

**PRELIMINARY**  
**FOUNDATION INVESTIGATION AND DESIGN REPORT**  
**BEATTY CREEK BRIDGE REPLACEMENT**  
**HIGHWAY 534**  
**G.W.P. 5200-03-00, SITE 44-016**

**Geocres Number: 31L-105**

**Report to**

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**PART A: PRELIMINARY FOUNDATION INVESTIGATION REPORT**

## **1 INTRODUCTION**

This report presents the factual findings obtained from a preliminary foundation investigation conducted for the proposed replacement of the Beatty Creek bridge located on Highway 534 approximately 100 m west of the Highway 654 junction.

The purpose of the preliminary investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, borehole logs, stratigraphic profile and a written description of the subsurface conditions. A model of the subsurface conditions was developed in sufficient detail to make preliminary recommendations for planning purposes, including assessment of structure foundation design, embankment stability and settlement, and construction concerns.

Thurber carried out the investigation as a sub-consultant to McCormick Rankin Corporation, under the Ministry of Transportation Ontario (MTO) Agreement Number 5004-E-0056.

## **2 SITE DESCRIPTION**

The bridge site lies on Highway 534 approximately 100 m west of Highway 654 and 1 km south of the Village of Nipissing. It lies in the Township of Nipissing, District of Parry Sound.

The general site area is located within the physiographic region known as the Canadian Shield, characterized by Pre-Cambrian bedrock typically occurring as rounded knobs and ridges where exposed. The bedrock is locally overlain by deposits of glacio-fluvial sands and gravels, and glacio-lacustrine soils. More recent organic deposits are present in poorly drained swamp environments.

The immediate area of the bridge is generally wooded, low-lying and wet. Photographs of the site are provided in Appendix C. At the site, Beatty Creek is a very slow moving watercourse within a meandering channel typically ranging from 6 to 8 m wide. An abandoned meander with ponded water exists in the southwest quadrant of the creek crossing. The site is prone to flooding during heavy rainfall events and spring snowmelt.

An abandoned road alignment, now a snowmobile trail, runs south of the current road alignment. A general store is present at the junction of Highway 654.

### 3 SITE INVESTIGATION AND FIELD TESTING

The preliminary site investigation and field testing for this project were carried out during the period August 28 to September 8, 2006. The investigation consisted of drilling and sampling nine boreholes as follows:

- Five boreholes (Nos. 06-B01 to 06-B04 and 06-B06) were drilled to refusal on bedrock at depths of 39.6 to 44.6 m on alternative alignments for the structure. Bedrock was proven in three of the boreholes by recovering approximately 3 m of rock core;
- Four additional boreholes were drilled along alternative highway alignments, two of which were terminated at depths of 20.4 and 20.1 m (Nos. 06-B09 and 06-B10), and two that were terminated upon refusal at 12.6 and 17.7 m depth (Nos. 06-B07 and 06-B08).

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

Thurber positioned the boreholes in the field relative to the centreline of Highway 534 and the existing bridge structure. The coordinates and ground surface elevations at the boreholes were subsequently established by MRC. The coordinates and elevations of the boreholes are given on the Borehole Locations and Soil Strata Drawing and on the individual Record of Borehole Sheets in Appendix A.

A combination of hollow stem auger and rotary drilling techniques was used to advance the boreholes and samples were obtained using a split spoon sampler in conjunction with Standard Penetration Tests (SPT). The in situ strength of the cohesive soils was assessed using the MTO shear vane, and thin wall tube samples were recovered from the soft cohesive deposits. Bedrock cores were recovered using NQ coring equipment.

The boreholes were supplemented by dynamic cone penetration testing conducted adjacent to five boreholes (Nos. 06-B01 to 06-B04 and 06-B06).

A member of Thurber's engineering staff supervised the drilling and sampling operations on a full time basis. The inspector logged the soil and groundwater conditions encountered in the boreholes, and collected, labelled and arranged for transport of the samples to Thurber's laboratory.

Standpipe piezometers were installed in five of the boreholes to monitor groundwater levels. The completion details of the piezometers are presented in Table 3.1.

Table 3.1 – Piezometer Details

Piezometer Location	Tip Position (m)		Completion Details
	Depth	Elevation	
BH06-B01	42.7	154.4	Sand filter and screen from 42.7 to 40.8 m, bentonite seal to 39.6, grout to 9.1 m, bentonite to surface.
BH06-B02	40.5	156.9	Sand filter and screen from 40.5 to 38.7 m, bentonite seal to surface.
BH06-B06	42.5	154.5	Sand filter and screen from 42.5 to 40.7 m, bentonite seal to surface.
BH06-B08	16.8	181.2	Sand filter and screen from 16.8 to 14.9 m, bentonite seal to 14.0 m, grout to 6.1 m, bentonite to surface.
BH06-B10	20.1	179.4	Sand filter and screen from 20.1 to 17.7 m, bentonite seal to surface.

The boreholes without piezometers were backfilled with bentonite grout upon completion.

#### 4 LABORATORY TESTING

All recovered soil samples were subjected to visual identification and to natural moisture content determination. The results of this testing are shown on the Record of Borehole sheets in Appendix A.

Selected samples were subjected to gradation analysis (sieve and hydrometer) and Atterberg Limits testing. Thin wall tube samples were also selected for consolidation testing and unconfined compression tests. The results are shown on the Record of Borehole sheets in Appendix A and on the charts in Appendix B.

The rock core descriptions were confirmed in the laboratory and Point Load Tests were conducted to assess the compressive strength of the rock.

#### 5 DESCRIPTION OF SUBSURFACE CONDITIONS

##### 5.1 General

Reference is made to the Record of Borehole sheets in Appendix A and to the Borehole Locations and Soil Strata Drawing in Appendix D. An overall description of the stratigraphy based on the conditions encountered in the boreholes is given in the following paragraphs. However, the factual data presented in the borehole logs takes precedence over this general description and interpretation of the site conditions.

The soil stratigraphy encountered at this site generally consists of existing roadbase fill and/or relatively thin layers of sand, sandy silt and silt, underlain by a deposit of very soft to firm silty clay to clayey silt. The upper clay deposit is underlain by a unit of sands and silts, and a deeper, relatively thick layer of very soft to stiff silty clay to clayey silt. The lower clay deposit overlies sands and silts which mantle bedrock in four boreholes, and directly overlies bedrock in one borehole.

The thickness and gradation of the particular deposits vary with location. Further, the deposits have a layered structure and often contain discontinuous seams and layers of coarser or finer material within each generalized unit.

More detailed descriptions of the individual strata are presented below.

## **5.2 Roadway Pavement and Embankment Fill**

A 40 to 90 mm thick layer of asphalt, appearing to consist of chip seal surface treatment, was encountered in boreholes 06-B03, 06-B04 and 06-B10 drilled on Highway 534. The asphalt was underlain by granular fill (sand and gravel to gravelly sand) extending to depths of 2.1 and 2.4 m (elevation 196.9 and 196.6 m) at the bridge location, and 1.4 m (elevation 198.1 m) in borehole 06-B10. SPT N-values in the granular fill ranged from 7 to 49, indicating a loose to very dense condition.

A sand and gravel fill layer was placed at the location of borehole 06-B02 as a levelling and support pad for drilling equipment.

## **5.3 Surficial Layers of Sand and Silt**

Relatively thin, discontinuous layers of cohesionless sand, sandy silt and silt were encountered below the fill or at the ground surface in eight of the boreholes. The sand and silt layers ranged in thickness from 0.3 to 3.2 m, and extended to depths of 0.3 to 4.6 m (elevation 194.9 to 196.8 m). In borehole 06-B09, a 0.9 m thick layer of silty clay was encountered within the sand/silt layers.

SPT values of 2 to 3 blows per 0.3 m of penetration were measured in the sand/silt in boreholes 06-B01, 06-B03, 06-B04 and 06-B06 located adjacent to the bridge, indicating a very loose condition. In boreholes 06-B07 to 06-B10, N-values of 3 to 16 blows/0.3 m were obtained, indicating a very loose to compact state. Natural moisture contents ranged from 19 to 34%, with one value of 4% determined above 0.5m depth in borehole 06-B09. The results of grain size distribution analyses conducted on this unit are presented in Figure B1 in Appendix B.

## **5.4 Upper Silty Clay to Clayey Silt**

Cohesive silty clay was encountered below the surficial fill, sand and silt layers in all boreholes, grading to clayey silt at the upper and lower boundaries of this unit at many locations. The upper boundary of the silty clay/clayey silt was encountered at depths of 0.3 to 4.6 m (elevation 194.9 to 196.8 m), and the lower boundary was encountered at depths of 7.5 to 14.9 m (elevation 183.3 to 189.7 m).

The clay was interrupted in boreholes 06-B02, 06-B06 and 06-B10 by 1.5 to 4.6 m thick layers of sand, silt and silty sand at depths of 7.6 to 11.6 m. An isolated layer of silty clay, 3.1 m thick, was also encountered at 13.7 m depth in borehole 06-B08. The total thickness of the upper cohesive deposit, excluding the non-cohesive sand and silt layers, ranged from 6.7 to 11.9 m.

N-values obtained in the silty clay and clayey silt typically ranged from 0 to 2 blows/0.3 m, with values of up to 5 blows/0.3 m obtained near the layer boundaries in several boreholes. The undrained shear strength of the silty clay determined using the MTO field vane varied from 12 to 36 kPa, with a sensitivity of 2.5 to 5.1. Undrained shear strengths of 10.8 and 8.5 kPa were determined by laboratory unconfined compression testing of two samples (documented in Appendix B). Based on this data, the clay has a very soft to firm consistency.

Moisture contents of 25 to 112% were measured in this unit. The results of grain size distribution analyses conducted on the upper cohesive deposit are shown on Figures B2 to B5, Appendix B. The results of Atterberg Limits testing are presented on Figures B11 to B13, and are summarized below.

**Table 5.1 – Atterberg Limits**

	10 Samples	3 Samples
Liquid Limit	50 to 87	32 to 35
Plastic Limit	16 to 42	17 to 22
Plasticity Index	31 to 51	11 to 19
Classification	High Plastic	Low Plastic

The results of consolidation testing conducted on two samples of the silty clay are included in Appendix B and summarized in Table 5.2.

**Table 5.2 – Consolidation Test Parameters**

Borehole	Sample Depth (m)	w <sub>o</sub> (%)	γ (kN/m <sup>3</sup> )	e <sub>o</sub>	p <sub>o</sub> ' (kPa)	p <sub>c</sub> ' (kPa)	OCR	C <sub>c</sub>	C <sub>r</sub>
06-B04	6.1-6.7	93	14.6	2.61	85	90	1.1	2.49	0.18
06-B06	4.8-5.0	97	14.5	2.67	40	80	2.0	1.89	0.16

Comparison of the existing and preconsolidation pressures (p<sub>o</sub>' and p<sub>c</sub>') derived from the test results indicate that the natural silty clay is lightly preconsolidated. The clay under the embankment is normally consolidated due to the load of the embankment. The coefficient of consolidation, c<sub>v</sub>, recorded during the test generally decreased with increasing pressure, with values near 10<sup>-3</sup> to 10<sup>-4</sup> cm<sup>2</sup>/s for the typical pressure range anticipated in the field.

The parameters listed in the table were obtained from testing of two samples recovered from discrete depths in the boreholes. The compressibility characteristics will vary with depth in accordance with the moisture content and shear strength profiles.



### 5.5 Intermediate Sands and Silts

Various deposits of non-cohesive sand, silty sand, sandy silt and silt were encountered between the upper and lower clay units. The upper boundary of these strata was encountered at depths of 7.5 to 14.9 m (elevation 183.3 to 189.7 m). In boreholes 06-B01 to 06-B06 drilled at the bridge location, the sand/silt layers were 3.1 to 13.8 m in total thickness, with a lower boundary encountered at depths of 16.8 to 21.3 m (elevation 175.8 to 182.2 m). Boreholes 06-B07 and 06-B08 advanced 4.4 and 8.6 m through these deposits before encountering refusal at depths of 12.6 and 17.7 m (elevation 185.3 and 180.3 m). Boreholes 06-B09 and 06-B10 were terminated at depths of 20.4 and 20.1 m (elevation 177.7 and 179.4 m) after penetrating 11.3 and 5.2 m into these layers.

As noted previously, isolated layers of sands and silts were also encountered within the overlying silty clay and clayey silt unit in boreholes 06-B02, 06-B08 and 06-B10. A 1.0 m thick layer of dense gravel was encountered at the base of borehole 06-B07, and between 12.2 and 13.1 m depth (elevation 185.9 and 185.0 m) in borehole 06-B09. The lower 1.2 m of borehole 06-B09 graded to sand and gravel.

The results of grain size distribution analyses conducted on the sands and silts are shown on Figures B6 and B7, Appendix B.

N-values obtained in the sand and silt layers ranged variously from 1 to 22 blows/0.3 m (very loose to compact). N-values of 31 to 130 were obtained in borehole 06-B07, indicating a dense to very dense condition. Moisture contents varied from 8 to 31%.

### 5.6 Lower Clayey Silt to Silty Clay

Cohesive clayey silt and silty clay were encountered below the sand and silt layers in boreholes 06-B01 to 06-B06. The upper boundary of the silty clay/clayey silt was encountered at depths of 16.8 to 21.3 m (elevation 175.8 to 182.2 m), and the lower boundary was encountered at depths of 36.6 to 39.6 m (elevation 157.4 to 162.4 m). The total thickness of the lower cohesive deposit ranged from 15.3 to 21.3 m. The clay overlies bedrock in borehole 06-B06.

The cohesive material was interrupted in boreholes 06-B01 and 06-B06 by an approximate 3.0 m thick sand layer at 24.4 and 27.4 m depth.

N-values obtained in the clayey silt and silty clay ranged from 1 to 11 blows/0.3 m. An N-value of 1 was recorded throughout this layer in boreholes 06-B03 and 06-B04. The undrained shear strength of the silty clay determined using the MTO vane at a limited number of depths varied from 20 to 32 kPa, with a sensitivity of 2.5 to 3.3. Based on the vane and SPT data, the clay has a very soft to stiff consistency.

Moisture contents of 23 to 52% were measured in this unit. The results of grain size distribution analyses conducted on the lower cohesive deposit are shown on Figures B8 to B10, Appendix B. The results of Atterberg Limits testing are presented on Figures B14 and B15, and are summarized below.

**Table 5.3 – Atterberg Limits**

	<b>6 Samples</b>	<b>1 Sample</b>
Liquid Limit	27 to 35	48
Plastic Limit	15 to 24	26
Plasticity Index	9 to 19	21
Classification	Low Plastic	Medium Plastic

### 5.7 Basal Sands and Silts

Cohesionless sand, sandy silt and silt deposits were encountered below the clayey silt and silty clay units, and overlying bedrock, in boreholes 06-B01 to 06-B04. The sands and silts had a total thickness of 2.3 to 7.0 m, and an upper boundary at depths of 36.6 to 39.6 m (elevation 157.8 to 162.4 m). SPT N-values obtained in the sand and silt layers varied from 8 to 36 blows/0.3 m, indicating a loose to dense condition. Moisture contents ranged from 16 to 27%.

### 5.8 Bedrock and/or Refusal

Bedrock or refusal was encountered at the depths and elevations listed in Table 5.4.

**Table 5.4 – Depth to Bedrock and/or Refusal**

Location	Borehole	Bedrock and/or Refusal		
		Depth (m)	Elevation (m)	Criteria
West Abutment	06-B01	43.6	153.5	Auger refusal
	06-B03	44.6	154.4	Cored
East Abutment	06-B02	41.9	155.5	Cored
	06-B04	41.8	157.2	Auger refusal
	06-B06	39.6	157.4	Cored
Roadway	06-B07	12.6	185.3	Auger refusal
	06-B08	17.7	180.3	Auger refusal

The bedrock was proved in boreholes 06-B02, 06-B03 and 06-B06 by coring approximately 3.0 m. The bedrock consists of salmon and black granite of the Pre-Cambrian Canadian Shield. The rock is described as fresh, with black banding and occasional horizontal to vertical joints.

The core recovery was 100% in all but one core run in borehole 06-B03 where the recovery was 93%. With the exception of the second core run in borehole 06-B06, RQD values ranged from 80 to 100%, indicating an excellent rock quality. A lower RQD value of 60% was obtained in the second run from borehole 06-B06 where a vertical joint was encountered. The Fracture Index was generally 0 to 1, with isolated values of 2 to 5 fractures/0.3 m.

Based on Point Load Testing, the unconfined compressive strength of the bedrock was estimated to range from about 120 to 160 MPa. Based on these strength values and the

classification system given in the Canadian Foundation Engineering Manual, the rock is classified as very strong.

### 5.9 Groundwater

The initial and final groundwater depths and elevations measured in the boreholes and piezometers are shown in Table 5.5.

**Table 5.5 – Groundwater Depths and Elevations**

Location	Borehole	Date	Water Level (m)		Comment
			Depth*	Elevation	
West Abutment	06-B01	30-Aug-2006	0.3 ags	197.4	Upon completion
		30-Aug-2006	1.2 ags	198.3	In piezometer
		25-Sept-2006	1.5 ags	198.6	In piezometer
East Abutment	06-B02	07-Sept-2006	0.0	197.4	Upon completion
		08-Sept-2006	0.4 ags	197.8	In piezometer
		25-Sept-2006	1.1 ags	198.5	In piezometer
	06-B06	07-Sept-2006	1.8 ags	198.8	Upon completion
		11-Sept-2006	1.4 ags	198.4	In piezometer
		25-Sept-2006	1.5 ags	198.5	In piezometer
Roadway	06-B07	28-Aug-2006	0.3 ags	198.2	Upon completion
	06-B08	05-Sept-2006	1.5 bgs	196.5	Upon completion
		06-Sept-2006	0.3 ags	198.3	In piezometer
		25-Sept-2006	0.4 ags	198.4	In piezometer
	06-B09	31-Aug-2006	1.5 bgs	196.6	Upon completion
	06-B10	06-Sept-2006	1.1 bgs	198.4	In piezometer
		25-Sept-2006	1.2 bgs	198.3	In piezometer

\* ags = above ground surface (artesian condition); bgs= below ground surface

The above water levels reflect the piezometric head at the level of the piezometer tips at the time of the investigation. The measurements are short-term observations and seasonal fluctuations of the groundwater level are to be expected.

Shallow groundwater levels in the upper deposits will fluctuate with the water level in Beatty Creek. Higher levels should be expected after the spring snowmelt or after periods of heavy rainfall, and lower levels may be anticipated after dry periods. The water level in Beatty Creek was near elevation 197 m at the time of the investigation, and rose above the adjacent ground surface following a subsequent heavy rainfall.

## 6 MISCELLANEOUS

Surveyors retained by MRC determined the co-ordinates and ground elevations at the boreholes following completion of the site investigation.

George Downing Estate Drilling Ltd. supplied and operated the drilling and sampling equipment. Full time supervision of the field activities, including obtaining utility clearances, was carried out by Mr. George Azzopardi and Mr. Ken Hui of Thurber.

Supervision of the field program, interpretation of the field data, and preparation of the report was performed by Mr. Murray Anderson, P.Eng. The report was reviewed by Mr. Alastair Gorman, P.Eng., and by Dr. P.K. Chatterji, Ph.D., a Designated Principal Contact for MTO Foundations Projects.

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**PART B: PRELIMINARY FOUNDATION DESIGN REPORT**

## **7 INTRODUCTION**

This report presents interpretation of the geotechnical data in the factual report and presents preliminary geotechnical design recommendations to assist planning of the foundation system and approach fills for the proposed bridge replacement.

The typical bridge arrangement shown on a drawing prepared by McCormick Rankin Corporation (dated 2006/08/09) indicates that the proposed structure will be approximately 11 m wide and have a single span of 14.7 m. Options are shown for two new bridge alignments to the north and south of the existing bridge, staging alignments north and south of the existing structure, and a detour alignment for construction of a new bridge on the existing alignment.

The preliminary road profile drawing provided by MRC (dated 2006/11/15) indicates that road grade at the bridge will be raised approximately 1.5 m to elevation 200.5m. The west and east approaches will be raised by approximately 1 to 2 m respectively to accommodate the bridge grade revision.

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

## **8 STRUCTURE FOUNDATIONS**

A comparison of the technical advantages and disadvantages of alternative foundation schemes is presented in Table C1 of Appendix C. Initial consideration was given to spread footings on native soil or engineered fill, driven steel H-piles, and caissons (drilled shafts) for both the permanent and temporary structures.

Preliminary design parameters for viable alternatives are presented in the following sections. A preliminary recommendation regarding the foundation scheme preferred from a foundations perspective is presented based on the subsurface conditions identified at the site.

Based on the results of the exploratory boreholes drilled at the proposed abutment locations, the subsurface stratigraphy along each proposed alignment is similar, consisting of existing roadbase

fill and/or relatively thin layers of sand, sandy silt and silt, underlain by a 6.7 to 11.9 m thick deposit of very soft to firm, compressible silty clay to clayey silt. The upper clay deposit is underlain by a unit of sands and silts, and a second, 15.3 to 21.3 m thick layer of very soft to stiff silty clay to clayey silt. The lower clay deposit overlies sands and silts which mantle bedrock in four boreholes, and directly overlies bedrock in one borehole.

## 8.1 Spread Footings

### 8.1.1 Spread Footings on Native Soil

The native deposits at this site are considered unsuitable for support of spread footings due to the very low bearing resistance available and the potential for substantial immediate and long-term settlements. Accordingly spread footings founded on native soil are not recommended.

### 8.1.2 Spread Footings on Engineered Fill

Construction of spread footings on engineered fill is not recommended in view of the potential for substantial immediate and long-term settlements in the underlying native soils, and construction concerns related to excavation within very loose/soft soils below a high groundwater table. The native clay soils may experience significant consolidation settlement under small increases in surface loading imposed by engineered fill construction. Therefore engineered fill construction is not recommended.

## 8.2 Driven Steel Piles

The geotechnical conditions encountered at this site are considered suitable for driven steel H-pile foundations. The piles must be driven to bedrock and are expected to encounter refusal on bedrock near elevation 153.5 to 157.4 m. Preliminary design of the piles for each alignment should be carried out on the basis of the axial geotechnical resistances given in Table 8.1.

**Table 8.1 – Pile Geotechnical Resistance**

Pile Section	ULS (Factored)	Estimated Pile Tip Elevation	
		W. Abutment	E. Abutment
HP 310 X 110	2,000 kN	153.5-154.4	155.5-157.4
HP 360 X 132	2,400 kN	153.5-154.4	155.5-157.4

The pile tip elevations are based on the depths to bedrock encountered in two boreholes on the west side of the creek crossing and three boreholes on the east side of the creek. The tip elevations are presented for estimating purposes only and may vary along different alignments and abutment locations. Additional drilling will be required during the detailed design stage to determine the rock depths at the proposed bridge abutment locations once final alignments have been selected.

