.57 |
| ✿ | BC-5 | 7.92 | 196.00 |

THURBALT 1197.GPJ 8/9/11

Date August 2011

Project 478-00-00

THURBER

Prep'd AN

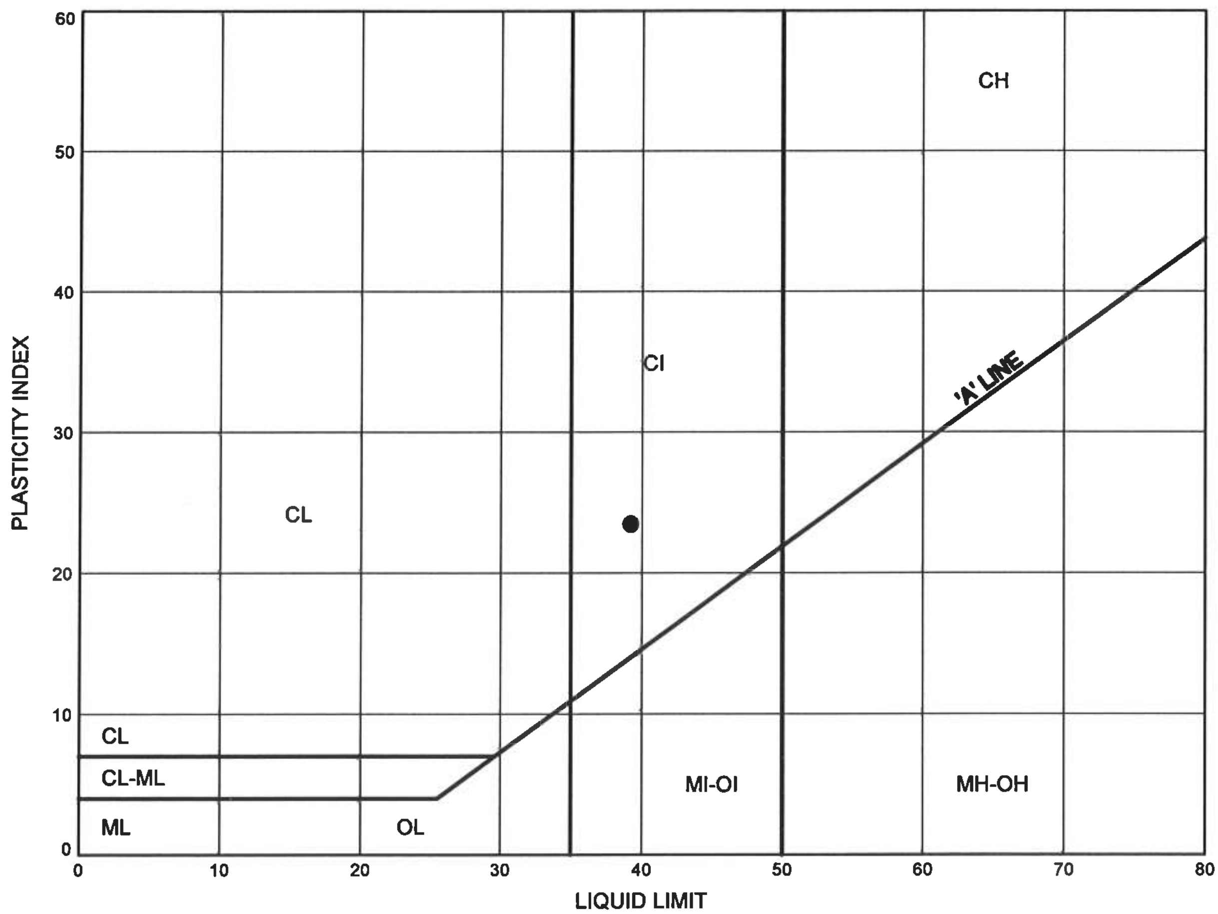
Chkd. RPR

NWR 32 Rehabs

# ATTERBERG LIMITS TEST RESULTS

FIGURE B9

## SILTY CLAY




| SYMBOL | BH | DEPTH (m) | ELEV. (m) |
|---|---|---|---|
| ● | BC-6 | 4.88 | 199.24 |

THURBALT 1197.GPJ 8/9/11

Date August 2011

Project 478-00-00

THURBER

Prep'd AN

Chkd. RPR

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

# POINT LOAD TEST SHEET

| | | | |
|---|---|---|---|
| **Job No :** | 19-1351-197 | **Client :** | MRC |
| | | **Date Drilled :** | 7/18/2011 |
| **Project Name :** | Blend Creek Bridge Structure Replacement | **Date Tested :** | Juuly 28, 2011 |
| **Core Size :** | NQ **BH No :** BC-03 | **Tester :** | DB |

| Test No. | Run No. | Depth (m) | Axial or Diametral | Gauge (kPa) | Diameter (mm) | Length (mm) | UCS (MPa) | Rock Type | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 15.1 | D | 9960 | 47.9 | 142.7 | 96.9 | Schist | Strong |
| 2 | 1 | 15.5 | D | 6000 | 47.9 | 175.0 | 58.4 | Schist | Strong |
| 3 | 1 | 15.6 | D | 10480 | 47.8 | 85.0 | 102.3 | Schist | Very Strong |
| 4 | 1 | 16.1 | D | 1920 | 47.8 | 73.1 | 18.7 | Schist | Weak |
| 5 | 2 | 16.6 | D | 6220 | 47.9 | 191.0 | 60.5 | Schist | Strong |
| 6 | 2 | 17.0 | D | 10400 | 47.8 | 114.5 | 101.5 | Schist | Very Strong |
| 7 | 2 | 17.3 | D | 2940 | 47.7 | 72.3 | 28.8 | Schist | Medium Strong |
| 8 | 2 | 17.8 | D | 2540 | 47.8 | 95.7 | 24.8 | Schist | Weak |
| 9 | | | | | | | | | |
| 10 | | | | | | | | | |
| 11 | | | | | | | | | |
| 12 | | | | | | | | | |
| 13 | | | | | | | | | |
| 14 | | | | | | | | | |
| 15 | | | | | | | | | |
| 16 | | | | | | | | | |
| 17 | | | | | | | | | |
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| 19 | | | | | | | | | |
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| 22 | | | | | | | | | |
| 23 | | | | | | | | | |
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| 25 | | | | | | | | | |
| 26 | | | | | | | | | |
| 27 | | | | | | | | | |
| 28 | | | | | | | | | |
| 29 | | | | | | | | | |
| 30 | | | | | | | | | |

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have 0.7 x D on either side of test point.

