

CONTRACT NO: 40-97-15

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**Ministry
of
Transportation**

**Ministère
des
Transports**

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	Foundation Investigation Report for
3 - 32	Rigaud River Bridge W.P. 317-94-00, Site 31-20 Hwy 34, District 42, Ottawa Contract 40-97-15

Note: For purposes of the contract, this report supersedes all other Foundation Reports prepared by, or for the Ministry in connection with the above-mentioned project.

EXPLANATION OF TERMS USED IN REPORT

2

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
C_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{VO}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	°	APPARENT ANGLE OF INTERNAL FRICTION
τ_r	kPa	RESIDUAL SHEAR STRENGTH
T_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{T_r}$

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{\min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{\max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m^3	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

**Rigaud River Bridge Replacement
WP 317-94-00
MTO Site #31-20**

Geocres No 31G-216

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BR-10697-A/G
December 12, 1996

PART 1 Foundation Investigation

1. Introduction

This submission presents the results of a geotechnical investigation completed by Trow Consulting Engineers Ltd. (Trow) for the Rigaud River Bridge Replacement, WP 317-94-00, Site number 31-20. The project consists of two parts, namely: (i) construction of a temporary culvert and roadway (detour) around the existing Rigaud River Bridge and (ii) removal of the existing 10.06 m single span concrete rigid frame bridge and construction of a replacement. It is understood that the replacement options are either a rigid frame structure similar to the existing bridge or a twin cell box culvert with an opening width of 8 m situated along the existing alignment.

2. Site Description and Geological Setting

2.1 Site Description

The site is located on Highway 34 between stations $22 + 800 \pm$ and $23 + 350 \pm$ in the county of Stormont, Dundas and Glengarry. Physiographically, the site lies within the Glengarry Till Plain which has generally flat to moderately undulating terrain. The terrain in the immediate area of the project site is relatively flat.

Between stations $23+056 \pm$ and $23+120 \pm$, the Rigaud River flows from north to south and is situated to the west of Highway 34. At station $23+047 \pm$, the river begins to flow in an easterly direction crossing from the west side of Highway 34 to the east side. The existing Rigaud River Bridge is a rigid frame concrete structure with a span of $10.0 \pm$ m located at station $23+046.7$. Highway 34 is a two lane highway and both north and south approaches to the bridge are straight.

Photograph 1 in Appendix A shows the existing Rigaud River Bridge from a location just east of the proposed temporary culvert/detour alignment while Photograph 2 in Appendix A shows the existing bridge from the south approach.

2.2 Geological Setting

According to the OGS Map 2556, the overburden soils at the site consist of till which is predominantly sandy silt to silt and often rich in clay. Intervening glaciomarine and marine deposits (comprised of silts and clay) and muskegs may also occur in the area. The underlying bedrock in the area is from the Rockcliffe Formation (OGS Map 2544) which consists of inter-bedded shaly bioclastic limestone, dark grey to maroon shales, and light grey, fine grained, calcareous to non-calcareous quartz sandstone.

3. Investigative Procedures

3.1 General

Part 1 of this report describes the investigative procedures adopted for the geotechnical assessment of the Rigaud River Bridge Replacement. Properties of the overburden soils at the site were obtained by in situ and laboratory testing and the procedures employed during the investigation are described below.

3.2 Field Investigation

3.2.1 Rigaud River Bridge Replacement

The field work for the investigation related to the replacement of the existing Rigaud River Bridge was carried out on October 21 and 22, 1996, and consisted of four (4) boreholes (Boreholes 1 to 4) which were advanced to depths ranging from 7.9 metres to 8.6 metres. Two (2) boreholes were drilled near each of the north and south abutments. The borehole locations are shown on Drawing 1 in Appendix B and all elevations are reference to MTO Temporary Benchmark (El. 86.904) at station 22+951 of King's Highway 34.

The boreholes were advanced through the overburden soils on the site using a truck mounted CME-55 drill rig equipped with solid and hollow stem augers. Soil samples were obtained using a split spoon sampler in conjunction with Standard Penetration Tests (ASTM D1586) at approximately 0.75 metre and 1.5 metre intervals. The Standard Penetration (N) values were recorded and used to provide an assessment of the relative denseness of the overburden soils at the site and the soil samples were used for identification and laboratory testing.

At each of the four (4) boreholes, conventional rock coring techniques were used to advance the boreholes approximately 3.0 metres into the underlying bedrock. Standard NQ size core barrels and casings were used and core samples of the bedrock were retrieved for rock quality determinations and classification purposes.

3.2.2 Temporary Detour and Culvert

The field work for the investigation related to the proposed temporary detour and culvert was carried out on October 25, 1996, and consisted of six (6) boreholes which were advanced to depths ranging from 2 metres to 6.1 metres. Two (2) boreholes were drilled near the north and south abutments of the proposed culvert and two (2) boreholes were drilled along each of the alignment of the north and south approaches to the culvert. Drawing 1 in Appendix B shows the locations of the boreholes drilled along the temporary detour alignment (see Boreholes 5 to 10 on Drawing 1).

The boreholes were advanced through the overburden soils on the site using a track mounted CME-55 drill rig equipped with solid and hollow stem augers. Soil samples were obtained using a split spoon sampler in conjunction with Standard Penetration Tests (ASTM D1586) at approximately 0.75 metre and 1.5 metre intervals. The Standard Penetration (N) values were recorded and used to provide an assessment of the relative denseness of the overburden soils at the site and the soil samples were used for identification and laboratory testing. A groundwater sample was obtained from Borehole 7 for pH and sulphate analysis.

At Borehole 8 located near the north culvert abutment, conventional rock coring techniques were used to advance the boreholes approximately 3.0 metres into the underlying bedrock. Standard NQ size core barrels and casings were used and rock core samples of the bedrock were retrieved for rock quality determinations and classification purposes.

3.3 Laboratory

The laboratory testing program for select soil samples consisted of the following:

- Atterberg Limits
- Natural Moisture Contents
- Unit Weights
- Grain Size Distributions

The laboratory test results are summarized on the attached Borehole Logs in Appendix B. pH and sulphate analyses was performed on a groundwater sample taken from Borehole 7 and the results are contained in Appendix D. Appendix D also contains grain size distributions for soil samples from boreholes 2 and 9, respectively.

4. Subsurface Conditions

4.1 Existing Bridge Location

As previously indicated, the Borehole locations are shown on Drawing 1 of Appendix B and the results of the geotechnical investigation near the existing bridge location are summarized on the attached Borehole Logs number 1, 2, 3, and 4 in Appendix B. Asphaltic concrete and concrete were found overlying fill in Boreholes 1, 2, 3 and 4 adjacent to the north and south bridge abutments. The fill ranged in thickness from 4.5 m to 4.8 m and was underlain by a thin silt and gravel till layer. The silt and gravel layer (glacial till) was found to range in thickness from approximately 0.4 m to 0.8 m and was underlain by bedrock consisting of inter-layered shaly limestone and shale. Drawing 1 in Appendix C shows the summarized stratigraphic profile for both the north and south bridge abutments.

4.1.1 Asphaltic Concrete and Concrete

Approximately 150 mm of asphalt was found overlying 200 mm of concrete at Boreholes 2, 3, and 4. The asphaltic concrete and concrete encountered in Borehole 1 were found to be slightly thicker (200 mm and 280 mm, respectively).

4.1.2 FILL

Underlying the asphaltic concrete and concrete, fill was encountered. The fill was predominantly clayey silt (ML-CL) with some gravel and coarse sand, and occasional zones with organic material. Based on Standard Penetration N-values, the consistency of the fill was found to be highly variable ranging from soft to very stiff. The Standard Penetration N-values ranged from 3 blows/300mm to 27 blows/300mm and the natural moisture content ranged from approximately 10% to 80%.

The large range of natural moisture content is due in part to the organic materials present in portions of the fill. It was generally observed that the Penetration resistance of the fill was inversely proportional to the moisture content. For example, natural moisture contents in excess of 40% generally coincided with low blow counts in the order of 3 to 4 (blows/300 mm). Moisture contents in the order of 20%± generally coincided with blow counts of 10 or greater.

4.1.3 SILT and GRAVEL till (ML-GL)

A thin layer of compact to dense silt and gravel till (ML-CL) with sand and a trace of clay was found beneath the fill in Boreholes 1, 2, 3 and 4. The silt and gravel till layer (ML-GL) ranged in thickness from approximately 0.4 to 0.8 m. Standard Penetration N-values in this layer ranged from 27 blows/300mm to 60 blows/130 mm and natural moisture contents varied from approximately 10% to 14.5%. Grain size analysis on Split Spoon Sample 5 from Borehole 2 (see Figure 1 in Appendix D) indicated 22% gravel, 38% sand, 38 % silt and 3 % clay.

4.1.4 BEDROCK

The bedrock was proven in Boreholes 1, 2, 3 and 4 by obtaining NQ cores which were used for subsequent classification of the rock. The bedrock at the bridge site is relatively flat ranging in Elevation from 78.66 m to 79.30 m.