The SLS condition based on geotechnical considerations will not govern design of piles bearing on bedrock. The effects of axial compression of the pile under the applied vertical load must be assessed by the structural designer.

The tips of all piles should be fitted with H-section rock points from an approved manufacturer such as Titus Steel (Standard H-point), Pruyn Points or approved equivalent. Rock points are recommended for setting the piles on bedrock and tip protection when penetrating dense gravely deposits, or if cobbles or boulders are encountered above the bedrock.

Downdrag forces will develop along the length of pile embedded in the silty clay deposits, the overlying fill and native soil, and the intermediate sands and silts if new embankments are constructed or embankment loads are increased by placement of additional fill. For preliminary purposes, an unfactored downdrag force of 720 kN is recommended.

A check of the effects of downdrag forces should be performed in accordance with Section 6.8.4 of the CHBDC. This check is based on factored permanent loads and downdrag loads at the neutral plane which, at this site, will be close to the pile tip. Live loads and downdrag loads are not combined. The recommended pile resistances to be used in the downdrag check are:

HP 310 X 110	2,800 kN
HP 360 X 132	3,400 kN

If integral abutment design is planned, the upper 3 m of pile length is expected to lie within very loose and very soft to firm deposits which may provide sufficient flexibility. The use of batter piles to resist lateral loads (for conventional abutments) is not recommended due to the depth to rock and the potential that bending stresses will be imposed on the pile as the surrounding soil consolidates.

### **8.3 Caissons**

The use of augered caissons is not recommended in view of the depth to suitable bearing material (bedrock at 40 to 45 m depth) and the anticipated difficulties constructing caissons at this site. Constructing caissons would require use of a liner socketed into rock and/or slurry methods to control groundwater, support the sidewalls of the shaft, and prevent heave in the base while augering in the saturated non-cohesive deposits.

### **8.4 Recommended Foundation**

From a geotechnical perspective, the recommended foundation system for both abutments at this site is steel H-piles driven to bedrock.

### **8.5 Abutment Type**

From a geotechnical perspective, the subsurface conditions at this site are considered to be suitable for the construction of conventional, semi-integral or integral abutments. The recommended foundation system of H-piles makes integral abutments a feasible option.

### **8.6 Frost Protection**

The depth of earth cover required to provide frost protection for footings and pile caps at this site is 2.0 m. It is possible to reduce the thickness of earth cover by the substitution of synthetic insulation.

## **9 APPROACH EMBANKMENTS**

Based on the elevations established at the borehole locations, road grade over the existing Beatty Creek bridge is presently near elevation 199.0 m and the adjacent ground surface is at elevation 197.0 m. Preliminary profile drawings indicate that the road grade will be raised to near elevation 200.5 m, approximately 1.5 m above existing road grade and 3.5 m above the adjacent ground surface.

Preliminary stability analyses were carried out for both earth fill and rockfill embankments under static loading conditions. For cohesive soils, short term (undrained) and long term (effective stress) conditions were assessed. Embankment slope inclinations of 2H:1V for earth fill and 1.25H:1V for rockfill were assumed. The input parameters and soil model used in the stability analyses, including soil stratigraphy, engineering properties, groundwater conditions, and embankment geometry, are shown on Figures C1 to C4 in Appendix C.

The results of the stability analyses indicate that the Factor of Safety (FS) for a 3.5 m high embankment will be near 1.3 for short-term conditions, and marginally below 1.5 for long-term conditions. Therefore, measures to improve the stability of new or raised embankments should not be necessary. Further investigation and analyses during detailed design, including seismic analysis, is required to more closely define the shear strength profile of the silty clay deposit and provide detailed recommendations for embankment design.

Construction of approach embankments along a new alignment, widening of the existing embankment, or raising embankment grades is expected to result in significant long-term consolidation settlement of the thick silty clay layers. Based on the preliminary data, consolidation settlement is anticipated to be in the order of 1.2 m under a new 3.5 m high embankment and 200 mm under a 1.5 m raise of the existing roadway embankment. Consolidation will occur over an extended period of 5 to 10 years before substantially completed. Methods of increasing the rate and/or reducing the magnitude of post-construction settlement, such as embankment surcharging, wick drains or EPS, will be required.



## 10 ALIGNMENT COMPARISON

The subsurface conditions on all permanent and temporary alignments are similar and therefore bridge foundation design considerations will not impact on the selection of the preferred alignments. However, selection of the alignments must take into consideration the potential settlement under load increases imposed by new or modified approach embankments:

- Minimal settlement issues are anticipated if the existing alignment, grade and platform width is maintained.
- Some settlement issues will have to be addressed if the existing alignment is adjusted, grades are raised, or the platform is widened.
- Severe settlement issues will have to be addressed if a new alignment is planned for either the permanent or detour road.

From a geotechnical viewpoint, maintaining the existing alignment and profile is preferred. For platform widening, grade raises, or new embankments, advance construction (one year or more) must be considered along with measures to increase the rate and/or reduce the magnitude of post-construction settlement, as discussed elsewhere in this report.

## 11 EARTH PRESSURE COEFFICIENTS (ABUTMENTS)

Earth pressures acting on the abutment walls 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 below)

$\gamma$  = unit weight of retained soil (see table below)

$h$  = 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 11.1.

**Table 11.1 – Earth Pressure Coefficient (K)**

Condition	Earth Pressure Coefficient (K)					
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$		Rock Fill (Limited to 300 mm size) $\phi = 42^\circ, \gamma = 19 \text{ kN/m}^3$	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall(2H:1 V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall(2H:1 V)
Active (Unrestrained Wall)	0.27	0.40*	0.31	0.43*	0.20	0.30*
At rest (Restrained Wall)	0.43	-	0.47	-	0.33	-
Passive (Movement Towards Soil Mass)	3.7	-	3.3	-	5.0	-

\* For wing walls.

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. In the case of integral abutments, material with a lower passive pressure coefficient (e.g. Granular B Type I) might be preferred as it results in lower forces acting on the ballast wall as the wall moves toward the soil mass.

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.

## 12 CONSTRUCTION CONCERNS

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

- The surficial soils at the site are generally very soft and wet with numerous roots and organics. These materials are highly susceptible to disturbance by construction traffic and particular attention/measures will be required to provide a stable trafficable base for movement of heavy equipment.
- Approach fill placement and compaction must be carefully controlled to prevent shear failure of the underlying low-strength silty clay. Stockpiling of materials on site should be avoided.
- Excavation adjacent to the creek and within the existing embankment for foundation construction will require shoring of the excavation walls and control of creek water and groundwater.
- Construction activities, particularly excavation, pile driving and fill placement, may impact on the existing bridge, roadway embankment and profile. Procedures must be adopted that

minimize the potential for disturbance and settlement of the existing bridge, roadway or detour if traffic is to be maintained during construction.

- The possibility exists that piles will encounter cobbles, boulders or very dense sand and gravel lenses prior to contacting bedrock, or reach refusal on large boulders. In this case, pre-drilling to penetrate the boulders may be necessary.
- Erosion and sedimentation control while maintaining streamflow.
- Potential rising water levels and flooding of the site during construction.

### 13 SCOPE OF DETAILED INVESTIGATION

As design progresses, additional geotechnical investigation and analysis will be required to prepare geotechnical design recommendations for the detail design phase of the project. The recommended scope of site investigation and field testing for detail design is as follows:

1. The soil and bedrock conditions must be confirmed at the selected alignment of the replacement bridge structure. For deep foundations, this is typically accomplished by drilling two sampled boreholes within each new abutment footprint. Bedrock must be proved by coring at least one borehole at each abutment a minimum 3.0 m into bedrock. The remaining boreholes at the abutments must be advanced to refusal on bedrock.

The data obtained from boreholes drilled during the current investigation may be used where located within the final abutment footprint.

2. Subsurface conditions must be explored in each immediate approach fill, generally within 20 m of the bridge abutment, as well as along areas of embankment widening, new embankments, and detours. These boreholes must be sampled to a depth equal to the height of the embankment, and to penetrate the upper silty clay layer.
3. Detailed shear strength profiles of the silty clay strata must be obtained to confirm the embankment stability and assess embankment construction procedures. This should entail frequent in situ vane tests using an MTO vane, and laboratory triaxial testing.
4. Relatively undisturbed samples of the silty clay must be obtained for laboratory consolidation testing to provide a detailed profile of the compression characteristics of the clay units. Detailed settlement analysis must be carried out during detailed design to further evaluate the magnitude and duration of consolidation settlements to be expected under the embankment loads, and to design appropriate measures to reduce the effects (surcharge, wick drains, lightweight fill).
5. The scope of the detailed foundation investigations must also address the fill embankments outside of the immediate approach fill, including stability analysis, settlement analysis, and construction concerns. Exploration at maximum 50 m intervals along the proposed embankment areas is recommended. The boreholes should be advanced and sampled to a depth equal to the height of the embankment, and to penetrate the upper silty clay layer.

The geotechnical design recommendations must address the issues normally included in a Foundation Investigation and Design Report for Detail Design.

#### 14 CLOSURE

Engineering analysis and preparation of the preliminary foundation design report was conducted by Mr. Murray Anderson, P.Eng. The report was reviewed by Mr. Alastair Gorman, P.Eng., and by Dr. P.K. Chatterji, Ph.D., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.  
Murray R. Anderson, P.Eng., M.Eng.  
Senior Geotechnical Engineer



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Project Manager



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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 <sup>(1)</sup> 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

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


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


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

### 5. LEGEND FOR RECORDS OF BOREHOLES

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

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

 Water Level

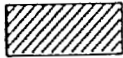

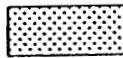


 Shear Strength Determination by Pocket Penetrometer

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

DISCONTINUITY SPACING		STRENGTH CLASSIFICATION			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
<u>TERMS</u>		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
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.				





# RECORD OF BOREHOLE No 06-B01

1 OF 5

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 308.55 E 303 697.02 ORIGINATED BY GA  
 HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
 DATUM Geodetic DATE 2006.08.29 - 2006.08.30 CHECKED BY MA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
197.1							+1.5							
0.0	SAND, some silt, occasional rootlets Very Loose Dark Brown Dry		1	SS	2		197							*Artesian
196.6														
0.5	SILT, some clay to clayey, trace sand Very Soft Grey Wet		2	SS	2		196							
			3	SS	1		195							0 1 84 15
			4	SS	1		194							
194.1														
3.0	Silty CLAY, occasional black staining Very Soft Grey Wet (CL)		5	SS	1		193							
			6	SS	1		192							0 1 54 45
			1	TW			191	4.0						
189.6							190							
7.5	SAND, fine grained, some silt Loose Grey Wet		7	SS	6		189							
188.0							188							
9.1	SILT, some clay, trace sand Very Soft Grey Wet		8	SS	1									

Continued Next Page

+ 3, x 3: Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

ONTMT4S 5198.GPJ 04/04/07

## METRIC

G.W.P.	<u>5200-03-00</u>	LOCATION	<u>Beatty Creek Bridge N 5 105 308.55 E 303 697.02</u>	ORIGINATED BY	<u>GA</u>
HWY	<u>534</u>	BOREHOLE TYPE	<u>Hollow Stem Augers/NW Casing</u>	COMPILED BY	<u>WM</u>
DATUM	<u>Geodetic</u>	DATE	<u>2006.08.29 - 2006.08.30</u>	CHECKED BY	<u>MA</u>

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL	
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL						
Continued From Previous Page																
186.4	SAND, trace silt, trace gravel Loose Grey Wet		9	SS	8		187							7 89 4 (SI+CL)		
10.7								186								
184.9	Sandy SILT, trace clay Compact to Loose Grey Wet  Occasional clay seams		10	SS	15		185									
12.2							184									
			11	SS	5		183									
							182									
			12	SS	6		181									
							180									
					179											
			13	SS	4		178									

+ 3, x 3: Numbers refer to Sensitivity

# RECORD OF BOREHOLE No 06-B01

3 OF 5

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 308.55 E 303 697.02 ORIGINATED BY GA  
 HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
 DATUM Geodetic DATE 2006.08.29 - 2006.08.30 CHECKED BY MA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W P W W L	WATER CONTENT (%)			
Continued From Previous Page														
175.8	Clayey SILT Firm Grey Wet (CL)  with clay seams and silty sand layers		14	SS	6		177							
21.3								176						
172.7	SAND, fine grained, some silt Compact Grey Wet		15	SS	13		175							
24.4								174						
169.8	Clayey SILT, trace to some sand Soft Grey Wet		16	SS	3		173							
27.3								172						
							171							
							170							
							169							
							168							

Continued Next Page

+ 3, x 3; Numbers refer to  
Sensitivity 20  
15 5  
10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 06-B01

4 OF 5

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 308.55 E 303 697.02 ORIGINATED BY GA  
 HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
 DATUM Geodetic DATE 2006.08.29 - 2006.08.30 CHECKED BY MA

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 NATURAL MOISTURE CONTENT LIQUID LIMIT W <sub>p</sub> W W <sub>L</sub> WATER CONTENT (%) 20 40 60 UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				
	Continued From Previous Page								
166.6 30.5	Silty CLAY, trace sand Very Soft to Firm Grey Wet (CL)		17	SS	3		167		0 3 57 40 Artesian Flow
							166		
							165		
							164		
			18	SS	5		163		
							162		
160.5 36.6	Sandy SILT Loose Grey Wet		19	SS	8		161		
							160		
							159		
157.5 39.6	SAND, fine grained, some silt Compact		20	SS	14		158		

Continued Next Page

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

ONTMT4S 5198.GPJ 04/04/07

# RECORD OF BOREHOLE No 06-B01

5 OF 5

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 308.55 E 303 697.02 ORIGINATED BY GA  
 HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
 DATUM Geodetic DATE 2006.08.29 - 2006.08.30 CHECKED BY MA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60	W <sub>p</sub> W W <sub>L</sub>				
	Continued From Previous Page													
	Grey Wet (SW)						157							
							156							
							155							
			21	SS	24		154							
153.5														
43.6	END OF BOREHOLE AT 43.59 m. AUGER REFUSAL AT 43.59 m ON PROBABLE BEDROCK OR BOULDERS. BOREHOLE OPEN AND ARTESIAN FLOW TO 0.3 m ABOVE GROUND SURFACE. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 2006-08-30 1.2 above G.S. 2006-08-31 1.5 above G.S. 2006-09-06 1.5 above G.S. 2006-09-08 1.5 above G.S. 2006-09-11 1.5 above G.S. 2006-09-25 1.5 above G.S.													

# RECORD OF BOREHOLE No 06-B02

1 OF 5

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 320.69 E 303 714.37 ORIGINATED BY GA  
 HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
 DATUM Geodetic DATE 2006.09.06 - 2006.09.07 CHECKED BY MA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>P</sub> W W <sub>L</sub>	20 40 60			
197.4 0.0	SAND and GRAVEL, occasional rootlets Brown (FILL)		1	SS	11		+1.12*							*Artesian
196.8 0.6	Silty CLAY, occasional rootlets Very Soft to Firm Grey Damp to Wet (CL)		2	SS	5									
			3	SS	2									
			4	SS	1									
			1	TW										
			5	SS	0									
			6	SS	1									
189.8 7.6	SAND, fine grained, some silt Loose Grey Wet		7	SS	5									
188.3 9.1	SILT, some clay, trace sand Soft Grey Wet		8	SS	3									

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+ 3 . X 3 : Numbers refer to  
Sensitivity 20  
15 5  
10 (%) STRAIN AT FAILURE

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# RECORD OF BOREHOLE No 06-B02

2 OF 5

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 320.69 E 303 714.37  
 HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing  
 DATUM Geodetic DATE 2006.09.06 - 2006.09.07  
 ORIGINATED BY GA  
 COMPILED BY WM  
 CHECKED BY MA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT Y kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	
	Continued From Previous Page							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	WATER CONTENT (%)			
186.7							187					
10.7	SAND, fine to medium grained, trace silt Loose Grey Wet		9	SS	7		186					
185.2							185					
12.2	Silty CLAY, trace sand Very Soft Grey to Reddish Brown Wet		10	SS	2		184					0 1 30 69
184.0							183					
13.4	SILT and SAND Loose Grey Wet		11	SS	8		182					0 41 55 4
							181					
							180					
179.1							179					0 1 84 15
18.3	SILT, some clay to clayey, trace sand Very Soft Grey Wet		13	SS	3		178					

Continued Next Page

+<sup>3</sup> × 3: Numbers refer to Sensitivity  
 20  
 15 10 5  
 (%) STRAIN AT FAILURE

ONTMT4S 5198.GPJ 08/03/07

# RECORD OF BOREHOLE No 06-B02

3 OF 5

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 320.69 E 303 714.37 ORIGINATED BY GA  
 HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
 DATUM Geodetic DATE 2006.09.06 - 2006.09.07 CHECKED BY MA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT Y kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W P	W	W L		
	Continued From Previous Page							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE		20 40 60				
176.1	Silty CLAY, trace sand, layered with occasional silt seams and sand seams Firm Grey Wet		14	SS	7		177	3.3						
21.3							176							
							175							
			15	SS	11		174							
							173							
							172							
							171							
			16	SS	5		170							
							169							
							168							

Continued Next Page

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



# RECORD OF BOREHOLE No 06-B02

4 OF 5

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 320.69 E 303 714.37 ORIGINATED BY GA  
 HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
 DATUM Geodetic DATE 2006.09.06 - 2006.09.07 CHECKED BY MA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES								
Continued From Previous Page													
			17	SS	6								0 4 54 42
			18	SS	1								Artesian Flow at 0.9 m inside casing
			19	SS	6								
157.8 39.6	SAND, fine grained, trace silt Compact		20	SS	14								

Continued Next Page

+ 3 . x 3 : Numbers refer to  
Sensitivity 20  
15 5  
10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 06-B02

5 OF 5

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 320.69 E 303 714.37 ORIGINATED BY GA  
 HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
 DATUM Geodetic DATE 2006.09.06 - 2006.09.07 CHECKED BY MA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  Y  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)		
								20	40	60			80	100	20
<div><div>DYNAMIC CONE PENETRATION RESISTANCE PLOT</div><div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE</div></div><div><div>PLASTIC LIMIT</div><div>NATURAL MOISTURE CONTENT</div><div>LIQUID LIMIT</div><div>W<sub>P</sub> — W — W<sub>L</sub></div></div><div><div>204060</div><div>20406080100</div><div>204060</div></div></div>															
	Continued From Previous Page														
	Grey Wet						157								
							156								
155.5															
41.9	Salmon and black, fresh, coarse grained, very strong, <b>GRANITE</b> , with black banding														
	Horizontal joint at 42.62 m		1	RUN			155								
	Horizontal joints at 43.87, 44.12 and 44.42 m		2	RUN			154								
152.4							153								
45.0	END OF BOREHOLE AT 44.98 m. BOREHOLE OPEN AND WATER LEVEL AT SURFACE ON COMPLETION. ARTESIAN CONDITION DISSIPATED. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 2006-09-08 0.39 above G.S. 2006-09-11 0.41 above G.S. 2006-09-25 1.12 above G.S.														

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

20  
15 5  
10 (%) STRAIN AT FAILURE






# RECORD OF BOREHOLE No 06-B03

2 OF 5

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 301.00 E 303 716.81 ORIGINATED BY KH  
 HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
 DATUM Geodetic DATE 2006.08.29 - 2006.08.29 CHECKED BY MA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE	×						
								● QUICK TRIAXIAL	×	LAB VANE						
	Continued From Previous Page						20 40 60 80 100	20 40 60 80 100	20 40 60							
187.4	SAND, fine to medium grained, trace silt Very Loose Grey Wet		10	SS	1		189							0 3 77 20		
11.6							188									
185.9			11	SS	3		187									
13.1	Silty SAND, trace clay Very Loose Grey Wet		12	SS	1		186									
							185									
			13	SS	1		184							0 68 28 4		
182.2	Silty CLAY, trace sand Very Soft Grey Wet		14	SS	1		183									
16.8							182									
							181									
							180									

Continued Next Page

+<sup>3</sup> ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 06-B03

3 OF 5

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 301.00 E 303 716.81 ORIGINATED BY KH  
 HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
 DATUM Geodetic DATE 2006.08.29 - 2006.08.29 CHECKED BY MA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES								
	Continued From Previous Page												
			15	SS	1		179						
							178						0 1 69 30
							177						
							176						
			16	SS	1		175						
							174						
							173						
							172						
			17	SS	1		171						
							170						

Continued Next Page

+ 3, x 3: Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 06-B03

4 OF 5

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 301.00 E 303 716.81 ORIGINATED BY KH  
 HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
 DATUM Geodetic DATE 2006.08.29 - 2006.08.29 CHECKED BY MA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	
	Continued From Previous Page							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	WATER CONTENT (%)			GR SA SI CL
			18	SS	1		169					0 1 58 41
							168					
							167					
							166					
			19	SS	1		165					
							164					
164.3							163					
34.7	SILT, some sand, some clay, occasional fine sand layers Compact Grey Wet						162					
			20	SS	22		161					0 13 74 13
							160					
161.2												
37.8	SAND, fine grained, some silt Compact Grey Wet											
			21	SS	17							

Continued Next Page

+ <sup>3</sup> . x <sup>3</sup> : Numbers refer to  
Sensitivity 20  
15 5  
10 (%) STRAIN AT FAILURE




ONTM/T4S 5198.GPJ 08/03/07

# RECORD OF BOREHOLE No 06-B03

5 OF 5

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 301.00 E 303 716.81 ORIGINATED BY KH  
 HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
 DATUM Geodetic DATE 2006.08.29 - 2006.08.29 CHECKED BY MA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					PLASTIC LIMIT  w <sub>p</sub>	NATURAL MOISTURE CONTENT  w	LIQUID LIMIT  w <sub>L</sub>
								○ UNCONFINED + FIELD VANE							
								● QUICK TRIAXIAL × LAB VANE							
Continued From Previous Page							20 40 60 80 100	20 40 60	20 40 60						
157.5	SILT, some sand Loose Grey Wet					159									
41.5						158									
						157									
			22	SS	9		156								
							155								
154.4	Salmon and black, fresh, coarse grained, very strong, <b>GRANITE</b>		1	RUN		154									
44.6						153									
						152									
			3	RUN											
151.2	END OF BOREHOLE AT 47.80 m. BOREHOLE BACKFILLED WITH BENTONITE AND SAND, WITH COLD PATCH AT SURFACE.														
47.8															




ONTMT4S 5198.GPJ 09/03/07

# RECORD OF BOREHOLE No 06-B04

1 OF 5

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 316.00 E 303 723.57 ORIGINATED BY KH  
 HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
 DATUM Geodetic DATE 2006.08.30 - 2006.08.30 CHECKED BY MA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE						
								● QUICK TRIAXIAL	× LAB VANE						
199.0						20	40	60	80	100	20	40	60	GR SA SI CL	
0.0	ASPHALT: (90 mm) Gravelly SAND Compact to Loose Brown Moist (FILL)		1	SS	26										
0.1			2	SS	7										
			3	SS	28										
196.6	Sandy SILT, trace clay, trace gravel, occasional wood fragments Very Loose Grey Wet		4	SS	2										
2.4															
196.0	Silty CLAY, trace gravel and organics to 4.11 m Very Soft to Soft Grey Wet		5	SS	2										
3.0															
					6	SS	1								
			1	TW										0 0 33 67	
			7	SS	1									0 0 37 63	
			8	SS	1										

Continued Next Page

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



# RECORD OF BOREHOLE No 06-B04

2 OF 5

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 316.00 E 303 723.57 ORIGINATED BY KH  
 HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
 DATUM Geodetic DATE 2006.08.30 - 2006.08.30 CHECKED BY MA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
	Continued From Previous Page													
			9	SS	2									
			10	SS	3									
			11	SS	1									
184.1														
14.9	SILT, trace sand, trace clay Very Loose Grey Wet		12	SS	2									
181.0														
18.0	Clayey SILT, trace sand, with layers of silt and silty clay Very Soft Grey Wet		13	SS	1									



Continued Next Page

+ 3, x 3: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

## METRIC

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			"N" VALUES	20				
	Continued From Previous Page						SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				γ	GR SA SI CL
							WATER CONTENT (%) 20 40 60		20 40 60			

[illegible]

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

ONTMT4S 5198.GPJ 08/03/07

# RECORD OF BOREHOLE No 06-B04

4 OF 5

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 316.00 E 303 723.57 ORIGINATED BY KH  
 HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
 DATUM Geodetic DATE 2006.08.30 - 2006.08.30 CHECKED BY MA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT Y kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
	Continued From Previous Page						SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				
			17	SS	1						0 8 61 31
			18	SS	3						0 8 60 32
162.4 36.6	SAND, fine grained, some silt Compact to Dense Grey Wet		19	SS	22						
			20	SS	36						

Continued Next Page

+<sup>3</sup> ×<sup>3</sup>: Numbers refer to  
Sensitivity 20  
15 5  
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 06-B04

5 OF 5

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 316.00 E 303 723.57 ORIGINATED BY KH  
HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
DATUM Geodetic DATE 2006.08.30 - 2006.08.30 CHECKED BY MA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
	Continued From Previous Page						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	20 40 60					
159													
158													
157.2													
41.8	END OF BOREHOLE AT 41.76 m. CASING REFUSAL AT 41.76 m ON PROBABLE BEDROCK OR BOULDERS. BOREHOLE BACKFILLED WITH BENTONITE AND SAND, WITH COLD PATCH AT SURFACE.												



