FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 11
BLACKWATER RIVER BRIDGE REPLACEMENT
GREENSTONE COMMUNITY, DISTRICT OF THUNDER BAY, ONTARIO

G.W.P. 6066-09-00, Site No. 48C-1

Geocres Number: 42E-14

Report to

McCormick Rankin Corporation

Thurber Engineering Ltd.
2010 Winston Park Drive, Suite 103
Oakville, Ontario
L6H 5R7
Phone: (905) 829 8666
Fax: (905) 829 1166

January 22, 2013
File: 19-1351-197

H:\19\1351\197 NWR 32 Rehabs\Reports & Memos\Blackwater River\Blackwater River Bridge-FIDR-FINAL.doc

TABLE OF CONTENTS

PART 1 FACTUAL INFORMATION

1 INTRODUCTION 1

2 SITE DESCRIPTION 1

3 SITE INVESTIGATION AND FIELD TESTING 2

4 LABORATORY TESTING 3

5 DESCRIPTION OF SUBSURFACE CONDITIONS 4

5.1 Pavement Structure 4
5.2 Sand Fill 4
5.3 Gravelly sand 5
5.4 Sand to Sandy Silt 5
5.5 Silt 7
5.6 Sand 7
5.7 Sand and Gravel 8
5.8 Gravel 8
5.9 Water Levels 9

6 MISCELLANEOUS 9

PART 2 ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL 11

8 STRUCTURE FOUNDATIONS 12

8.1 Spread Footings on Native Soils 12
8.2 Socketted Drilled Shafts/Caissons 13
8.3 Driven Steel H-piles 13
8.3.1 Pile Installation 14
8.3.2 Downdrag 15
8.3.3 Lateral Resistance for H-piles 15
8.4 Recommended Foundation 16
8.5 Frost Cover 16
8.6 Impact of Pile Driving on Existing Bridge 16

9 SHEET PILE WALLS 17

10 EXCAVATION AND GROUNDWATER CONTROL 18

11 APPROACH EMBANKMENTS 19

11.1 Slope Stability 19
11.2 Settlement 20
12 EROSION PROTECTION 20
13 ROADWAY PROTECTION 20
14 SEISMIC CONSIDERATIONS 21
14.1 Seismic Design Parameters 21
15 CONSTRUCTION CONCERNS 22

Appendices

Appendix A	Record of Borehole Sheets
Appendix B	Laboratory Test Results
Appendix C	Foundation Comparison
Appendix D	Slope Stability Output
Appendix E	List of SPs and OPSS, and Suggested Text for Selected NSSP
Appendix F	Site Photographs
Appendix G	Drawing titled "Borehole Locations and Soil Strata"

FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 11
BLACKWATER RIVER BRIDGE REPLACEMENT
GREENSTONE COMMUNITY, DISTRICT OF THUNDER BAY, ONTARIO

G.W.P. 6066-09-00, Site No. 48C-1

Geocres Number: 42E-14

PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the site of a proposed replacement of the existing bridge which carries Highway 11 over the Blackwater River. The bridge is located approximately 70 Km north of Nipigon, District of Thunder Bay, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the investigation.

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

2 SITE DESCRIPTION

The site is located at the crossing of Highway 11 over the Blackwater River, approximately 400 m north of Garnet Drive in the Greenstone Community, Thurder Bay District, Ontario. At present, the highway crosses the river on a seven-span structure supported on two abutments and six piers. The total length of the bridge is 51.3 m and the width is 11.5 m. The existing north and south embankment heights are approximately 2.0 m to 3.0 m.

At this site, the Blackwater River flows to the west. The river channel is approximately 30 m wide and approximately 3.5 m deep at the bridge. Rock protection is visible above the river level throughout the lower parts of the approach embankments.

The area surrounding the bridge site is generally flat. Crater Lake is approximately 170 m northeast of the bridge. The areas to north of the site are generally heavily treed.

Photographs in Appendix F show the general nature of the site.

The site lies within the physiographic region known as the Wabigoon Subprovince of the Superior Province of the Canadian Shield. The region is characterized by metasedimentary rocks. Locally, at this site, bedrock was not contacted within the depth of exploration. The native soils typically consist of sands and silts.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out on July 18, 25, 27, 28, 29 and 31 and August 9, 11 and 12, 2012 consisted of drilling and sampling six boreholes (numbered BWR-01, BWR-03, BWR-04, BWR-07, BWR-8 and BWR-10) in the area of the proposed south and north approaches, abutments and piers. Boreholes BWR-01 and BWR-10, drilled at the south approach and north approach, respectively, were terminated at 9.8 m depth (elevations 295.7 and 296.1). Boreholes drilled at the south and north abutments and piers were terminated at depths ranging from 31.2 m to 42.8 m (elevations 260.8 to 267.6).

Dynamic Cone Penetration Tests (DCPT), numbered BWR-03D, BWR-07D and BWR-08D, were conducted adjacent to Boreholes BWR-03, BWR-07 and BWR-08 to depths ranging from 14.4 m to 21.0 m (elevations 284.1 to 288.9) and below borehole termination depth in Boreholes BWR-03, BWR-04, BWR-07 and BWR-08, extending to depths ranging from 35.5 m to 42.3 m (elevations 261.3 to 263.3). The DCPTs were conducted to supplement the data/information collected from the boreholes.

Records of boreholes drilled during the investigation are included in Appendix A.

The approximate locations of the boreholes are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix G.

The borehole locations were marked in the field and utility clearances were obtained prior to drilling.

The drilling was carried out from the highway grade and through the bridge deck using a CME 55 truck-mounted drill rig. Hollow stem augers and NW casing were used to advance the boreholes through the soils. Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT).

The drilling and sampling operations were supervised on a full time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

Two standpipe piezometers consisting of 19 mm PVC pipe with slotted screen and enclosed in filter sand were installed at this site to permit longer term groundwater level monitoring. The boreholes were backfilled with bentonite holeplug in general accordance with O.Reg. 903 upon completion. The location and completion details of the piezometer and boreholes are presented in Table 3.1. Piezometers were decommissioned as per O. Reg. 903 on September 26, 2012.

Table 3.1 – Borehole Abandonment Details

Location	Borehole	Piezometer Tip Depth/ Elevation (m)	Abandonment Details
South approach	BWR-01	None installed	Borehole backfilled with holeplug to 7.9 m, auger cuttings from 7.9 m to 0.15 m, then asphalt to surface.
South abutment	BWR-03	13.0/290.6	Borehole caved-in from 42.8 m to 31.5 m upon completion of drilling. Borehole backfilled with holeplug from 31.5 m to 13.0 m, sand from 13.0 m to10.5 m, then bentonite holeplug to surface. At bridge deck, borehole backfilled with concrete and asphalt.
South pier	BWR-04	None installed	Borehole caved-in upon completion of drilling.
North pier	BWR-07	None installed	Borehole caved-in upon completion of drilling.
North abutment	BWR-08	12.7/290.8	Borehole backfilled with sand and holeplug from 42.8 m to 12.9 m, sand from 12.9 m to 10.0 m, then bentonite holeplug to ground surface. At bridge deck, borehole backfilled with concrete and asphalt.
North approach	BWR-10	None installed	Borehole backfilled with holeplug and auger cuttings from 9.8 m to 0.15 m, then asphalt 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). The results of this testing program are summarized on the Record of Borehole sheets in Appendix A and shown on the figures contained in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A. Details of the encountered soil stratigraphy are presented in these sheets and on the "Borehole Locations and Soil Strata" drawing 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.

In general terms, the stratigraphy encountered at this site consists of pavement structure overlying the embankment granular fill. The granular fill was 2.7 m to 3.0 m thick. Layers of native gravelly sand, sand and silt were encountered below the south and north approaches and at the abutment and pier locations. Layers of gravel and sand and gravel were encountered below the sand and silt layers in boreholes drilled at the south pier and north abutment. The native soils were generally very loose to compact in relative density with zones of dense layers.

More detailed descriptions of the individual strata are presented below.

5.1 Pavement Structure

Pavement structure was encountered in all the boreholes, which were drilled through the existing Highway 11 roadway or through the bridge deck. The thickness of the asphalt was 100 mm.

A layer of concrete ranging from 200 mm to 225 mm in thickness was encountered below the asphalt in Boreholes BWR-03, BWR-4, BWR-07 and BWR-08, which were drilled through the bridge deck and approach slabs.

5.2 Sand Fill

Fill was encountered below the asphalt pavement in Borehole BWR-01 and BWR-10 drilled at the south and north approaches, respectively.

The fill comprising the existing highway embankment, consisted of the brown sand and silty sand containing trace to some gravel and trace clay. The thickness of the granular fill was 3.0 m and 2.7 m in Boreholes BWR-01 and BWR-10, respectively.

The depth to the base of the fill was 3.1 m and 2.8 m (elevations 302.4 and 303.1) in Boreholes BWR-01 and BWR-10, respectively.

SPT N-values recorded in the fill ranged from 3 to 13 blows per 0.3 m of penetration, indicating a very loose to compact relative density.

Moisture content in the fill layer ranged from 2% to 17%.

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

Soil Particles	Sand Fill and Silty Sand Fill Percentage (%)
Gravel	0 to 1
Sand	58 to 79
Silt	18 to 39
Clay	2 to 3

5.3 Gravelly sand

A layer of gravelly sand was contacted in Borehole BWR-10 below the silty sand fill at 2.8 m depth (elevation 303.1). The thickness of the gravelly sand layer was 0.7 m.

The depth to the base of the gravelly sand layer was 3.5 m (elevation 302.4).

An SPT N-value measured in the gravelly sand layer was 15 blows per 0.3 m of penetration, indicating a compact relative density.

The moisture content of the gravelly sand layer was 19% to 21%

5.4 Sand to Sandy Silt

Native brown to grey sand to sandy silt containing trace gravel and trace clay was contacted at various depths and elevations as indicated in Table 5.1.

In Boreholes BWR-07 and BWR-08, wood fragments were noted in the upper 2.0 m of the sand layer. The upper 1.0 m of sand was mixed with clay and organics in Boreholes BWR-01 and BWR-04. At depth, cobbles and boulders were noted in the sand layer.

Table 5.1 – Depths and Elevations of Native Sand to Sandy Silt

Foundation Unit	Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
South approach	BWR-01	3.1 to 4.6 7.2 to 9.8[1]	302.4 to 300.9 298.3 to 295.7	1.5 2.6
South abutment	BWR-03	0.0 to 5.2 6.7 to 7.9	303.6 to 298.4 296.9 to 295.7	5.2 1.2
South pier	BWR-04	0 to 10.7	298.8 to 288.1	10.7
North pier	BWR-07	0 to 1.9 4.9 to 20.6	299.5 to 297.6 294.6 to 278.9	1.9 15.7
North abutment	BWR-08	0 to 19.2	303.5 to 284.3	19.2
North approach	BWR-10	3.5 to 9.8[1]	302.4 to 296.1	6.3

[1]Borehole termination depth

SPT 'N' values recorded in the sand and sandy silt ranged from 0 to 29 blows per 0.3 m of penetration, indicating a very loose to compact relative density. SPT N-values of 56 blows per 0.3 of penetration, indicating a very dense relative density, were recorded in Borehole BWR-08 near elevation 285.9.

The moisture contents of the sand and sandy silt ranged from 8% to 30%. Moisture contents of 45 % and 50% were measured in Borehole BWR-03 near elevation 300.8 and in Borehole BWR-07 just below the river bed, respectively. A moisture content of >80% was measured in the sand with wood fragments just below the river bed in Borehole BWR-04.

Grain size distribution curves for samples of the sand and sandy silt tested are presented on the Record of Borehole sheet and on Figures B2, B3 and B6 of Appendix B. The results of the laboratory test are summarized as follows:

Soil Particles	Sandy Silt (%)	Sand (%)
Gravel	0 to 7	0 to 4
Sand	25 to 54	65 to 98
Silt	40 to 73	28
Clay	1 to 5	2
Silt & Clay	-	13 to 33

5.5 Silt

Native brown to grey silt containing trace to some sand and trace clay was contacted at various depths and elevations as indicated in Table 5.2.

Table 5.2 – Depths and Elevations of Native Silt

Foundation Unit	Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
South approach	BWR-01	4.6 to 7.2	300.9 to 298.3	2.6
South abutment	BWR-03	5.2 to 6.7 7.9 to 24.2	298.4 to 296.9 295.7 to 279.4	1.5 16.3
South pier	BWR-04	10.7 to 29.7	288.1 to 269.1	19.0
North pier	BWR-07	20.6 to 35.9[(1)]	278.9 to 263.6	15.3
North abutment	BWR-08	19.2 to 35.2	284.3 to 268.3	16.0

[(1)]Borehole termination depth

SPT 'N' values recorded in the silt ranged from 2 to 50 blows per 0.3 m of penetration, indicating loose to dense relative density. Generally, the silt layer is in a compact state.