Detailed descriptions of the rock are included on the attached Borehole Logs in Appendix B. The upper 1.0 to 2.0 metres of the bedrock cores was classified as shaly limestone. The rock was grey, fine to medium grained, weak to medium strong with very close to moderately close fracture spacing. The lower portions of the rock cores obtained from Boreholes 1, 2, 3, and 4 were found to consist of grey to dark grey shale with shaly limestone and mudstone seams (50 - 200 mm thick).

Rock core recovery ranged from 50% to 100% and Rock Quality Designation (RQD) values ranged from 0% in the upper core run of Borehole 4 (El. 79.30 m to 77.80 m) to 72% in the lower core run of Borehole 3 (El. 77.12 m to 75.62 m). In generally, the Rock Mass Quality was found to be very poor to poor in the upper 0.3 to 0.4 metres of bedrock for Boreholes 1 and 2. Below the upper 0.3 to 0.4 metre zone of highly fractured rock, the Rock Mass Quality improves to fair with an average RQD of approximately 60%.

4.2 Temporary Detour and Culvert Alignment

The results of the geotechnical investigation for the temporary detour and culvert are summarized on Borehole logs 5, 6, 7, 8, 9 and 10 in Appendix B. An organic clayey silt root mat (CL-OL) varying in thickness from 0.18 metres to 1.3 metres was encountered overlying silty clay (CL-CH). The silty clay (CL-CH) was found to be greater than 1.8 metres thick at Borehole 10 and was absent in Boreholes 6 and 8. Silt and gravel till (ML-GL) was encountered below the silty clay (CL-CH) in Boreholes 5, 6, 7, and 8 and bedrock was encountered in Borehole 8 at an Elevation of 78.94 metres. Boreholes 9 and 10 were terminated within the upper silty clay (ML-CL) deposit. A summary of the inferred stratigraphical profile along the proposed alignment of the temporary detour and culvert is shown on Drawing 2 in Appendix C.

4.2.1 ORGANIC CLAYEY SILT (root mat) over SILTY CLAY

An organic clayey silt layer (OL-CL) was encountered in all boreholes drilled along the proposed alignment of the temporary detour and culvert. The thickness of the organic layer (root mat) varied from 0.18 metres in Borehole 5 to 1.8 metres in Borehole 7. Moisture contents for this subsurface layer typically ranged from 50% to 60% and Standard Penetration N-values varied from 2 to 8 blows/300mm. The consistency of this deposit is soft to firm based on the Penetration resistance.

The upper root mat was underlain by a similar soil deposit ranging from soft to stiff SILTY clay (no significant root fibers). The average moisture content of this overburden layer was approximately 36% and Standard Penetration N-values varied from 2 to 10 blows/300mm.

4.2.2 SILT and GRAVEL till (ML-GL)

Compact to dense silt and gravel till (ML-CL) with sand and a trace of clay was found below the upper clayey silt layers in Boreholes 5, 6, 7 and 8. The silt and gravel till (ML-GL) layer was penetrated completely by Borehole 8 only. The thickness of the layer at Borehole 8 was found to be approximately 1.6 metres. Standard Penetration N-values in this layer ranged from 23 to 47 blows/300mm and natural moisture contents varied from approximately 10% to 20%.

4.2.3 BEDROCK

The bedrock was proven in Borehole 8 by obtaining NQ rock cores which were used for subsequent classification of the rock. The bedrock was encountered at an Elevation of 78.9 m.

Detailed description of the rock is included on the attached Borehole log for Borehole 8 in Appendix B. The upper 1.9 metres of the bedrock core was classified as shaly limestone. The rock was grey, fine to medium grained, weak to medium strong with very close to moderately close fracture spacing. The lower portion of the bedrock core obtained from Borehole 8 was found to consist of grey to dark grey shale with shaly limestone and mudstone seams (50 - 100 mm thick).

Rock core recovery ranged from 81 to 90% and Rock Quality Designation (RQD) values were general good ranging from 81% in the upper core run of Borehole 8 (El. 78.94 m to 77.42 m) to 90% in the lower core run of Borehole 8 (El. 77.42 m to 75.89 m). Generally, the Rock Mass Quality was found to be fair to good below the upper 0.3 metres of the Bedrock.

5. Groundwater Conditions

At the time of the investigation, the water level in the Rigaud River was measured to be 81.2 metres (Geodetic Elevation). Information regarding the groundwater levels at the site was obtained by measuring the water levels in the open boreholes after the completion of drilling. No free standing water was observed in Boreholes 1 to 5 and 8 to 10. For Boreholes 6 and 7, water was encountered in the open boreholes at an Elevation of $81.6 \pm$ m as indicated on Borehole logs 6 and 7 in Appendix B. It is, however, unlikely that sufficient time was allowed for these water levels to stabilize. Based on the above noted observations and relatively flat terrain in the vicinity of the bridge, the groundwater levels at the site can be expected to closely follow the Elevation of the water level in the Rigaud River. As such, ground water tables will be subject to seasonal fluctuations and the prevailing hydraulics of the river.

pH and sulphate tests were performed on a groundwater sample taken from Borehole 7 and the results are shown in Appendix D. The pH was found to be 7.27 and the sulphate test showed 23.5 mg/ml of sulphate.


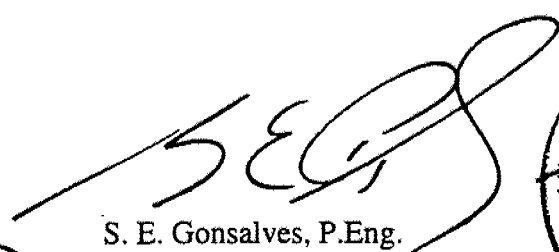
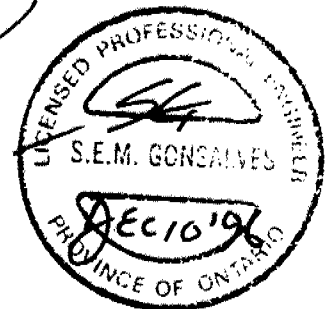
7. General

The information presented in this report is based on a limited investigation designed to provide information to support an overall assessment of the current geotechnical conditions at the site of the proposed Rigaud River Bridge Replacement. The conclusions presented in this report reflect site conditions existing at the time of the investigation. It is noted that the soil boundaries indicated on the borehole logs are inferred from discontinuous sampling and observations during drilling. These boundaries are intended to reflect transition zones for the purpose of geotechnical design and should not be interpreted as exact planes of geological change.

This report has been prepared by Sean Hinchberger and reviewed by S.E. Gonsalves and Peter Chan. Peter Chan coordinated the field investigation and Clement Chow performed the fieldwork.

We trust this report is satisfactory for your purposes. Should you have any questions, please do not hesitate to contact this office.

Trow Consulting Engineers Ltd.


S. Hinchberger, Ph.D.
Peter Chan, P.Eng.
S. E. Gonsalves, P.Eng.

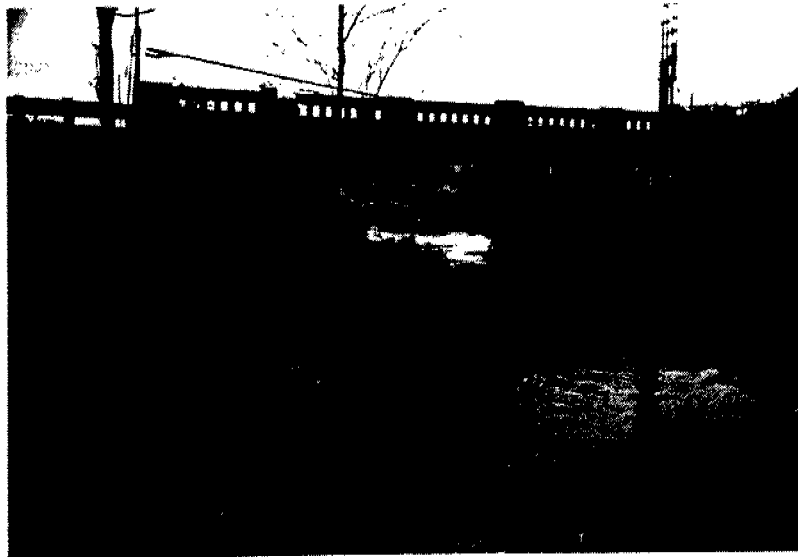
NOTE: The preceding report is a copy of the factual information from the Foundation Investigation and Design Report prepared by Trow Consulting Engineers Ltd. (consulting geotechnical engineers for this project), for the Ministry of Transportation, Pavements and Foundations Design Section.

A handwritten signature in black ink, reading "D. Dundas". The signature is written in a cursive style with a large, stylized "D" and a long, sweeping underline.