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

# POINT LOAD TEST SHEET

**Job No :** 19-1351-197
**Client :** MRC
**Date Drilled :** 7/18/2011
**Project Name :** Blend Creek Bridge Structure Replacement
**Date Tested :** Juuly 28, 2011
**Core Size :** NQ **BH No :** BC-05
**Tester :** DB

| Test No. | Run No. | Depth (m) | Axial or Diametral | Gauge (kPa) | Diameter (mm) | Length (mm) | UCS (MPa) | Rock Type | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 19.0 | D | 12160 | 47.7 | 147.0 | 119.0 | Schist | Very Strong |
| 2 | 1 | 19.1 | D | 14380 | 47.8 | 132.6 | 140.3 | Schist | Very Strong |
| 3 | 1 | 19.3 | D | 16520 | 47.8 | 146.2 | 161.2 | Schist | Very Strong |
| 4 | 2 | 20.1 | D | 15620 | 47.9 | 159.0 | 151.9 | Schist | Very Strong |
| 5 | 2 | 20.2 | D | 15420 | 48.0 | 105.5 | 149.5 | Schist | Very Strong |
| 6 | 2 | 20.5 | D | 10520 | 47.9 | 314.0 | 102.3 | Schist | Very Strong |
| 7 | 2 | 20.7 | D | 8940 | 47.9 | 107.5 | 87.0 | Schist | Strong |
| 8 | | | | | | | | | |
| 9 | | | | | | | | | |
| 10 | | | | | | | | | |
| 11 | | | | | | | | | |
| 12 | | | | | | | | | |
| 13 | | | | | | | | | |
| 14 | | | | | | | | | |
| 15 | | | | | | | | | |
| 16 | | | | | | | | | |
| 17 | | | | | | | | | |
| 18 | | | | | | | | | |
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| 21 | | | | | | | | | |
| 22 | | | | | | | | | |
| 23 | | | | | | | | | |
| 24 | | | | | | | | | |
| 25 | | | | | | | | | |
| 26 | | | | | | | | | |
| 27 | | | | | | | | | |
| 28 | | | | | | | | | |
| 29 | | | | | | | | | |
| 30 | | | | | | | | | |

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
* Diametral Test should have 0.7 x D on either side of test point.

# Appendix C

## Site Photographs

**Photograph 1** – Blend Creek Bridge, looking south

**Photograph 2** – Blend Creek Bridge, looking north


**Photograph 3** – Blend Creek Bridge, looking southwest

**Photograph 4** – Blend Creek Bridge

**Appendix D**

**Foundation Comparison**

## COMPARISON OF FOUNDATION ALTERNATIVES

| Driven H-Piles | Footings on Native Soil | Caissons |
|---|---|---|
| ***Advantages:***<br>i. High geotechnical resistance is available for piles driven to bedrock.<br>ii. Installation of piles could continue in freezing weather<br>iii. Foundation construction may require less volume of excavation than footings.<br><br>***Disadvantages:***<br>i. Higher unit costs than footings.<br>ii. Relatively long pile lengths will be required to contact bedrock.<br>iii. Pile lengths required to achieve design resistance may vary.<br>iv. Limiting deviation at pile head for site specific bridge design may require use of driving template and/or modified driving procedure.<br>v. Potential for upward artesian flow around pile shaft.<br><br>**RECOMMENDED** | ***Advantages:***<br>i. Generally less costly construction than deep foundation elements.<br>ii. Conventional bridge abutment design is feasible.<br><br>***Disadvantages:***<br>iii. Low available geotechnical resistance in native clay deposit.<br>iv. Excavation to base of existing roadway embankment is required for footing construction.<br>v. Dewatering and stream diversion will be required.<br>vi. Potential disturbance of creek during excavation.<br><br>**NOT RECOMMENDED** | ***Advantages:***<br>i. High geotechnical resistance is available for caissons extended to bedrock.<br>ii. Construction of caissons could continue in freezing weather.<br><br>***Disadvantages:***<br>i. Higher cost than spread footings<br>ii. Specialized installation measures such as temporary liners and drilling mud will be required to install caissons in artesian groundwater conditions.<br>iii. Cleaning and inspecting of caisson bases will not be practical.<br><br>**NOT RECOMMENDED** |