The moisture content of the silt ranged from 18% to 28%.

Grain size distribution curves for samples of the silt tested are presented on the Record of Borehole sheet and on Figures B4 and B5 of Appendix B. The results of the laboratory test are summarized as follows:

Soil Particles	Silt (%)
Gravel	0
Sand	0 to 19
Silt	75 to 94
Clay	4 to 8

5.6 Sand

A layer of grey sand containing some silt to silt, trace gravel, trace clay and occasional cobbles and boulders was contacted below the silt at 24.2 m depth (elevation 279.4) in Borehole BWR-03 and at 35.2 m depth (elevation 268.3) in Borehole BWR-08. The thickness of the sand was 3.6 m in Borehole BWR-08.

The depth to the base of the sand in Borehole BWR-08 was 38.8 m (elevation 264.7). Borehole BWR-03 was terminated within the sand at 42.8 m depth (elevation 260.8).

SPT 'N' values recorded in the sand ranged from 24 to 38 blows per 0.3 m of penetration, indicating compact to dense relative density. An SPT-N value of 100 blows with no penetration, indicating a very dense relative density, was recorded in Borehole BWR-08 near elevation 265.3.

The moisture content of the silt ranged from 17% to 22%.

Grain size distribution curves for samples of the sand tested are presented on the Record of Borehole sheet and on Figure B6 of Appendix B. The results of the laboratory test are summarized as follows:

Soil Particles	Sand (%)
Gravel	0 to 2
Sand	74 to 98
Silt	22
Clay	2
Silt & Clay	2

5.7 Sand and Gravel

A layer of sand and gravel was contacted below the sand at 1.9 m depth (elevation 297.6) in Borehole BWR-07. The thickness of the sand and gravel layer was 3.0 m. The depth to the base of the sand and gravel layer was 4.9 m (elevation 294.6).

In Borehole BWR-08, a layer of sand and gravel was contacted at 38.8 m depth (elevation 264.7). Borehole BWR-08 was terminated within the sand and gravel layer at 39.5 m depth (elevation 264.0).

In Borehole BWR-07, the SPT N-values measured in the sand and gravel layer were 10 and 0 blows per 0.3 m of penetration, indicating a compact to very loose relative density. An SPT N-value of 45 blows per 0.3 m of penetration was measured in Borehole BWR-08, indicating a dense relative density.

The moisture content of the sand and gravel layer ranged from 8% to 21%.

5.8 Gravel

A layer of gravel was contacted in Borehole BWR-04 below the silt at 29.7 m depth (elevation 269.1)

Borehole BWR-04 was terminated within the gravel layer at 31.2 m depth (elevation 267.6).

The SPT N-value measured in the gravel layer was 20 blows per 0.3 m of penetration, indicating a compact relative density

5.9 Water Levels

Water levels were monitored in the open boreholes during and upon completion of drilling. Two standpipe piezometers were installed in Boreholes BWR-03 and BWR-08 to monitor water levels after completion of drilling. The water levels measured in the piezometer and open boreholes are summarized in Table 5.3.

Table 5.3 – Water Level Measurements

Borehole	Date	Water Level (m)		Comments
		Depth	Elevation	
BWR-01	July 29, 2012	3.8	301.7	Open borehole
BWR-03	September 13, 2012 September 26, 2012	2.9 2.6	302.7 303.0	In piezometer
BWR-08	September 13, 2012 September 26, 2012	2.6 2.3	303.2 303.5	In piezometer
BWR-10	July 29, 2012	3.4	302.5	Open borehole

Piezometric readings indicate that the water level is near elevations 303.0 and 303.5, at the south and north abutments, respectively.

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

GA drawing indicates that the water level in Blackwater River was at Elevation 301.2 in April 2011. Normal high water level is at elevation 302.4, for a two year return period.

6 MISCELLANEOUS

Borehole locations were selected and established in the field by Thurber Engineering Ltd. MRC provided plan drawings to obtain the co-ordinates and the ground surface elevations for the boreholes.

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

Eastern Ontario Diamond Drilling Ltd. from Hawkesbury, Ontario supplied truck mounted CME 55 drill rig and conducted the drilling, sampling and in-situ testing operations.

The drilling and sampling operations in the field were supervised on a full time basis by Mr. George Azzopardi and Ms. Eckie Siu of Thurber Engineering Ltd.

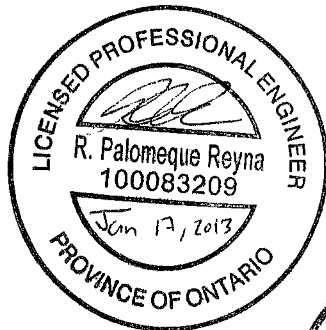
Routine laboratory testing was carried out by Thurber Engineering Ltd.

Overall planning and supervision of the field program was conducted 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.

Thurber Engineering Ltd.

Rocío Palomeque Reyna, P.Eng., M.Eng.
Geotechnical Engineer



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

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

FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 11
BLACKWATER RIVER BRIDGE REPLACEMENT
GREENSTONE COMMUNITY, DISTRICT OF THUNDER BAY, ONTARIO

G.W.P. 6066-09-00, Site No. 48C-1

Geocres Number: 42E-14

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL

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 located at the crossing of Highway 11 over the Blackwater River in Greenstone Community, Thurder Bay District, Ontario.

The existing bridge is a seven-span structure with a concrete deck supported on timber bents and 10.7-m long timber piles. The length of the bridge is 51.3 m and the width is 11.5 m. The existing approach embankments are approximately 2.0 m to 3.0 m high.

Based on the preliminary General Arrangement (GA) drawing provided by MRC, the proposed bridge is a three-span structure consisting of a deck supported on precast pre-stressed concrete box girders supported on two abutments and two piers. The abutments and piers will be supported on steel H-piles. A sheet pile wall will be installed immediately behind the row of H-piles at the abutments to contain the approach fill, in lieu of a conventional abutment. The spans of the new structure will be 12.0 m, 19.0 m and 12.0 m and the width will be 12.7 m. The construction will be staged to maintain one lane of traffic.

The discussion and recommendations presented in this report are based on the information provided by MRC and on the factual data obtained in the course of the investigation.

8 STRUCTURE FOUNDATIONS

In general terms, the stratigraphy encountered at the site generally consists of pavement structure over 2.7 m to 3.0 m of sand fill approach embankment. The relative density of the sand fill varied from very loose to compact. The native soils generally consist of cohesionless soils varying in gradation from sands to silts and sandy silts. These native soils are in a very loose to compact state. In a few locations, the native soils are in a dense state. Occasional cobbles and boulders were encountered in the native soil. Layers of gravel and sand and gravel were encountered below the silt and sand layers in boreholes drilled at the south pier and north abutment. Bedrock or a layer of refusal was not encountered in any of the boreholes within the depth of exploration of 31.0 m to 42.0 m.

Piezometric readings indicate that the groundwater level is near elevations 303.0 and 303.5, at the south and north abutments, respectively. GA drawing indicates that the water level in Blackwater River was at Elevation 301.2 on April 2011. Normal high water level is 302.4, for a two year return period.

Based on existing site conditions, initial consideration was given to the following foundation types:

- Spread footings on native soils
- Augered Caissons (drilled shafts)
- Driven steel H-piles

A comparison of the foundation alternatives based on advantages and disadvantages of each is included in Appendix D.

8.1 Spread Footings on Native Soils

Consideration was given to supporting the structure on spread footings founded on native soils. However, this option is not recommended due to the following reasons:

- Low geotechnical capacities are available at this site in the native very loose to compact sands and silts.
- Unacceptable settlements, larger than 25 mm, under footing loads will occur if footings are placed on the native soils.
- Suitable bearing stratum is not available within a reasonable and practical depth of excavation.
- Temporary footing excavation may have environmentally impact on the river.
- Scour protection will be required for footings.

In light of the above factors, the spread footings option was not further developed.

8.2 Socketted Drilled Shafts/Caissons

Caissons are not recommended at this site since suitable end bearing materials were not encountered within the borehole exploration depth, which ranged from 31.2 m to 42.8 m. In addition, construction of caissons in the cohesionless soils below water table will be challenging. Sealing of the caisson liner into the founding stratum will be difficult and base boiling may also be encountered. Caisson base inspection will also not be possible at this site.

This option, therefore, was not developed further.

8.3 Driven Steel H-piles

The subsurface conditions at the abutments and piers are considered suitable for the design of foundations supported on steel H-piles. Driven steel H-piles will develop resistance to vertical loads primarily through frictional resistance along the sides of the H-piles within the native loose to compact silts and sands.

The factored Geotechnical Resistances at ULS (per pile) and Geotechnical Resistance at SLS (25 mm settlement) estimated for two pile sections, HP 310x110 and HP 360x 132, driven to various depths into the native silts and sands are as indicated in Table 8.1.

Table 8.1 – Recommended Axial Resistances for Steel H-Piles

Foundation Unit	Pile length below underside of pile cap	Pile Tip Elevation	HP 310x110		HP 360x132	
	(m)		ULS (kN)	SLS (kN)	ULS (kN)	SLS (kN)
Abutments	15	289.5	190	160	240	200
	20	284.5	370	310	460	380
	25	279.5	600	500	740	615
	30	274.5	885	740	1,085	900
	35	269.5	1,200	1,000	1,400	1,150
	40	264.5	1,400	1,150	1,700	1,400
	44.8	259.7	1,700	1,400	1,900	1,580
Piers	18.5	285.5	190	160	240	200
	23.5	280.5	370	310	460	380
	28.5	275.5	600	500	740	615
	33.5	270.5	885	740	1,085	900
	38.5	265.5	1,100	920	1,400	1,150
	42	262.0	1,350	1,125	1,700	1,400

-Native silts and sands were contacted near elevations 303.5 and 299.0 at the abutments and piers, respectively.
-Based on GA drawing, the underside of pile cap is approximately at elevations 304.5 at the abutments and 304.0 at the piers.

8.3.1 Pile Installation

Pile installation should be in accordance with OPSS 903, November 2009.

No pile shoe or tip protector should be used since the piles are designed as friction piles.

For piles driven into compact silts and sands, pile driving must be controlled by the Hiley Formula and an ultimate pile resistance to be specified by the designer in accordance with Clause 3.3.2 (b) Construction Stage of the Structural Manual. The Hiley formula need not be used until the piles are within 2.0 m of design tip elevation. The appropriate pile driving note is "Piles to be driven in accordance with Standard SS 103-11 using an ultimate resistance of "R" kN per pile". "R" must have a minimum value of twice the design load at ULS.

To facilitate pile installation, embankment fill through which piles will be driven must not contain oversize material, i.e. no particles exceeding 75 mm in size.

It should be noted that rockfill is visible on the side slopes of the highway embankments. If such obstructions are encountered at the proposed location of the H-piles they will have to be removed to facilitate driving of H-piles.

8.3.2 Downdrag

Downdrag on the piles is not considered to be an issue at this site.

8.3.3 Lateral Resistance for H-piles

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

$$k_s = n_h \cdot z / D \quad (kN/m^3)$$

$$p_{ult} = 3 \cdot \gamma \cdot z \cdot K_p \quad (kPa)$$

where z = depth of embedment of pile in metres

D = pile width/diameter in metres

n_h = coefficient related to soil density
3,000 kN/m^3 in native loose to compact silt/sand below groundwater level

γ = unit weight
10 kN/m^3 (buoyant unit weight below water table)

K_p = passive earth pressure coefficient
3.0 for native loose to compact silt/sand

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/diameter (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 110 kN at ULS and 40 kN at SLS for a pile section HP 310x110 and no more than 150 kN at ULS and 50 kN at SLS for a pile section HP 360x132.

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

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.

8.4 Recommended Foundation

From a geotechnical perspective, the recommended foundation alternative to support the bridge abutments and piers at this site is driven steel H-piles.

8.5 Frost Cover

The design depth of frost penetration at this site is 2.6 m.

Frost protection should be provided for buried pile caps, if used, and should consist of a minimum of 2.6 m of soil cover.

8.6 Impact of Pile Driving on Existing Bridge

The pier piles for the new bridge will be driven in between the existing timber bents. The distance between the proposed pier locations and the nearest timber bents ranged from 2.0 m to 6.0 m for the south pier and 2.5 m to 3.0 m for the north pier. The new abutment piles will be driven approximately 2.8 m in front of the existing abutments.

It is considered that the risk of settlement of the existing bridge foundations by adjacent pile driving is low, but it is recommended that the contract documents include a monitoring program for the existing structure. As a minimum, this program should require the contractor to establish reference points over each abutment and each pile bent of the existing structure and to monitor movement of these points relative to known, fixed reference points on a regular basis during driving of the piles. Inspection of the existing pile bents should be conducted during pile driving to identify any movement.