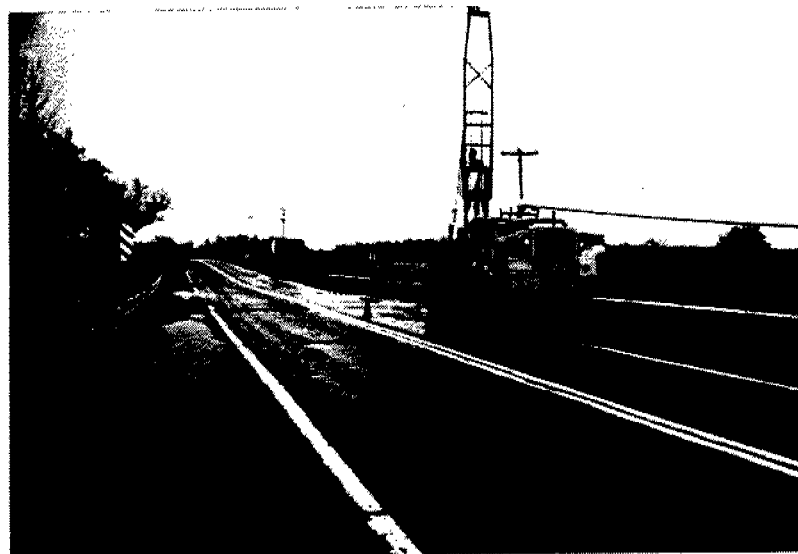
D. Dundas, P. Eng.

Senior Foundation Engineer

Appendix A: Photographs

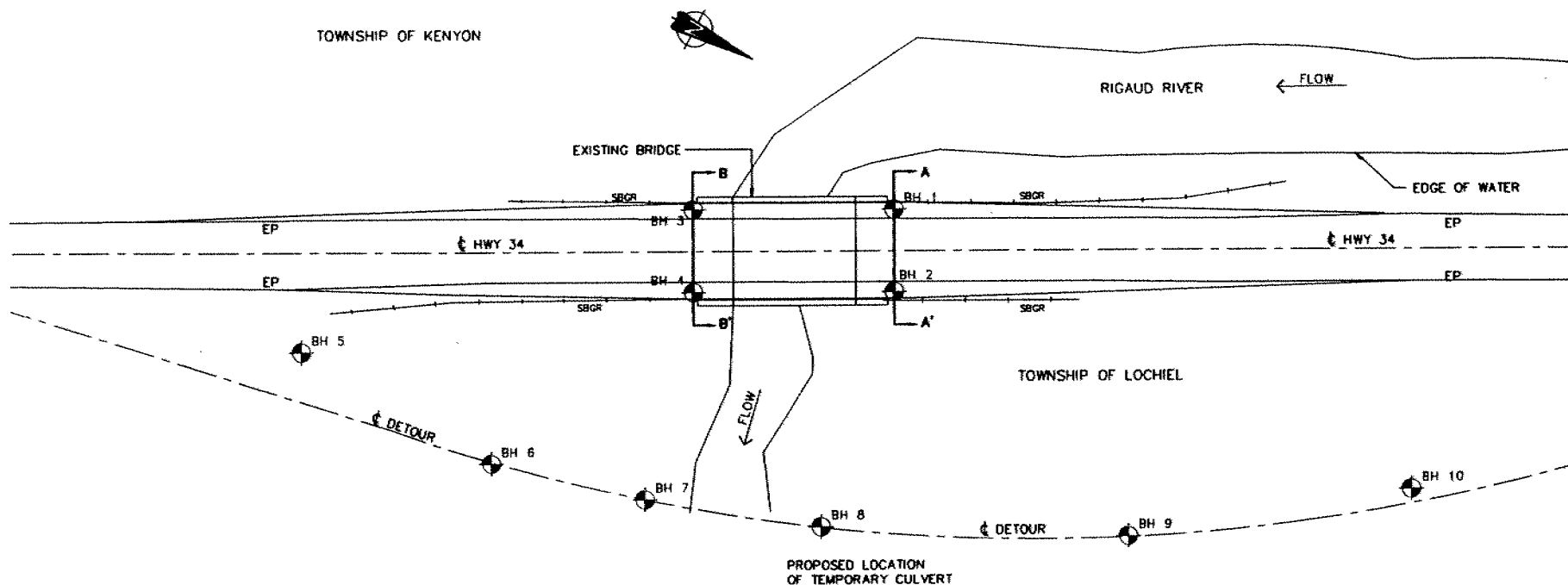


PHOTOGRAPH 1 View of Existing Rigid Frame Bridge from the Location of the Proposed Temporary Culvert - Rigaud River and Hwy 34.



PHOTOGRAPH 2 View of Existing Rigaud River Bridge from the South Approach.

Appendix B: Plan Location of Boreholes & Borehole Logs



General Notes

- 1) The boundaries and soil types have been established only at Borehole locations. Between boreholes they are assumed and may be subject to considerable error.
- 2) Soil samples will be retained in storage for 1 year and then destroyed unless client advises that an extended time period is required.
- 3) Topsoil quantities should not be established from the information provided at the borehole locations.
- 4) This drawing forms part of the report, project number as referenced, and should be used only in conjunction with this report.

Geocres No 31G - 216



METRIC

SCALE 1:400



TROW CONSULTING ENGINEERS LTD.
BRAMPTON BRANCH

BOREHOLE LOCATION PLAN
PROPOSED CROSSING AT KING'S
HIGHWAY 34 AND RIGAUD RIVER
LOT 1 CONCESSION 7 TWP KENYON
LOT 38 CONCESSION 6 TWP LOCHIEL
LADGAN ONTARIO

PROJECT NO.: BR-10697-A
SCALE: 1:400
DRAWN BY: J
CHECKED BY: SDH
DATE: OCTOBER 1996
DRAWING NO.: 1

RECORD OF BOREHOLE 1

1 OF 1

METRIC

W.P. 317-94-00 LOCATION N 5027.9810km E 210.4610km ORIGINATED BY S.D.H.
 DIST 23+059 HWY 34 BOREHOLE TYPE H.S. Augers, NQ Core Barrel, SPT COMPILED BY S.D.H.
 DATUM Geodetic DATE 1996 October 21 CHECKED BY S.E.G.

SOIL PROFILE				SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS/0.3m			TEST (N Value)								
								10	20	30	40					
B4.18	GROUND SURFACE															
0.00	200mm ASPHALTIC CONCRETE															
83.83	280mm CONCRETE															
0.25																
83.83																
0.55	FILL - predominantly clayey silt (ML-CL) with some gravel and coarse sand, some zones of organic material, moist to very moist, grey and brown, soft to firm.		1	SPT	9											
			2	SPT	10										19.20	
			3	SPT	5											
			4	SPT	3										22.50	
78.46																
4.72	SILT and GRAVEL till (ML-GL) - with sand, trace of clay, wet, grey, dense.		5	SPT	30										73.7	
78.69																
5.49	SHALY LIMESTONE - grey, fine to medium grain, medium strong. Fracture spacing: moderately close. Fracture Orientation: 85-90 deg. to core axis. Fair Rock Mass Quality.		1	NQ												REC 100% RQD 60%
77.68																
6.50	SHAPE - occasional shaly limestone seams (50-100 mm thick), dark grey, fine grain, weak. Fracture spacing: moderate to close. Fracture Orientation: 85-90 deg. to core axis. Fair Rock Mass Quality.		2	NQ												REC 100% RQD 65%
75.65																
8.53	End of Borehole															

RECORD OF BOREHOLE 2

1 OF 1

METRIC

W.P. 317-94-00

LOCATION N 5027.9850km E 210.4670km

ORIGINATED BY S.D.H.

DIST 23+059 HWY 34

BOREHOLE TYPE H.S. Augers, NQ Core Barrel, SPT

COMPILED BY S.D.H.

DATUM Geodetic

DATE 1996 October 22

CHECKED BY S.E.G.

SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (IN Value)				PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER TYPE			10	20	30	40					
84.19	GROUND SURFACE													
84.00	150 mm ASPHALTIC CONCRETE													
83.76	280 MM CONCRETE													
83.76	FILL - predominantly clayey silt (ML-CL) with some gravel and coarse sand, some zones of organic material, moist to very moist, grey and brown, soft to firm.		1 SPT 7										21.50	
			2 SPT 7											
			3 SPT 4											
			4 SPT 4											
79.31	SILT and GRAVEL till (ML-GL) - with sand, trace of clay, wet, grey, dense.		5 SPT 27											22 38 38 2
78.70	SHALY LIMESTONE - grey, fine to medium grain, medium strong. Fracture spacing: very close in upper 0.3 m, close for remainder. Fracture Orientation: 85-90 deg. to core axis. Poor Rock Mass Quality.		1 NQ											REC 100% RQD 28%
77.24	SHALE - occasional shaly limestone seams (50-100 mm thick), dark grey, fine grained, medium strong. Fracture spacing: moderately close. Fracture Orientation: 85-90 deg. to core axis. Poor Rock Mass Quality.		2 NQ											REC 100% RQD 48%
75.66	End of Borehole													

RECORD OF BOREHOLE 3

1 OF 1

METRIC

W.P. 317-94-00

LOCATION N 5027.9640km E 210.4700km

ORIGINATED BY S.D.H.