# RECORD OF BOREHOLE No 06-B06

2 OF 5

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 311.29 E 303 735.18 ORIGINATED BY GA  
 HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
 DATUM Geodetic DATE 2006.09.07 - 2006.09.08 CHECKED BY MA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
Continued From Previous Page											
186.3	Silty CLAY Very Soft Grey to Reddish Brown Wet		9	SS	2		187 186 185 184 183 182 181 180 179 178	20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	w <sub>p</sub> — w — w <sub>L</sub> WATER CONTENT (%)		
10.7											
183.3	SILT, some sand, trace clay Loose to Very Loose Grey Wet		10	SS	1						0 15 81 4
13.7											
			11	SS	8						
			12	SS	5						
			13	SS	3						

Continued Next Page

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

ONTMT4S 5198.GPJ 08/03/07

# RECORD OF BOREHOLE No 06-B06

3 OF 5

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 311.29 E 303 735.18 ORIGINATED BY GA  
 HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
 DATUM Geodetic DATE 2006.09.07 - 2006.09.08 CHECKED BY MA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES								
176.9	Continued From Previous Page												
20.1	SILT, clayey to some clay, trace sand, occasional sand seams Soft to Very Soft Grey Wet		14	SS	4								
			15	SS	3								
169.6													
27.4	SAND, fine to medium grained, some silt Compact Grey Wet		16	SS	27								0 87 13 (SI+CL)
													Slight Artesian Flow

Continued Next Page

+ 3, x 3: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 06-B06

4 OF 5

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 311.29 E 303 735.18 ORIGINATED BY GA  
 HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
 DATUM Geodetic DATE 2006.09.07 - 2006.09.08 CHECKED BY MA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	20 40 60		
166.5	CLAY, silty, occasional sand seams Stiff Grey Wet		17	SS	9								0 1 61 38
165													
164													
163			18	SS	10								
162													
161													
160			19	SS	8								
159													
158													
157.4	Occasional gravel seam												
157.4	Salmon, black and dark grey, fresh, coarse grained, very strong, GRANITE												Water at 0.6 m above G.S. in casing
39.6													RUN 1# TCR=100%,

Continued Next Page

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

ONTMT4S 5198.GPJ 08/03/07



# RECORD OF BOREHOLE No 06-B06

5 OF 5

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 311.29 E 303 735.18 ORIGINATED BY GA  
 HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
 DATUM Geodetic DATE 2006.09.07 - 2006.09.08 CHECKED BY MA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE			w <sub>p</sub> w w <sub>L</sub>						
Continued From Previous Page							20 40 60 80 100	20 40 60									
154.5	Sub horizontal joint at 40.23 m Horizontal joint at 40.31 m  Vertical joint from 41.00 to 41.61 m  Broken zone from 41.00 to 41.30 m and 41.61 to 41.76 m		1	RUN		157								1	GR SA SI CL SCR=96%, RQD=93%, UCS=146MPa		
																1	
																	0
																	5
																	2
42.5	END OF BOREHOLE AT 42.52 m. BOREHOLE OPEN AND WATER LEVEL AT 1.8 m ABOVE GROUND SURFACE UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 2006-09-11 1.4 above G.S. 2006-09-25 1.5 above G.S.		2	RUN		156								0	RUN 2# TCR=100%, SCR=60%, RQD=60%, UCS=138MPa		
																0	
																0	
																0	
																0	

# RECORD OF BOREHOLE No 06-B07

1 OF 2

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 093.68 E 303 642.56 ORIGINATED BY GA  
 HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
 DATUM Geodetic DATE 2006.08.28 - 2006.08.28 CHECKED BY MA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)	
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL							× LAB VANE
197.9						20	40	60	80	100	20	40	60	GR	SA	SI	CL
0.0	SAND, some silt, trace organics Loose to Very Loose Brown Dry (SP)  Grey Wet		1	SS	4							○					
			2	SS	3							○					
196.4																	
1.5	SILT, some clay to clayey Very Soft Grey Wet (ML-NP)		3	SS	2							○					
			4	SS	1							○					0 0 82 18
194.9																	
3.0	Silty CLAY, trace sand Very Soft Grey Wet (CL)		5	SS	2												
			6	SS	1												
			7	SS	1												
			8	SS	4												
189.7																	
8.2	SAND, fine grained, trace to some silt Dense Grey Wet (SW)																0 1 31 68
			9	SS	31												

Continued Next Page

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

ONTMT-4S 5198.GPJ 08/03/07

# RECORD OF BOREHOLE No 06-B07

2 OF 2

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 093.68 E 303 642.56 ORIGINATED BY GA  
 HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
 DATUM Geodetic DATE 2006.08.28 - 2006.08.28 CHECKED BY MA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
	Continued From Previous Page							20 40 60 80 100							
186.3			10	SS	31		187								
11.6	GRAVEL, some sand, occasional granite fragments Very Dense Wet						186								
185.3			11	SS	130										
12.6	END OF BOREHOLE AT 12.65 m. AUGER REFUSAL AT 12.65 m ON PROBABLE BEDROCK OR BOULDERS. BOREHOLE OPEN AND ARTESIAN FLOW TO 0.3 m ABOVE GROUND SURFACE UPON COMPLETION. ARTESIAN CONDITION DISSIPATED AFTER 20 MIN. BOREHOLE BACKFILLED WITH HOLEPLUG AND CONCRETE AT SURFACE.														

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

# RECORD OF BOREHOLE No 06-B08

1 OF 2

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 196.21 E 303 667.23 ORIGINATED BY GA  
 HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
 DATUM Geodetic DATE 2006.09.05 - 2006.09.05 CHECKED BY MA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE						
198.0							20	40	60	80	100				
0.0	SAND, some silt, with rootlets and organics		1	SS	6		20	40	60	80	100				*Artesian
197.7															
0.3	SAND, fine to medium grained, trace silt, occasional iron oxide staining Loose Brown Dry to Wet		2	SS	5										
			3	SS	4										0 94 6 (SI+CL)
195.7															
2.3	Silty CLAY Very Soft to Soft Grey Wet		4	SS	2										
			5	SS	1										
			6	SS	1										
			7	SS	1										0 0 33 67
			8	SS	0										
188.9															
9.1	SAND, fine to medium grained, trace silt Loose to Compact Grey Wet		9	SS	9										

Continued Next Page

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

ONTMT4S 5198.GPJ 04/04/07

# RECORD OF BOREHOLE No 06-B08

2 OF 2

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 196.21 E 303 667.23 ORIGINATED BY GA  
 HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
 DATUM Geodetic DATE 2006.09.05 - 2006.09.05 CHECKED BY MA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
	Continued From Previous Page													
			10	SS	18									0 94 6 (SI+CL)
			11	SS	7									
184.3														
13.7	Silty CLAY, trace sand, occasional silt seams Soft Grey Wet		12	SS	3		2.8							
			13	SS	3									0 2 36 62
181.2														
16.8	SILT, trace sand, occasional sand seams Compact Grey Wet		14	SS	21									
180.3			15	SS	100									
17.7	END OF BOREHOLE AT 17.68 m. AUGER REFUSAL AT 17.68 m ON PROBABLE BEDROCK OR BOULDERS. BOREHOLE OPEN AND WATER LEVEL AT 1.52 m ON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 2006-09-06 0.30 above G.S. 2006-09-08 0.30 above G.S. 2006-09-11 0.31 above G.S. 2006-09-25 0.35 above G.S.													

ONTMT4S 5198 GPJ 04/04/07

## METRIC

[illegible]

+ 3, × 3: Numbers refer to Sensitivity

# RECORD OF BOREHOLE No 06-B09

2 OF 3

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 202.30 E 303 701.05 ORIGINATED BY GA  
 HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
 DATUM Geodetic DATE 2006.08.31 - 2006.08.31 CHECKED BY MA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	T <sub>N</sub> VALUES			20	40	60	80	100	
	Continued From Previous Page							SHEAR STRENGTH kPa					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					
								WATER CONTENT (%)					
								PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT					
								w <sub>p</sub> w w <sub>L</sub>					
187.4													
10.7	SAND, fine to coarse grained, trace silt Compact Grey Wet		10	SS	15								
185.9													
12.2	GRAVEL, some sand, trace silt, with granite fragments Compact Grey Wet		11	SS	17								
185.0													
13.1	SAND, fine to coarse grained, trace silt, trace gravel Loose Grey Wet		12	SS	8								
182.9													
15.2	SILT, some sand Compact Grey Wet		13	SS	12								
181.3													
16.8	SAND, fine to coarse grained, trace silt, trace gravel Compact Grey Wet		14	SS	14								
178.9													
19.2	SAND and GRAVEL Compact Grey Wet												

Continued Next Page

+ <sup>3</sup> × <sup>3</sup> : Numbers refer to Sensitivity  
 20  
 15 10 5 0  
 (%) STRAIN AT FAILURE

ONTMT4S 5198.GPJ 09/03/07

RECORD OF BOREHOLE No 06-B09

3 OF 3

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 202.30 E 303 701.05 ORIGINATED BY GA  
HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
DATUM Geodetic DATE 2006.08.31 - 2006.08.31 CHECKED BY MA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
	Continued From Previous Page		15	SS	22			20 40 60 80 100						
177.7														
20.4	END OF BOREHOLE AT 20.42 m. BOREHOLE OPEN to 19.81 m AND WATER LEVEL AT 1.52 m ON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE.													

ONTMT4S 5198.GPJ 08/03/07



# RECORD OF BOREHOLE No 06-B10

1 OF 3

METRIC

G.W.P. 5200-03-00 LOCATION Beatty Creek Bridge N 5 105 376.19 E 303 758.13 ORIGINATED BY KH  
 HWY 534 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM  
 DATUM Geodetic DATE 2006.08.31 - 2006.08.31 CHECKED BY MA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	
199.5	ASPHALT: (50 mm) Gravelly SAND, trace silt Very Dense to Compact Brown Moist (FILL)		1	SS	49		199					
198.1	Silty SAND, fine grained, trace clay, trace rootlets Compact to Loose Grey Wet		2	SS	15		198					
196.5	SILT, trace to some sand, trace clay Very Loose Grey Wet		3	SS	16		197					0 60 40 (SI+CL)
194.9	Clayey SILT, fine grained, some sand Very Soft Grey Wet (CL-ML)		4	SS	7		196					
194.0	Silty CLAY Very Soft Grey Wet		5	SS	1		195					0 2 82 16
			6	SS	1		194					
			7	SS	1		193					
			8	SS	1		192					0 0 38 62
			9	SS	1		191					
							190					

Continued Next Page

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

20  
15  
10

(%) STRAIN AT FAILURE



## METRIC

[illegible]

## **Appendix B**

### **Laboratory Test Results**

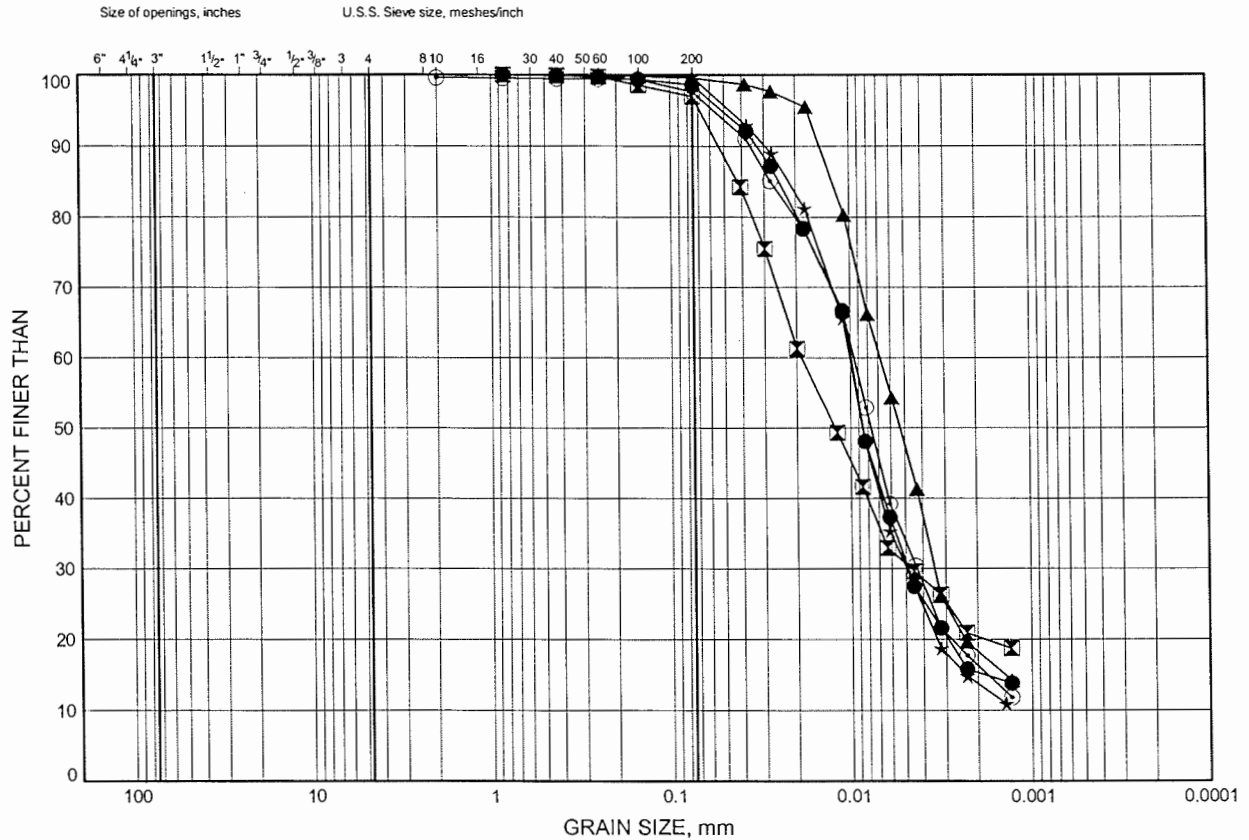


# Beatty Creek Bridge Replacement

## GRAIN SIZE DISTRIBUTION

FIGURE B2

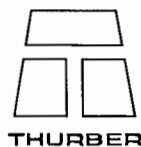
### Upper Clayey Silt



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-B01	1.83	195.27
⊠	06-B03	10.67	188.33
▲	06-B07	2.59	195.31
★	06-B09	2.59	195.51
⊙	06-B10	4.88	194.62

Date December 2006  
Project 5200-03-00



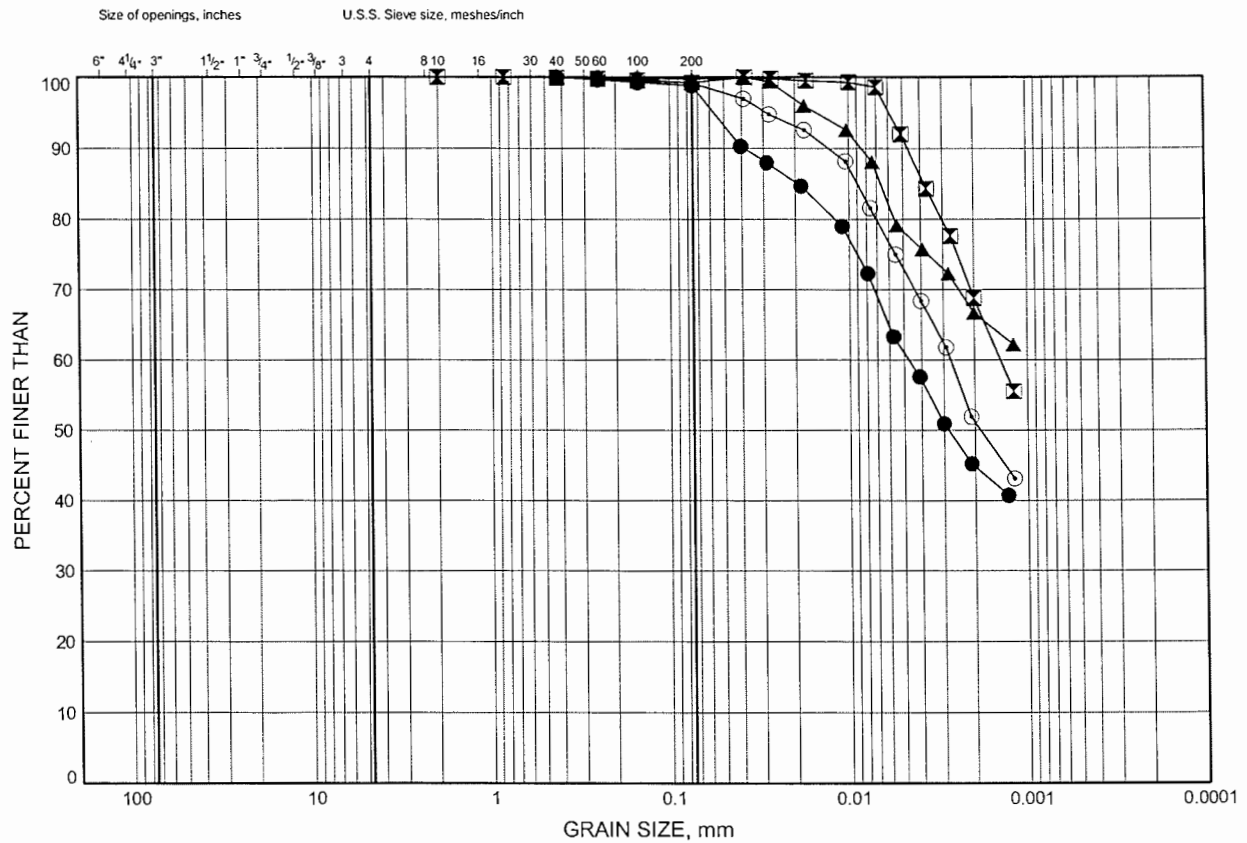
Prep'd JHL  
Chkd. MRA

# Beatty Creek Bridge Replacement

## GRAIN SIZE DISTRIBUTION

FIGURE B3

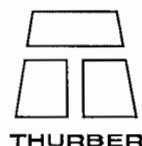
### Upper Silty Clay



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-B01	4.88	192.22
⊠	06-B02	12.50	184.90
▲	06-B04	6.40	192.60
★	06-B04	7.62	191.38
⊙	06-B04	13.72	185.28