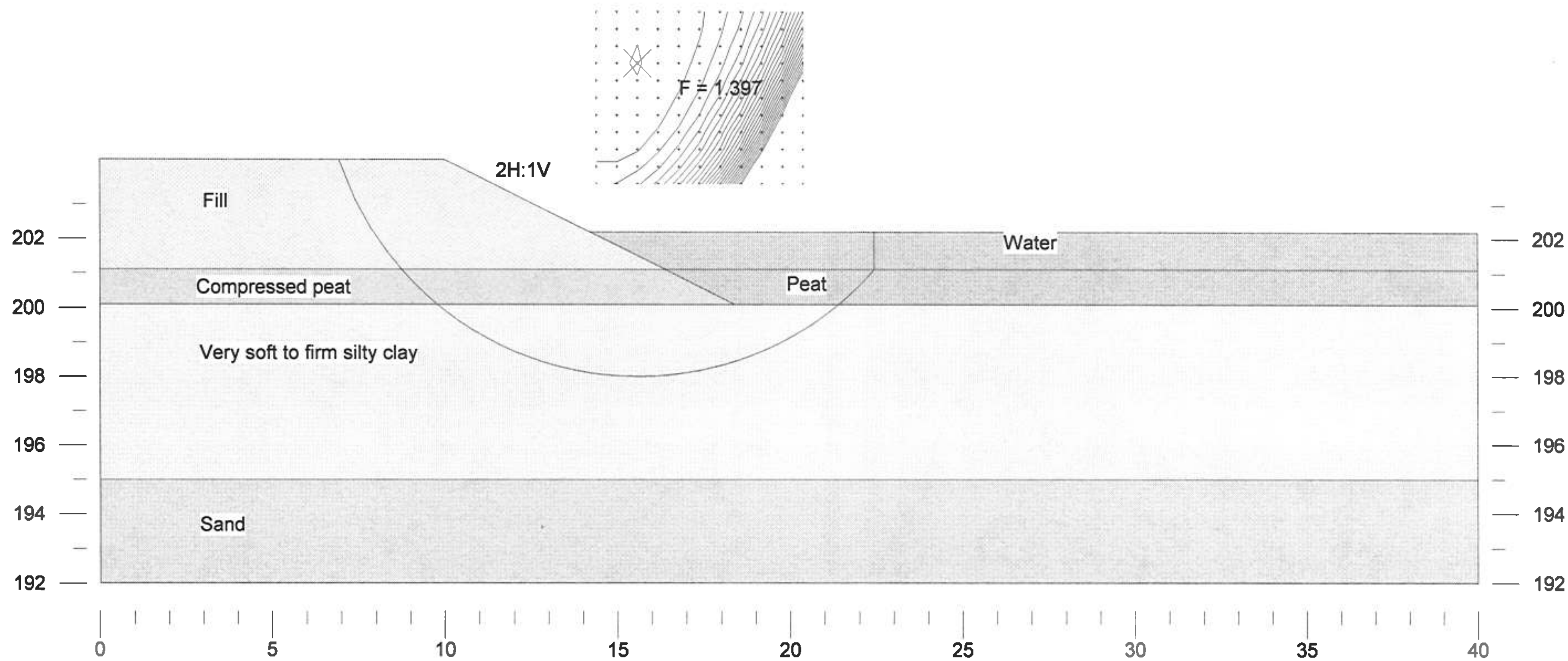
THURBER

# Appendix E

## Slope Stability Output

| | Gamma kN/m3 | C kPa | Phi deg | Min c/p | Piezo Surf. |
|---|---|---|---|---|---|
| Water | 10 | 0 | 0 | 0 | 1 |
| Fill | 21 | 0 | 30 | 0 | 1 |
| Peat | 14 | 0 | 26 | 0 | 1 |
| Compressed peat | 17 | 0 | 28 | 0 | 1 |
| Silty Clay | 18 | 0 | 29 | 0 | 1 |
| Sand | 21 | 0 | 32 | 0 | 1 |

Thurber Engineering Ltd. - Toronto
19-1351-197
Blend Creek Bridge
July 29, 2011
Hwy 587, Site 48C-46
Height 3.2m, Slope 2H:1V




7/29/2011 10:42:06 AM C:\DOCUME~1\RREYNA\MYDOCU~1\BLEND.GSL Thurber Engineering Ltd. - Toronto F = 1.397

FIGURE 1

# Appendix F

## List of SPs and OPSS, and Suggested Text for Selected NSSP

## 1. List of Special Provisions and OPSS Documents Referenced in this Report

- OPSS 501
- OPSS 539
- OPSS 804
- OPSS 902
- OPSS 903
- OPSS 1010
- SP 110S13
- OPSD 208.010
- OPSD 3101.150

## 1. Suggested text for pile driving

Steel H-piles driven at this site must be founded on bedrock. All driven piles shall be fitted with cast steel, H-section rock points from an approved manufacturer such as Titus Steel (Standard H-point) or approved equivalent.

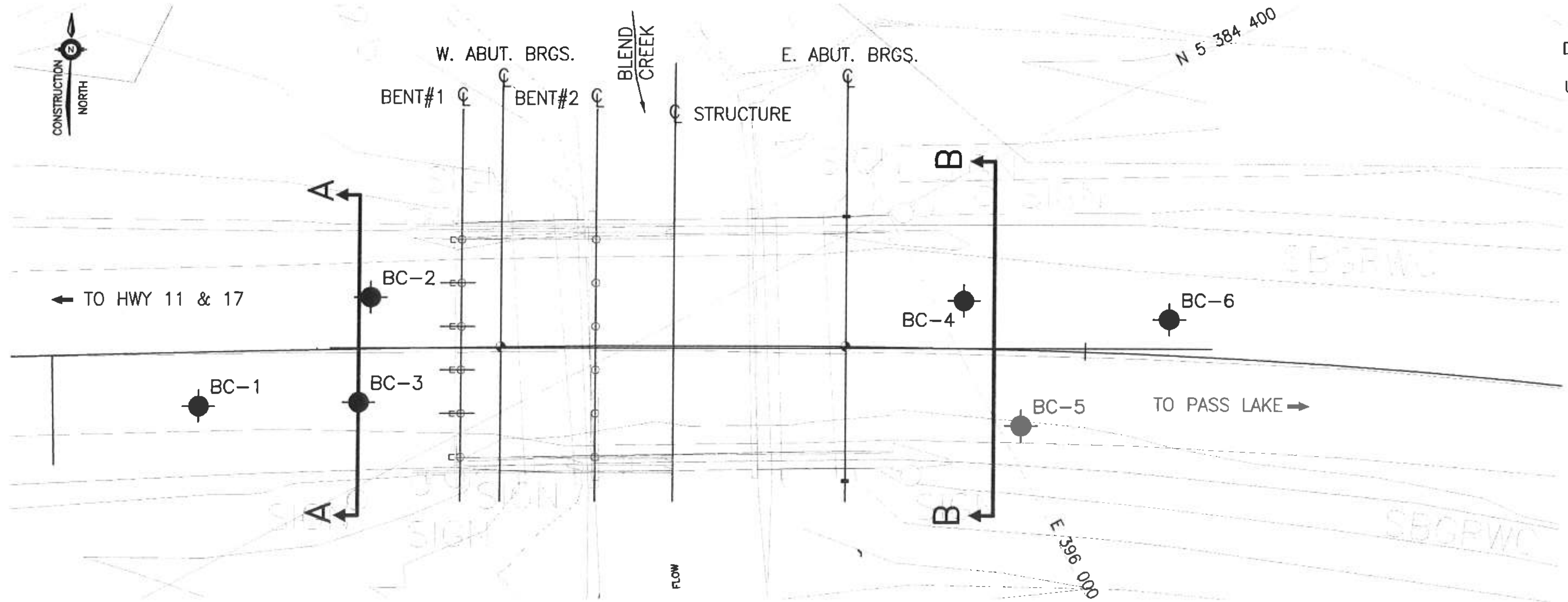
## 2. Suggested text for a NSSP on Pile Installation