DIST 23+037 HWY 34

BOREHOLE TYPE H.S. Auger, NO Core Barrel, SPT

COMPILED BY S.D.H.

DATUM Geodetic

DATE 1996 October 22

CHECKED BY S.E.G.

SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT (wp)	NATURAL MOISTURE CONTENT (w)	LIQUID LIMIT (wl)	UNIT WEIGHT (kN/m ³)	REMARKS & GRAIN SIZE DISTRIBUTION			
ELEV. DEPTH	DESCRIPTION	STRATA	NUMBER	TYPE		10	20	30	40					GR	SA	SI	CL
84.15	GROUND SURFACE																
84.00	150 mm ASPHALTIC CONCRETE																
83.80	200 mm CONCRETE																
83.80	FILL - predominantly clayey silt (ML-CL) with some gravel and coarse sand, some zones of organic material, moist to very moist, grey and brown, soft to firm.		1	SPT	11												
			2	SPT	3								78.8				
			3	SPT	3								68				
			4	SPT	16								75.7				
			5	SPT	25												
79.27	SILT and GRAVEL till (ML-GL) - with sand, trace of clay, wet, grey, dense (inferred from drill rates)																
78.66	SHALY LIMESTONE - grey, fine to medium grain, weak to medium strong. Fracture spacing: close in upper 0.4 m and moderate close for remainder. Fracture Orientation: 85-90 deg. to core axis. Poor to Fair Rock Mass Quality.		1	NQ													REC 100% RQD 53%
76.90	SHALE - occasional shaly limestone and mud stone seams (50-150 mm thick), fine grain. Fracture spacing: medium close. Fracture Orientation: 85-90 deg. to core axis. Fair Rock Mass Quality.		2	NQ													REC 100% RQD 72%
75.62	End of Borehole																

RECORD OF BOREHOLE 4

1 OF 1

METRIC

W.P. 317-94-00

LOCATION N 5027.9680km E 210.4760km

ORIGINATED BY S.D.H.

DIST 23+038 HWY 34

BOREHOLE TYPE H.S. Auger, NO Core Barrel, SPT

COMPILED BY S.D.H.

DATUM Geodetic

DATE 1996 October 22

CHECKED BY S.E.G.

SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE		10	20	30	40					
84.19	GROUND SURFACE													
84.00	150 mm ASPHALTIC CONCRETE													
83.84	200 mm CONCRETE													
83.84	FILL - predominantly clayey silt (ML-CL) with some gravel and coarse sand, some zones of organic material, moist to very moist, grey and brown, soft to firm.		1	SPT	5								20.70	
			2	SPT	27									
			3	SPT	3								17.50	
			4	SPT	25									
79.66	SILT and GRAVEL till (ML-GL) - with sand, trace of clay, wet, grey, dense		5	SPT	60									N = 60/130mm
79.30	SHALY LIMESTONE - grey, fine to medium grain, weak to medium strong. Fracture spacing: very close. Fracture Orientation: 75-90 deg. to core axis. Very Poor Rock Mass Quality.		1	NQ										REC 50% RQD 0%
77.50	SHALE - occasional mud stone and shaly limestone seams (100-200m thick), dark grey, fine grain, weak to medium strong. Fracture spacing: moderate close. Fracture Orientation: 85-90 deg. to core axis. Fair Rock Mass Quality.		2	NQ										REC 100% RQD 100%
76.27	End of Borehole													

RECORD OF BOREHOLE 5

1 OF 1

METRIC

W.P. 317-94-00

LOCATION N 5027.9380km E 210.5000km

ORIGINATED BY S.D.H.

DIST 23+002 HWY 34

BOREHOLE TYPE H.S. Augers, SPT

COMPILED BY S.D.H.

DATUM Geodetic

DATE 1996 October 25

CHECKED BY S.E.G.

SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER TYPE BLOWS/0.3m			10	20	30	40					
84.13	GROUND SURFACE													
84.00 82.73 0.18	ORGANIC CLAYEY SILT (CL-OL) - root fibres, some fine sand, moist, brown, firm to stiff.		1 SPT 8		84	⊗					○			
	SILTY CLAY (CL) - some fine sand, moist, brown, firm to stiff		2 SPT 10		83	⊗						○		
82.73 1.40	SILT and GRAVEL till (ML-GL) - with sand, trace of clay, grey, wet, dense.		3 SPT 38					⊗		○				
82.15 1.98	End of Borehole													

RECORD OF BOREHOLE 6

1 OF 1

METRIC

W.P. 317-94-00

LOCATION N 5027.9590km E 210.5000km

ORIGINATED BY S.D.H.

DIST 23+017 HWY 34

BOREHOLE TYPE H.S. Auger, STP

COMPILED BY S.D.H.

DATUM Geodetic

DATE 1996 October 25

CHECKED BY S.E.G.

SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION
ELEV. DEPTH	DESCRIPTION	STRATA PLOT NUMBER	TYPE			10	20	30	40					
82.11	GROUND SURFACE													
0.00	ORGANIC CLAYEY SILT (CL-OL) - root fibres, some fine sand, moist, brown, firm to stiff		1 SPT 3		82								16.40	
81.54														
0.57	SILT and GRAVEL till (ML-GL) - with sand, trace of clay, wet, grey, dense.		2 SPT 23		81									
			3 SPT 26											
80.13														
1.98	End of Borehole													

RECORD OF BOREHOLE 7

1 OF 1

METRIC

W.P. 317-94-00

LOCATION N 5027.9740km E 210.4960km

ORIGINATED BY S.D.H.

DIST 23+033 HWY 34

BOREHOLE TYPE H.S. Auger, SPT

COMPILED BY S.D.H.

DATUM Geodetic

DATE 1996 October 25

CHECKED BY S.E.G.

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT wp	NATURAL MOISTURE CONTENT w	LIQUID LIMIT wl	UNIT WEIGHT kn/m ³	REMARKS & GRAIN SIZE DISTRIBUTION GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE			10	20	30	40					
82.20	GROUND SURFACE														
0.00	ORGANIC CLAYEY SILT (CL-OL) - root fibres, some fine sand, very wet, brown, soft to firm.		1	SPT 4		82								16.00	
80.80			2	SPT 2		81									
1.30	SILTY CLAY (CH) - high plasticity, sensitive, very wet, grey, soft to firm		3	SPT 4											
80.20			4	SPT 42		80									
2.00	SILT and GRAVEL till (ML-GL) - with sand, trace of clay, wet, grey, dense		5	SPT 82		79									
78.75	Probable Bedrock														N = 82/254mm
3.45	End of Borehole Notes: 1. Borehole terminated on probable bedrock.														

RECORD OF BOREHOLE 8

1 OF 1

METRIC

W.P. 317-94-00

LOCATION N 5027.9790km E 210.4900km

ORIGINATED BY S.D.H.

DIST 23+049 HWY 34

BOREHOLE TYPE H.S. Auger, NQ Core Barrel, SPT

COMPILED BY S.D.H.

DATUM Geodetic

DATE 1996 October 25

CHECKED BY S.E.G.

SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT wp	NATURAL MOISTURE CONTENT w	LIQUID LIMIT wl	UNIT WEIGHT kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION
ELEV. DEPTH	DESCRIPTION	STRATA	NUMBER TYPE			10	20	30	40					
81.99	GROUND SURFACE													
0.00	ORGANIC CLAYEY SILT (CL-OL) - root fibres, some fine sand, moist, brown, firm to stiff.		1 SPT 3										16.10	
			2 SPT 6		81									
80.47														
1.52	SILT and GRAVEL till (ML-GL) - some sand, trace of clay, wet, grey, dense.		3 SPT 23		80									
			4 SPT 47											
78.94					79									
3.05	SHALY LIMESTONE - grey, fine to medium grain, medium strong. Fracture spacing: close to moderate close. Fracture Orientation: 85-90 deg. to core axis. Poor to Fair Rock Mass Quality.		1 NQ		78									REC 81% RQD 55%
77.04					77									
4.95	SHALE - occasional shaly limestone seams (50-100 mm thick), dark grey, fine grain, weak. Fracture spacing: moderate close. Fracture Orientation: 85-90 deg. to core axis. Fair to Good Rock Mass Quality.		2 NQ		76									REC 90% RQD 78%
75.89														
6.10	End of Borehole													

RECORD OF BOREHOLE 9

1 OF 1

METRIC

W.P. 317-94-00

LOCATION N 5028.0150km E 210.4770km

ORIGINATED BY S.D.H.

DIST 23+079 HWY 34

BOREHOLE TYPE H.S. Auger, SPT

COMPILED BY S.D.H.

DATUM Geodetic

DATE 1996 October 25

CHECKED BY S.E.G.

SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER TYPE BLOWS/0.3m			10	20	30	40					
82.57	GROUND SURFACE													
0.00 82.57 0.20	ORGANIC CLAYEY SILT (CL-OL) - root fibres, some fine sand, moist, brown, stiff		1 SPT 6		82	⊗						○	17.90	0 5 35 60
	SILTY CLAY (CL-CH) - some fine sand, moist, brown, firm becoming soft below El. 81.2 m		2 SPT 7			⊗						○		
			3 SPT 2		81	⊗						○	59.5	
80.59 1.98	End of Borehole													

RECORD OF BOREHOLE 10

1 OF 1

METRIC

W.P. 317-94-00

LOCATION N 5028.0370km E 210.4600km

ORIGINATED BY S.D.H.

DIST 23+105 HWY 34

BOREHOLE TYPE H.S. Auger, SPT

COMPILED BY S.D.H.

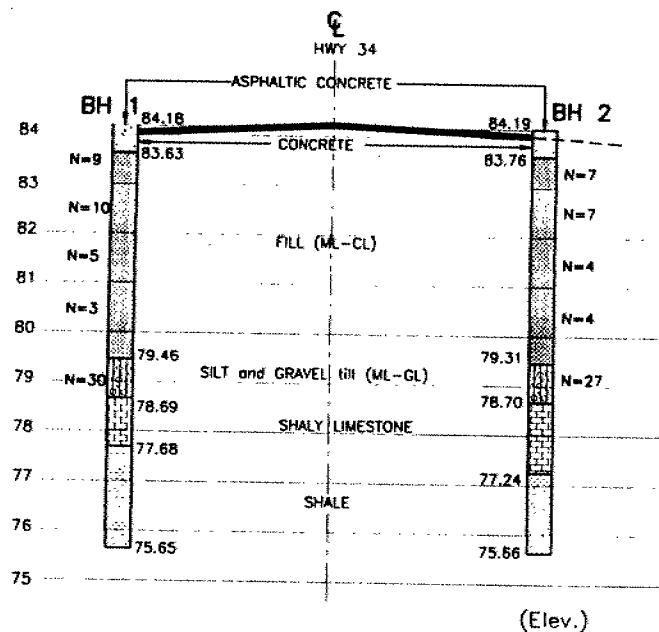
DATUM Geodetic

DATE 1996 October 25

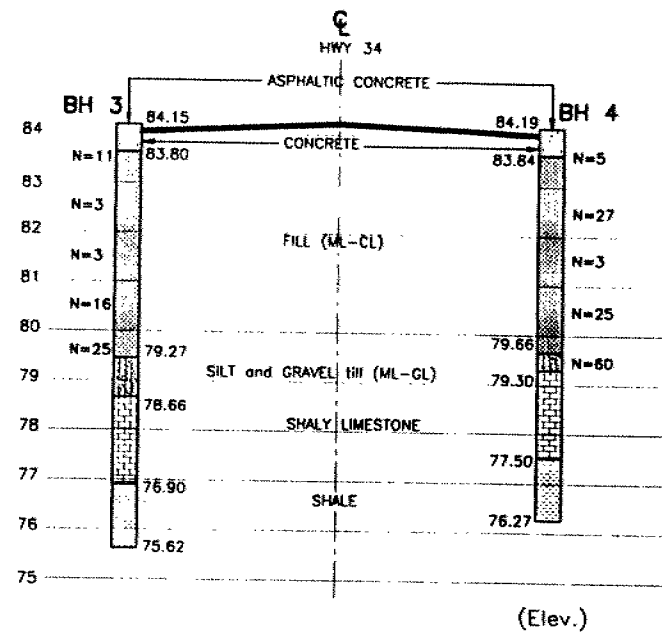
CHECKED BY S.E.G.

SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT wp	NATURAL MOISTURE CONTENT w	LIQUID LIMIT wl	UNIT WEIGHT kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRATA PLAT	NUMBER TYPE			10	20	30	40					
82.87	GROUND SURFACE													
0.00 82.87 0.20	ORGANIC CLAYEY SILT (CL-OL) - root fibres, some fine sand, moist, brown, stiff SILTY CLAY (CL-CH) - some fine sand, moist, brown, firm to stiff.		1 SPT 8			⊗						○		
			2 SPT 12		82	⊗						○		
			3 SPT 8		81	⊗						○		
80.89 1.98	End of Borehole													

Appendix C: Stratigraphies Beneath Bridge Abutments & Temporary Detour



SECTION A-A' (NORTH ABUTMENT)



SECTION B-B' (SOUTH ABUTMENT)