Date December 2006  
Project 5200-03-00



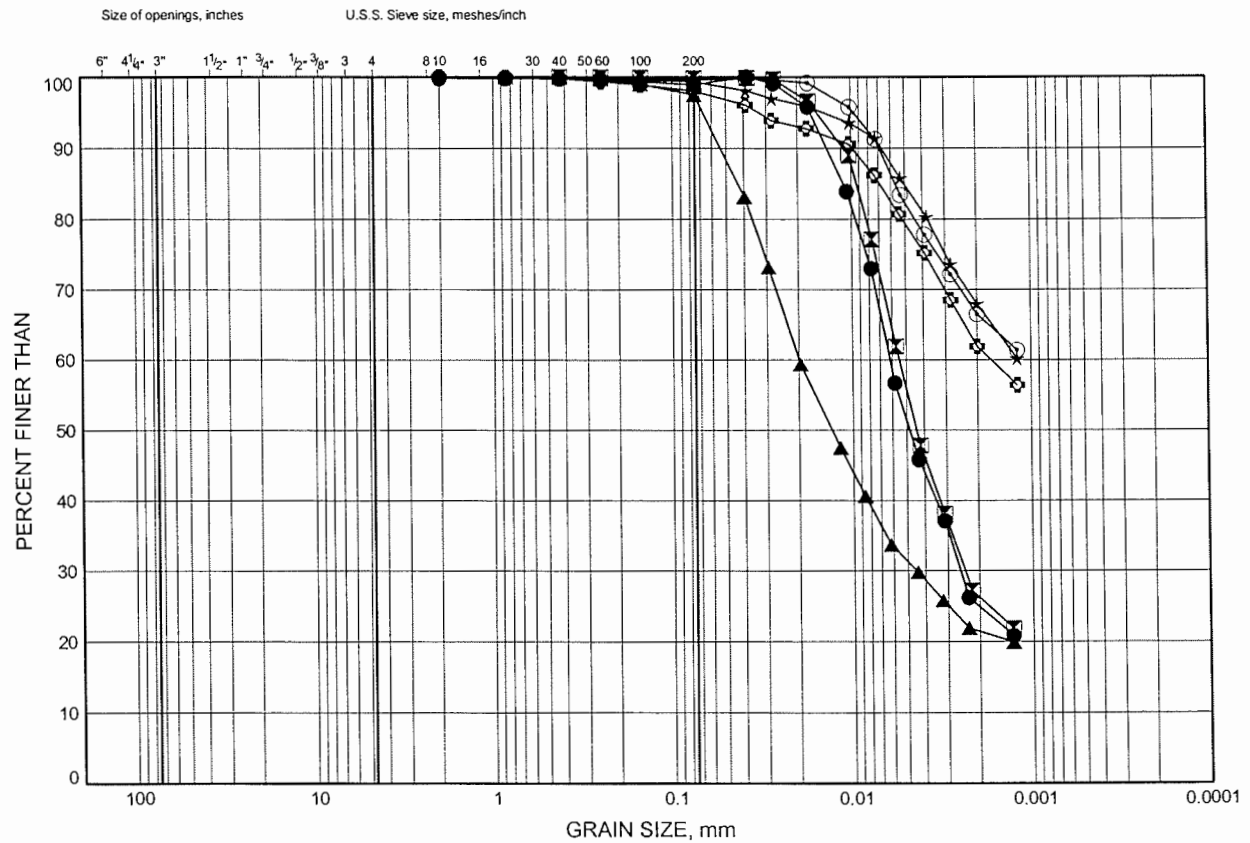
Prep'd JHL  
Chkd. MRA

# Beatty Creek Bridge Replacement

## GRAIN SIZE DISTRIBUTION

FIGURE B4

### Upper Silty Clay

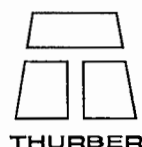


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-B06	3.35	193.65
⊠	06-B06	4.88	192.12
▲	06-B06	7.92	189.08
★	06-B07	7.92	189.98
⊙	06-B08	6.40	191.60
⊛	06-B08	15.54	182.46

Date December 2006

Project 5200-03-00



THURBER

Prep'd JHL

Chkd. MRA

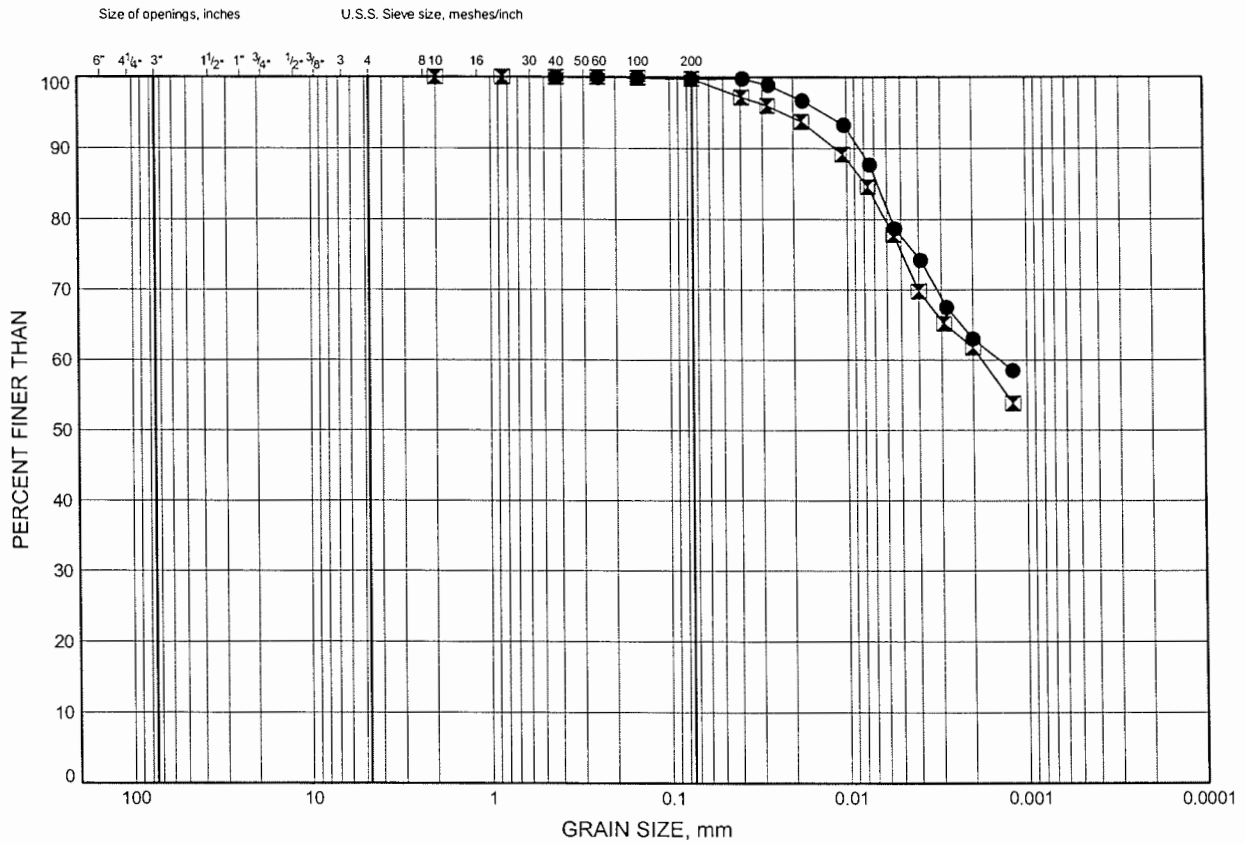


# Beatty Creek Bridge Replacement

## GRAIN SIZE DISTRIBUTION

FIGURE B5

### Upper Silty Clay

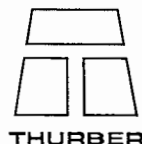


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-B09	6.40	191.70
■	06-B10	7.62	191.88

Date December 2006

Project 5200-03-00



Prep'd JHL

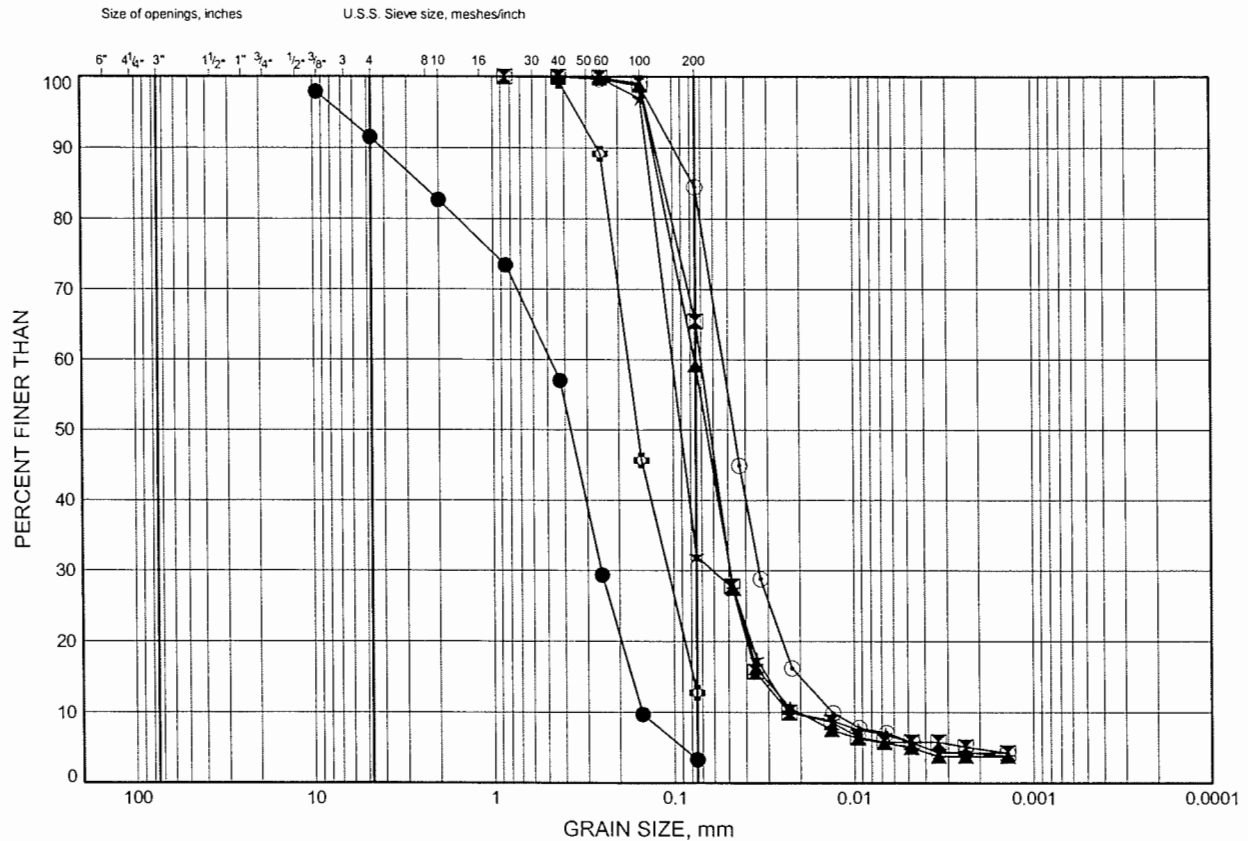
Chkd. MRA

# Beatty Creek Bridge Replacement

## GRAIN SIZE DISTRIBUTION

FIGURE B6

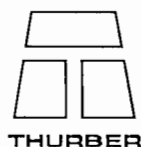
### Intermediate Sand to Silt



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-B01	10.97	186.13
⊠	06-B01	15.54	181.56
▲	06-B02	15.54	181.86
★	06-B03	15.24	183.76
⊙	06-B06	14.02	182.98
⊕	06-B06	27.74	169.26

Date December 2006

Project 5200-03-00



Prep'd JHL

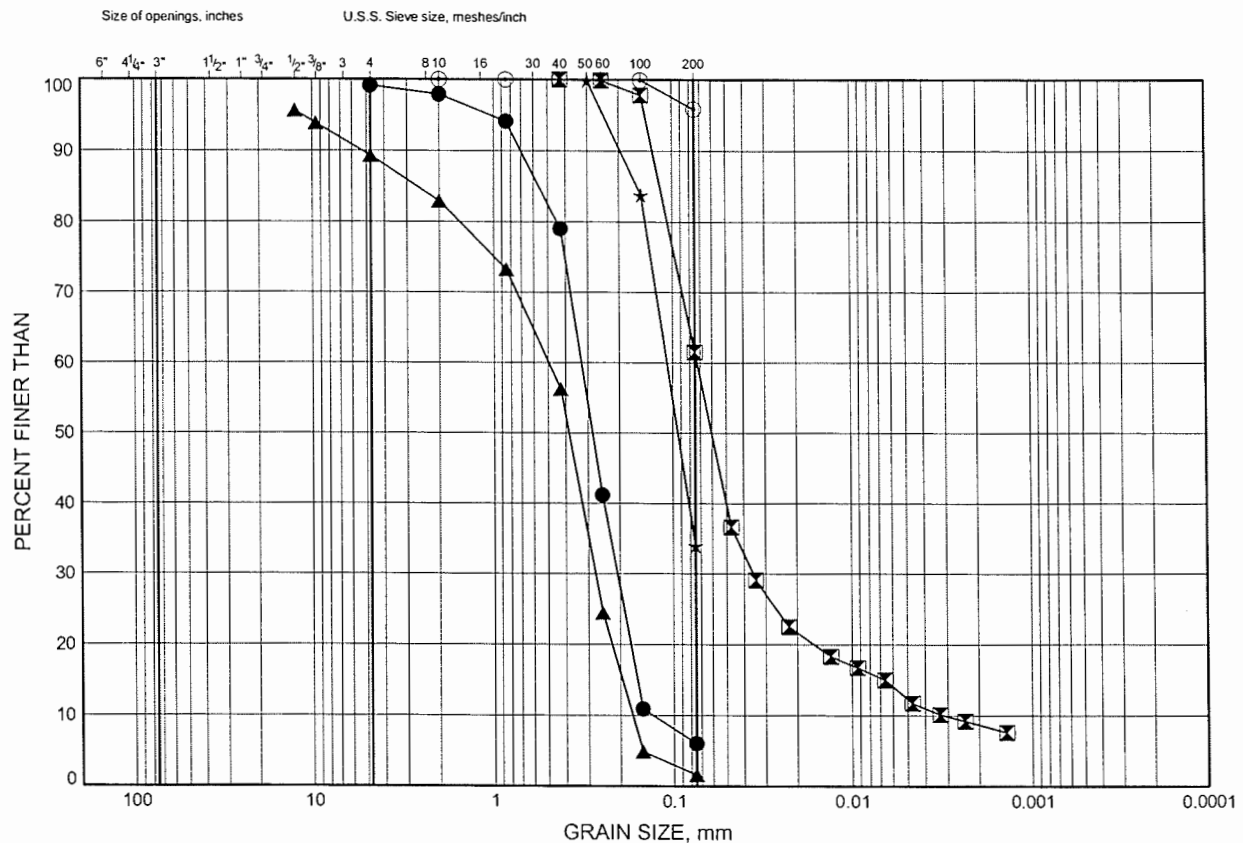
Chkd. MRA

# Beatty Creek Bridge Replacement

## GRAIN SIZE DISTRIBUTION

FIGURE B7

Intermediate Sand to Silt

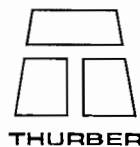


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-B08	10.97	187.03
⊠	06-B09	9.45	188.65
▲	06-B09	14.02	184.08
★	06-B10	12.19	187.31
⊙	06-B10	16.76	182.74

Date December 2006

Project 5200-03-00



Prep'd JHL

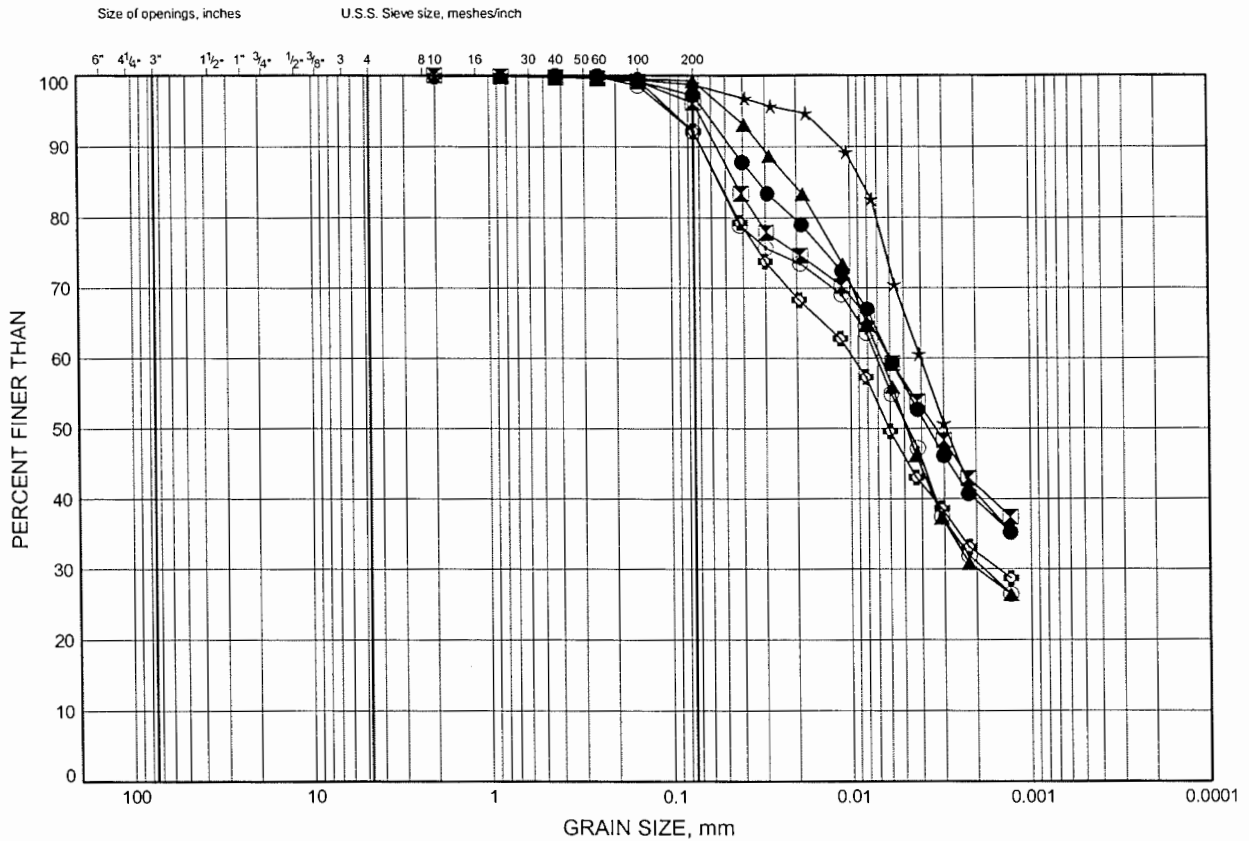
Chkd. MRA

# Beatty Creek Bridge Replacement

## GRAIN SIZE DISTRIBUTION

FIGURE B8

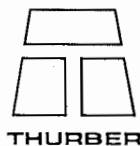
### Lower Silty Clay



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-B01	30.78	166.32
⊠	06-B02	30.78	166.62
▲	06-B03	21.34	177.66
★	06-B03	30.48	168.52
⊙	06-B04	30.48	168.52
⊗	06-B04	33.53	165.47

Date December 2006  
Project 5200-03-00



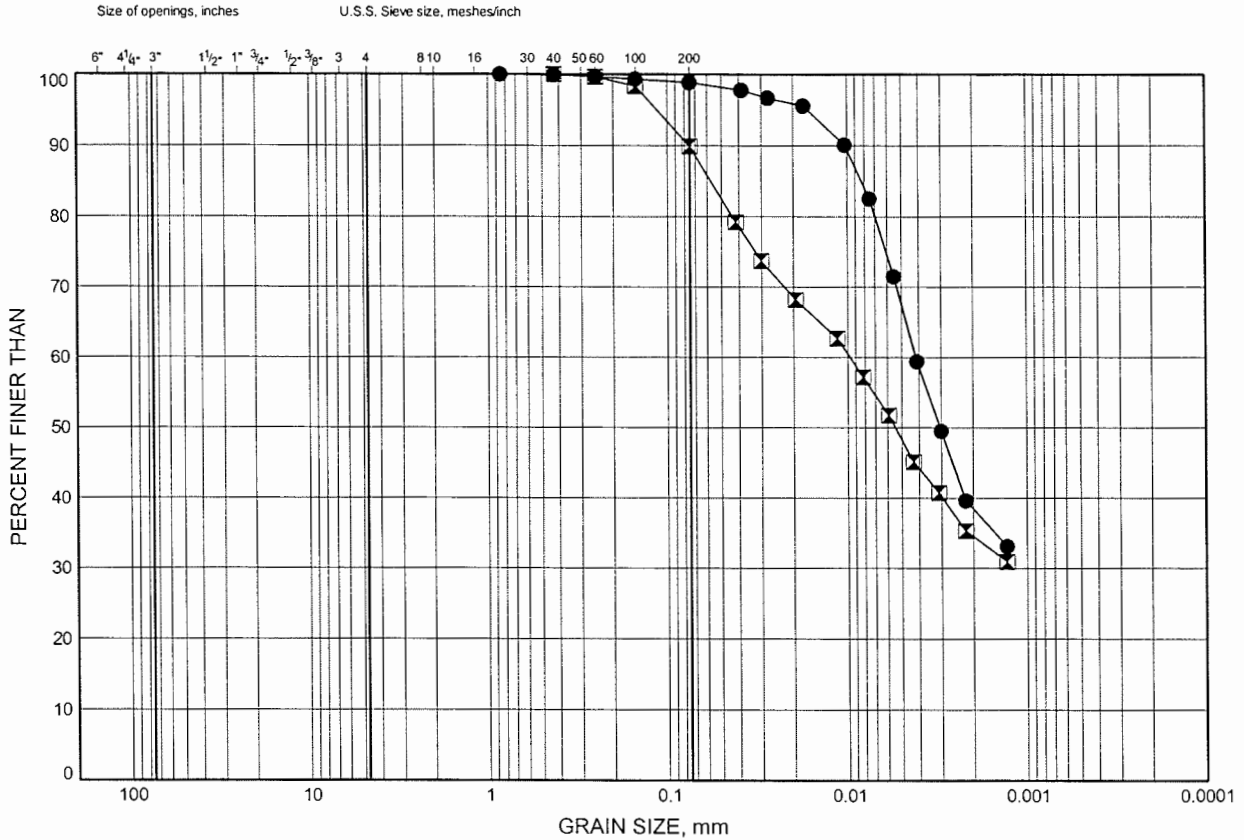
Prep'd JHL  
Chkd. MRA

# Beatty Creek Bridge Replacement

## GRAIN SIZE DISTRIBUTION

FIGURE B9

### Lower Silty Clay

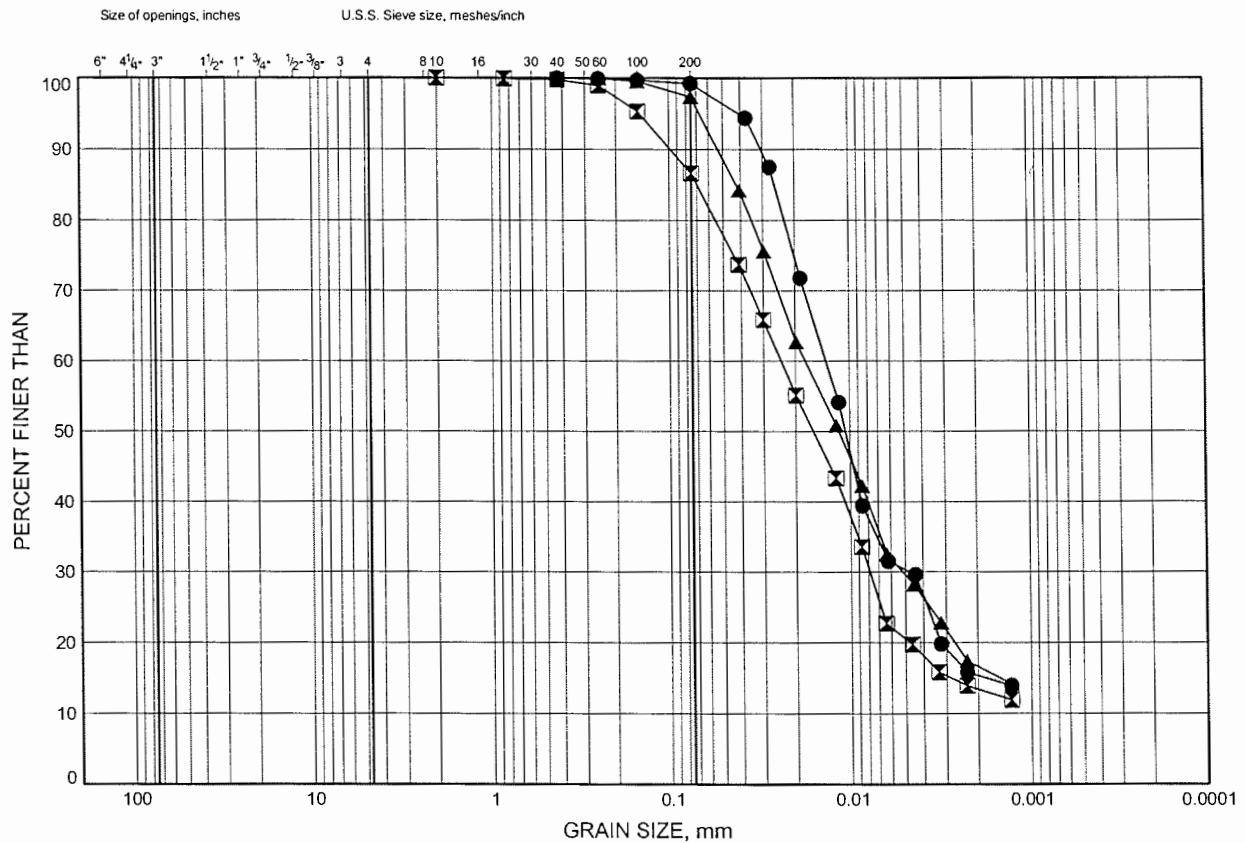


# Beatty Creek Bridge Replacement

## GRAIN SIZE DISTRIBUTION

FIGURE B10

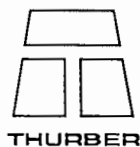
### Lower Clayey Silt



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-B02	18.59	178.81
◻	06-B03	36.58	162.42
▲	06-B04	18.29	180.71