The native sand above the bedrock contains occasional cobbles and boulders, which will potentially have an impact on the installation of piles at the site. Some possible impacts that must be taken into consideration include, but are not necessarily limited to:

- The need to provide protection n to the pile tips in the form of rock points.
- The cobbles may impede the driving of the piles resulting in more arduous driving to reach bedrock.
- As a result of the presence of boulders, piles may meet refusal at varying depths.
- Pile driving must be controlled according to the criteria specified for the site.
- If a pile meets refusal at a depth less than the anticipated depth, the QVE must terminate driving before the pile is damaged due to over-driving.

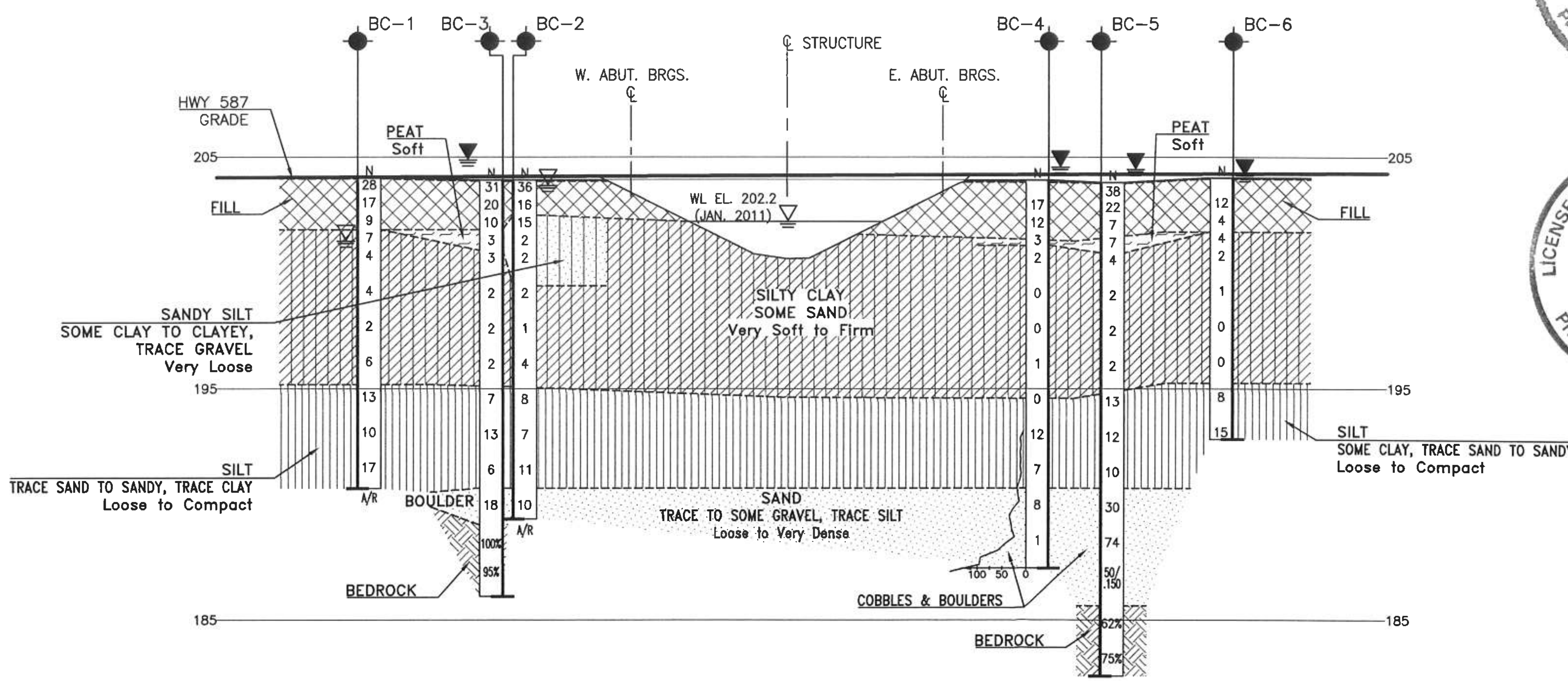
**Appendix G**

**Drawing titled "Borehole Locations and Soil Strata"**




PLAN

5 0 5 10m
SCALE 1:250




PROFILE ALONG HWY 587

5 0 5 10m
SCALE 1:250

# METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

LICENSED PROFESSIONAL ENGINEER
M. R. ANDERSON
Jan 26/12
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Jan 26/12
PROVINCE OF ONTARIO

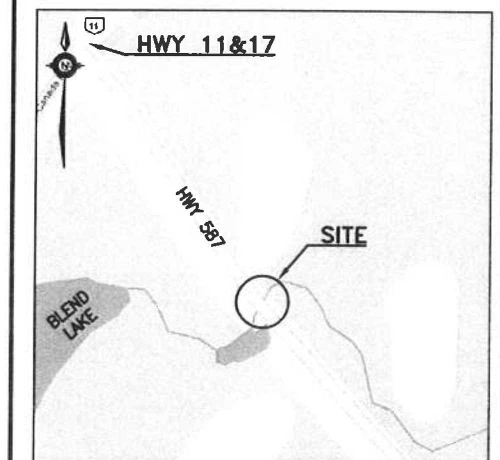
CONT No
WP No 478-00-00

HIGHWAY 587
BLEND CREEK BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET 12

McCORMICK RANKIN CORPORATION

THURBER ENGINEERING LTD.