SOIL STRATIGRAPHY BELOW NORTH AND SOUTH BRIDGE ABUTMENT

Geocres No 31G-216

METRIC



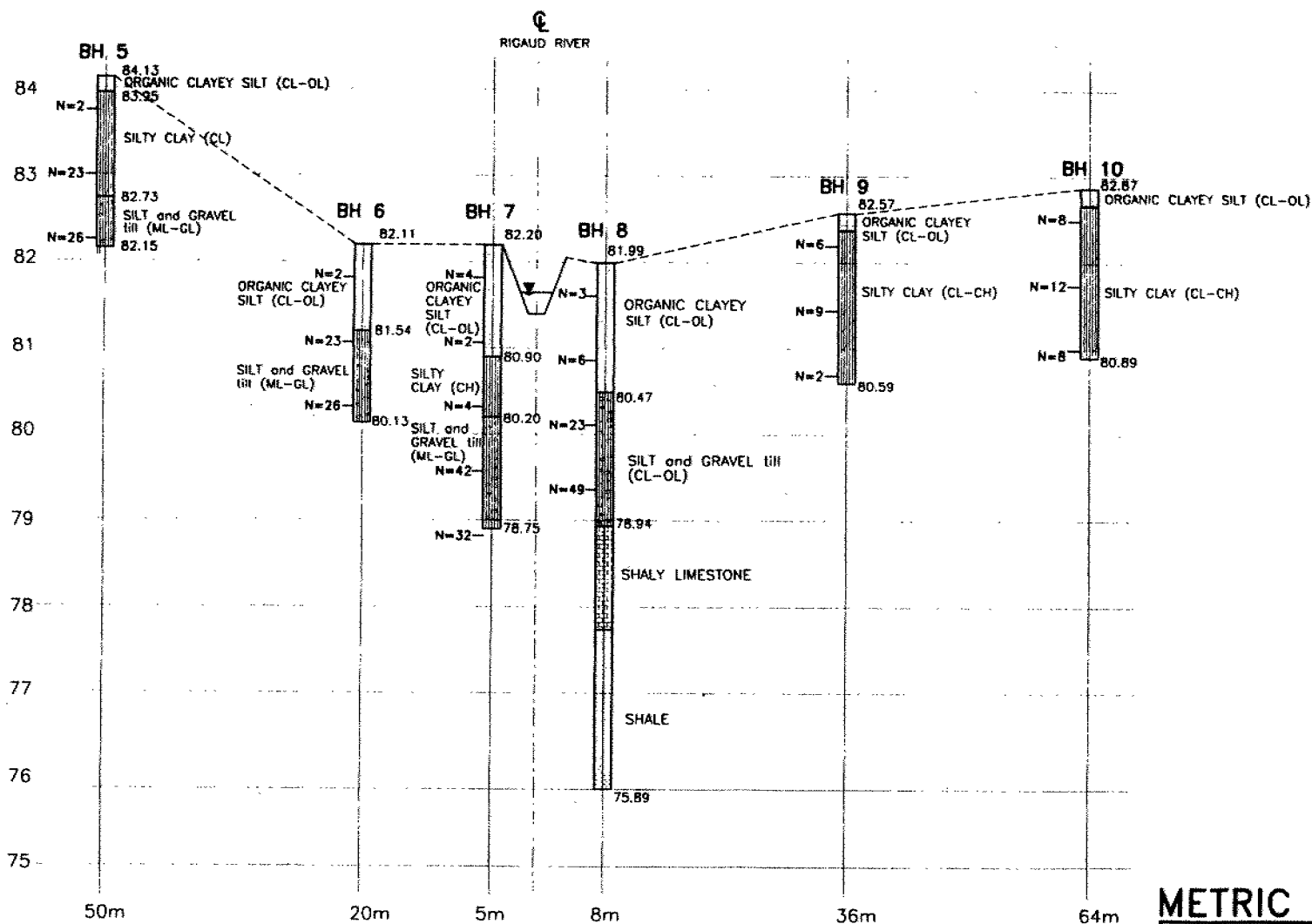
TROW CONSULTING ENGINEERS LTD.
BRAMPTON BRANCH

GEOTECHNICAL INVESTIGATION
RIGAUD RIVER
BRIDGE REPLACEMENT

LAGGAN

ONTARIO

PROJECT NO.:	BR-10897-A
SCALE:	1:100
DRAWN BY:	YB
CHECKED BY:	SDH
DATE:	NOVEMBER 1996
DRAWING NO.:	1



SUMMARY OF SOIL STRATIGRAPHY FOR PROPOSED ALIGNMENT
OF TEMPORARY DETOUR AND CULVERT

Geocres No 31G - 216

METRIC



TROW CONSULTING ENGINEERS LTD.
BRAMPTON BRANCH

**GEOTECHNICAL INVESTIGATION
RIGAUD RIVER
BRIDGE REPLACEMENT**

PROJECT NO: BR-10697-A
SCALE: H=1:500, V=1:50
DRAWN BY: VS
CHECKED BY: SH
DATE: NOVEMBER 1996
DESIGN NO: 2

LACAN

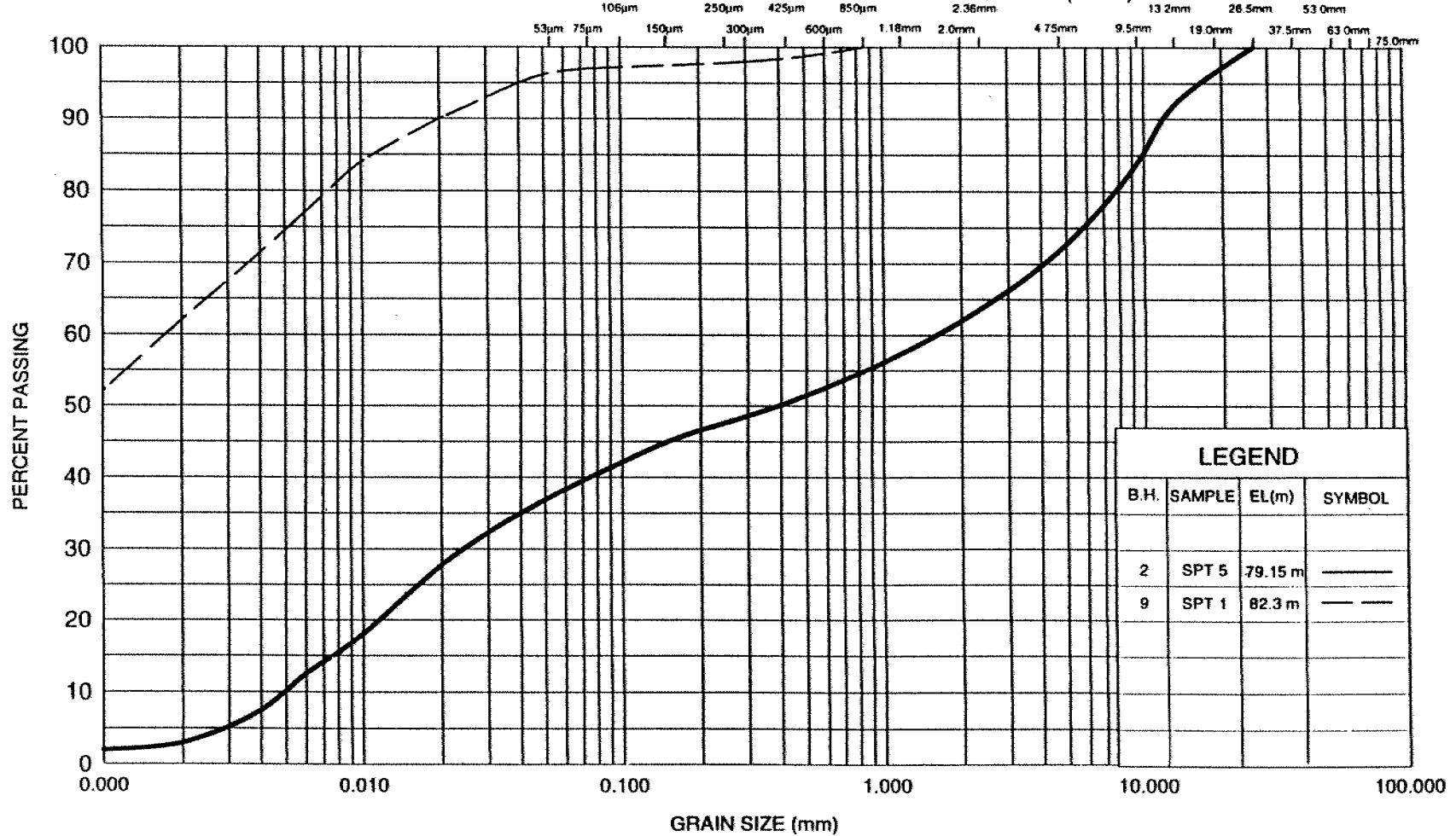
ONTARIO

Appendix D: Laboratory Results

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT	SAND			GRAVEL	
	FINE	MEDIUM	COARSE	FINE	COARSE

MINISTRY SIEVE DESIGNATION (Metric)



Ministry of
Transportation

METRIC

GRAIN SIZE DISTRIBUTION

B.H. 2 - SAMPLE 5: SILT and GRAVEL till (ML-GL) - with sand and a trace of clay.
B.H. 9 - SAMPLE 1: SILTY CLAY (CH)

FIGURE 1

W.P. 317-94-00


Client: **Trow Markham**
 Attention: **Clement Chow**
 Project: **BR 10697 A**
 P.O.:
 Sample Type: **Water**
 Date Received: **Oct 28/96**
 Date Reported: **Oct 30/96**

ENTECH

A Division of Agri-Service Lab Inc.
 6820 Kilmist Rd., Unit #4
 Mississauga, ONT L6N 6M3
 TEL: (905) 821-1112
 FAX: (905) 821-2095