Date December 2006  
Project 5200-03-00

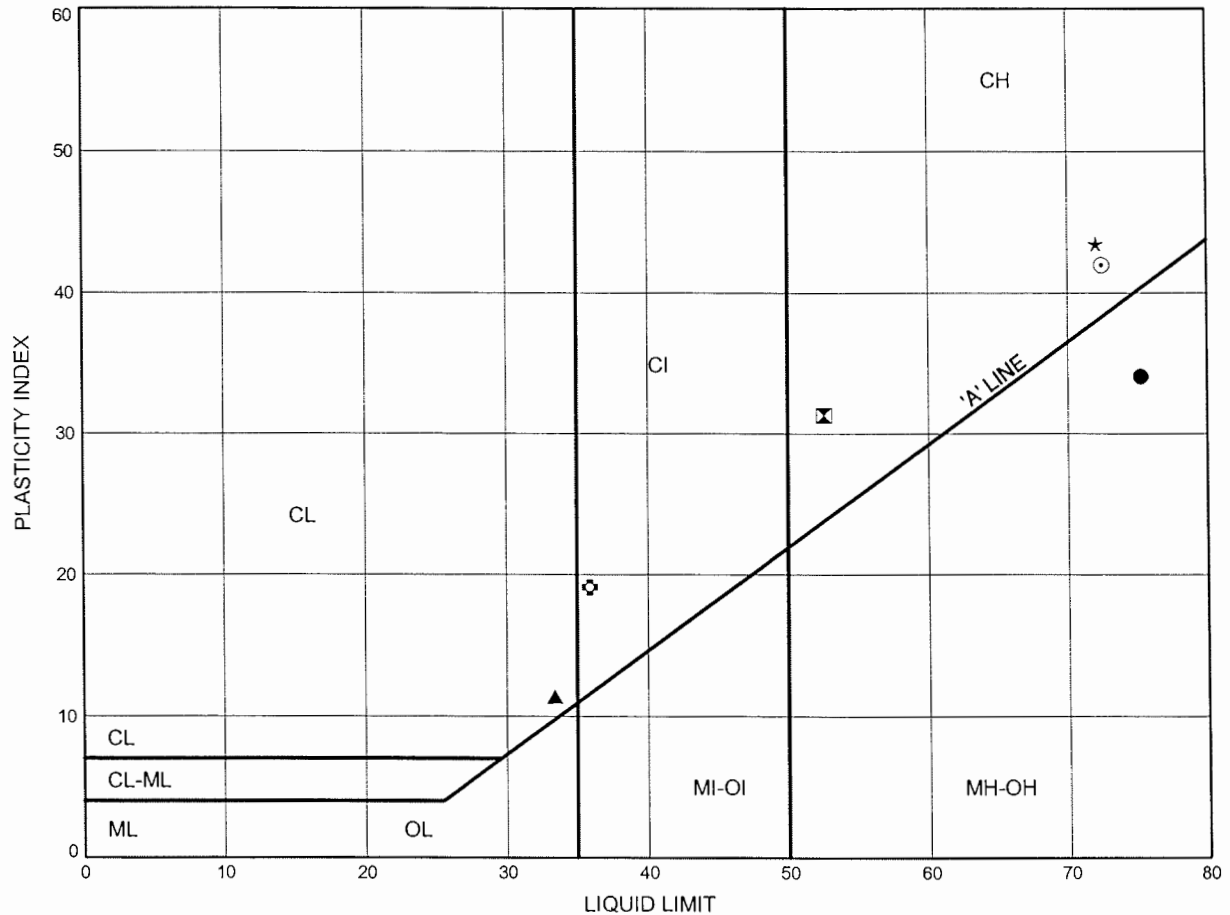


Prep'd JHL  
Chkd. MRA

Beatty Creek Bridge Replacement  
**ATTERBERG LIMITS TEST RESULTS**

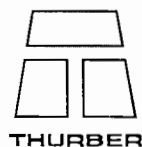
FIGURE B11

Upper Silty Clay



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-B01	4.88	192.22
⊠	06-B02	12.50	184.90
▲	06-B03	4.88	194.12
★	06-B04	6.40	192.60
⊙	06-B04	7.62	191.38
⊛	06-B04	13.72	185.28

Date December 2006  
 Project 5200-03-00

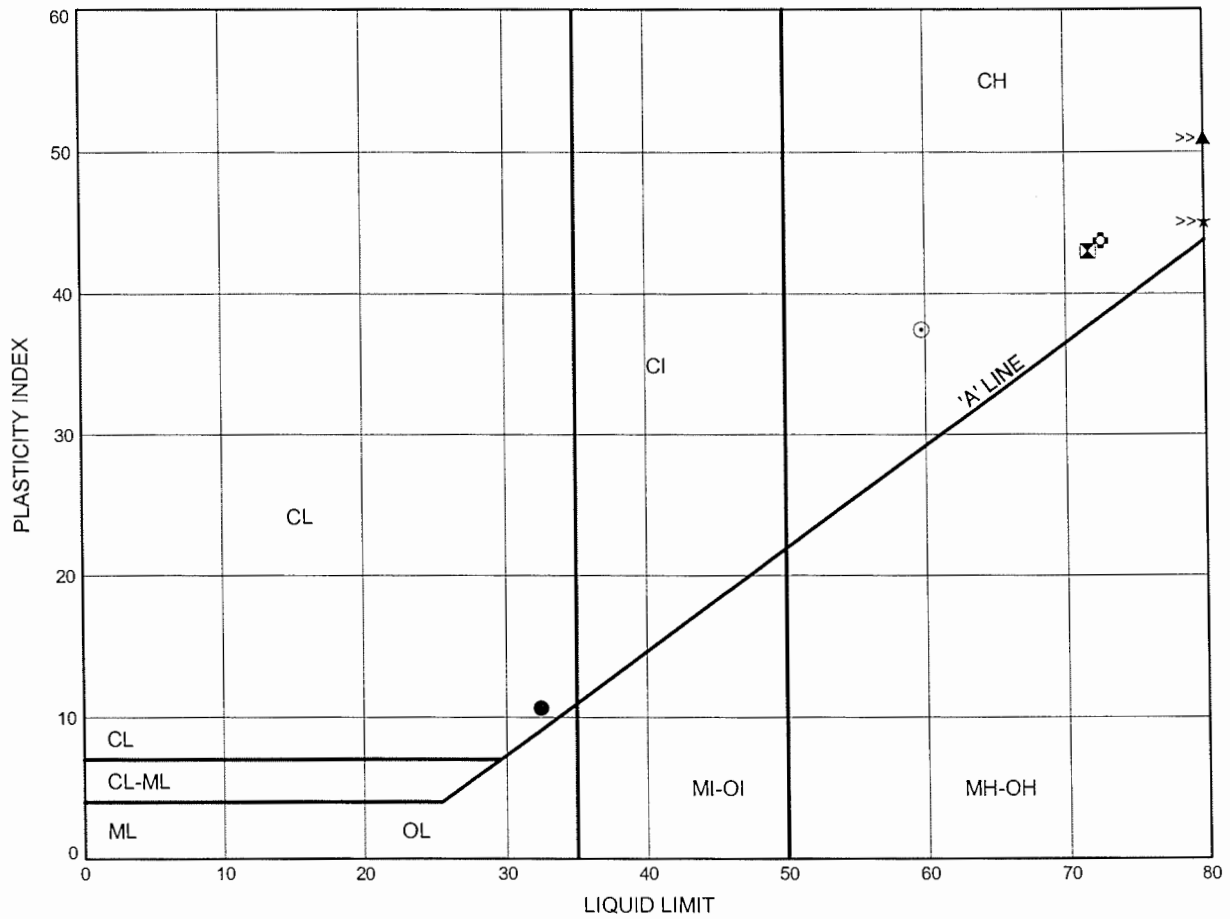


Prep'd JHL  
 Chkd. MRA

# Beatty Creek Bridge Replacement ATTERBERG LIMITS TEST RESULTS

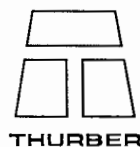
FIGURE B12

## Upper Silty Clay



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-B06	3.35	193.65
⊠	06-B06	4.88	192.12
▲	06-B07	7.92	189.98
★	06-B08	6.40	191.60
⊙	06-B08	15.54	182.46
⊕	06-B09	6.40	191.70

Date December 2006  
Project 5200-03-00



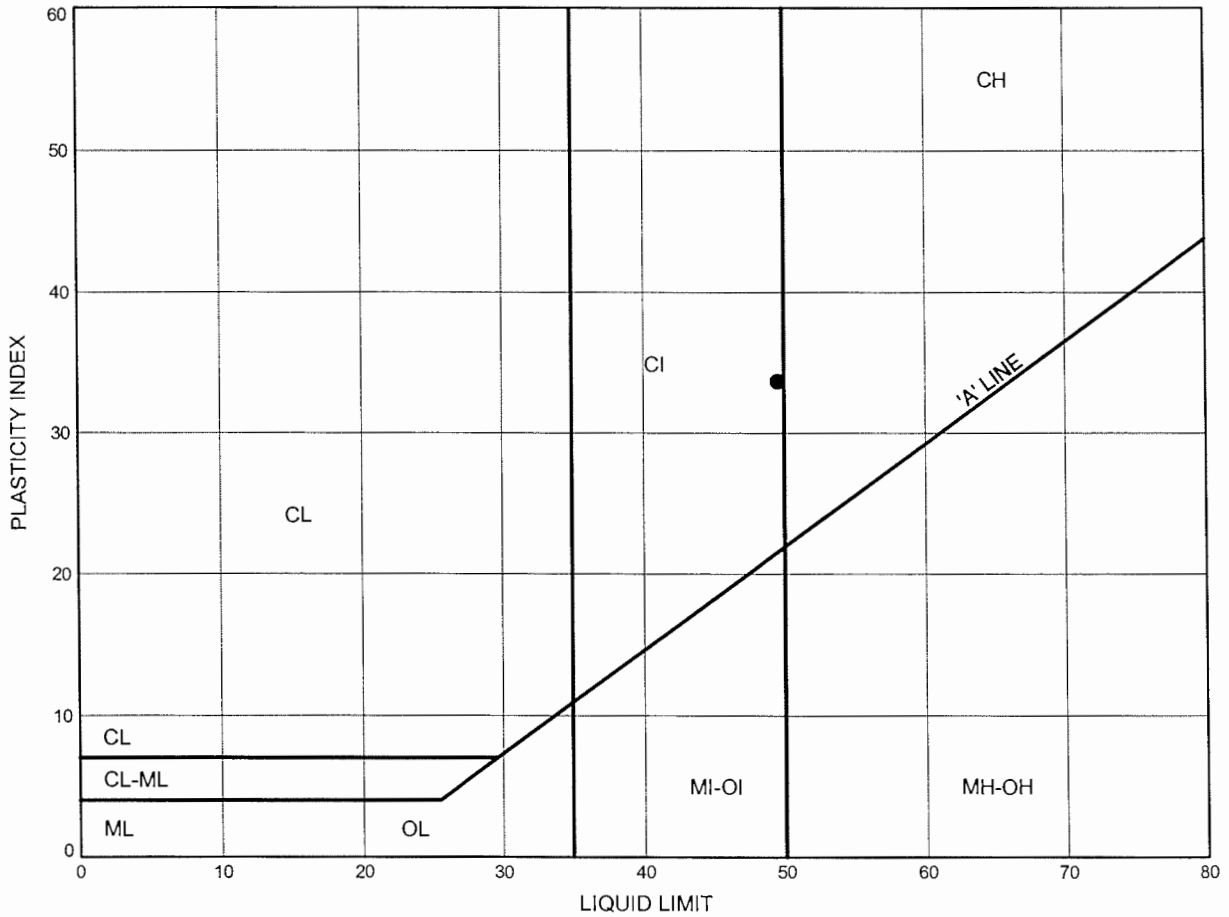
Prep'd JHL  
Chkd. MRA



Beatty Creek Bridge Replacement  
**ATTERBERG LIMITS TEST RESULTS**

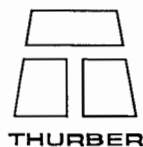
FIGURE B13

Upper Silty Clay



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-B10	7.62	191.88

Date December 2006  
 Project 5200-03-00

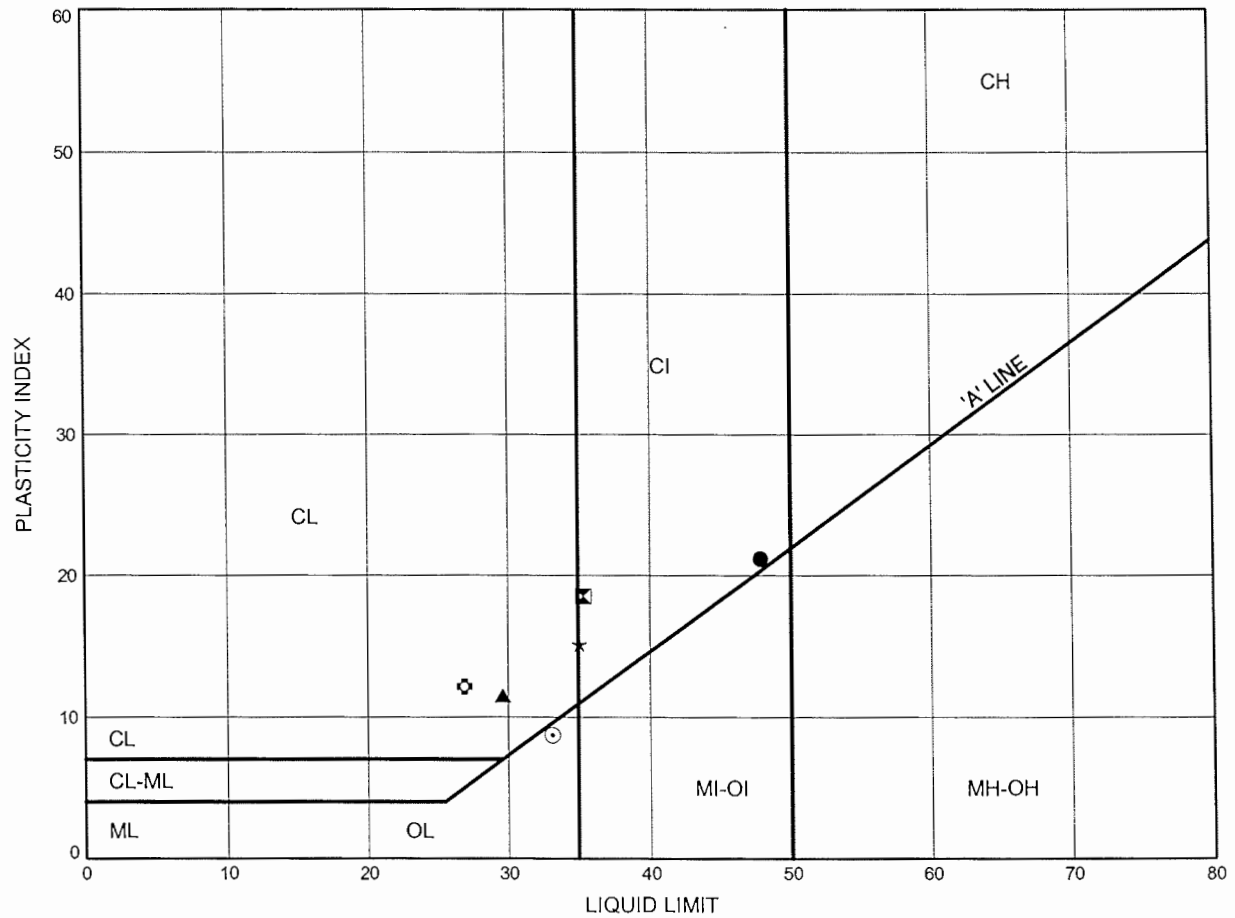


Prep'd JHL  
 Chkd. MRA

Beatty Creek Bridge Replacement  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B14

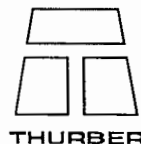
Lower Silty Clay



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-B01	30.78	166.32
⊠	06-B02	30.78	166.62
▲	06-B03	21.34	177.66
★	06-B03	30.48	168.52
⊙	06-B04	30.48	168.52
⊕	06-B04	33.53	165.47

Date December 2006

Project 5200-03-00



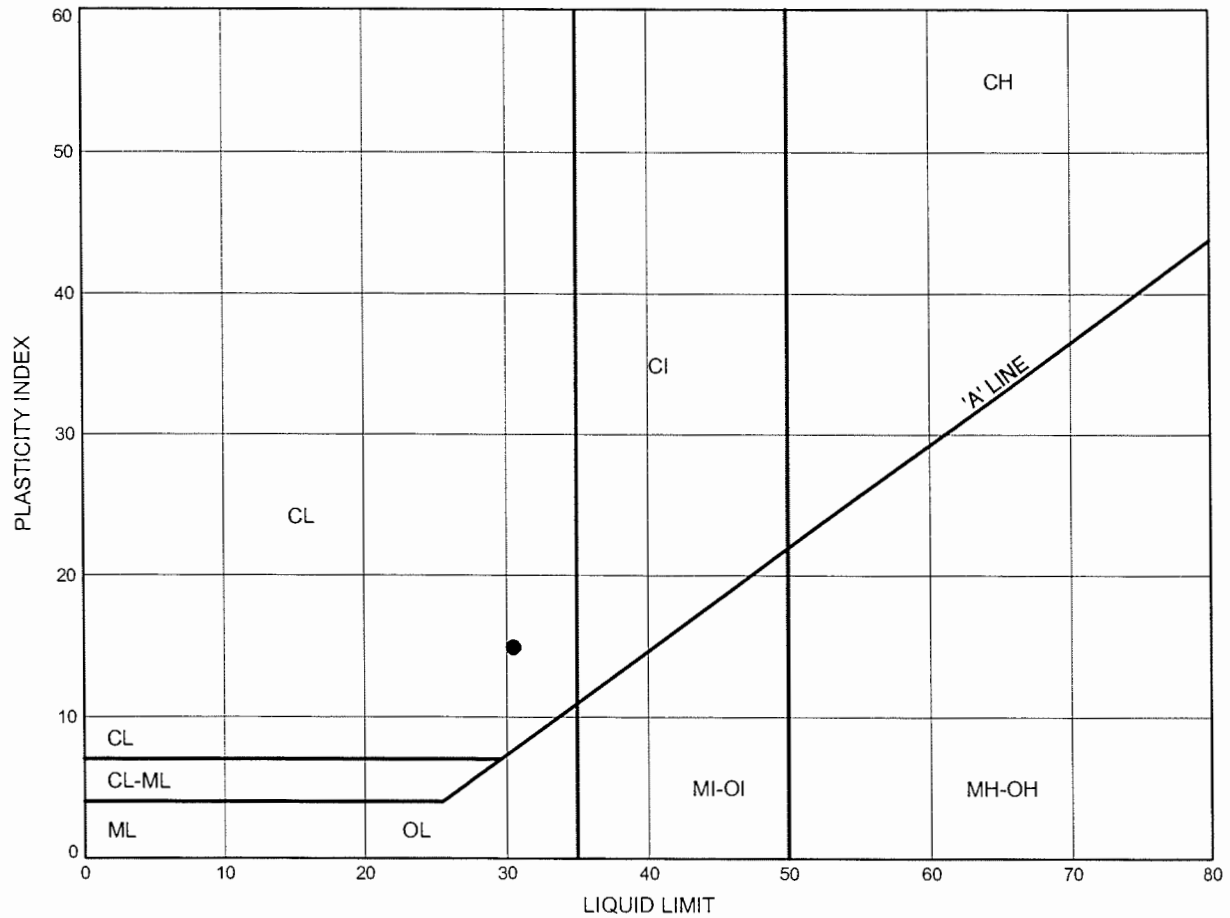
Prep'd JHL

Chkd. MRA

Beatty Creek Bridge Replacement  
**ATTERBERG LIMITS TEST RESULTS**

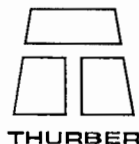
FIGURE B15

Lower Silty Clay

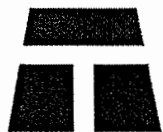


SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-B06	33.83	163.17

Date December 2006  
 Project 5200-03-00



Prep'd JHL  
 Chkd. MRA



## Consolidation Test Report

CLIENT: **McCormick Rankin Corporation**

FILE NUMBER: 18-45-1 / 19-1351-98

PROJECT: Mindemoya and Beatty Creek

REPORT DATE: 24-Oct-06

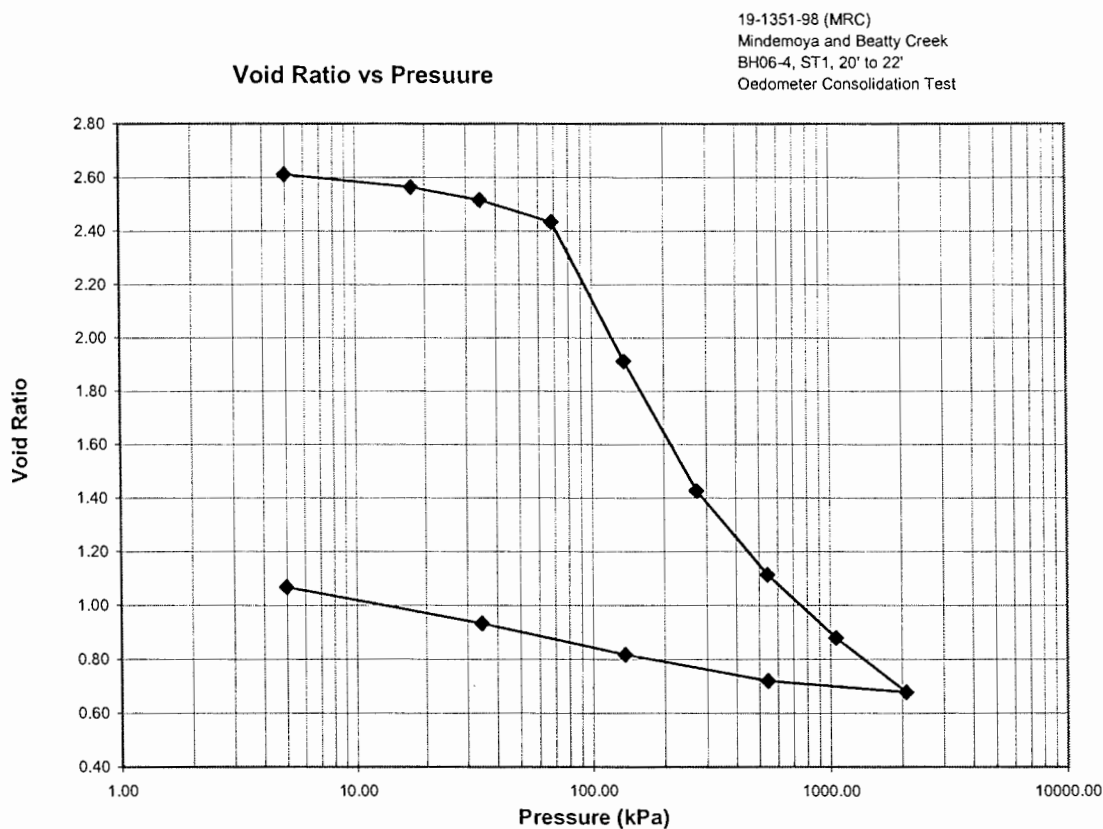
TEST DATES: September 13, 2006 - September 27, 2006