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 | NORTHING | EASTING |
|---|---|---|---|
| BC-1 | 204.1 | 5 384 405.7 | 395 972.6 |
| BC-2 | 204.1 | 5 384 406.4 | 395 980.6 |
| BC-3 | 204.0 | 5 384 402.9 | 395 978.3 |
| BC-4 | 204.1 | 5 384 395.6 | 396 001.1 |
| BC-5 | 203.9 | 5 384 390.2 | 396 000.8 |
| BC-6 | 204.1 | 5 384 391.3 | 396 007.8 |

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

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

**GEOCRES No. 52A-149**

| REVISIONS | DATE | BY | DESCRIPTION |
|---|---|---|---|
| DESIGN RPR | CHK RPR | CODE | LOAD | DATE JAN. 2012 |
| DRAWN AN | CHK PKC | SITE 48C-46 | STRUCT | DWG 2 |

FILENAME: H:\Drafting\19\1351\197\td1197-BlendCreek(Plan&Profile).dwg
PLOTDATE: 1/25/2012 4:46 PM

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

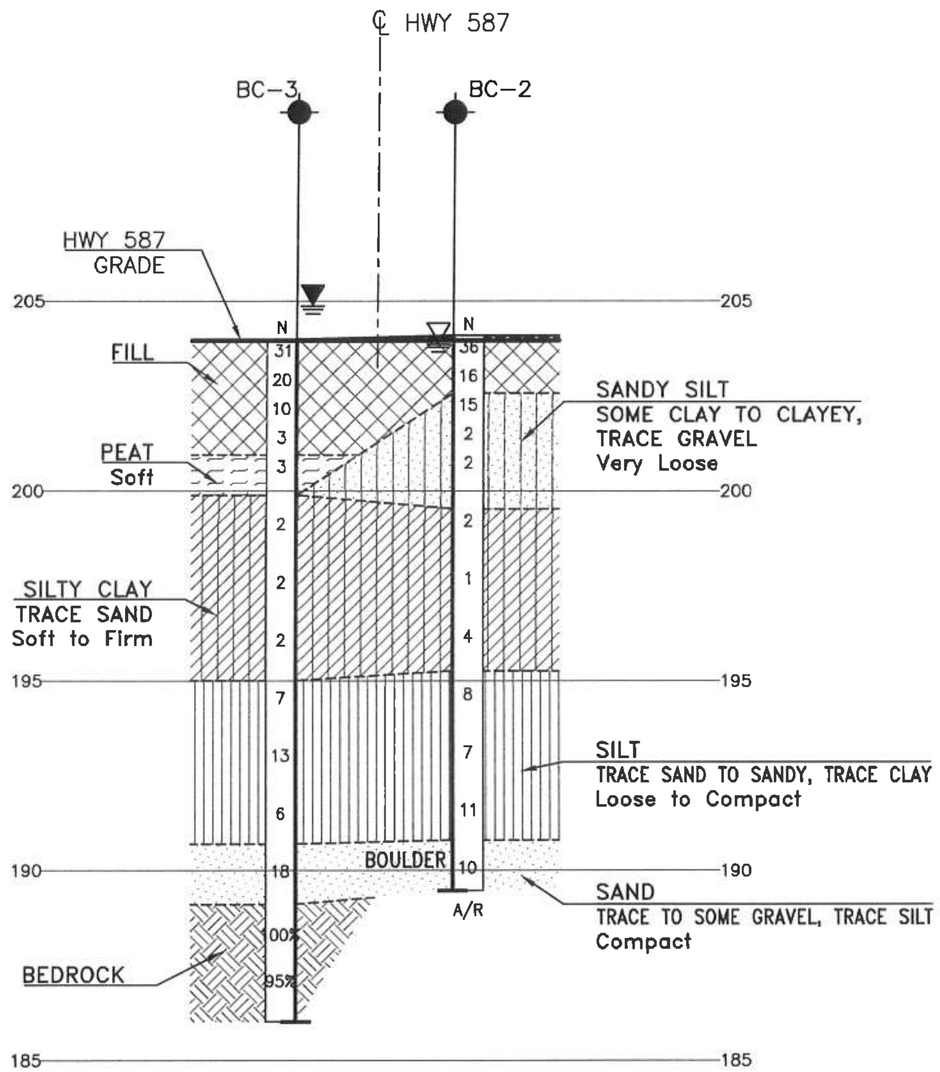
CONT No
WP No 478-00-00

SHEET
13

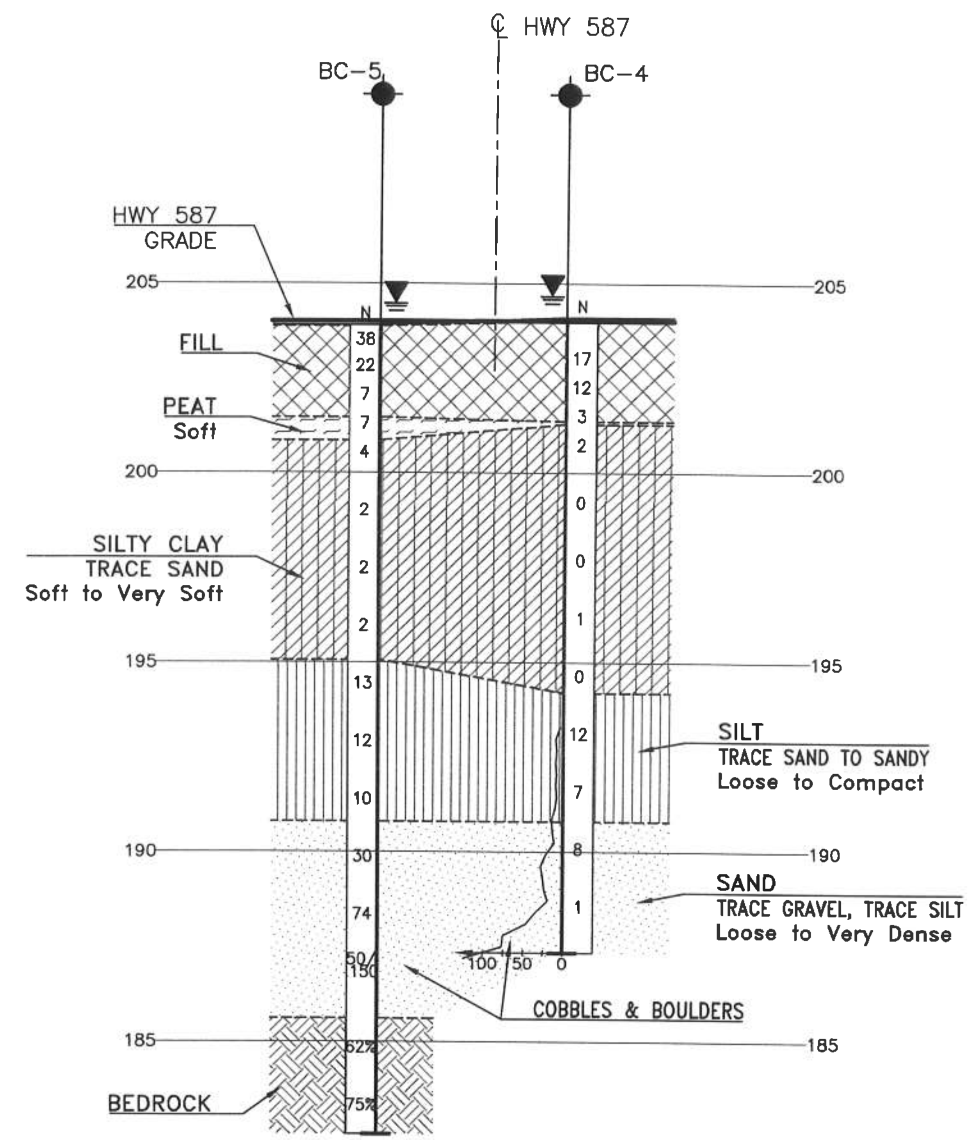
HIGHWAY 587
BLEND CREEK BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA

McCORMICK RANKIN CORPORATION