The structural design team should assess the magnitude of settlement or horizontal displacement that would constitute a concern for the stability or serviceability of the existing structure and these limits should be incorporated into a monitoring program in the construction contract.

9 SHEET PILE WALLS

Steel sheet pile walls will be driven adjacent to the H-pile foundations at each abutment. The sheet piles will provide containment and resistance to lateral earth pressures from the approach fill. Alignment of the sheet pile walls should be carefully selected so that during installation of the sheet piles, they do not encounter the timber piles below the existing abutment on the proposed steel H-piles for the new abutment.

Driving of the sheet piles through the existing approach fill (very loose to compact sand) is feasible.

Backfill to the sheet pile walls should be in accordance with OPSS 902. Granular backfill should be placed to the extents shown in OPSD 3101.150. All granular material should meet the specifications of OPSS 1010 as amended by Special Provision 110S13. Compaction equipment to be used adjacent to retaining structures should be restricted in accordance with OPSS 501.

Earth pressures acting on the sheet pile walls may be assumed to be triangular and to be governed by the characteristics of the abutment backfill and the underlying native soils. 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 9.1)

γ = unit weight of retained soil (see Table 9.1)

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

q = value of any surcharge (kPa)

Earth pressure coefficients for backfill to the abutment wall are dependent on the material used as backfill. Typical values are shown in Table 9.1.

Table 9.1 – Earth Pressure Coefficient (K)

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		Native Sand/Silt $\phi = 30°$, $\gamma = 20$ kN/m^3		
	Horizontal Surface	Sloping Surface in front of Wall (2H:1V)	Horizontal Surface	Sloping Surface in front of Wall (2H:1V)	Horizontal Surface	Sloping Surface in front of Wall (2H:1V)	Surface in front of Wall (3H:1V)
Active (Unrestrained Wall)	0.27	0.38	0.31	0.46	0.33	0.54	0.41
At rest (Restrained Wall)	0.43	0.43	0.47	0.47	0.5	0.5	0.51
Passive (Movement Towards Soil Mass)	3.7	2.1	3.3	1.7	3.0	1.5	2.1

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) is preferred as it results in lower earth pressures acting on the wall.

The factors in Table 9.1 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 C6.16 in the Commentary to the Canadian Highway Bridge Design Code.

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.

10 EXCAVATION AND GROUNDWATER CONTROL

If any 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.

Piezometric readings indicate that the water level is near elevations 303.0 and 303.5, at the south and north abutments, respectively. GA drawing indicates that the water level in Blackwater River was at Elevation 301.2 on April 2011. Normal high water level is 302.4, for a two year return period.

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

It is recommended that excavation for removal of existing structures be maintained above the water level in the river. Any excavation below the groundwater level/river level without prior dewatering is not recommended since the inflow of groundwater will make it difficult to maintain a dry, sound base on which to work.

In general, 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

Based on a site observations and GA drawing provided by MRC, it was estimated that the existing approach embankments are approximately 2.0 m to 3.0 m high with forward slopes near inclinations of about 2H:1V to 3H:1V. The foundation soils governing stability of the approach embankments consist generally of native loose to compact sands and silts.

Communication with MRC indicates that no grade raise is anticipated at the existing Highway 11.

It is understood that additional fill will be required between the existing abutment and behind the new sheet pile wall. This new fill is expected to have a maximum thickness of about 2.5 m to 3.5 m. The sides of the new approach fill will be contained by sheet pile walls. Prior to placement of new fill, all topsoil, organics or other unsuitable materials must be stripped from the subgrade.

Comments regarding stability of embankment slopes and settlement of the foundations soils are provided in the following sections.

11.1 Slope Stability

The existing embankments bearing on the foundation soils at this site appear to be performing satisfactorily under the existing conditions.

The additional approach fill (approximately 2.5 m to 3.5 m) to be placed behind the new abutment will be supported within a sheet pile enclosure and therefore the stability of the new approach will be governed by the sheet pile wall design. A global slope stability analysis was conducted to assess the embedment requirements for a sheet pile supporting the new approach fill behind the sheet pile walls. The analyses were carried out using the Morgenstern-Price method of slope stability analysis.

The results of the analyses indicate that an adequate factor of safety of 1.5 is achieved for the long term conditions if the sheet pile is driven to or below elevations 298.0 and 298.9 at the south and north abutment, respectively.

The slope stability computation outputs are included in Appendix E.

The stability of the embankments was not checked under seismic loading as the zonal acceleration at this site is 0.0g.

11.2 Settlement

The placement of approximately 2.5 m to 3.5 m of new fill behind the sheet pile abutments will induce immediate (elastic) settlement in the existing non-cohesive fill and the underlying native sand and silt layers.

The total immediate settlement was assessed using elastic methods theory. Based on these analyses, the settlement at the bridge approaches under the weight of the additional approach fill is estimated to be in the order of 25 mm to 30 mm.

Due to the non-cohesive nature of the foundation soils, these settlements will be immediate and essentially completed when construction of the bridge is completed.

Figure 1 in Appendix D shows that a minimum factor of safety of 1.1.4 is obtained for a shallow failure mode. Any over steepening of the river bank may result in more extensive failure. It is therefore critical to prevent river bank erosion so that the forward slope is not undermined.

12 EROSION PROTECTION

The native sands and silts at this site are susceptible to erosion. It is recommended that the potential for erosion be investigated by the bridge designer. As indicated in Section 11.1, any river bank erosion under the abutments must be prevented by providing rock protection.

A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion, in general accordance with OPSS 804.

13 ROADWAY PROTECTION

The bridge construction will be done in stages in order to keep at least one highway lane operational. Roadway protection will be required to facilitate staging of removals and support the existing Highway 11.

Roadway protection should be provided in accordance with OPSS 539 and designed for Performance Level 2.

Continuous sheet piles or conventional steel soldier pile and timber lagging walls are two options to provide temporary support to the roadway during excavation. 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:

γ	=	21 kN/m^3	(bulk unit weight)
γ_w	=	11 kN/m^3	(submerged unit weight under groundwater table)
K_a	=	0.33	(Active pressure coefficient for: road embankment sand fill and native sand/silt)
K_p	=	3.0	(Passive pressure coefficient for: road embankment sand fill and native sand/silt)
h_w	=	303.5	(groundwater level at this site)

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 may 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.

14 SEISMIC CONSIDERATIONS

14.1 Seismic Design Parameters

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 III. Therefore, according to Table 4.4.6.1 of the CHBDC, a Site Coefficient "S" (ground motion amplification factor) of 1.5 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 14.1 may be used:

Table 14.1 – 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	**Native Sand/Silt** $\phi = 30°$, $\gamma = 20$ kN/m^3
Active (K_{AE})*	0.28	0.32	0.34
Passive (K_{PE})	3.7	3.2	2.9
At Rest (K_{OE})**	0.45	0.50	0.53

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

The potential for liquefaction of the foundations soils was assessed using the Seed and Idriss (1971) method for cohesionless soils.

Using the method, it is estimated that under the existing conditions, the foundation soils at the abutments are not prone to liquefaction.

15 CONSTRUCTION CONCERNS

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

- Visual site inspection indicates presence of rockfill on the surface of the embankment side slopes. These rockfill will have to be removed in the area of piling to facilitate driving of piles.
- As indicated in the report, the risk of settlement of the foundations of the existing structure by adjacent pile driving is considered to be low. A monitoring program for the existing structure should be implemented at this site before and during construction of the new bridge.

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.

LICENSED PROFESSIONAL ENGINEER
R. Palomeque Reyna
100083209
PROVINCE OF ONTARIO

Rocío Palomeque Reyna, P.Eng., M.Eng.
Geotechnical Engineer

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

LICENSED PROFESSIONAL ENGINEER
M. R. ANDERSON
PROVINCE OF ONTARIO

Report reviewed by:
P.K. Chatterji, P.Eng., Ph.D.
Review Principal

LICENSED PROFESSIONAL ENGINEER
P. K. CHAT?ERJI
PROVINCE OF ONTARIO

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No BWR-01

METRIC

W.P.	6066-09-00	LOCATION	Blackwater River Bridge N 5 497 207.0 E 235 637.0	ORIGINATED BY	ES
HWY	11	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.07.29 - 2012.07.29	CHECKED BY	LRB

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
305.5	
0.0	**ASPHALT:** (100mm)
0.1	**SAND**, some silt, trace clay Compact to Very Loose Brown Damp (FILL) Occasional oxide staining
302.4 / 3.1	**SAND**, trace silt, mixed with organics, occasional rootlets Very Loose Dark Brown Moist
300.9 / 4.6	**SILT**, trace sand, trace clay Compact Light Brown Wet Loose
298.3 / 7.2	Sandy **SILT**, some clay Very Loose Brown to Grey Wet Loose
295.7 / 9.8	END OF BOREHOLE AT 9.8m.

SAMPLES

NUMBER	TYPE	"N" VALUES	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	GS		
1	SS	13	
2	SS	4	0 79 18 3
3	SS	3	
4	SS	2	
5	SS	10	0 6 89 5
6	SS	4	
7	SS	1	0 47 51 2
8	SS	9	

Ground water level symbol (∇) at approx. elevation 301.8.

ELEVATION SCALE: 305, 304, 303, 302, 301, 300, 299, 298, 297, 296

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 Next Page

+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No BWR-01

METRIC

W.P.	6066-09-00	LOCATION	Blackwater River Bridge N 5 497 207.0 E 235 637.0	ORIGINATED BY	ES
HWY	11	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.07.29 - 2012.07.29	CHECKED BY	LRB

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, × 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
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	WATER LEVEL AT 3.8m UPON COMPLETION. BOREHOLE BACKFILLED WITH HOLEPLUG TO 7.9m, AUGER CUTTINGS TO 0.15m, THEN ASPHALT TO SURFACE.										

+ ³, × ³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No BWR-03

METRIC

W.P.	6066-09-00	LOCATION	Blackwater River Bridge N 5 497 221.0 E 235 636.0	ORIGINATED BY	ES
HWY	11	BOREHOLE TYPE	Casing/HW/NW	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.07.27 - 2012.07.28	CHECKED BY	RPR

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)

Ground surface elevation: 305.6

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
0.0	**ASPHALT:** (100mm)							
305.3 / 0.1	**CONCRETE:** (200mm)							
0.3	Gap between underside of bridge deck and ground surface							
303.6 / 2.0	Sandy **SILT**, trace clay, trace gravel Loose Brown Moist							
	Occasional cobbles	1	SS	4	7	38	54	1
	Occasional wood fragments Dark Brown Wet	2	SS	9				
		3	SS	8				
298.4 / 7.2	**SILT**, some sand, trace clay Very Loose Grey Moist	4	SS	2	0	14	81	5
296.9 / 8.7	**SAND**, trace silt Compact Grey Moist	5	SS	15				
295.7								

Elevation scale: 305, 304, 303, 302, 301, 300, 299, 298, 297, 296

Continued Next Page

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

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

ONTMT4S 1197.GPJ 10/15/12

RECORD OF BOREHOLE No BWR-03

METRIC

W.P. 6066-09-00 | LOCATION Blackwater River Bridge N 5 497 221.0 E 235 636.0 | ORIGINATED BY ES

HWY 11 | BOREHOLE TYPE Casing/HW/NW | COMPILED BY AN

DATUM Geodetic | DATE 2012.07.27 - 2012.07.28 | CHECKED BY RPR

Continued From Previous Page

SOIL PROFILE

ELEV/DEPTH 9.9 — **SILT**, trace sand, trace clay
- Grey
- Moist
- Loose
- No recovery
- Occasional cobbles
- Dense
- Moist to Wet
- Compact
- Wet

SAMPLES

Number	Type	"N" Values	Water Content (%)	Remarks & Grain Size Distribution (%) GR SA SI CL
6	SS	7	○	
7	SS	42		
8	SS	16	○	0 3 91 6
9	SS	23	○	
10	SS	23	○	
11	SS	15	○	0 7 88 5

Elevation scale: 295, 294, 293, 292, 291, 290, 289, 288, 287, 286

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

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 BWR-03

METRIC

W.P.	6066-09-00	LOCATION	Blackwater River Bridge N 5 497 221.0 E 235 636.0	ORIGINATED BY	ES
HWY	11	BOREHOLE TYPE	Casing/HW/NW	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.07.27 - 2012.07.28	CHECKED BY	RPR

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILT, trace to some sand, trace clay Compact Grey Moist	12	SS	22		
					285	
		13	SS	17	284	
					283	
					282	
	Dense	14	SS	31	281	0 17 76 7
					280	
279.4 26.2	**SAND**, some silt, trace gravel, trace clay Dense Grey Moist				279	
		15	SS	38	278	
					277	
					276	

Plot headings: 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; GROUND WATER CONDITIONS; STRAT PLOT.