SAMPLE: BH06-4, ST1, 20'-22'  
Silty Clay, dark grey, plastic, (CH), Lab Vane: 20 - 23 kPa (Soft)  
Grain Size: 67 % Clay & 33 % Silt

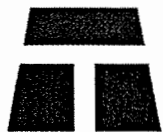
PROCEDURE: Tested in accordance with Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D 2435-04, method B

	<u>Start of Test</u>	<u>End of Test</u>
Wet Dens. (kg/m <sup>3</sup> )	1488.5	2095.2
Dry Dens. (kg/m <sup>3</sup> )	770.7	1349.1
Moisture Cont. (%)	93.1	55.3
Void Ratio	2.612	1.064
Saturation (%)	99.3	

Note: A Specific Gravity of 2.78 was measured for the void ratio and saturation calculations



TEST DONE BY: EA  
REVIEWED BY: JPL



## Consolidation Test Report

Mindemoya and Beatty Creek

18-45-1 / 19-1351-98

BH06-4, ST1, 20'-22'

**TRIMMING:** The Specimen was manually trimmed to the size of consolidation ring, then mounted in a fixed ring consolidometer

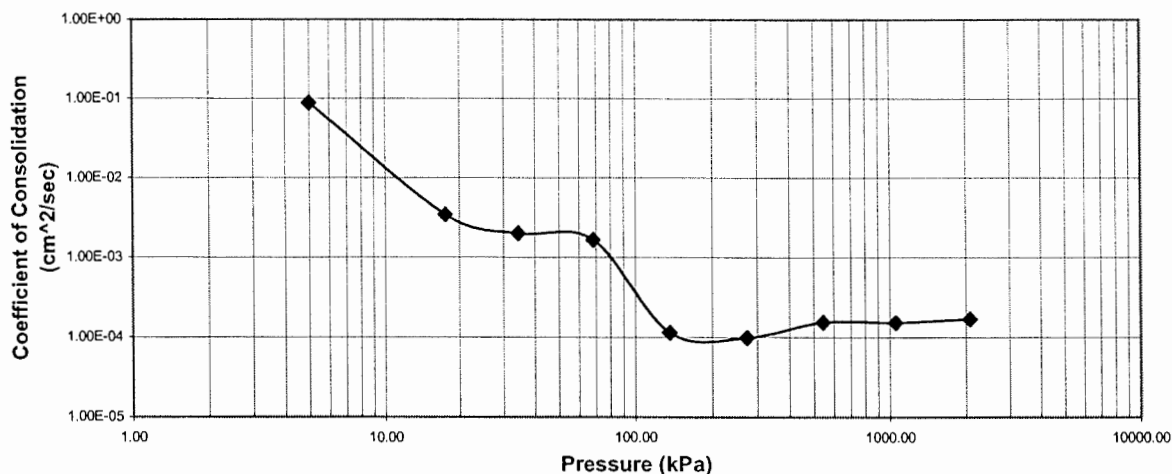
**LOADING:** A seating load of 5 kPa was applied and the consolidometer was flooded with distilled water. Sample was monitored to ensure no swelling effect occurred before the start of the test. Subsequent loads were applied and the duration of each load step was 24 hrs.

**CALCULATIONS:** Coefficients of Consolidation were calculated by the square root time method.

Pressure (kPa)	Corr. Hgt (mm)	Avg. Hgt. (mm)	T90 (min)	Cv (cm <sup>2</sup> /sec)	Void Ratio	mv (m <sup>2</sup> /kN)	k (cm/s)
0.00	19.850	19.850			2.612		
5.00	19.844	19.847	0.16	8.70E-02	2.611	1.06E-03	9.05E-06
17.50	19.581	19.712	4.00	3.43E-03	2.563	7.75E-04	2.61E-07
34.46	19.320	19.450	6.76	1.98E-03	2.516	6.68E-04	1.29E-07
68.42	18.869	19.094	7.84	1.64E-03	2.434	2.11E-03	3.40E-07
136.78	16.003	17.436	94.09	1.14E-04	1.912	9.87E-04	1.10E-08
273.12	13.331	14.667	77.40	9.82E-05	1.426	3.18E-04	3.06E-09
545.39	11.612	12.472	36.00	1.53E-04	1.114	1.27E-04	1.90E-09
1057.63	10.320	10.966	28.09	1.51E-04	0.878	5.46E-05	8.09E-10
2080.12	9.212	9.766	20.05	1.68E-04	0.677	7.58E-06	1.25E-10
545.39	9.443	9.328			0.719		
136.78	9.982	9.713			0.817		
34.46	10.618	10.300			0.933		
5.00	11.352	10.985			1.066		

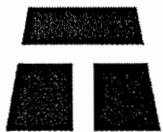
Coefficient of Consolidation vs Pressure

19-1351-98 (MRC)  
Mindemoya and Beatty Creek  
BH06-4, ST1, 20' to 22'  
Oedometer Consolidation Test



Notes: Cv and k calculated using  $t_{90}$  values

TEST DONE BY: EA  
REVIEWED BY: JPL



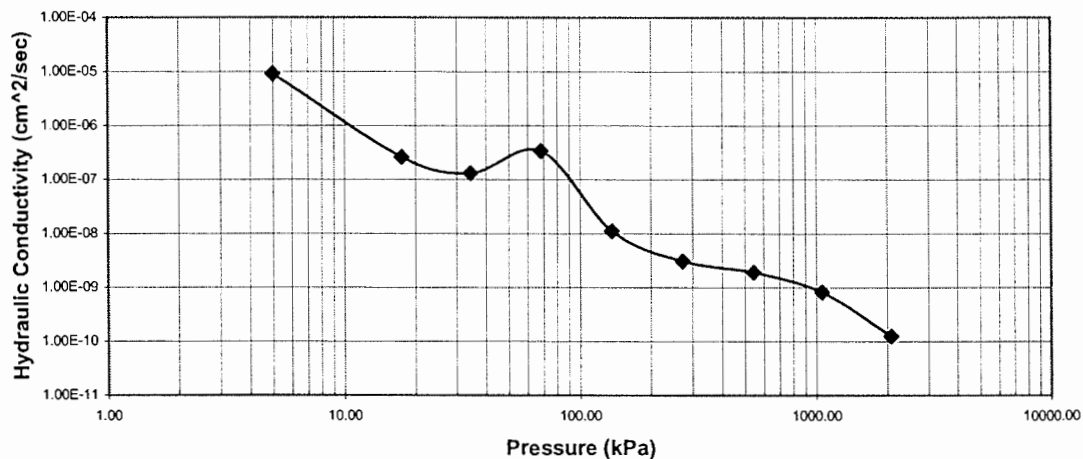
## Consolidation Test Report

Mindemoya and Beatty Creek  
18-45-1 / 19-1351-98

BH06-4, ST1, 20'-22'

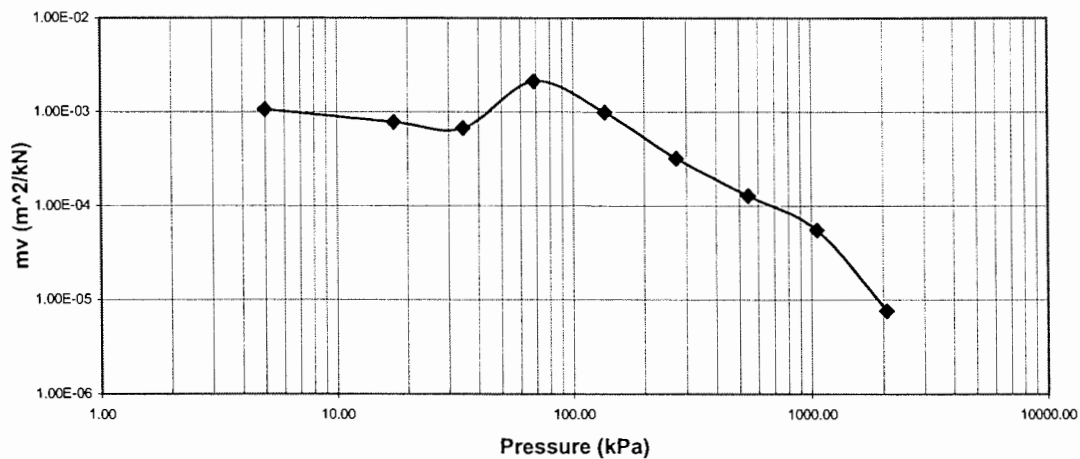
Hydraulic Conductivity vs Pressure

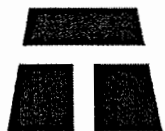
19-1351-98 (MRC)  
Mindemoya and Beatty Creek  
BH06-4, ST1, 20' to 22'  
Oedometer Consolidation Test



mv vs Pressure

19-1351-98 (MRC)  
Mindemoya and Beatty Creek  
BH06-4, ST1, 20' to 22'  
Oedometer Consolidation Test





## Consolidation Test Report

CLIENT: **McCormick Rankin Corporation**

FILE NUMBER: 18-45-1 /19-1351-98

PROJECT: Mindemoya and Beatty Creek

REPORT DATE: 24-Oct-06

TEST DATES: September 13, 2006 - September 27, 2006

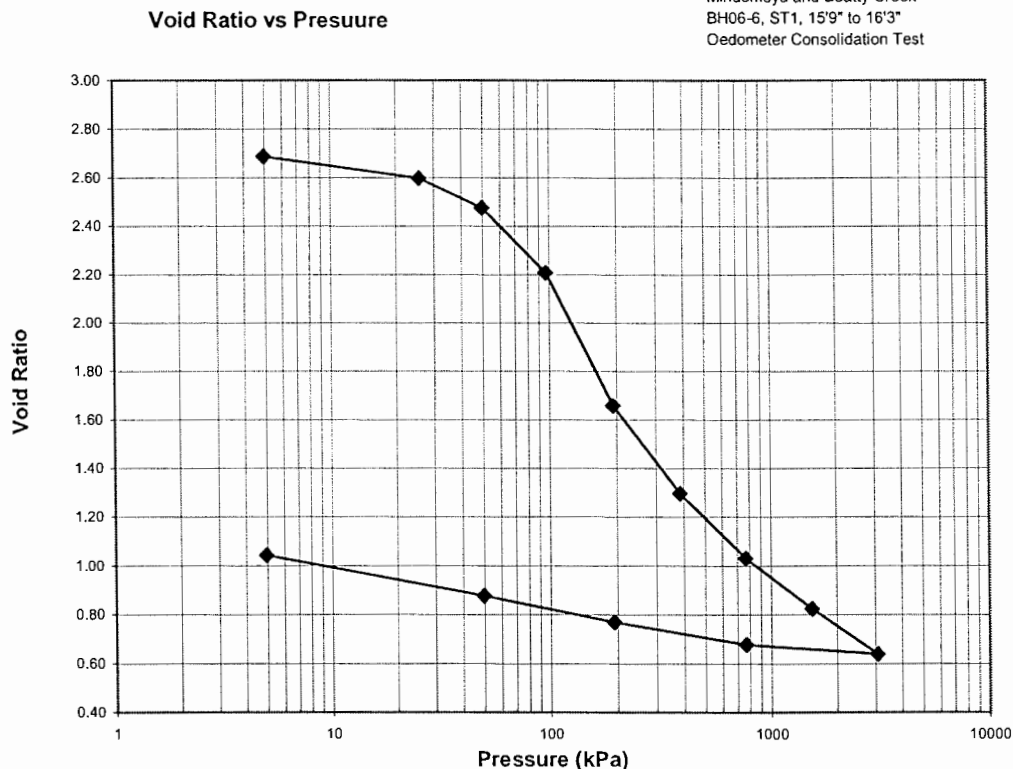
SAMPLE: BH06-6-ST1, 15'9" -16'3"  
Silty Clay, dark grey, plastic, (CH)  
Lab Vane: 16-20 kPa (Soft), Grain Size: 26 % Clay & 74 % Silt

PROCEDURE: Tested in accordance with Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D 2435-04, method B

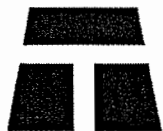
	<u>Start of Test</u>	<u>End of Test</u>
Wet Dens. (kg/m <sup>3</sup> )	1478.8	2005.6
Dry Dens. (kg/m <sup>3</sup> )	752.7	1358.0
Moisture Cont. (%)	96.5	43.8
Void Ratio	2.680	1.040
Saturation (%)	99.7	

Note: A Specific Gravity of 2.77 was measured for the void ratio and saturation calculations

19-1351-98 (MRC)  
Mindemoya and Beatty Creek  
BH06-6, ST1, 15'9" to 16'3"  
Oedometer Consolidation Test



TEST DONE BY: EA  
REVIEWED BY: JPL



## Consolidation Test Report

Mindemoya and Beatty Creek

18-45-1 /19-1351-98

BH06-6-ST1, 15'9 -16'3"

**TRIMMING:** The Specimen was manually trimmed to the size of consolidation ring, then mounted in a fixed ring consolidometer

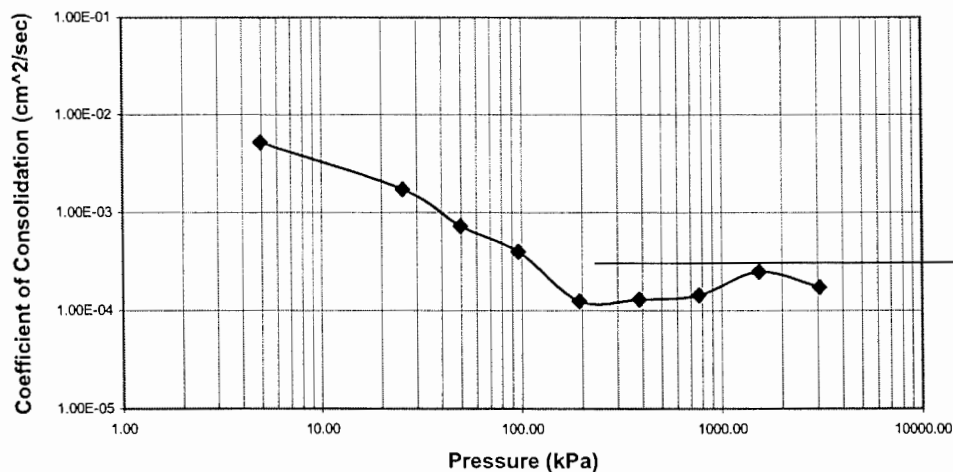
**LOADING:** A seating load of 4.97 kPa was applied and the consolidometer was flooded with distilled water. Sample was monitored to ensure no swelling effect occurred before the start of the test. Subsequent loads were applied and the duration of each load step was 24 hours.

**CALCULATIONS:** Coefficients of Consolidation were calculated by the square root time method.

Pressure (kPa)	Corr. Hgt (mm)	Avg. Hgt. (mm)	T90 (min)	Cv (cm <sup>2</sup> /sec)	Void Ratio	mv (m <sup>2</sup> /kN)	k (cm/s)
0.00	25.350	25.350			2.680		
4.97	25.395	25.372	4.41	5.16E-03	2.687	1.18E-03	5.97E-07
25.67	24.783	25.089	12.96	1.72E-03	2.597	1.37E-03	2.30E-07
49.86	23.957	24.370	29.16	7.20E-04	2.475	1.55E-03	1.10E-07
96.65	22.139	23.048	47.61	3.94E-04	2.208	1.55E-03	5.98E-08
193.24	18.396	20.267	116.64	1.24E-04	1.657	5.08E-04	6.20E-09
385.77	15.948	17.172	81.00	1.29E-04	1.297	1.88E-04	2.37E-09
770.72	14.140	15.044	56.25	1.42E-04	1.031	7.30E-05	1.02E-09
1540.91	12.733	13.436	26.01	2.45E-04	0.824	3.25E-05	7.81E-10
3081.80	11.482	12.107	30.25	1.71E-04	0.639	4.42E-06	7.42E-11
770.72	11.737	11.609			0.677		
193.24	12.361	12.049			0.769		
49.86	13.096	12.728			0.877		
4.97	14.213	13.655			1.041		

Coefficient of Consolidation vs Pressure

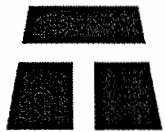
19-1351-98 (MRC)  
Mindemoya and Beatty Creek  
BH06-6, ST1, 15'9" to 16'3"  
Oedometer Consolidation Test



Notes: Cv and k calculated using  $t_{90}$  values

TEST DONE BY: EA  
REVIEWED BY: JPL





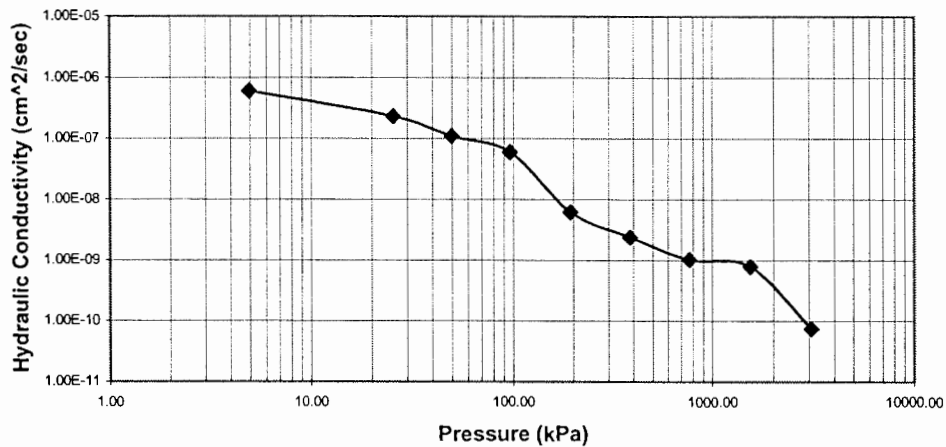
## Consolidation Test Report

Mindemoya and Beatty Creek  
18-45-1 /19-1351-98

BH06-6-ST1, 15'9" -16'3"

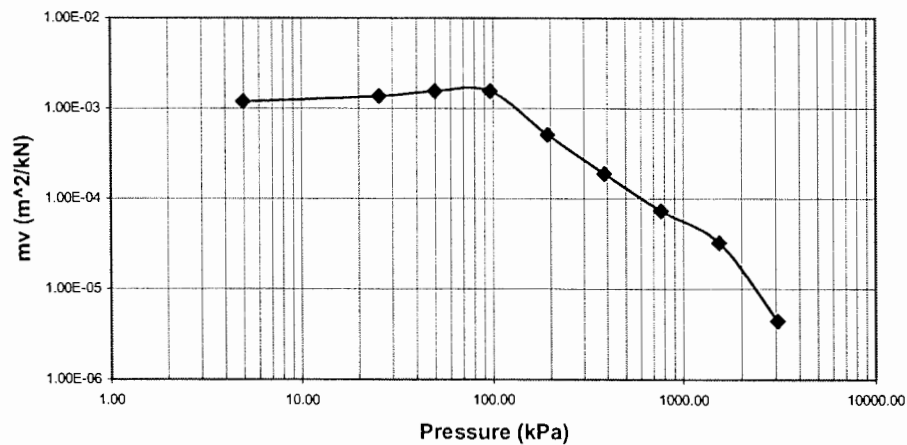
### Hydraulic Conductivity vs Pressure

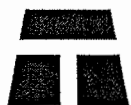
19-1351-98 (MRC)  
Mindemoya and Beatty Creek  
BH06-6, ST1, 15'9" to 16'3"  
Oedometer Consolidation Test



### mv vs Pressure

19-1351-98 (MRC)  
Mindemoya and Beatty Creek  
BH06-6, ST1, 15'9" to 16'3"  
Oedometer Consolidation Test