THURBER ENGINEERING LTD.




SECTION A-A

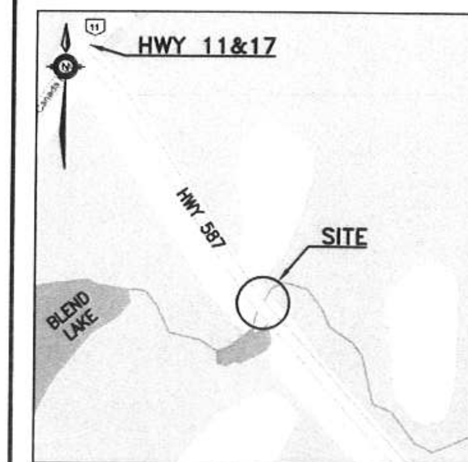



SECTION B-B

4 0 4 8m
SCALE 1:200

LICENSED PROFESSIONAL ENGINEER
M. R. ANDERSON
Jan 26/12
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Jan 26/12
PROVINCE OF ONTARIO




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 | NORTHING | EASTING |
|---|---|---|---|
| BC-1 | 204.1 | 5 384 405.7 | 395 972.6 |
| BC-2 | 204.1 | 5 384 406.4 | 395 980.6 |
| BC-3 | 204.0 | 5 384 402.9 | 395 978.3 |
| BC-4 | 204.1 | 5 384 395.6 | 396 001.1 |
| BC-5 | 203.9 | 5 384 390.2 | 396 000.8 |
| BC-6 | 204.1 | 5 384 391.3 | 396 007.8 |

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

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

**GEOCRES No. 52A-149**

| REVISIONS | DATE | BY | DESCRIPTION | | |
|---|---|---|---|---|---|
| DESIGN RPR | CHK RPR | CODE | LOAD | DATE JAN. 2012 | |
| DRAWN AN | CHK PKC | SITE 48C-46 | STRUCT | DWG 3 | |

FILENAME: H:\Drafting\19\1351\197\td1197-BlendCreek(Plan&Profile).dwg
PLOTDATE: 1/25/2012 4:46 PM