Continued Next Page

+ ³, × ³ : Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No BWR-03

METRIC

W.P.	6066-09-00	LOCATION	Blackwater River Bridge N 5 497 221.0 E 235 636.0	ORIGINATED BY	ES
HWY	11	BOREHOLE TYPE	Casing/HW/NW	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.07.27 - 2012.07.28	CHECKED BY	RPR

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND, some silt to silty, trace gravel, trace clay Compact Grey Moist					
		16	SS	28	275	2 74 22 2
					274	
					273	
	Casing from 30.5m to 33.5m					
		17	SS	27	272	
					271	
					270	
	Wet Occasional cobbles					
		18	SS	24	269	
					268	
					267	
	Occasional boulders					
	Trace silt and clay Dense				266	
		19	SS	37		0 98 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.

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 BWR-03

METRIC

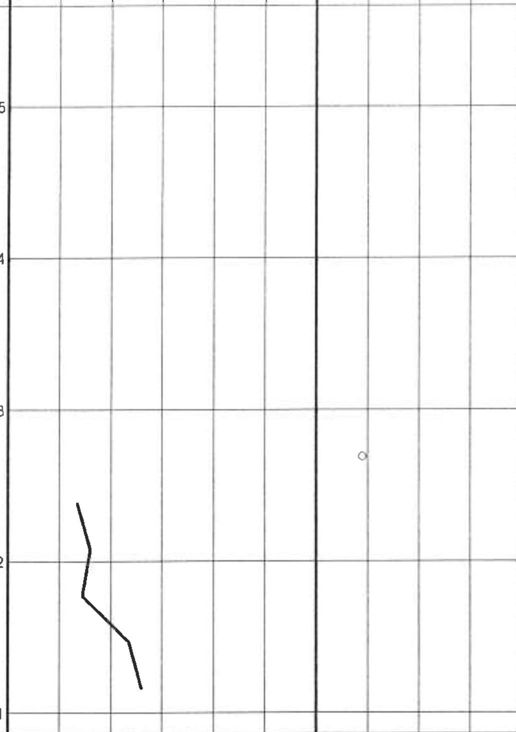
W.P.	6066-09-00	LOCATION	Blackwater River Bridge N 5 497 221.0 E 235 636.0	ORIGINATED BY	ES
HWY	11	BOREHOLE TYPE	Casing/HW/NW	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.07.27 - 2012.07.28	CHECKED BY	RPR

ELEV DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL (SI+CL)
	Continued From Previous Page								
	SAND, trace silt and clay Dense Grey Moist						265		
							264		
							263		
			20	SS	37				
	Start DCPT at 43.3m						262		
							261		
260.8 44.8	END OF BOREHOLE AT 44.8m. BOREHOLE CAVED IN FROM 33.5m TO 44.8m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.								

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



WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
Sep. 13/12	2.9	302.7
Sep. 26/12	2.6	303.0

+ ³, × ³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No BWR-04

METRIC

W.P. 6066-09-00	LOCATION Blackwater River Bridge N 5 497 231.7 E 235 625.1		ORIGINATED BY RK
HWY 11	BOREHOLE TYPE HW/NW		COMPILED BY AN
DATUM Geodetic	DATE 2012.08.11 - 2012.08.12		CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
305.7												
0.0	**ASPHALT:** (100mm)											
305.4 / 0.1	**CONCRETE:** (225mm)											
0.3	Gap between underside of bridge deck and ground surface					305, 304, 303, 302						
300.9 / 4.8	**WATER**					301, 300, 299						
298.8 / 6.9	**SAND,** mixed with organics, wood fragments Compact Dark Brown Wet	1	SS	11			>>					
298.1 / 7.6	Sandy **SILT**, trace clay, trace gravel Compact Grey Wet	2	SS	14		298, 297, 296	o		3	54	40	3

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

REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

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

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No BWR-04

METRIC

W.P. 6066-09-00 | LOCATION Blackwater River Bridge N 5 497 231.7 E 235 625.1 | ORIGINATED BY RK

HWY 11 | BOREHOLE TYPE HW/NW | COMPILED BY AN

DATUM Geodetic | DATE 2012.08.11 - 2012.08.12 | CHECKED BY RPR

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, 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	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
	Sandy **SILT**, trace clay Compact Grey Wet	3	SS	12					
					295				
		4	SS	15	294	0	25	73	2
					293				
		5	SS	11					
					292				
	Loose	6	SS	7	291				
					290				
		7	SS	8		0	45	53	2
					289				
288.1 / 17.6	**SILT**, trace clay, trace sand Compact Grey Wet	8	SS	13	288				
					287				
		9	SS	19	286				

Continued Next Page

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

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No BWR-04

METRIC

W.P. 6066-09-00 | LOCATION Blackwater River Bridge N 5 497 231.7 E 235 625.1 | ORIGINATED BY RK

HWY 11 | BOREHOLE TYPE HW/NW | COMPILED BY AN

DATUM Geodetic | DATE 2012.08.11 - 2012.08.12 | CHECKED BY RPR

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	SILT, trace clay, trace sand Compact Grey Wet				285					
					284					
		10	SS	15		~19	0	7	85	8
					283					
					282					
					281					
		11	SS	13		~20				
					280					
					279					
					278					
		12	SS	30		~18				
					277					
					276					

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

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No BWR-04

METRIC

W.P. 6066-09-00 LOCATION Blackwater River Bridge N 5 497 231.7 E 235 625.1 ORIGINATED BY RK

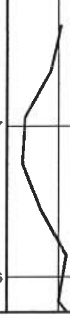
HWY 11 BOREHOLE TYPE HW/NW COMPILED BY AN

DATUM Geodetic DATE 2012.08.11 - 2012.08.12 CHECKED BY RPR

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILT, some sand, trace clay Compact Grey Wet	13	SS	24	
		14	SS	24	0 14 81 5
269.1 / 36.6	**GRAVEL** Compact Grey Wet	15	SS	20	
267.6 / 38.1	Start DCPT from 38.1m				

Elevation scale: 275, 274, 273, 272, 271, 270, 269, 268, 267, 266



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

Ministry of Transportation Ontario

THURBER

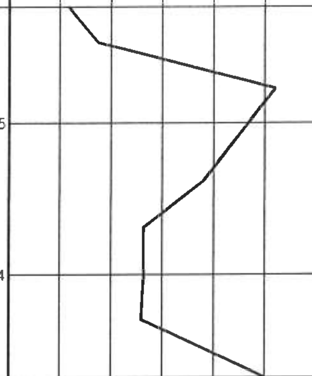
RECORD OF BOREHOLE No BWR-04

METRIC

W.P. 6066-09-00 LOCATION Blackwater River Bridge N 5 497 231.7 E 235 625.1 ORIGINATED BY RK

HWY 11 BOREHOLE TYPE HW/NW COMPILED BY AN

DATUM Geodetic DATE 2012.08.11 - 2012.08.12 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
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page						265 264				
263.3 42.4	END OF BOREHOLE AT 42.4m. BOREHOLE CAVED IN UPON COMPLETION OF DRILLING.										

ONTMT4S 1197.GPJ 9/18/12

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

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No BWR-07

METRIC

W.P.	6066-09-00	LOCATION	Blackwater River Bridge N 5 497 251.7 E 235 632.2	ORIGINATED BY	RK
HWY	11	BOREHOLE TYPE	HW	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.08.09 - 2012.08.11	CHECKED BY	RPR

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)
305.7					
0.0	**ASPHALT:** (100mm)				
305.4 / 0.1	**CONCRETE:** (225mm)				
0.3	Gap between underside of bridge deck and ground surface				
301.0 / 4.7	**WATER**				
299.5 / 6.2	**SAND**, wood fragments Very Loose Grey Wet	1	SS	2	
297.6 / 8.1	**SAND and GRAVEL**, some silt Compact Grey Wet	2	SS	10	

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (305, 304, 303, 302, 301, 300, 299, 298, 297, 296); 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 Next Page

+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No BWR-07

METRIC

W.P.	6066-09-00	LOCATION	Blackwater River Bridge N 5 497 251.7 E 235 632.2	ORIGINATED BY	RK
HWY	11	BOREHOLE TYPE	HW	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.08.09 - 2012.08.11	CHECKED BY	RPR

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND and **GRAVEL**, some silt Very Loose Grey Wet	3	SS	0	
294.6 11.1	Sandy **SILT** Loose Grey Wet	4	SS	4	
	Some gravel, trace clay Compact Light Brown Wet	5	SS	16	
291.5 14.2	**SAND**, coarse, trace gravel Loose to Compact Grey Wet	6	SS	5	
	No recovery	7	SS	12	
		8	SS	6	
287.4 18.3	Sandy **SILT**, trace clay Loose Grey Wet	9	SS	8	0 32 65 3

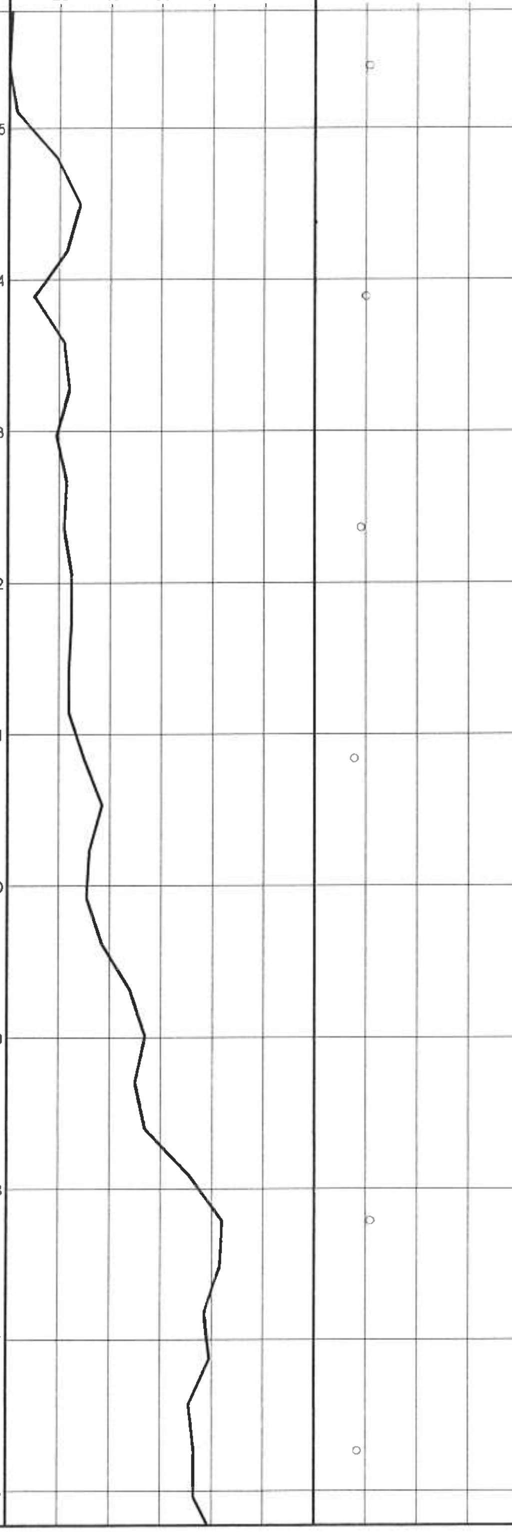
Elevation scale: 295, 294, 293, 292, 291, 290, 289, 288, 287, 286

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



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 BWR-07

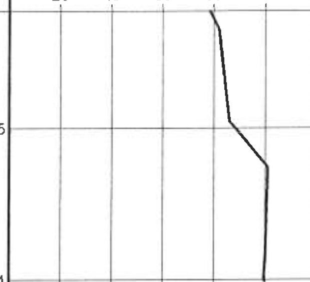
 METRIC

W.P.	6066-09-00	LOCATION	Blackwater River Bridge N 5 497 251.7 E 235 632.2	ORIGINATED BY	RK
HWY	11	BOREHOLE TYPE	HW	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.08.09 - 2012.08.11	CHECKED BY	RPR

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Sandy **SILT**, trace clay Compact Grey Wet				285, 284	
		10	SS	15	283	
					282, 281	
		11	SS	29	280	
278.9 26.8	**SILT**, trace clay, trace sand Compact Grey Moist				279, 278	
		12	SS	29	277	0 2 94 4
					276	

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

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 BWR-07

METRIC

W.P. 6066-09-00 LOCATION Blackwater River Bridge N 5 497 251.7 E 235 632.2 ORIGINATED BY RK

HWY 11 BOREHOLE TYPE HW COMPILED BY AN

DATUM Geodetic DATE 2012.08.09 - 2012.08.11 CHECKED BY RPR

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILT, trace sand, trace clay Compact Grey Wet					
					275	
		13	SS	26	274	
					273	
					272	
		14	SS	19	271	
					270	
					269	
	Some sand Dense	15	SS	38	268	0 19 75 6
					267	
					266	

Continued Next Page

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

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

ONTMT4S 1197.GPJ 10/15/12

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No BWR-07

METRIC

W.P.	6066-09-00	LOCATION	Blackwater River Bridge N 5 497 251.7 E 235 632.2	ORIGINATED BY	RK
HWY	11	BOREHOLE TYPE	HW	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.08.09 - 2012.08.11	CHECKED BY	RPR

Continued From Previous Page

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
	SILT, trace sand, trace clay Compact Grey Wet		16	SS	23		265				
	Boulders						264				
263.6 42.1	Start DCPT from 42.1m						263	162			
262.7 43.0	END OF BOREHOLE AT 43.0m. BOREHOLE CAVED IN UPON COMPLETION OF DRILLING.										