MISC. SAMPLE TEST

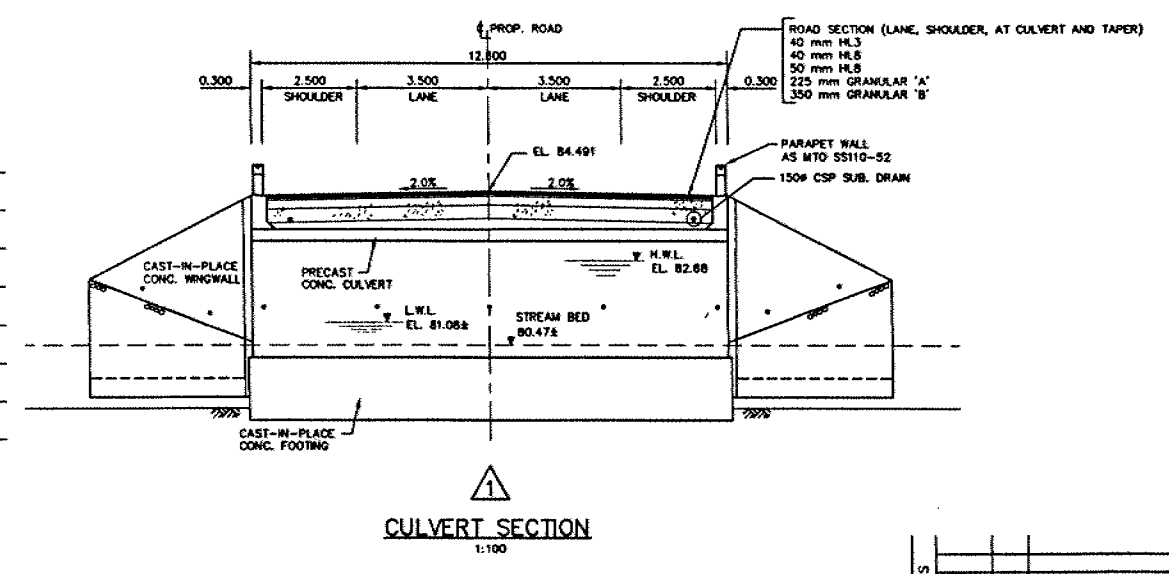
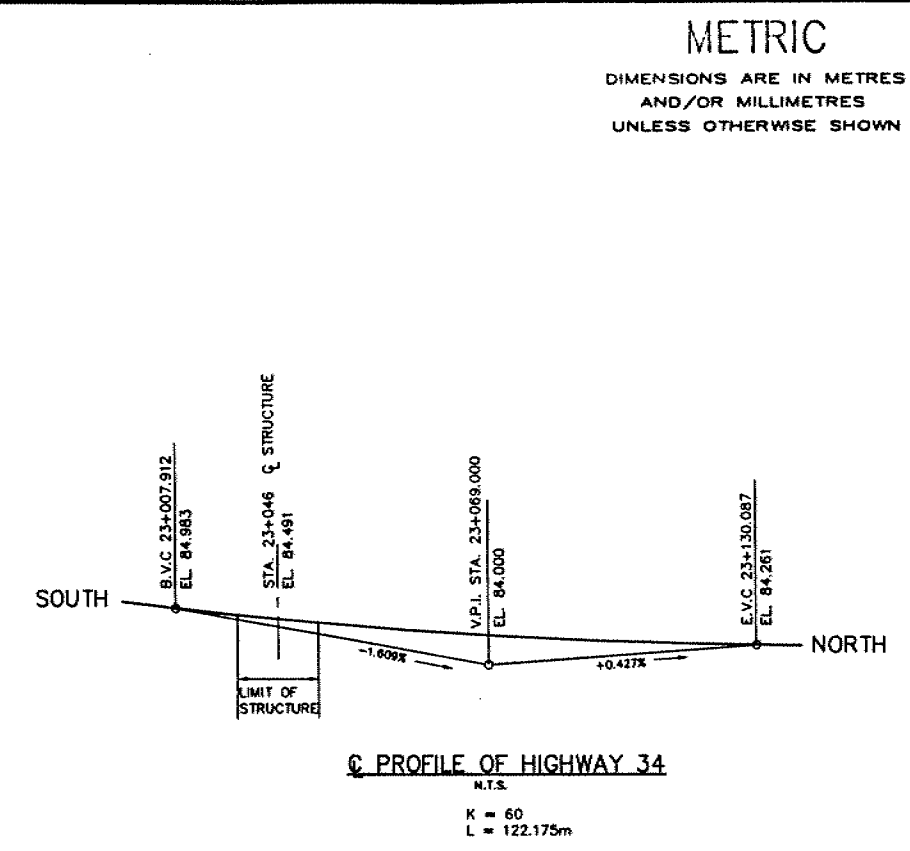
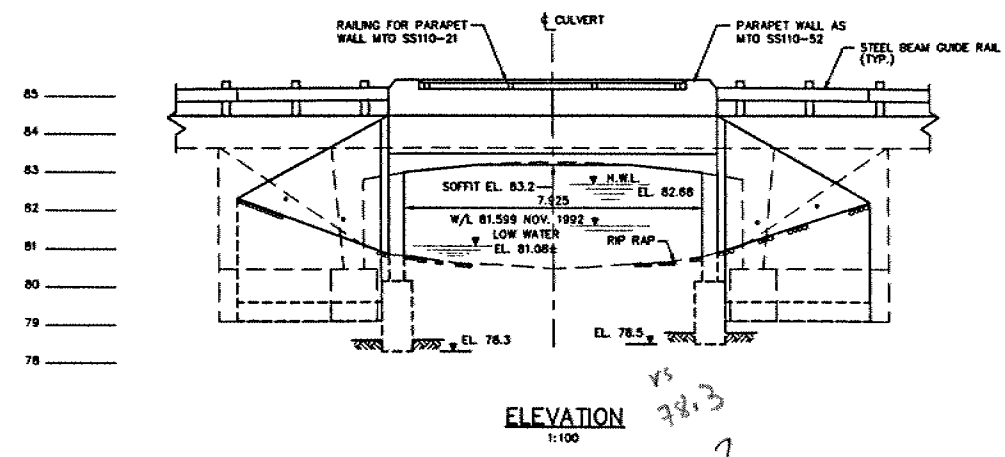
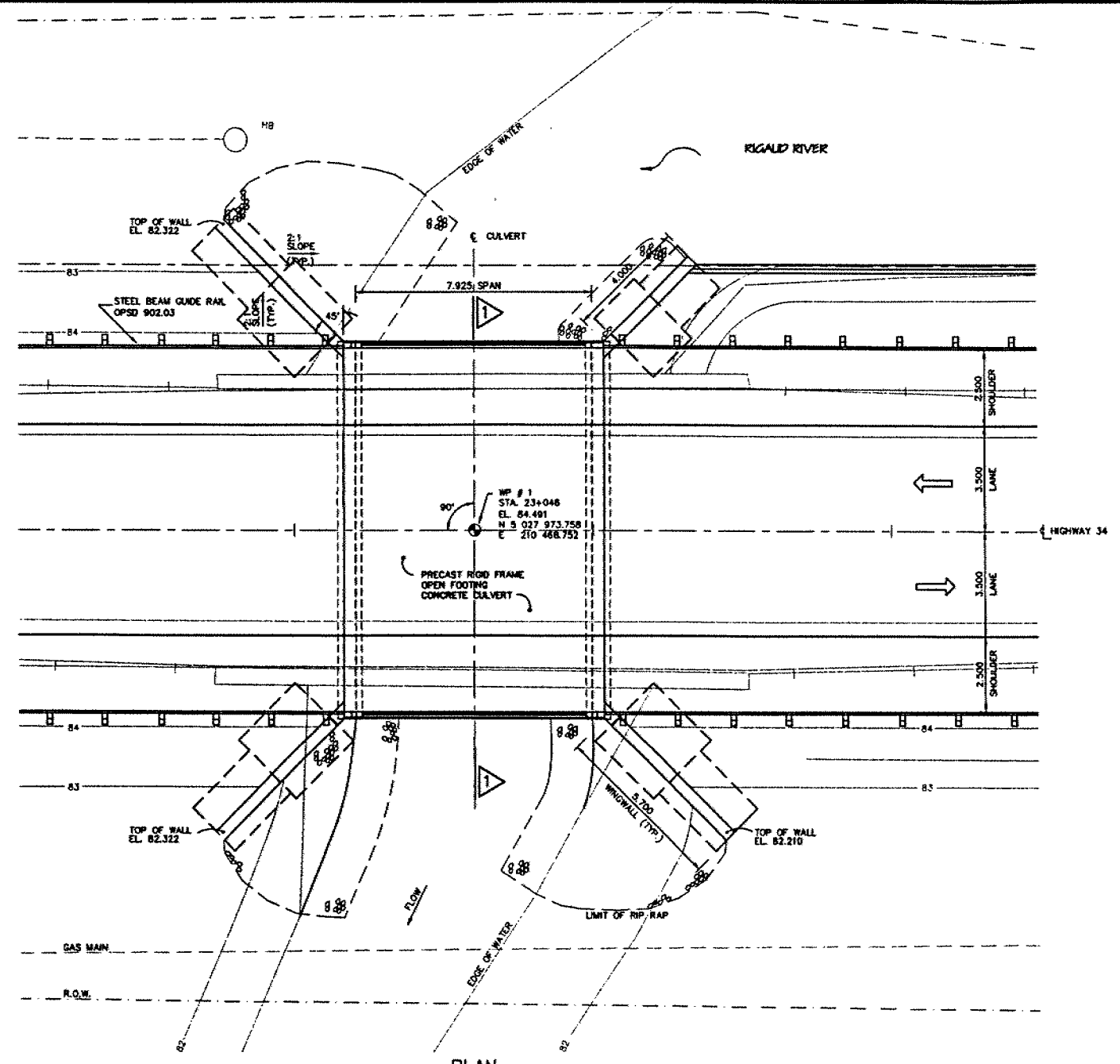
PARAMETER	Units	Method Detection Limit (ug/ml)	CONTROL SAMPLE			SAMPLE DATA				
			Expected (ug/ml)	Found (ug/ml)	Recovery %	24558 BH3				
pH	-	-	9.08	8.91	98	7.27				
Sulphate	ug/ml	0.2	400	412.5	103	23.5				


 Sam Sanyal, M.Sc., C. Chem

PR-D-707 68-05

MINISTRY OF TRANSPORTATION, ONTARIO

C:\30001\3074\3074-14 Wed Mar 12 16:25:33 1997



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

PLATE No. 388-34 / 101-0
CONT No 97-18
WP No 317-94-01



RIGAUD RIVER BRIDGE
PRELIMINARY
GENERAL ARRANGEMENT

SHEET
14

Cumming Cockburn Limited
Consulting Engineers and Planners



GENERAL NOTES

CLASS OF CONCRETE
ABUTMENTS, WINGWALLS, BARRIER WALLS AND
CULVERT SLABS.....30 MPa

CLEAR COVER TO REINFORCING STEEL
FOOTINGS.....100±25
WALLS AND WINGWALLS.....80±20
FRONT FACE.....80±20
BACK FACE.....70±20
TOP SLAB.....70±20
TOP.....70±20
BOTTOM.....40±10
REMAINDER.....70±20
UNLESS OTHERWISE NOTED

REINFORCING STEEL
SHALL BE GRADE 400 UNLESS OTHERWISE SPECIFIED.
BARS MARKED WITH SUFFIX C DENOTE COATED BARS.

CONSTRUCTION NOTES
BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND
BOTH SIDES OF CULVERT KEEPING THE HEIGHT OF THE
BACKFILL APPROXIMATELY THE SAME. AT NO TIME
SHALL THE DIFFERENCE IN ELEVATION BE GREATER
THAN 0.5m.

NO CONCRETE SHALL BE PLACED FOR ANY FOOTINGS UNTIL
THE DEPTH OF THE EXCAVATION AND CHARACTER OF
THE FOUNDATION HAVE BEEN APPROVED BY THE ENGINEER.

DESIGN CRITERIA
ONTARIO HIGHWAY BRIDGE DESIGN CODE 3RD EDITION.