HWY 587
CONT. No. 2011-6018
WP No. 478-00-00

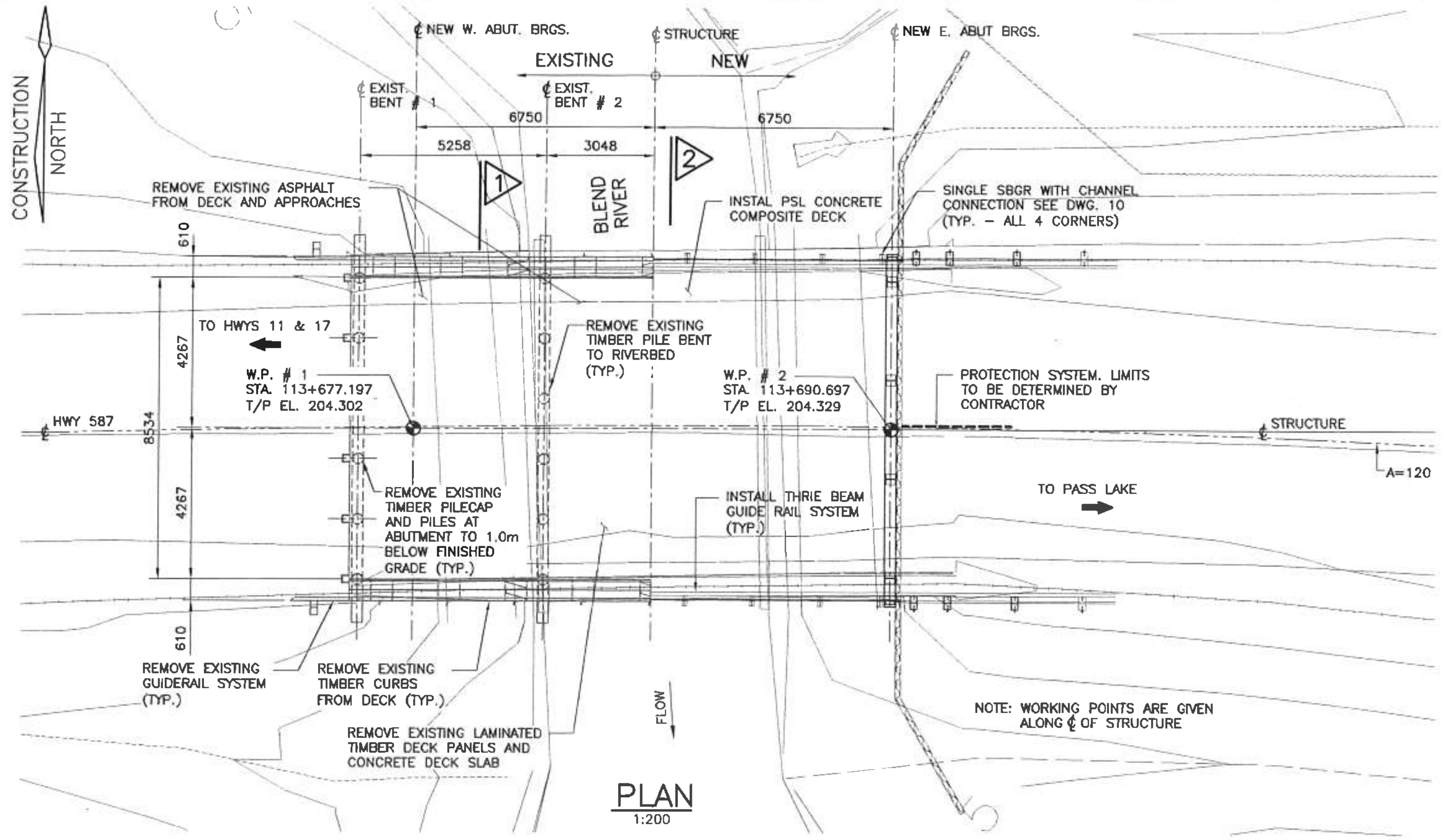
HWY 587
BLEND CREEK BRIDGE

GENERAL ARRANGEMENT

SHEET 11

McCORMICK RANKIN CORPORATION
A member of MMMGROUP

METRIC

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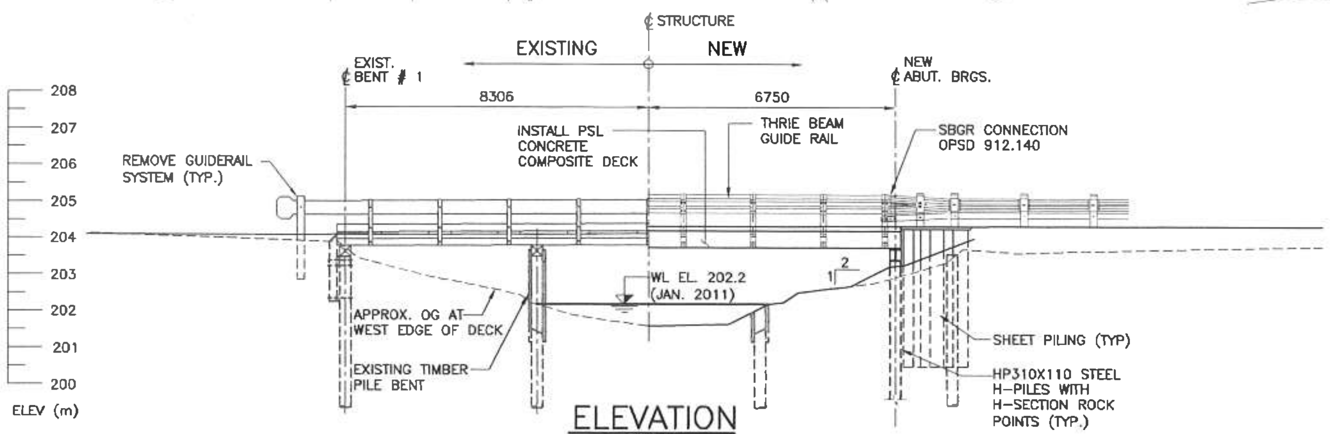
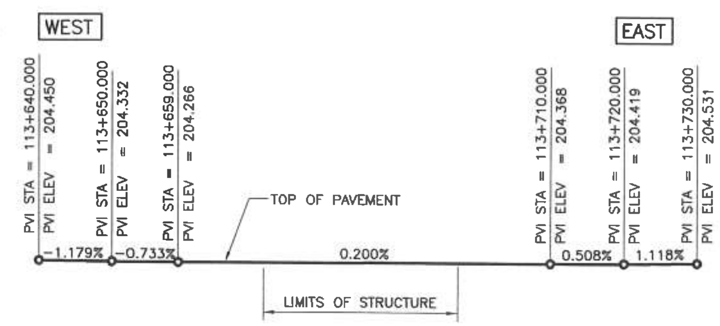
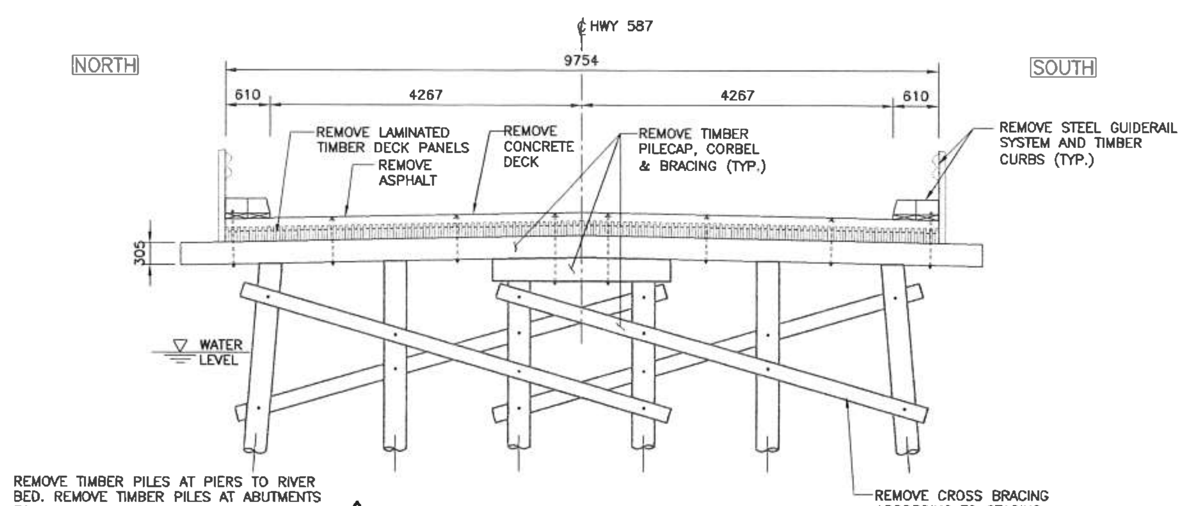