Dynamic cone penetration resistance plot scale: 20 40 60 80 100

Shear strength legend: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; scale 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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No BWR-08

METRIC

W.P. 6066-09-00	LOCATION Blackwater River Bridge N 5 497 262.5 E 235 621.2		ORIGINATED BY ES/SLL
HWY 11	BOREHOLE TYPE NW Casing		COMPILED BY AN
DATUM Geodetic	DATE 2012.07.18 - 2012.07.25		CHECKED BY LRB

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
305.8										
0.0	**ASPHALT:** (100m)									
305.5 / 0.1	**CONCRETE:** (225mm)									
0.3	Gap between underside of bridge deck and ground surface				305, 304					
303.5 / 2.3	**SAND**, some silt, trace gravel, trace clay, occasional wood fragments. Very Loose. Brown. Moist				303					
		1	SS	0		○				
	Approximately 1.0m of wood fragments				302, 301, 300					
	Loose	2	SS	8	299	○				
	Compact	3	SS	10	298	○				
		4	SS	29	297, 296	○	4	83	13 (SI+CL)	

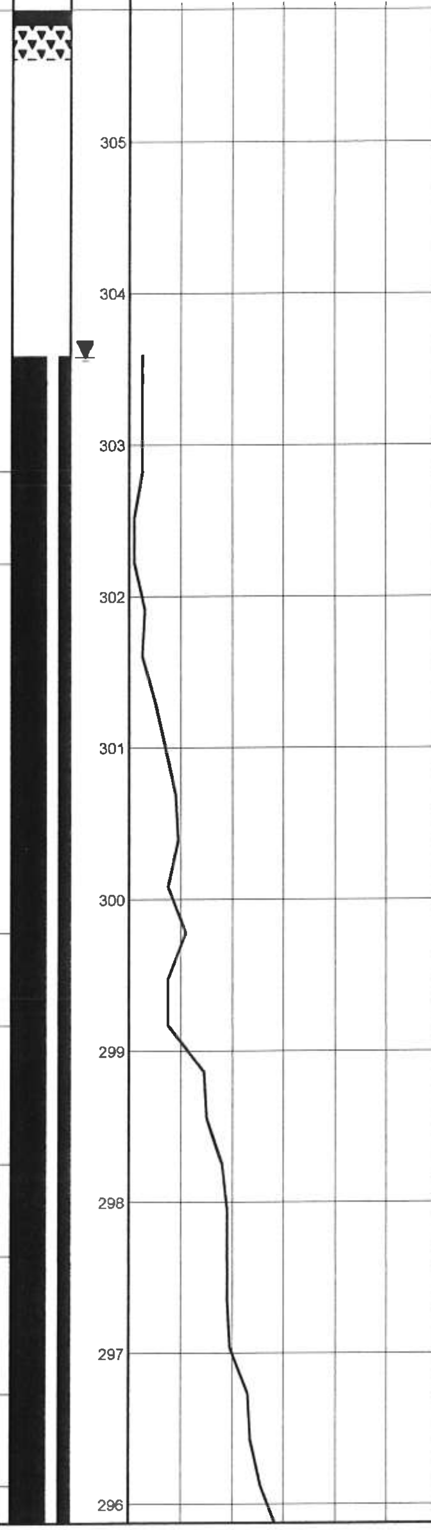
DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

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 Next Page

+³, ×³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No BWR-08

METRIC

W.P.	6066-09-00	LOCATION	Blackwater River Bridge N 5 497 262.5 E 235 621.2	ORIGINATED BY	ES/SLL
HWY	11	BOREHOLE TYPE	NW Casing	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.07.18 - 2012.07.25	CHECKED BY	LRB

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

SAND, some silt, trace gravel, trace clay
Compact
Grey
Wet

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
5	SS	18				
6	SS	23	2	65	33 (SI+CL)	
7	SS	18				
8	SS	26				
9	SS	29				
10	SS	20				

Elevation scale: 295, 294, 293, 292, 291, 290, 289, 288, 287, 286

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 BWR-08

METRIC

W.P.	6066-09-00	LOCATION	Blackwater River Bridge N 5 497 262.5 E 235 621.2	ORIGINATED BY	ES/SLL
HWY	11	BOREHOLE TYPE	NW Casing	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.07.18 - 2012.07.25	CHECKED BY	LRB

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND, some silt to silty, trace clay Very Dense Grey Wet	11	SS	56	○	0 70 28 2
284.3 21.5	**SILT**, trace clay Compact Grey Wet	12	SS	24	○	
	Very Dense	13	SS	50	○	
	Compact Casing	14	SS	29	○	0 0 93 7

Elevation scale: 285, 284, 283, 282, 281, 280, 279, 278, 277, 276

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; Unit weight γ kN/m³

Continued Next Page

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

ONTMT4S 1197.GPJ 10/15/12

RECORD OF BOREHOLE No BWR-08

METRIC

W.P.	6066-09-00	LOCATION	Blackwater River Bridge N 5 497 262.5 E 235 621.2	ORIGINATED BY	ES/SLL
HWY	11	BOREHOLE TYPE	NW Casing	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.07.18 - 2012.07.25	CHECKED BY	LRB

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE
	SILT, trace clay Compact Grey Wet				
					275
					274
		15	SS	13	
					273
					272
					271
		16	SS	19	
					270
					269
268.3 37.5	**SAND**, some silt Dense Grey Moist				
					268
		17	SS	34	
					267
					266

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; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

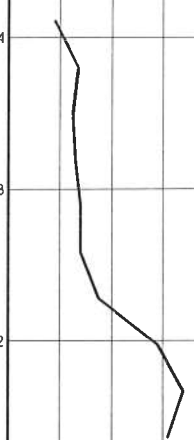
RECORD OF BOREHOLE No BWR-08

METRIC

W.P.	6066-09-00	LOCATION	Blackwater River Bridge N 5 497 262.5 E 235 621.2	ORIGINATED BY	ES/SLL
HWY	11	BOREHOLE TYPE	NW Casing	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.07.18 - 2012.07.25	CHECKED BY	LRB

SOIL PROFILE | 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 | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT
	Continued From Previous Page						
264.7	**SAND**, some silt Grey Moist Coring through cobbles and boulders from 40.5m to 41.8m		18	SS	100/ 0.0	265	
264.0 / 41.1	**SAND** and **GRAVEL** Dense Brown Moist		19	SS	45		c
261.0 / 41.8	End of sampling and start DCPT					264, 263, 262	
44.8	END OF BOREHOLE AT 44.8m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.						



WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
Sep. 13/12	2.6	303.2
Sep. 26/12	2.3	303.5

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No BWR-10

METRIC

W.P. 6066-09-00 | LOCATION Blackwater River Bridge N 5 497 275.0 E 235 620.5 | ORIGINATED BY ES

HWY 11 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY AN

DATUM Geodetic | DATE 2012.07.29 - 2012.07.29 | CHECKED BY LRB

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	GR	SA	SI	CL
305.9									
0.0	**ASPHALT:** (100mm)								
0.1	Silty **SAND**, trace to some gravel, trace clay, occasional oxide staining, Compact to Very Loose, Brown, Damp (FILL)	1	GS						
		1	SS	12					
		2	SS	3		1	58	39	2
	Occasional asphalt fragments	3	SS	10					
303.1 / 2.8	Gravelly **SAND**, Compact, Brown, Damp	4	SS	15	∇				
302.4 / 3.5	Sandy **SILT**, trace clay, Compact, Light Brown, Wet	5	SS	12		0	31	66	3
	Compact	6	SS	10					
	Loose, Grey	7	SS	5		0	27	68	5
		8	SS	9					
296.1 / 9.8	END OF BOREHOLE AT 9.8m.								

Elevation scale: 305, 304, 303, 302, 301, 300, 299, 298, 297

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 (%)

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 BWR-10

METRIC

W.P.	6066-09-00	LOCATION	Blackwater River Bridge N 5 497 275.0 E 235 620.5	ORIGINATED BY	ES
HWY	11	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.07.29 - 2012.07.29	CHECKED BY	LRB

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, × 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
ELEV DEPTH	DESCRIPTION Continued From Previous Page	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	WATER LEVEL AT 3.4m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO 0.15m, THEN ASPHALT TO SURFACE.										

+ ³, × ³: Numbers refer to Sensitivity

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

ONTMT4S 1197.GPJ 9/18/12

Appendix B

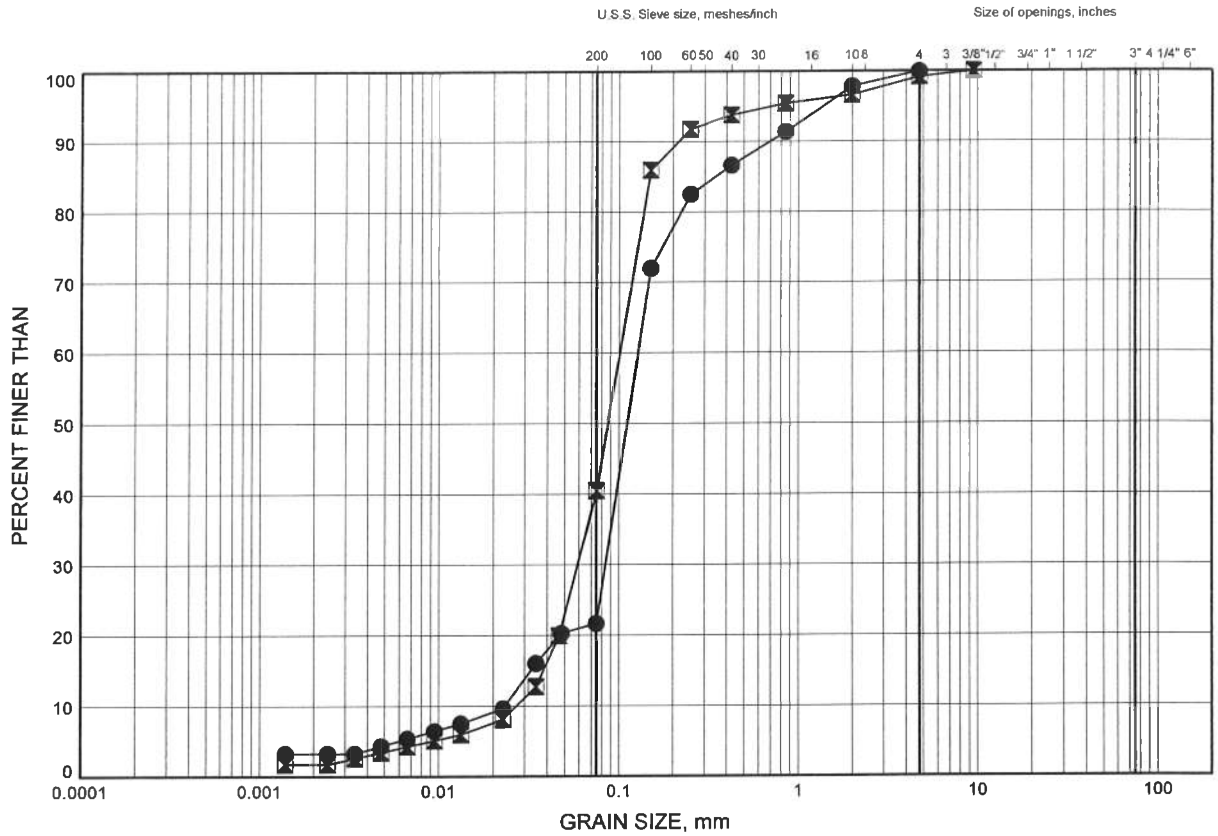
Laboratory Test Results

BLACKWATER RIVER BRIDGE

GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND & SILTY SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BWR-01	1.83	303.67
⊠	BWR-10	1.83	304.07