**THURBER ENGINEERING LTD.**  
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

## UNCONFINED COMPRESSION TEST REPORT

CLIENT: McCormick Rankin Corporation

FILE NUMBER: 19-1351-98

PROJECT: Mindemoya and Beatty Creek

REPORT DATE: 31-Oct-06

BOREHOLE No.: BH06-4

TEST DATE: 31-Oct-06

SAMPLE: ST-1, 6.1 - 6.4 m

DESCRIPTION: Silty CLAY (CH), dark grey, soft, plastic, undisturbed, Lab Vane: 20 kPa

Avg. Height (cm): 13.99

Wet Density (kg/cu.m.): 1,535

Avg. Diameter (cm): 6.94

Dry Density (kg/cu.m.): 863

Height to Dia. Ratio 2:1

Moisture Content\* (%): 77.8

Weight (g): 812.2

Void Ratio: 2.221

Measured Sp. Gr.: 2.78

Saturation (%): 97

AVG. RATE OF STRAIN TO FAILURE:

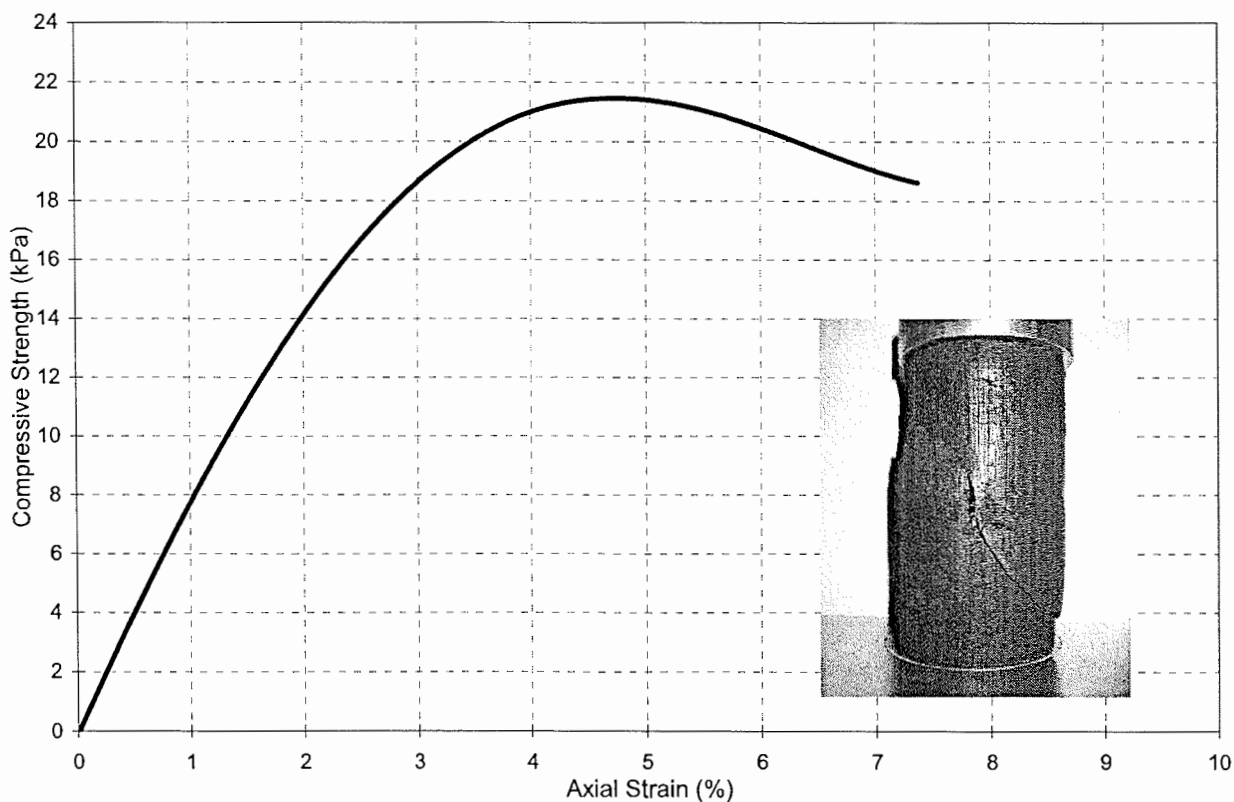
1%

UNCONFINED COMPRESSIVE STRENGTH:

21.5 kPa @ 4.85 % strain

UNDRAINED SHEAR STRENGTH:

10.8 kPa



Note:

\*

The water content was obtained after shear from the entire specimen

\*\*

Type of Failure: Diagonal shear approximately 58° from horizontal

TEST DONE BY: WM

REVIEWED BY: JPL

BH06-4-ST1(UCS).xls



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## UNCONFINED COMPRESSION TEST REPORT

CLIENT: McCormick Rankin Corporation

FILE NUMBER: 19-1351-98

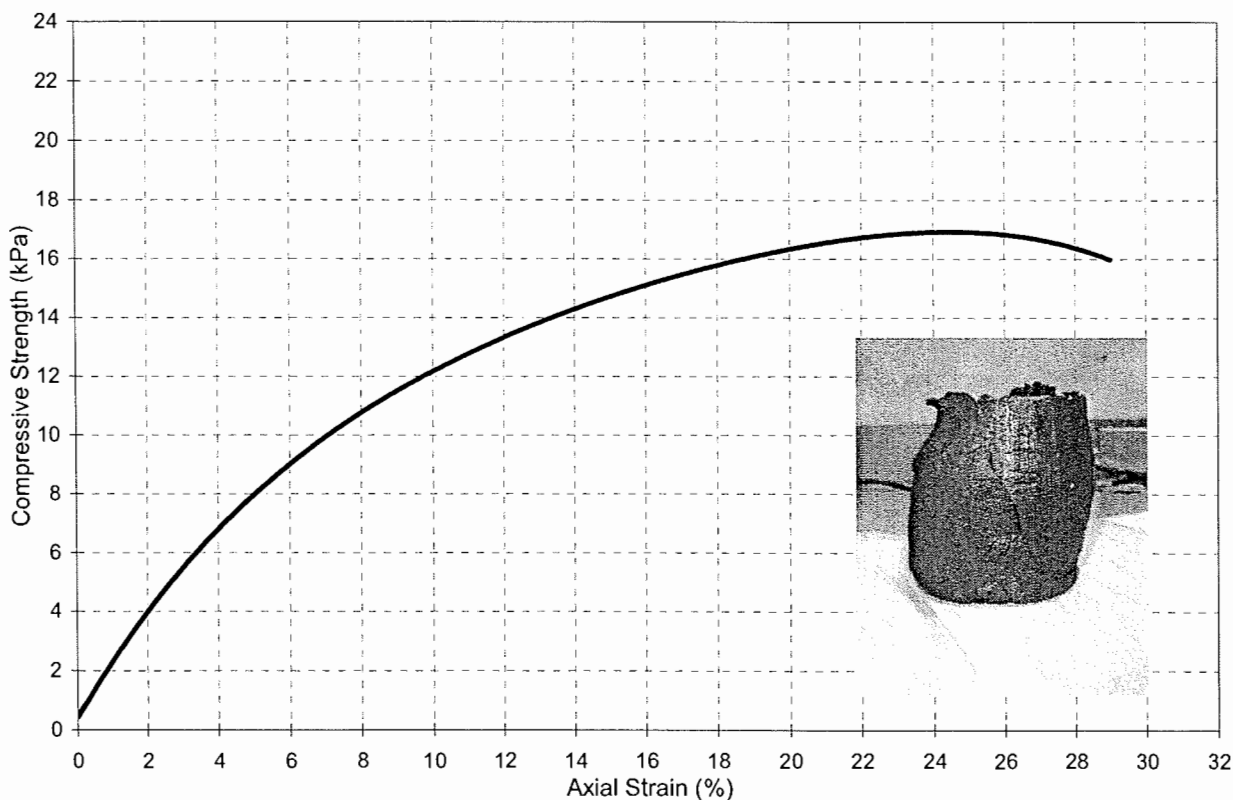
PROJECT: Mindemoya and Beatty Creek

REPORT DATE: 31-Oct-06

BOREHOLE No.: BH06-6 TEST DATE: 31-Oct-06  
SAMPLE: ST-1, 4.6 - 4.8 m  
DESCRIPTION: Silty CLAY (CH), dark grey, very soft to soft, plastic, undisturbed

Avg. Height (cm):	13.30	Wet Density (kg/cu.m.):	1,554
Avg. Diameter (cm):	6.86	Dry Density (kg/cu.m.):	875
Height to Dia. Ratio	2:1	Moisture Content* (%):	77.5
Weight (g):	763.8	Void Ratio:	2.164
Measured Sp. Gr.:	2.77	Saturation (%):	99

AVG. RATE OF STRAIN TO FAILURE: 1%  
UNCONFINED COMPRESSIVE STRENGTH: 17.0 kPa @ 24.2 % strain  
UNDRAINED SHEAR STRENGTH: 8.5 kPa



Note \* The water content was obtained after shear from the entire specimen  
\*\* Type of Failure: Bulged and diagonal shear approximately 60° from horizontal

TEST DONE BY: WM  
REVIEWED BY: JPL

BH06-6-ST1(UCS).xls

## **Appendix C**

### **Photographs, Figures and Tables**

## Beatty Creek Bridge Replacement



Photograph 1: North side of existing bridge (March 2006).



Photograph 2: Highway 534 looking east towards Beatty Creek bridge (March 2006).

## Beatty Creek Bridge Replacement



Photograph 3: South side of Highway 534 looking west at bridge (May 2006).



Photograph 4: North side of Highway 534 looking east at bridge (May 2006).

	Gamma C	Phi	Piezo
	kN/m <sup>3</sup>	deg	Surf.
Earth Fill	21	0	32
Silt/Sand	20	0	32
Soft-Firm Clay	17	25	0
Very Soft Clay	15	15	0
Soft-Firm Clay	17	25	0
Silt	20	0	30
Soft-Stiff Clay	17	30	0
Sand	21	0	32

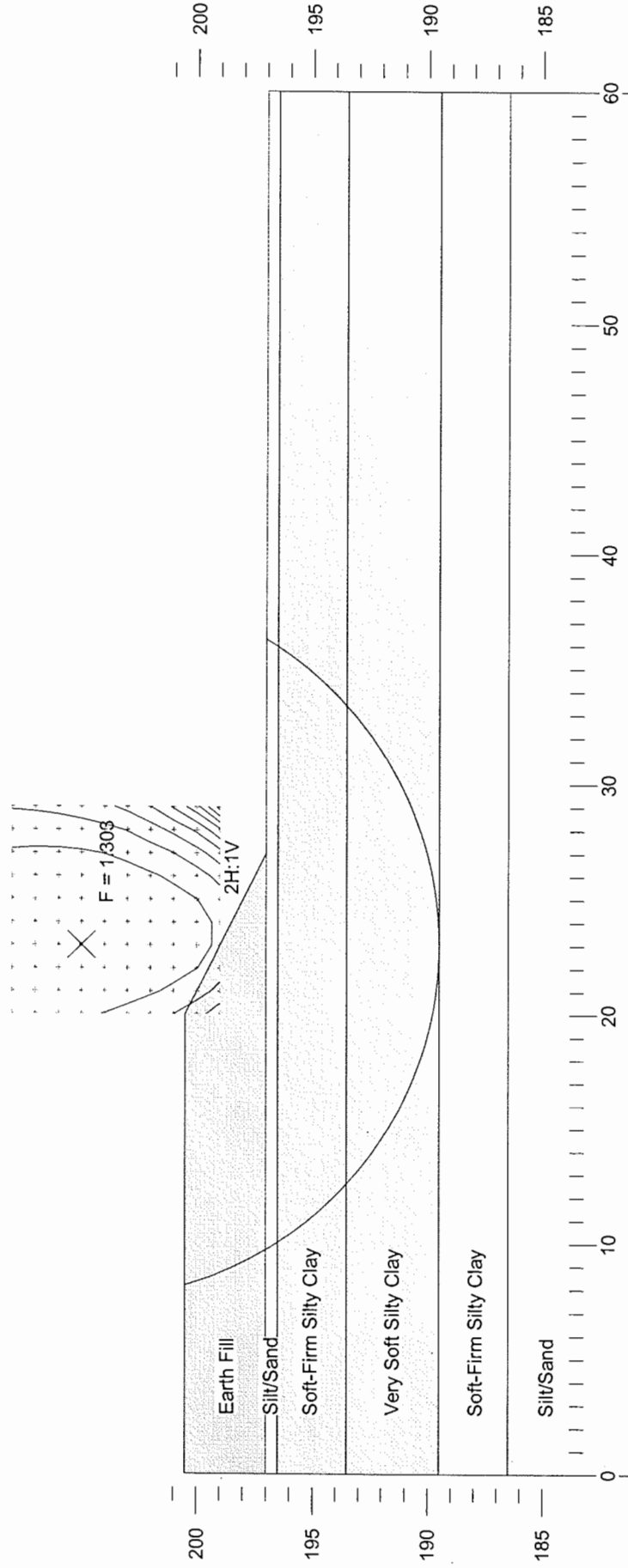


Figure C1



Thurber Engineering Ltd. - Toronto  
 19-1351-98  
 Beatty Creek  
 December 2006  
 3.5 m High Earth Embankment  
 Long Term

	Gamma C	Phi	Piezo
	kN/m3	deg	Surf.
Earth Fill	21	0	32
Silt/Sand	20	0	32
Soft-Firm Clay	17	0	28
Very Soft Clay	15	0	26
Soft-Firm Clay	17	0	28
Silt	20	0	30
Soft-Stiff Clay	17	0	28
Sand	21	0	32

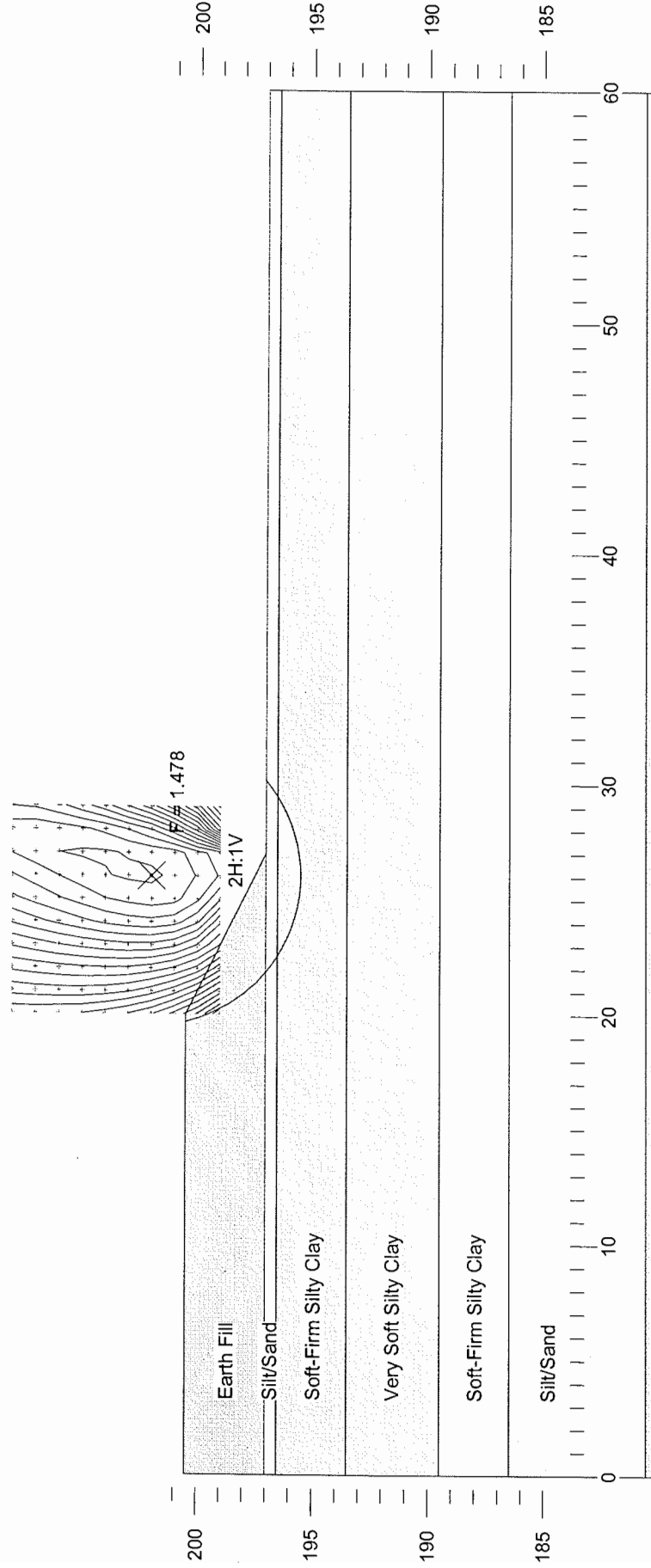


Figure C2



	Gamma C	Phi	Piezo
	kN/m <sup>3</sup>	deg	Surf.
Rockfill	21	0	42
Silt/Sand	20	0	32
Soft-Firm Clay	17	25	0
Very Soft Clay	15	15	0
Soft-Firm Clay	17	25	0
Silt	20	0	30
Soft-Stiff Clay	17	30	0
Sand	21	0	32

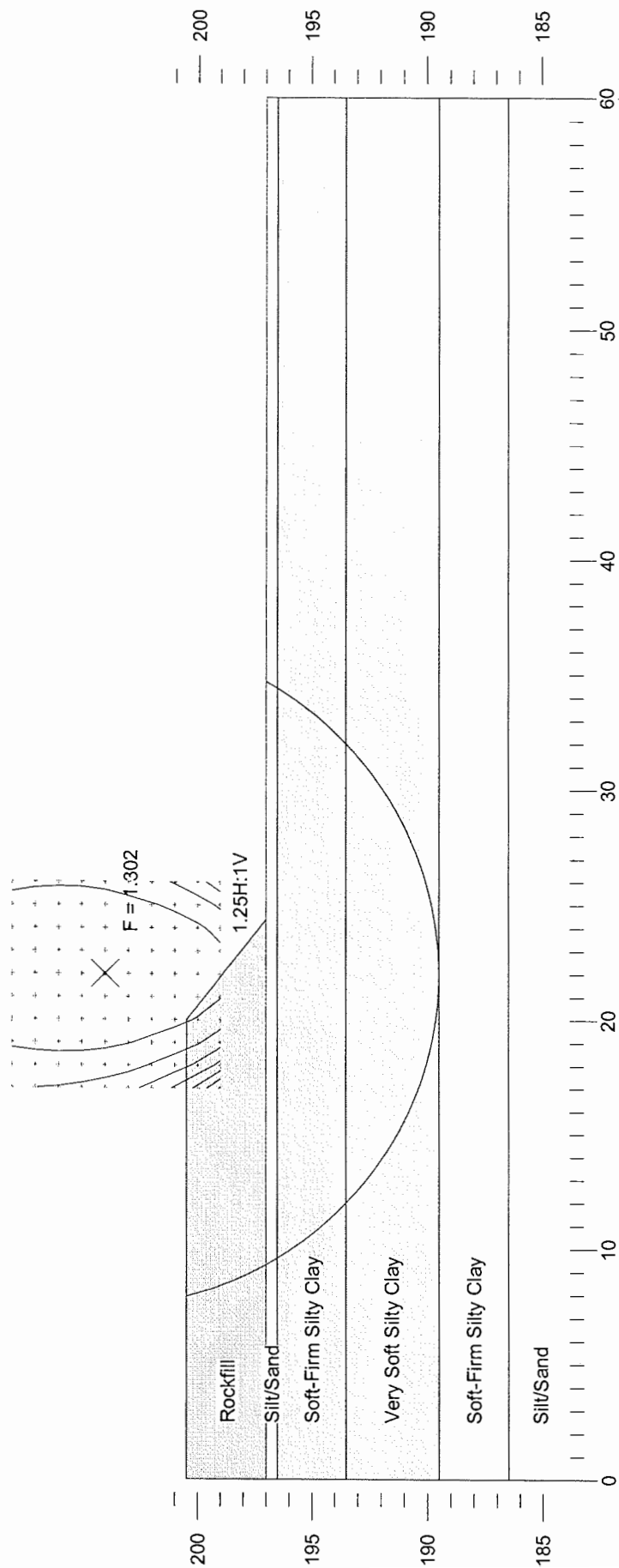


Figure C3

	Gamma C	Phi	Piezo
	kN/m3	deg	Surf.
Rockfill	21	0	42
Silt/Sand	20	0	32
Soft-Firm Clay	17	0	28
Very Soft Clay	15	0	26
Soft-Firm Clay	17	0	28
Silt	20	0	30
Soft-Stiff Clay	17	0	28
Sand	21	0	32