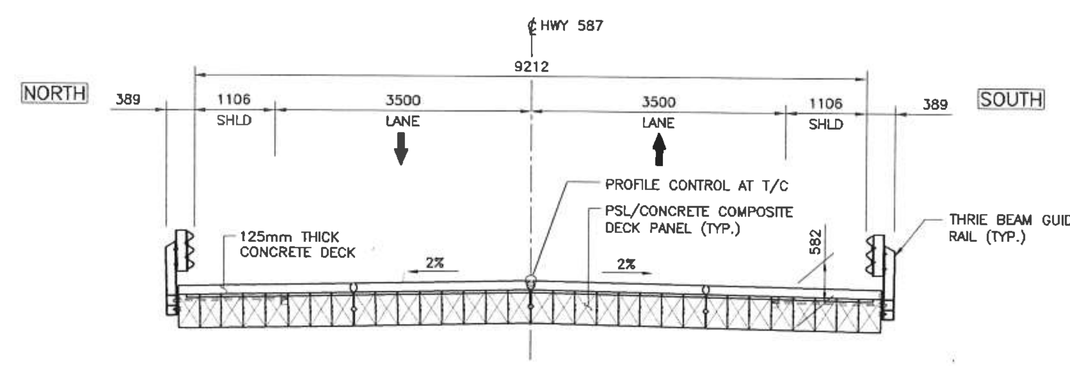

ELEVATION
1:200




HWY 587 PROFILE
N.T.S.




1 EXISTING TYPICAL SECTION
1:100




2 NEW SECTION
1:100

# GENERAL NOTES

## CLASS OF CONCRETE

ALL CONCRETE..................60 MPa (HPC)

## CLEAR COVER TO REINFORCEMENT

CONCRETE – DECK ....75±10 U.N.O.

## REINFORCING – GENERAL

1. STAINLESS STEEL SHALL BE TYPE 316LN

## GLASS FIBRE REINFORCED POLYMER (GFRP) BARS

1. GLASS FIBRE REINFORCED BAR SHALL BE GRADE I UNLESS NOTED OTHERWISE ON THE DRAWINGS.

## CONSTRUCTION NOTES

1. THE TEMPORARY ROADWAY PROTECTION SYSTEM SHALL CONFORM TO THE REQUIREMENTS OF PERFORMANCE LEVEL II

## TIMBER MATERIAL

ALL TIMBER FOR THE DECKING SYSTEM SHALL BE DOUGLAS FIR PARALLAM PSL (PARALLEL STRAND LUMBER)

## PRESERVATIVE TREATMENT

1. PRESERVATIVE TREATMENT TO BE USED SHALL BE CHROMATED COPPER ARSENATE (CCA) AND SHALL CONFORM TO CSA 080.14.
2. TARGET RETENTION LEVEL SHALL BE 9.6 KG/M3 (0.6 LB/FT3)

## APPLICABLE STANDARD DRAWINGS

| | |
|---|---|
| OPSD 912.102 | GUIDE RAIL SYSTEM, STEEL BEAM CHANNEL COMPONENT |
| OPSD 912.140 | GUIDE RAIL SYSTEM, STEEL BEAM WOODEN POST ASSEMBLY INSTALLATION – SINGLE RAIL |

## LIST OF ABREVIATIONS

| | |
|---|---|
| T/P | DENOTES TOP OF PAVEMENT |
| W.P. | DENOTES WORKING POINT |
| W.L. | DENOTES WATER LEVEL |
| HPC | DENOTES HIGH PERFORMANCE CONCRETE |

## LIST OF DRAWINGS:

1. GENERAL ARRANGEMENT
2. BOREHOLE LOCATIONS AND SOIL STRATA I
3. BOREHOLE LOCATIONS AND SOIL STRATA II
4. CONSTRUCTION STAGING
5. PILING AND SHEET PILING LAYOUT I
6. PILING AND SHEET PILING LAYOUT II
7. TIMBER PANEL FABRICATION & LAYOUT
8. DECK LAYOUT & DETAILS
9. TRAFFIC RAILING DETAILS
10. RAILING CONNECTION DETAILS
11. MISCELLANEOUS DETAILS

LICENSED PROFESSIONAL ENGINEER J. C. SHERLOCK PROVINCE OF ONTARIO

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DRAWING NOT TO BE SCALED
50mm ON ORIGINAL DRAWING

| REVISIONS | DESCRIPTION | | | | |
|---|---|---|---|---|---|
| DESIGN A.Y. | CHK J.S. | CODE CHBDC 06 | LOAD CL-625-ONT | DATE JAN/12 | |
| DRAWN Z.P. | CHK A.Y. | SITE 48C-46 | STRUCT | SCHEME | DWG 1 |