Date October 2012

W.P.# 6066-09-00

THURBER

Prep'd AN

Chkd. RPR

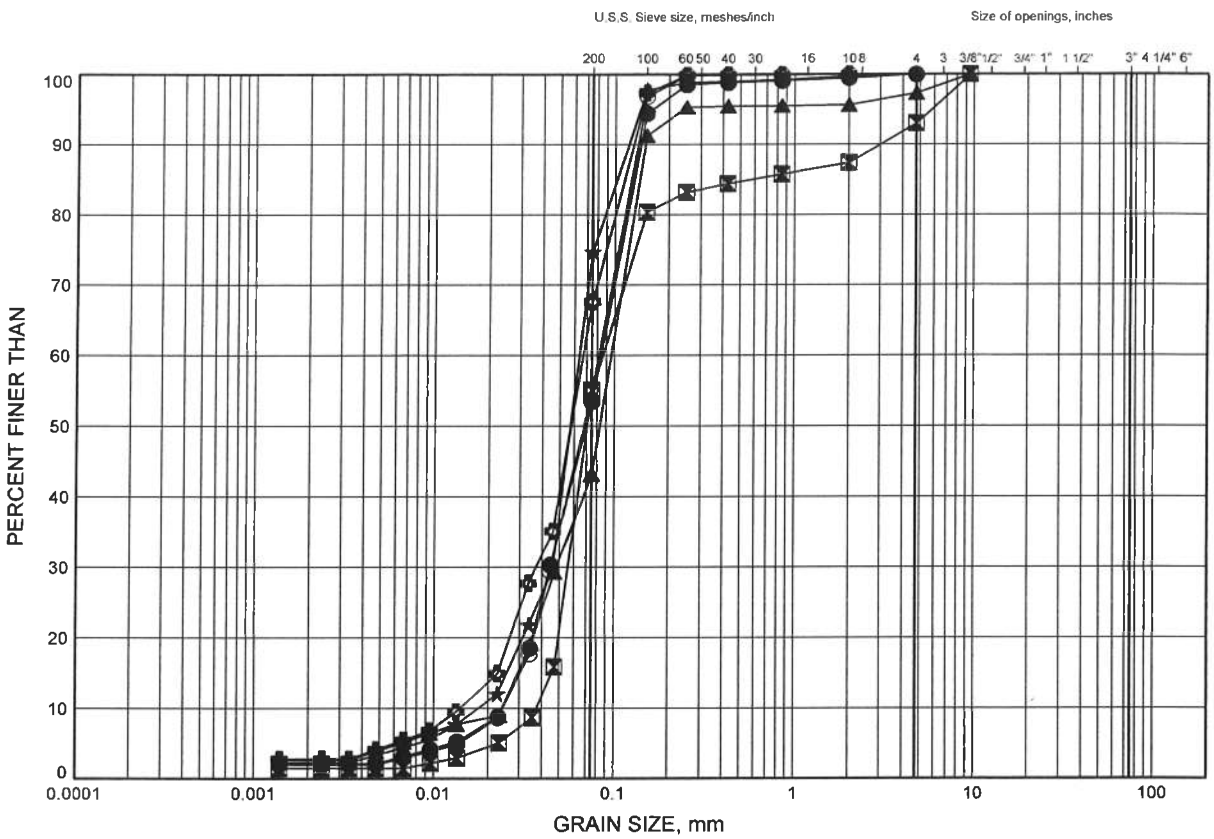
GRAIN SIZE DISTRIBUTION - THURBER 1197.GPJ 10/15/12

BLACKWATER RIVER BRIDGE

GRAIN SIZE DISTRIBUTION

FIGURE B2

SANDY SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BWR-01	7.92	297.58
⊠	BWR-03	3.35	302.25
▲	BWR-04	8.84	296.86
★	BWR-04	11.89	293.81
⊙	BWR-04	16.46	289.24
✿	BWR-07	19.51	286.19

Date September 2012

W.P.# 6066-09-00

THURBER

Prep'd AN

Chkd. RPR

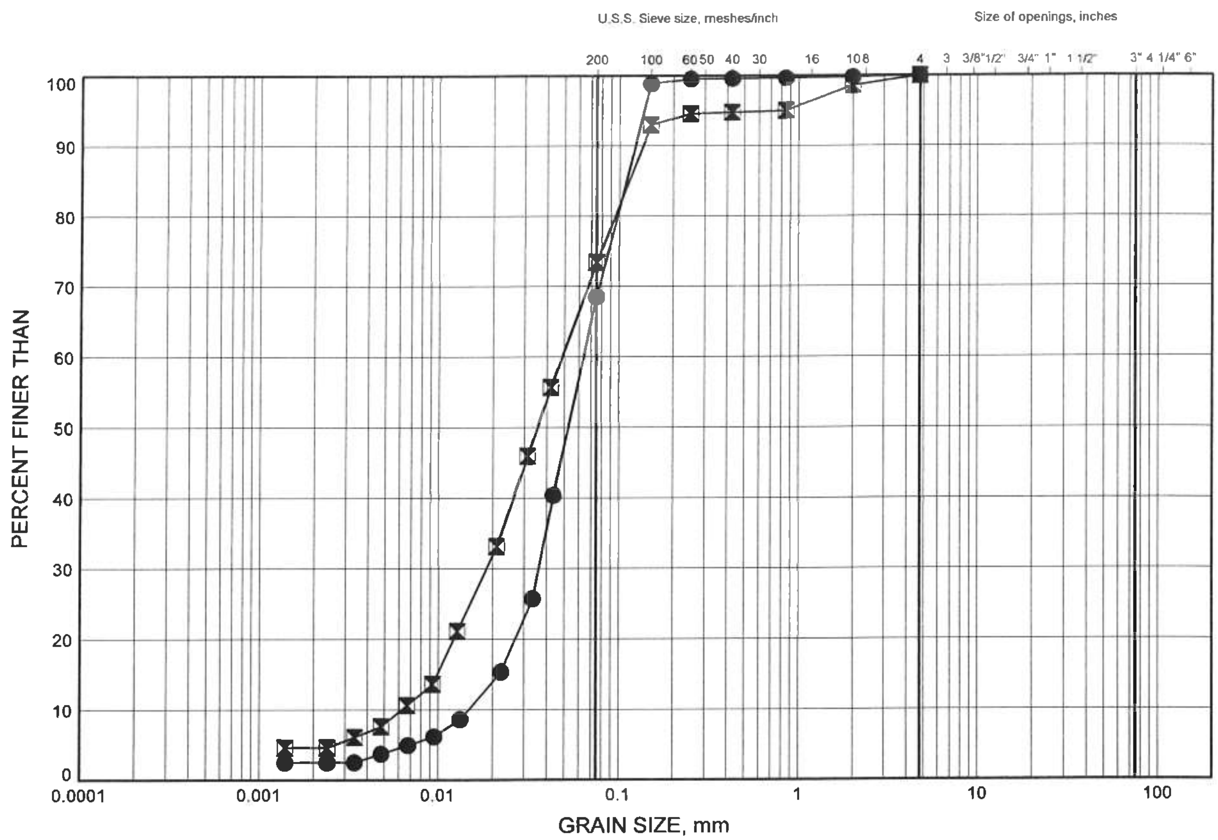
GRAIN SIZE DISTRIBUTION - THURBER 1197.GPJ 9/18/12

BLACKWATER RIVER BRIDGE

GRAIN SIZE DISTRIBUTION

FIGURE B3

SANDY SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BWR-10	4.88	301.02
⧗	BWR-10	7.92	297.98

GRAIN SIZE DISTRIBUTION - THURBER 1197.GPJ 10/15/12

Date October 2012

W.P.# 6066-09-00

THURBER

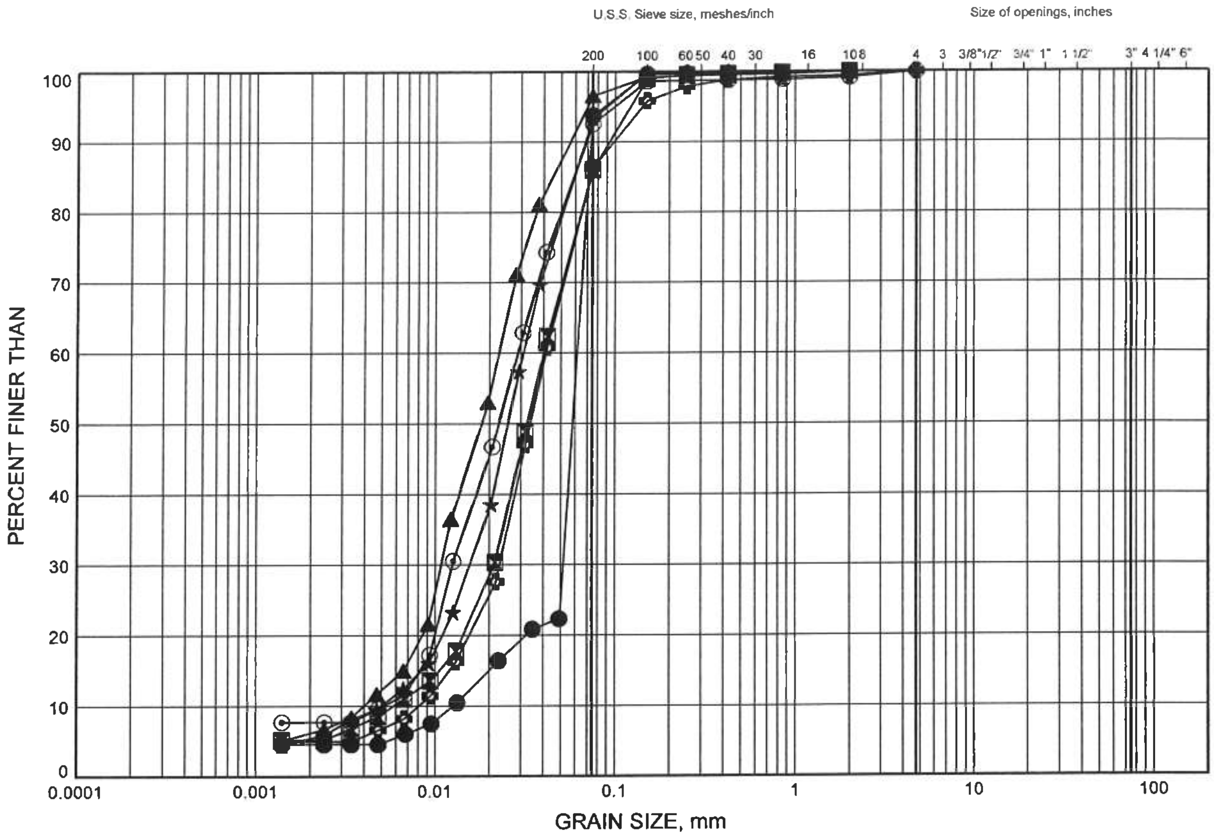
Prep'd AN

Chkd. RPR

BLACKWATER RIVER BRIDGE
GRAIN SIZE DISTRIBUTION

FIGURE B4

SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BWR-01	4.88	300.62
⊠	BWR-03	7.92	297.68
▲	BWR-03	14.02	291.58
★	BWR-03	18.59	287.01
⊙	BWR-04	22.56	283.14
✪	BWR-04	34.75	270.95