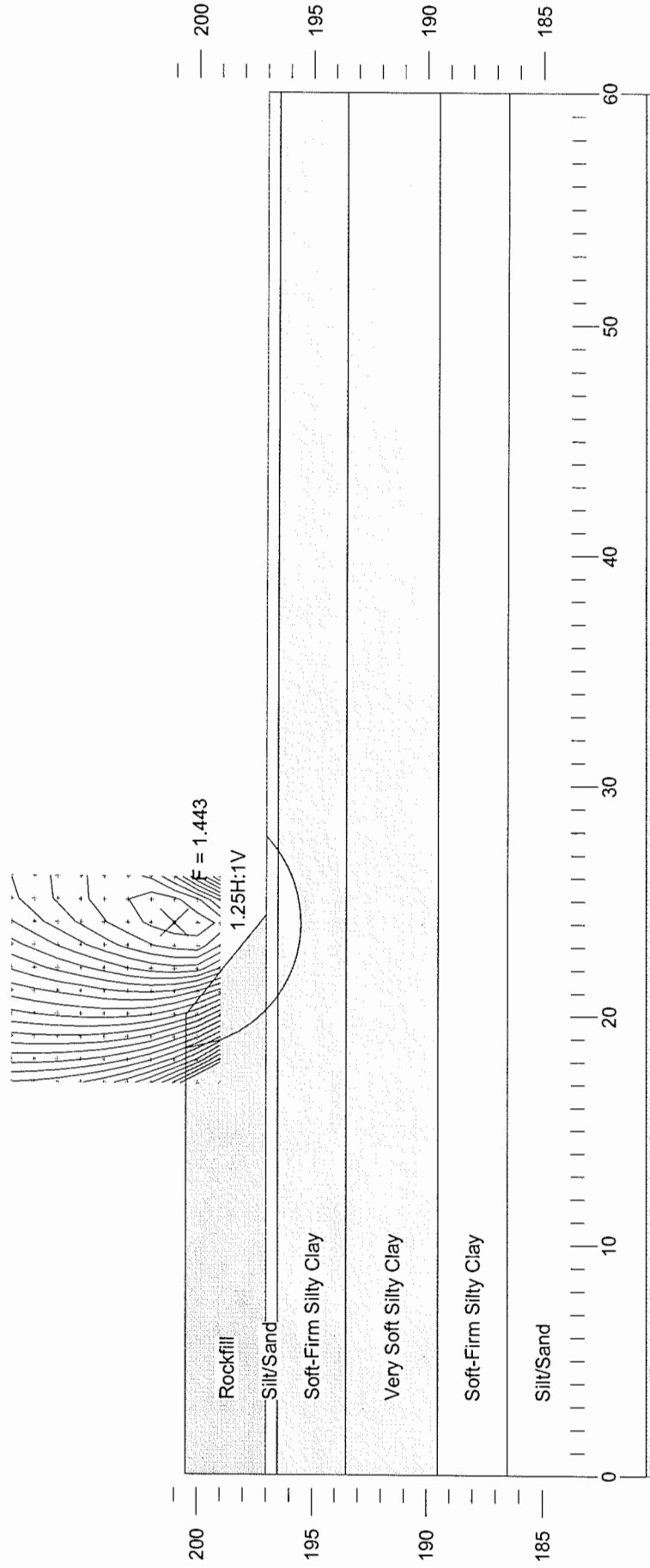


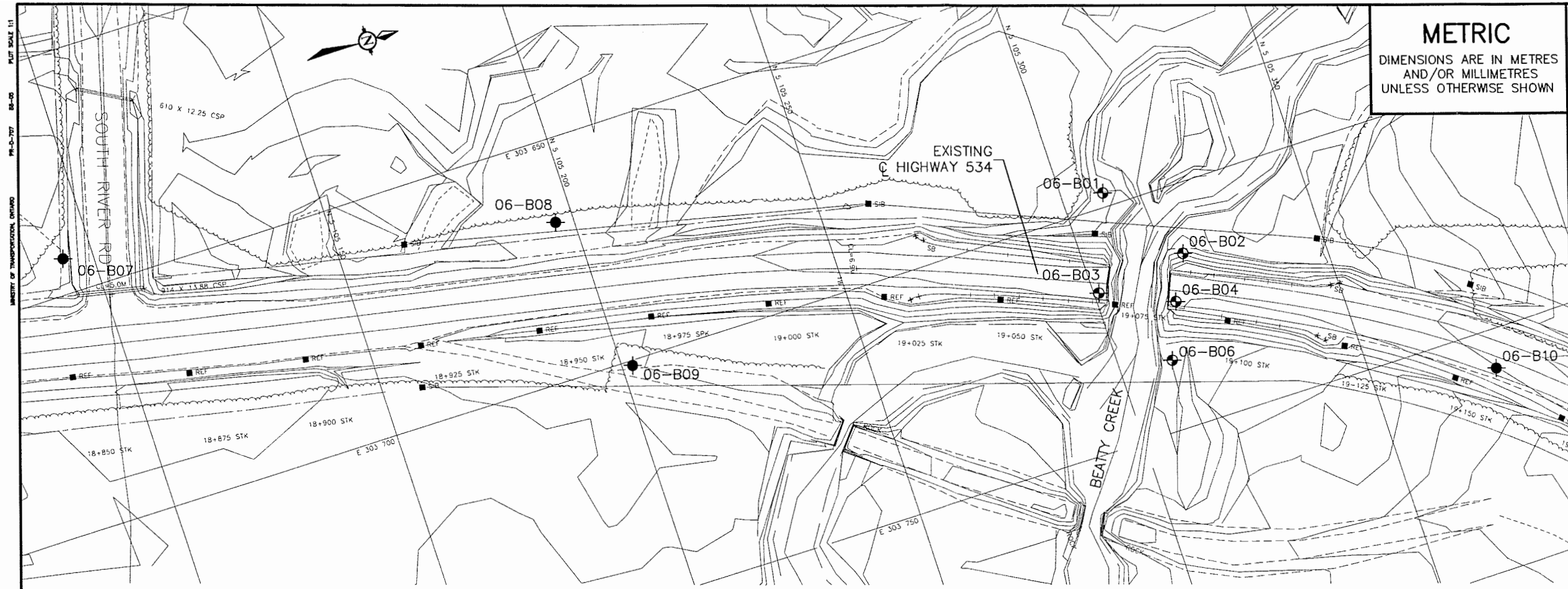
Figure C4

**TABLE C1: COMPARISON OF FOUNDATION ALTERNATIVES**

Footings on Native Soil	Footings on Engineered Fill	Driven Piles	Caissons
<p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. Ease of construction.</li> <li>ii. Allows choice of semi-integral or conventional abutment.</li> <li>iii. Lower cost than deep foundations.</li> </ul> <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Low geotechnical resistance available on native soil at this site.</li> <li>ii. Potential for post-construction settlement.</li> <li>iii. May require increased bridge span and/or increased abutment height.</li> <li>iv. Excavation within existing embankment fill below creek water level.</li> </ul> <p><b>NOT RECOMMENDED</b></p>	<p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. Would permit use of higher geotechnical resistance than is available on the native soil.</li> <li>ii. Allows choice of semi-integral or conventional abutment.</li> <li>iii. Allows use of perched abutments.</li> <li>iv. Lower cost than deep foundations.</li> </ul> <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Cost of constructing engineered fill.</li> <li>v. Potential for post-construction settlement.</li> <li>vi. May require increased bridge span and/or increased abutment height.</li> <li>ii. Excavation within existing dam embankment fill below lake and groundwater level.</li> </ul> <p><b>NOT RECOMMENDED</b></p>	<p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. Piles will develop high geotechnical resistance if driven to refusal on bedrock.</li> <li>ii. Construction of piles could continue in freezing weather.</li> <li>iii. Allows choice of integral, semi-integral or conventional abutment design.</li> <li>iv. Readily installed.</li> <li>v. Bridge span can be minimized.</li> </ul> <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Higher unit costs than footings.</li> <li>ii. Possibility that cobbles and boulders may be encountered in existing embankment fill or native sand above bedrock.</li> <li>iii. Downdrag will reduce the capacity of piles.</li> </ul> <p><b>RECOMMENDED</b></p>	<p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. High resistance is available for caissons founded on bedrock.</li> <li>ii. Construction of caissons could continue in freezing weather.</li> <li>iii. Choice of semi-integral or conventional abutment design.</li> </ul> <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Possibility of boulders being encountered during augering.</li> <li>ii. Significant depth to bedrock bearing stratum.</li> <li>iii. Steel liner will be required to support caisson excavation sidewalls and reduce seepage into caisson excavation below groundwater level.</li> <li>iv. Difficulty excluding seepage and flow of soil under rim of liner.</li> </ul> <p><b>NOT RECOMMENDED</b></p>

**Appendix D**

**Borehole Locations and Soil Strata Drawing**



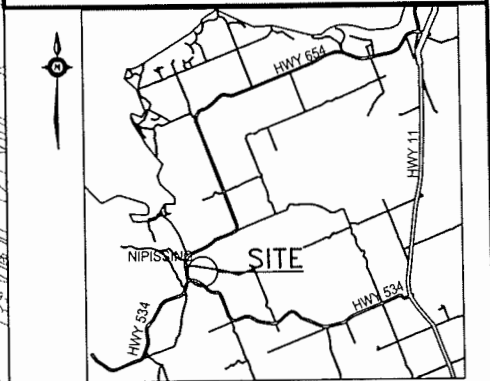
**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No  
GWP No.5200-03-00

HIGHWAY 534  
BEATTY CREEK BRIDGE  
REPLACEMENT  
BOREHOLE LOCATIONS AND SOIL STRATA

McCORMICK RANKIN  
CORPORATION

THURBER ENGINEERING LTD.  
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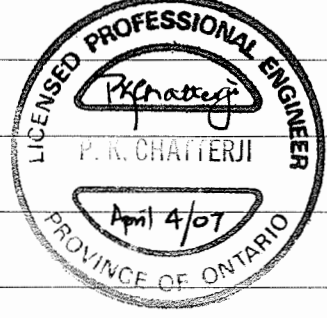
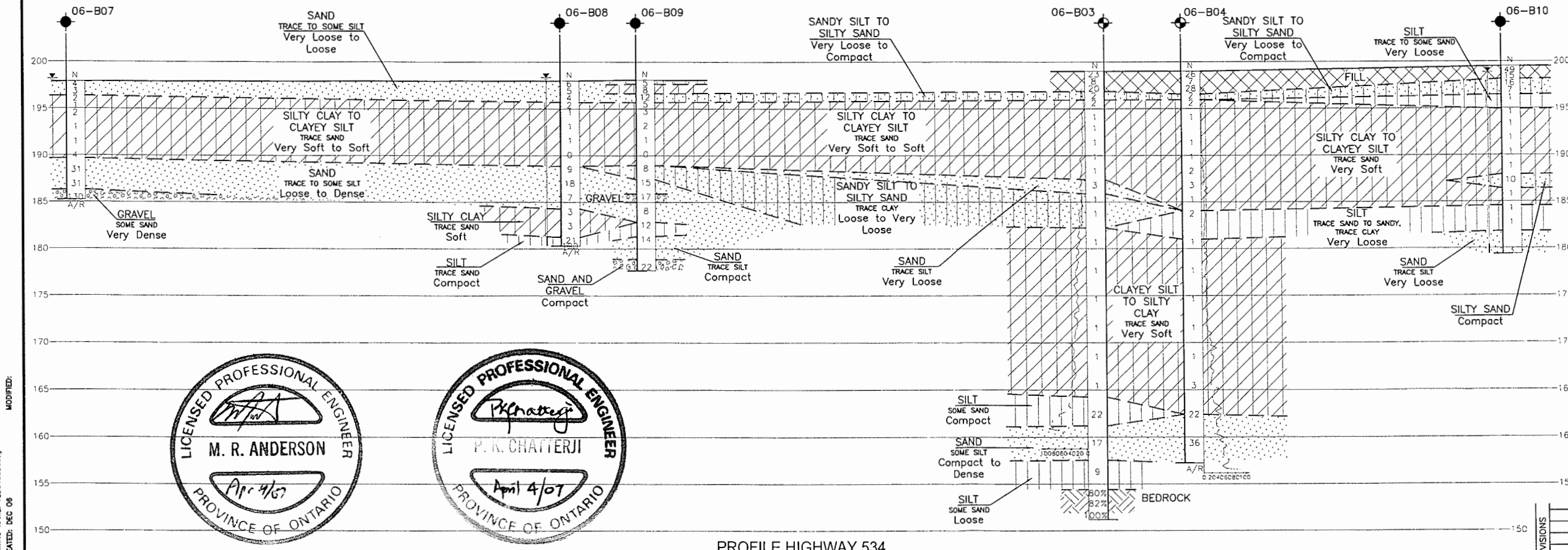


**KEYPLAN**  
**LEGEND**

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

NO	ELEVATION	NORTHING	EASTING
06-B01	197.1	5 105 308.55	303 697.02
06-B02	197.4	5 105 320.69	303 714.37
06-B03	199.0	5 105 301.00	303 716.81
06-B04	199.0	5 105 316.00	303 723.57
06-B06	197.0	5 105 311.29	303 735.18
06-B07	197.9	5 105 093.68	303 642.56
06-B08	198.0	5 105 196.21	303 667.23
06-B09	198.1	5 105 202.30	303 701.05
06-B10	199.5	5 105 376.19	303 758.13

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



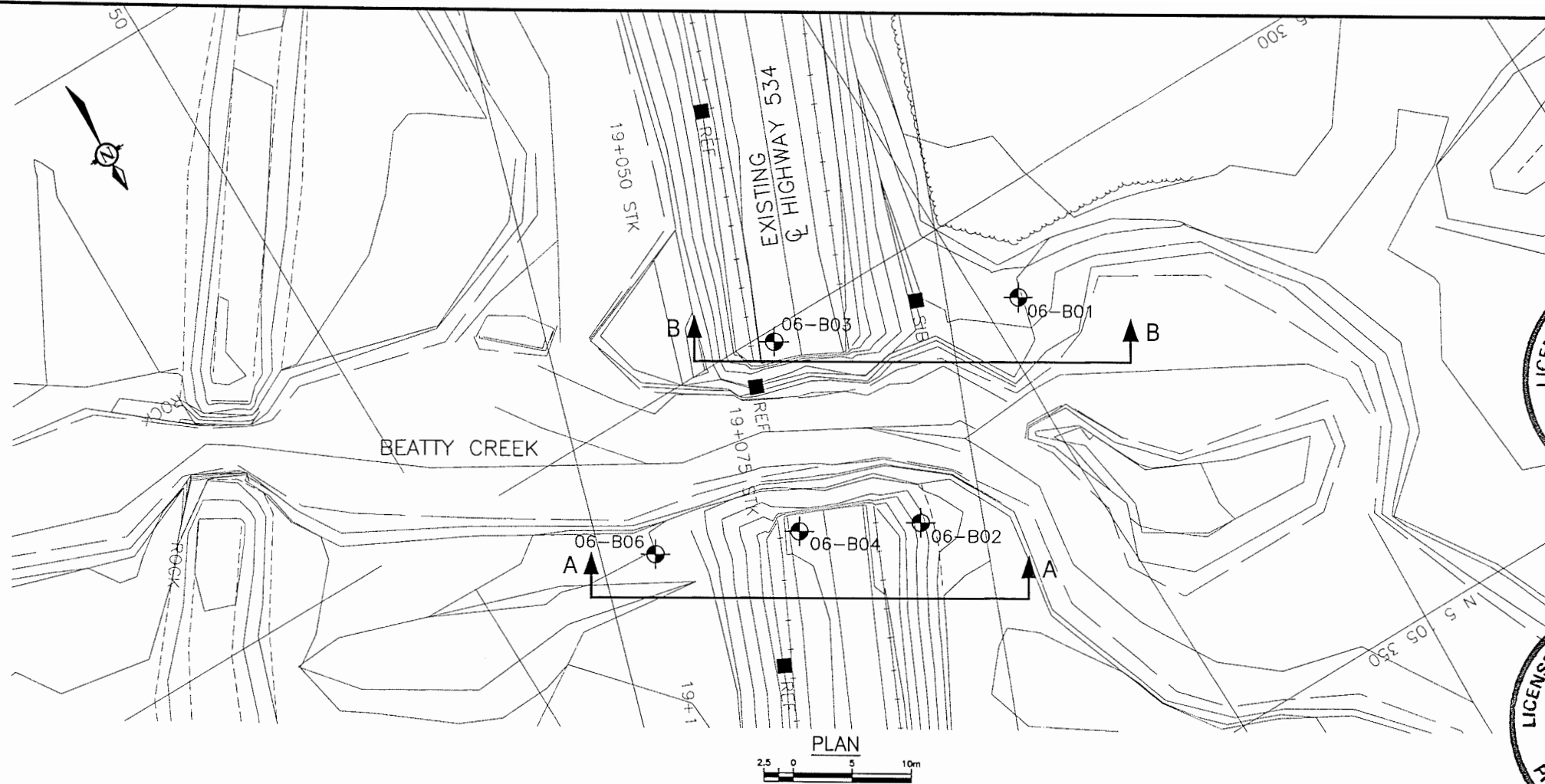
**PROFILE HIGHWAY 534**  
VERT 1:500  
HORIZ 1:1000

DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	MRA	CHK PKC	CODE
DRAWN	JHL	CHK PKC	SITE 44-016
STRUCT			LDWG 1
DATE	DEC 2006		

DRAWING NAME: 115198Beatty  
CREATED: DEC 06

FILENAME: D:\Job Files\115198\115198 Beatty Creek\115198Beatty.dwg  
PLOTDATE: Mar 27, 2007 - 8:26am



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

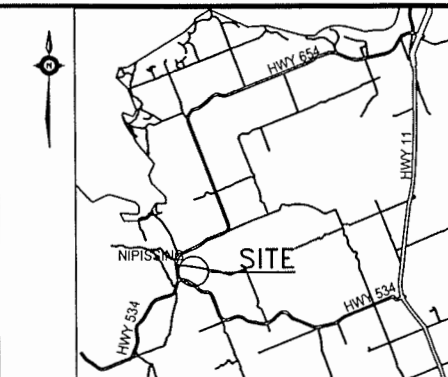


CONT No  
GWP No.5200-03-00

HIGHWAY 534  
BEATTY CREEK BRIDGE  
REPLACEMENT  
BOREHOLE LOCATIONS AND SOIL STRATA

**MCCORMICK RANKIN  
CORPORATION**

**THURBER ENGINEERING LTD.**  
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**KEYPLAN**

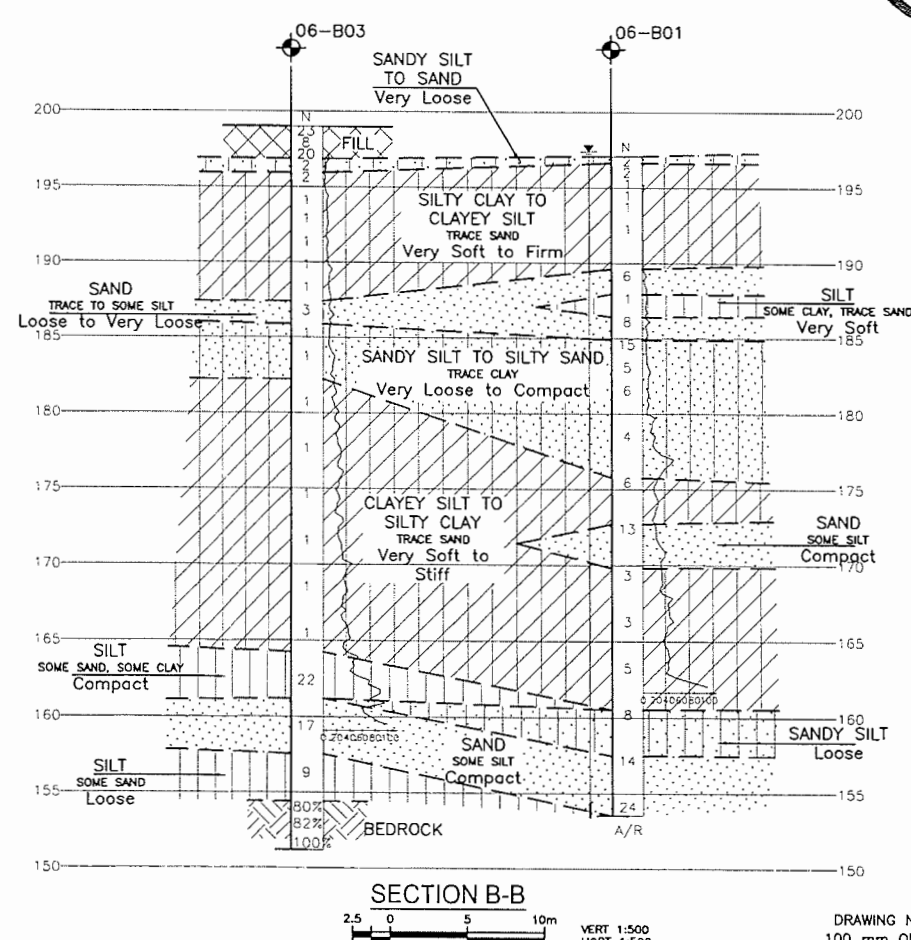
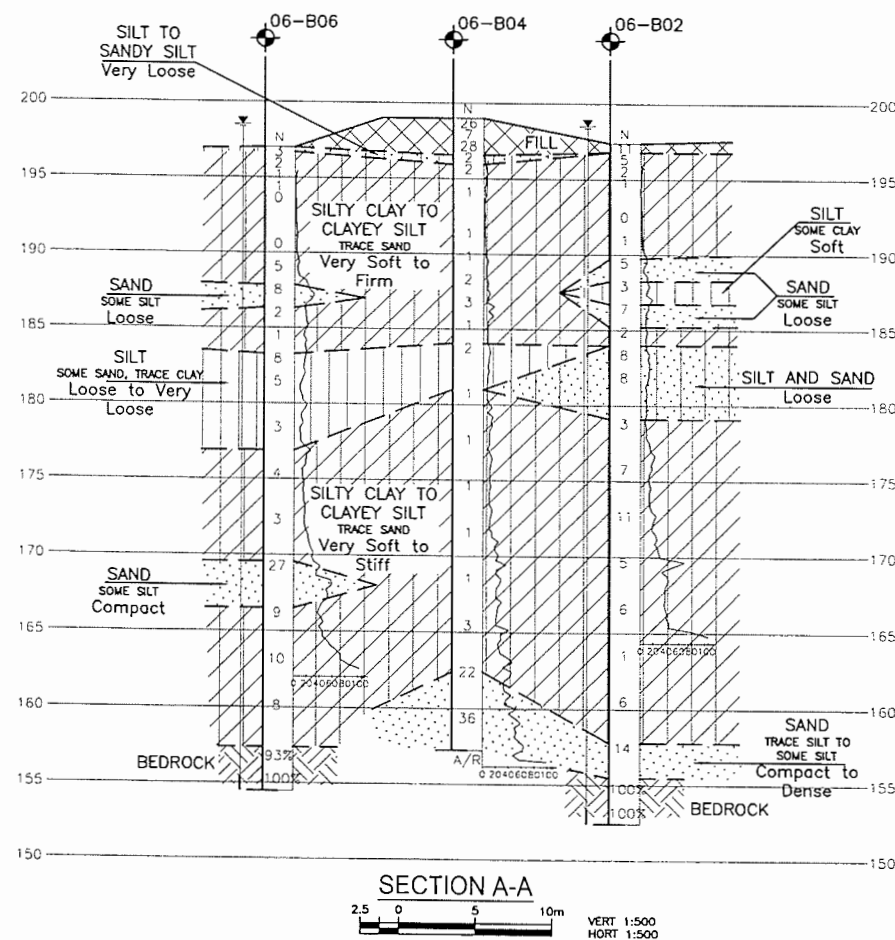
**LEGEND**

- ◆ 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
06-B01	197.1	5 105 308.55	303 697.02
06-B02	197.4	5 105 320.69	303 714.37
06-B03	199.0	5 105 301.00	303 716.81
06-B04	199.0	5 105 316.00	303 723.57
06-B06	197.0	5 105 311.29	303 735.18
06-B07	197.9	5 105 093.68	303 642.56
06-B08	198.0	5 105 196.21	303 667.23
06-B09	198.1	5 105 202.30	303 701.05
06-B10	199.5	5 105 376.19	303 758.13

**-NOTE-**

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



DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	MRA	CHK PKC	CODE
DRAWN	JHL	CHK PKC	SITE 44-016
STRUCT			DWG 2