Date September 2012

W.P.# 6066-09-00

THURBER

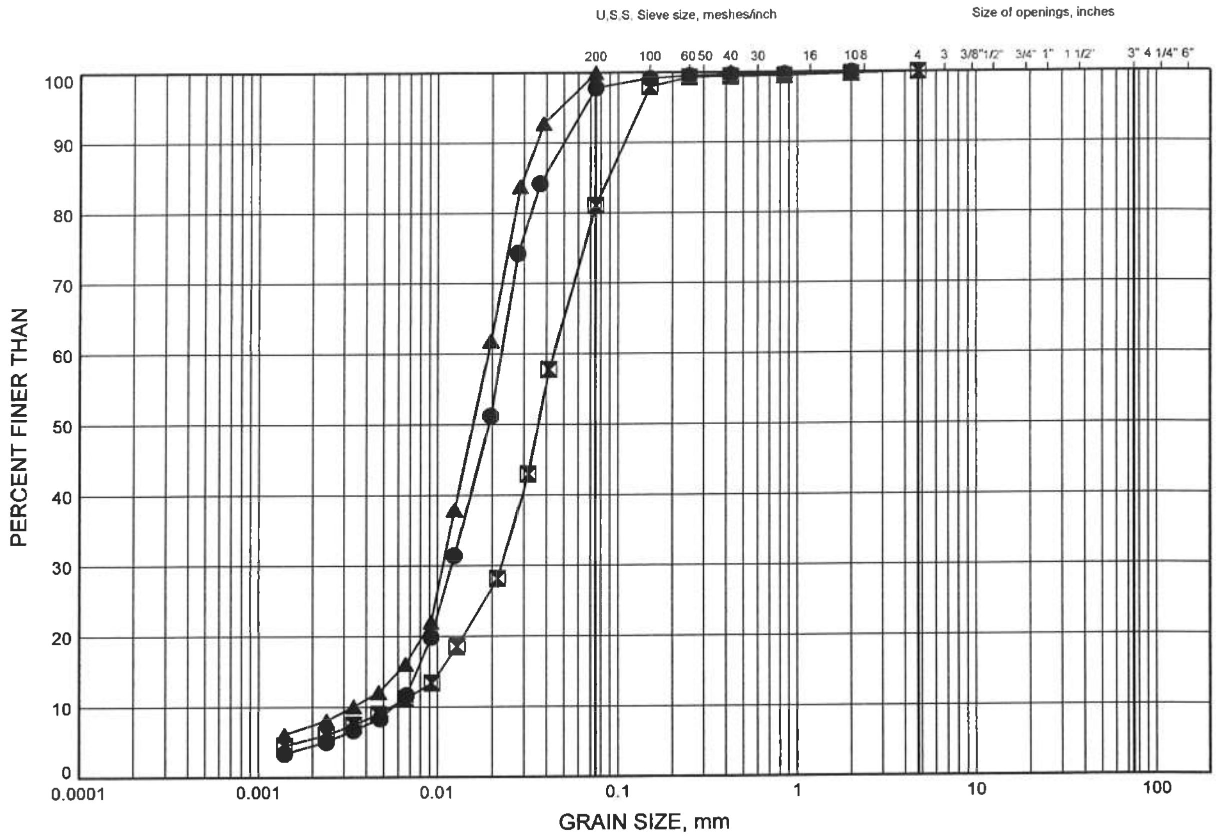
Prep'd AN

Chkd. RPR

GRAIN SIZE DISTRIBUTION - THURBER 1197.GPJ 9/18/12

BLACKWATER RIVER BRIDGE GRAIN SIZE DISTRIBUTION	FIGURE B5

SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BWR-07	28.65	277.05
⊠	BWR-07	37.80	267.90
▲	BWR-08	29.26	276.54

Date September 2012
W.P.# 6066-09-00

THURBER

Prep'd AN
Chkd. RPR

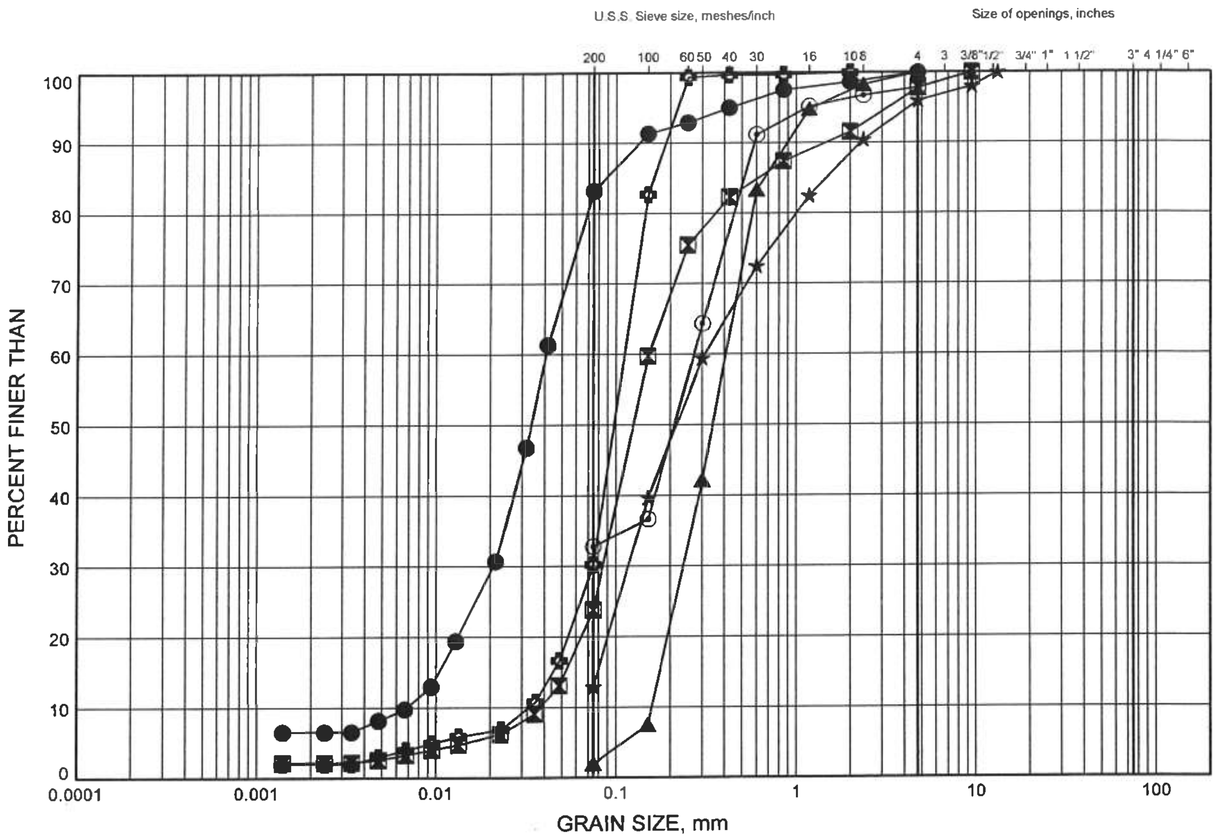
GRAIN SIZE DISTRIBUTION - THURBER 1197.GPJ 9/18/12

BLACKWATER RIVER BRIDGE

GRAIN SIZE DISTRIBUTION

FIGURE B6

SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BWR-03	24.69	280.91
⊠	BWR-03	30.78	274.82
▲	BWR-03	39.93	265.67
★	BWR-08	9.45	296.35
⊙	BWR-08	12.50	293.30
✪	BWR-08	20.12	285.68

GRAIN SIZE DISTRIBUTION - THURBER 1197.GPJ 9/18/12

Date September 2012

W.P.# 6066-09-00

THURBER

Prep'd AN

Chkd. RPR

Appendix C

Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT

Foundation Unit	Footing on Native Soil	Augered Caissons (drilled shafts)	Driven Piles to native sand/silt
	Advantages: i. Generally less costly construction than deep foundation elements. ***Disadvantages:*** i. Low available geotechnical resistance in native soils. ii. Potential for settlements. iii. Scour protection required.	***Advantages:*** i. Construction of caissons could continuc in freezing weather. ii. Subexcavation of fill not required. ***Disadvantages:*** i. Suitable bearing stratum was not encountered within the borehole depth of exploration. ii. Higher unit cost compared to spread footings. iii. Specialized installation measures such as temporary liners and drilling mud will be required to install caissons in cohesionless soils under the water table. iv. Potential difficulty in cleaning and inspecting bases.	***Advantages:*** i. Piles will develop geotechnical resistance by shaft friction in loose to compact silt/sand. ii. Installation of piles could continue in freezing weather. iii. Independent of groundwater conditions. iv. Foundation construction requires less volume of excavation than footings v. Readily installed. ***Disadvantages:*** i. Higher unit costs than footings. ii. Relatively low axial and lateral resistance available.
Abutments	**NOT RECOMMENDED**	**NOT RECOMMENDED**	**RECOMMENDED**
Piers	**NOT RECOMMENDED**	**NOT RECOMMENDED**	**RECOMMENDED**

Appendix D

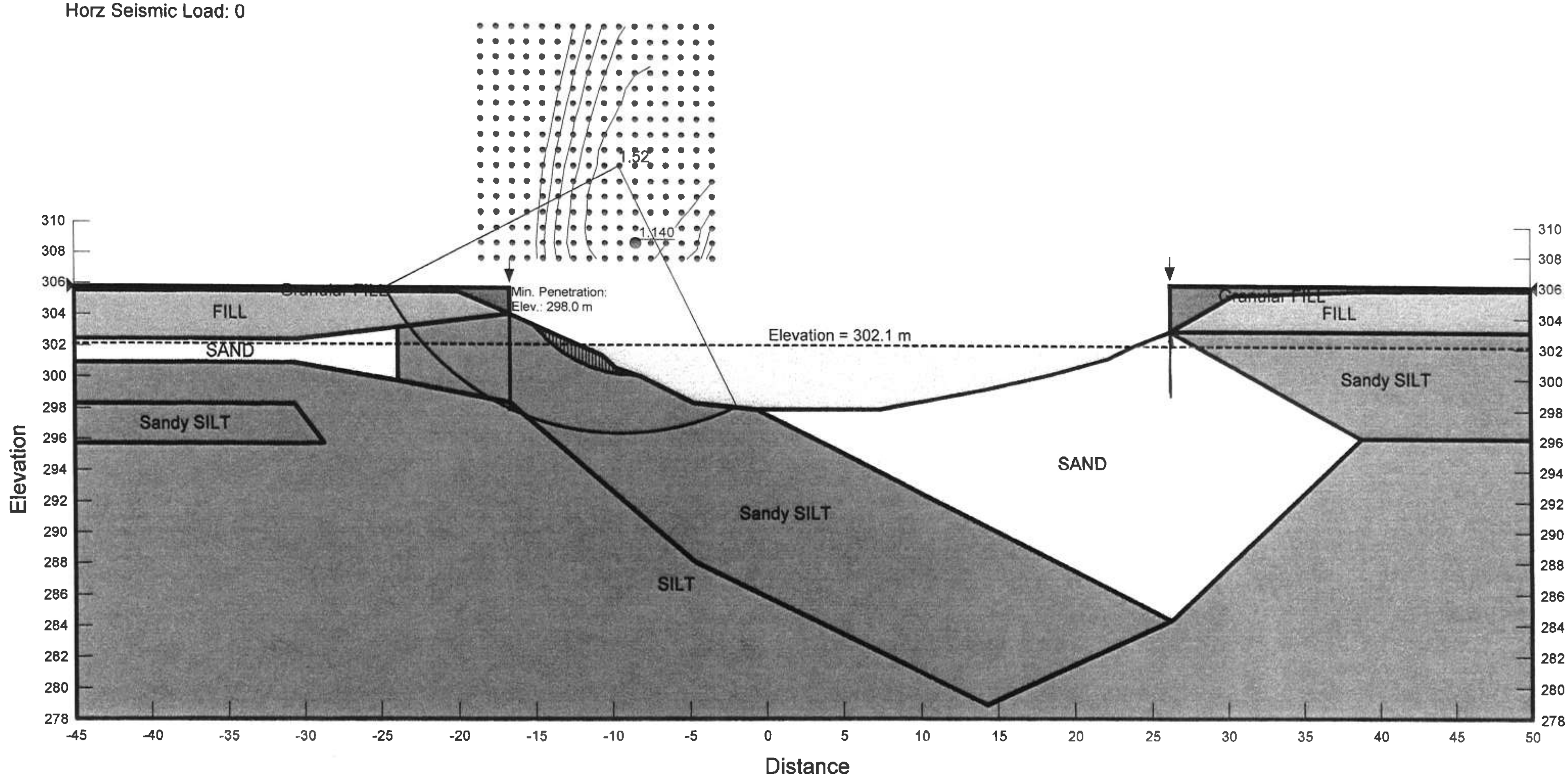
Slope Stability Output

THURBER

Title: Black Water Creek Bridge (HWY 11)
Name: South Abutment (ST/LT)
Description: Granular Fill
Date: 10/12/2012, 2:09:12 PM

Method: Morgenstern-Price
Interslice force function option: Half-Sine
Minimum Slip Surface Depth: 1 m
Horz Seismic Load: 0

FILL	20 kN/m³	0 kPa	30 °	1
SAND	20 kN/m³	0 kPa	32 °	1
Sandy SILT	20 kN/m³	0 kPa	30 °	1
SILT	20 kN/m³	0 kPa	30 °	1
Granular FILL	21 kN/m³	0 kPa	32 °	1



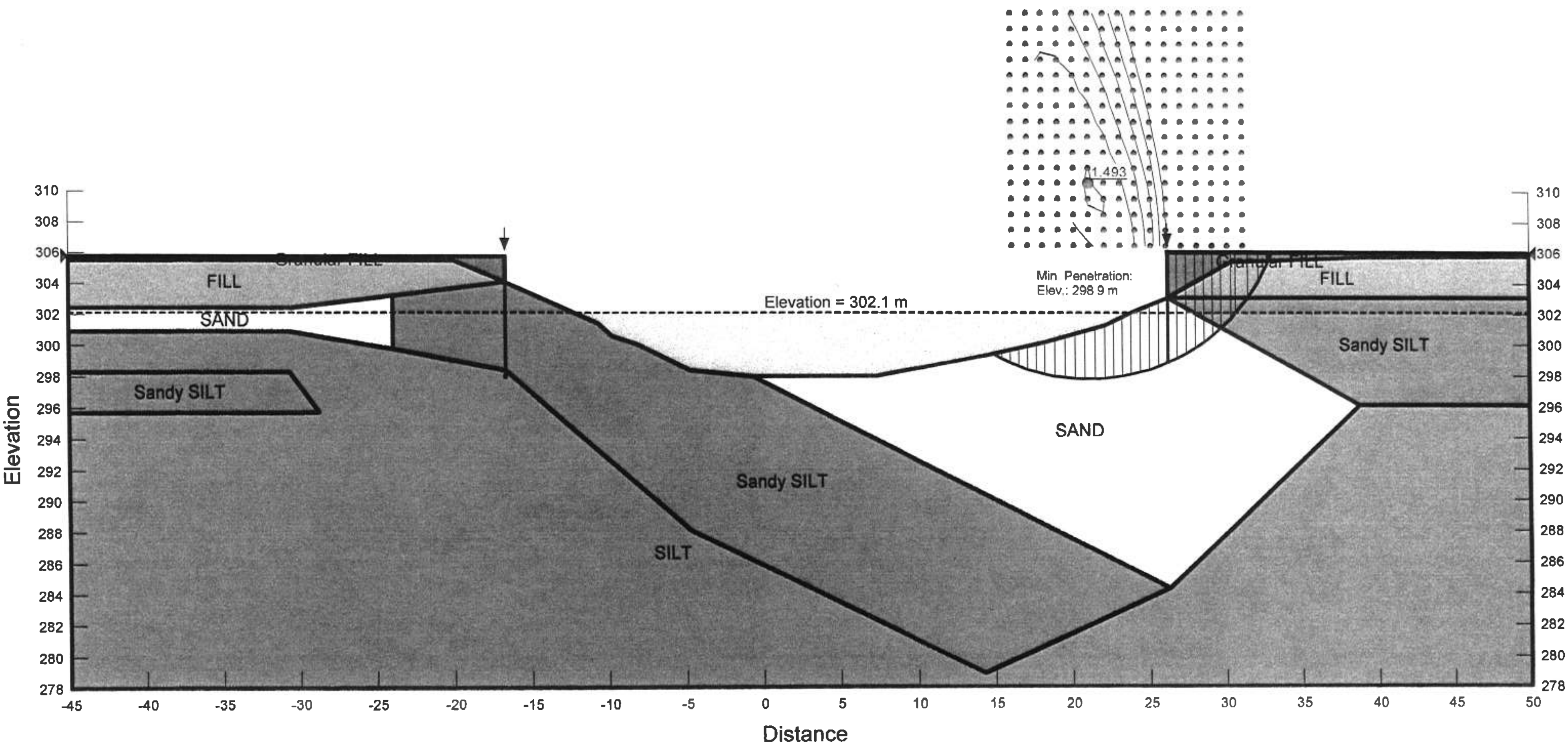
Directory: H:\19\1351\197 NWR 32 Rehabs\Reports & Memos\Blackwater River\Analysis\Stability\BlackWater_002.gsz

Figure 1

Title: Black Water Creek Bridge (HWY 11)
Name: North Abutment (ST/LT)
Description: Granular Fill
Date: 10/12/2012, 2:09:12 PM

Method: Morgenstern-Price
Interslice force function option: Half-Sine
Minimum Slip Surface Depth: 1 m
Horz Seismic Load: 0

FILL	20 kN/m³	0 kPa	30 °	1
SAND	20 kN/m³	0 kPa	32 °	1
Sandy SILT	20 kN/m³	0 kPa	30 °	1
SILT	20 kN/m³	0 kPa	30 °	1
Granular FILL	21 kN/m³	0 kPa	32 °	1



Directory: H:\19\1351\197 NWR 32 Rehabs\Reports & Memos\Blackwater River\Analysis\Stability\BlackWater_002.gsz

Figure 2

Appendix E

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

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

- OPSS 903
- OPSS 902
- OPSS 804
- OPSD 208.010
- OPSD 3101.150
- OPSS 539
- Special Provision 110S13 "Amendment to OPSS 1010, April 2004".

Appendix F

Site Photographs

Photograph 1– Blackwater River bridge

Photographs 2– Blackwater River bridge

Photographs 3 and 4– Blackwater River bridge embankment

Photographs 5 and 6– Blackwater River bridge, existing piers

Appendix G

Drawing titled "Borehole Locations and Soil Strata"

MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

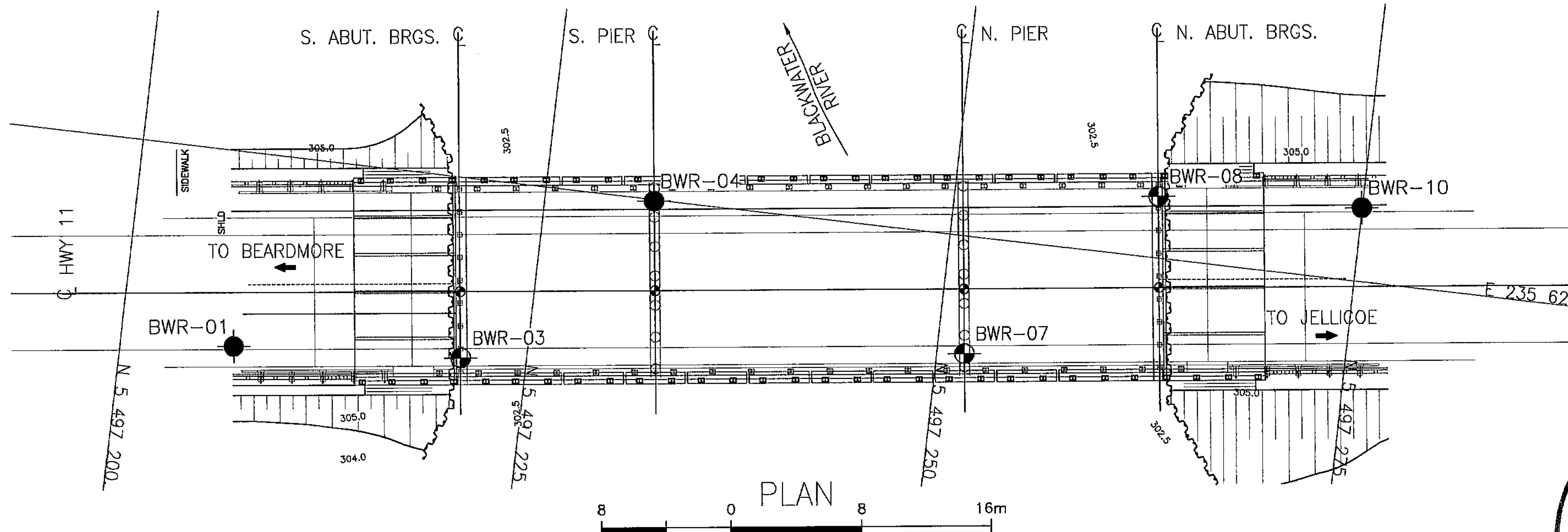
CONT. No.
WP No. 6066-09-00

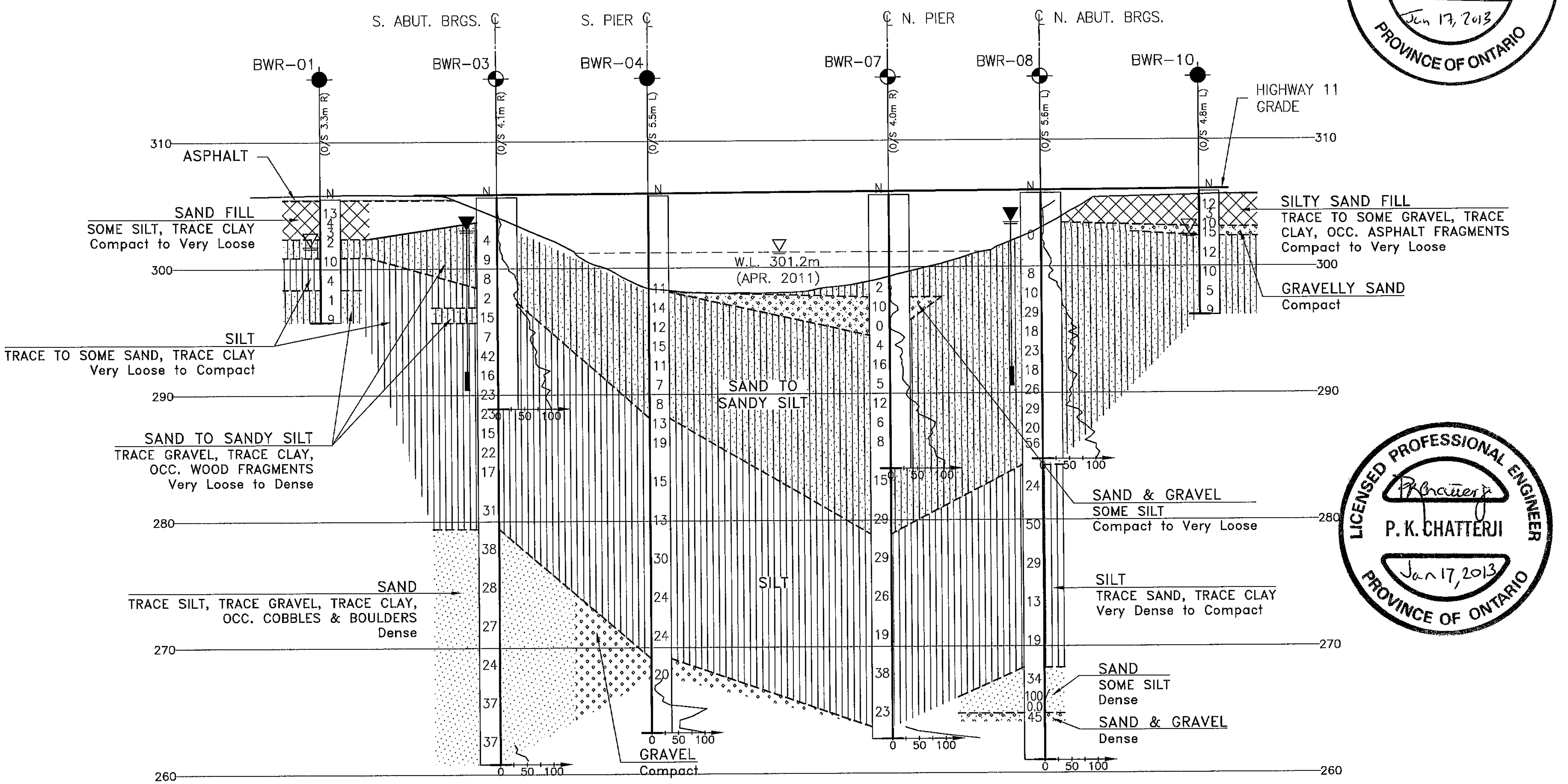
BLACKWATER CREEK BRIDGE REHABILITATION HWY 11
BOREHOLE LOCATIONS AND SOIL STARTA

SHEET 11

McCORMICK RANKIN
A member of MMM GROUP

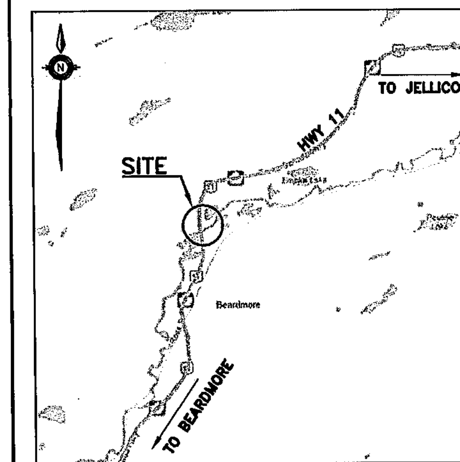
THURBER ENGINEERING LTD.





LICENSED PROFESSIONAL ENGINEER
R. Palomeque Reyna
100083209
Jan 17, 2013
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Jan 17, 2013
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 in Open Borehole
▼	Water Level in Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
BWR-01	305.5	5 497 207.0	235 637.0
BWR-03	305.6	5 497 221.0	235 636.0
BWR-04	305.7	5 497 231.7	235 625.1
BWR-07	305.7	5 497 251.7	235 632.2
BWR-08	305.8	5 497 262.5	235 621.2
BWR-10	305.9	5 497 275.0	235 620.5

-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. 42E-14

REVISIONS | DATE | BY | DESCRIPTION

DESIGN RPR | CHK RPR | CODE | LOAD | DATE JAN 2013
DRAWN AN | CHK | SITE 48C-1 | STRUCT | DWG 1

FILENAME: H:\Drafting\19\1351\197\ted1197-BlackWaterCreek(Plan&Profile).dwg
PLOTDATE: 1/17/2013 9:19 AM