- LIST OF DRAWINGS
- 14. GENERAL ARRANGEMENT
 - 16. CULVERT
 - 17. WINGWALLS
 - 18. CONCRETE PARAPET
 - 19. RAILING FOR BARRIER WALL

90-1
confirmed
90-1

DRAWINGS NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REVISIONS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													</
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AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

PLATE No. 388-34 / 101-0
CONT No 97-18
WP No 317-94-01

RIGAUD RIVER BRIDGE
CULVERT SECTIONS

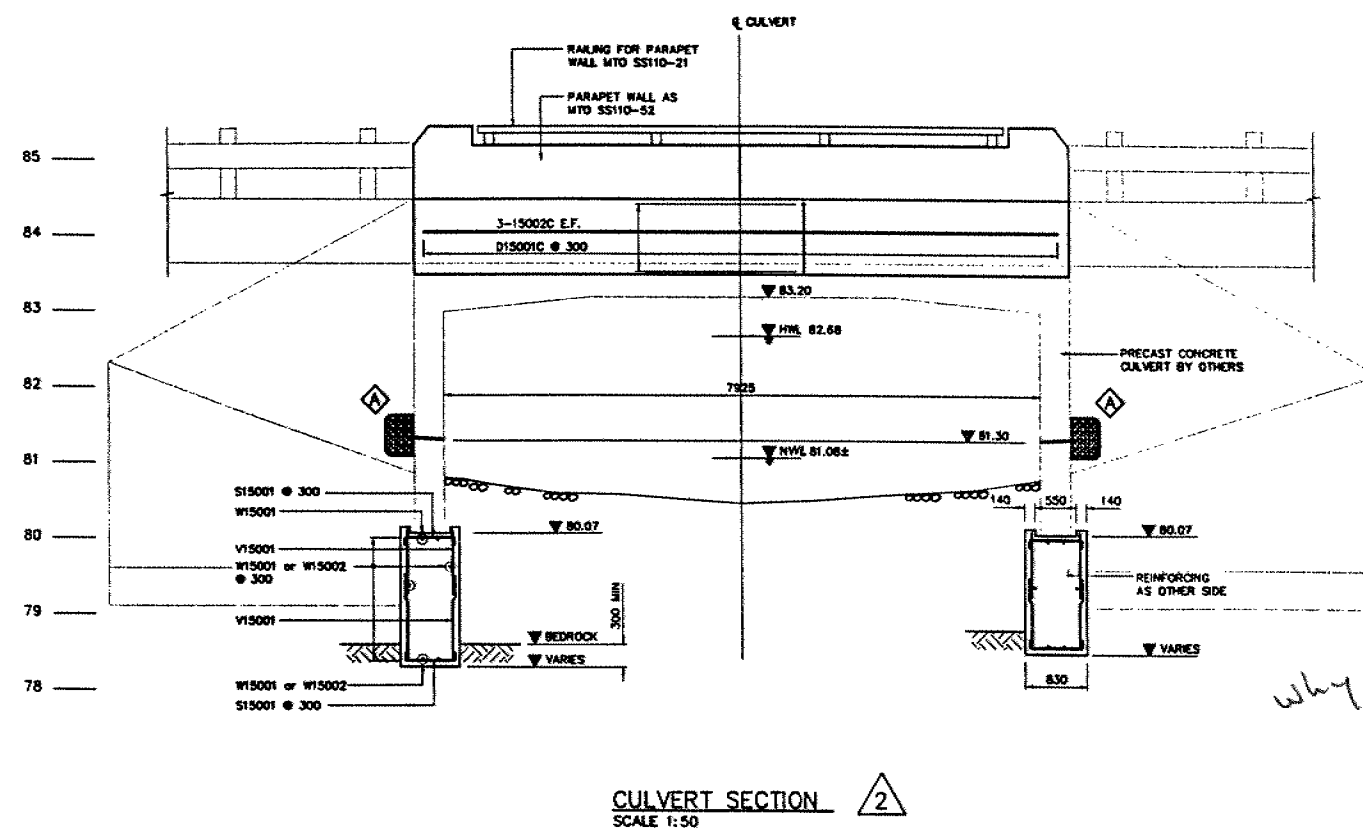
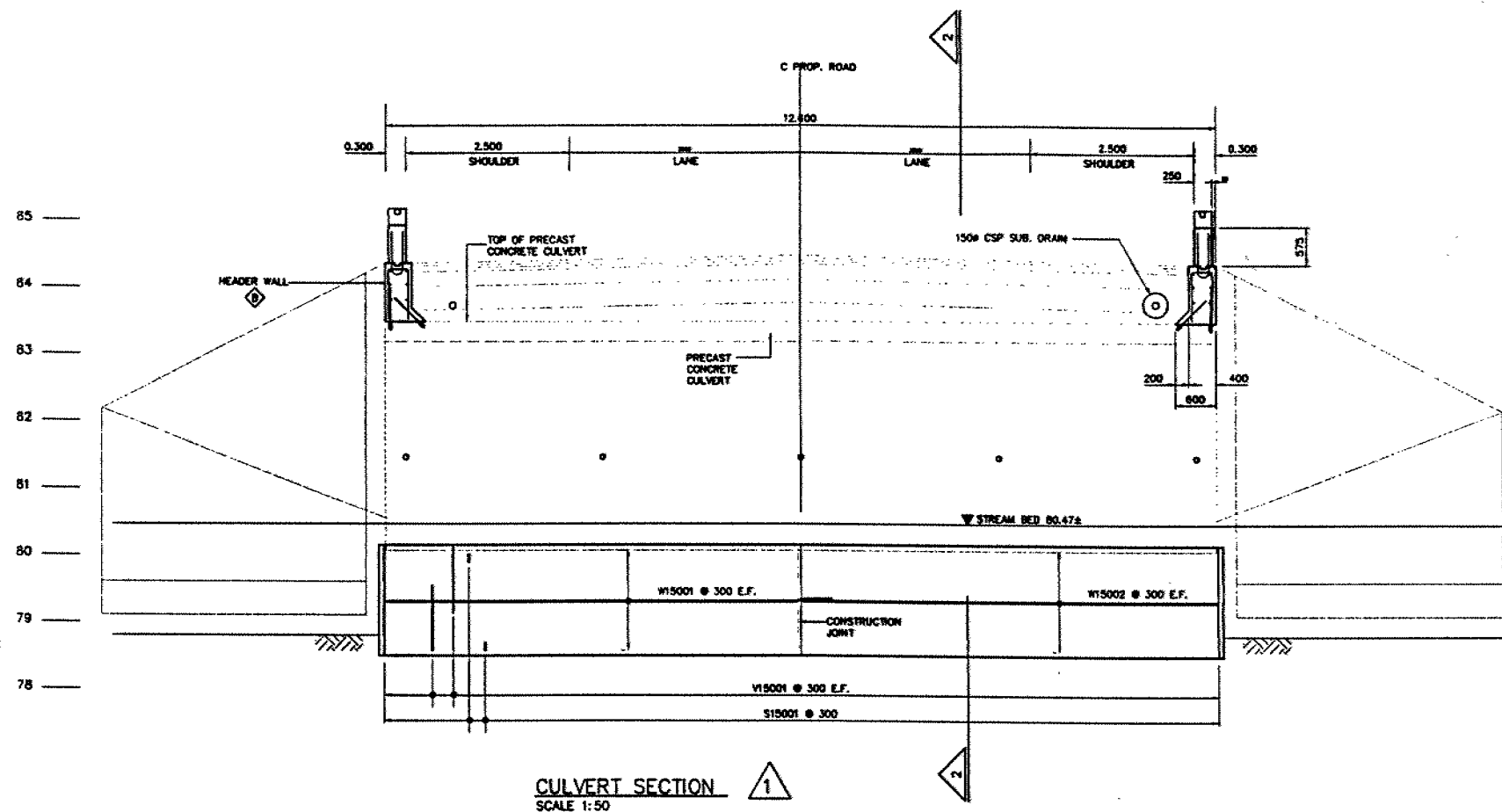
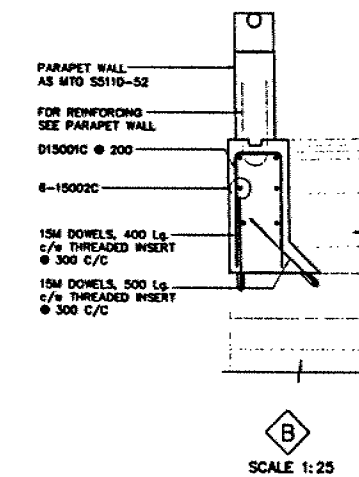
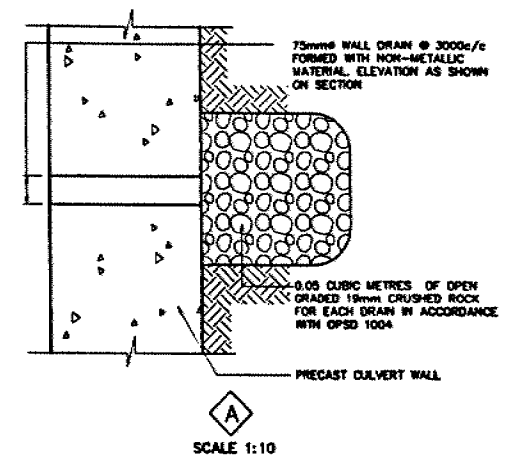
SHEET
15

CCU Cumming Cockburn Limited
Consulting Engineers and Planners



NOTES:

ALT. DENOTES ALTERNATE
I.F. DENOTES INSIDE FACE
O.F. DENOTES OUTSIDE FACE
E.F. DENOTES EACH FACE



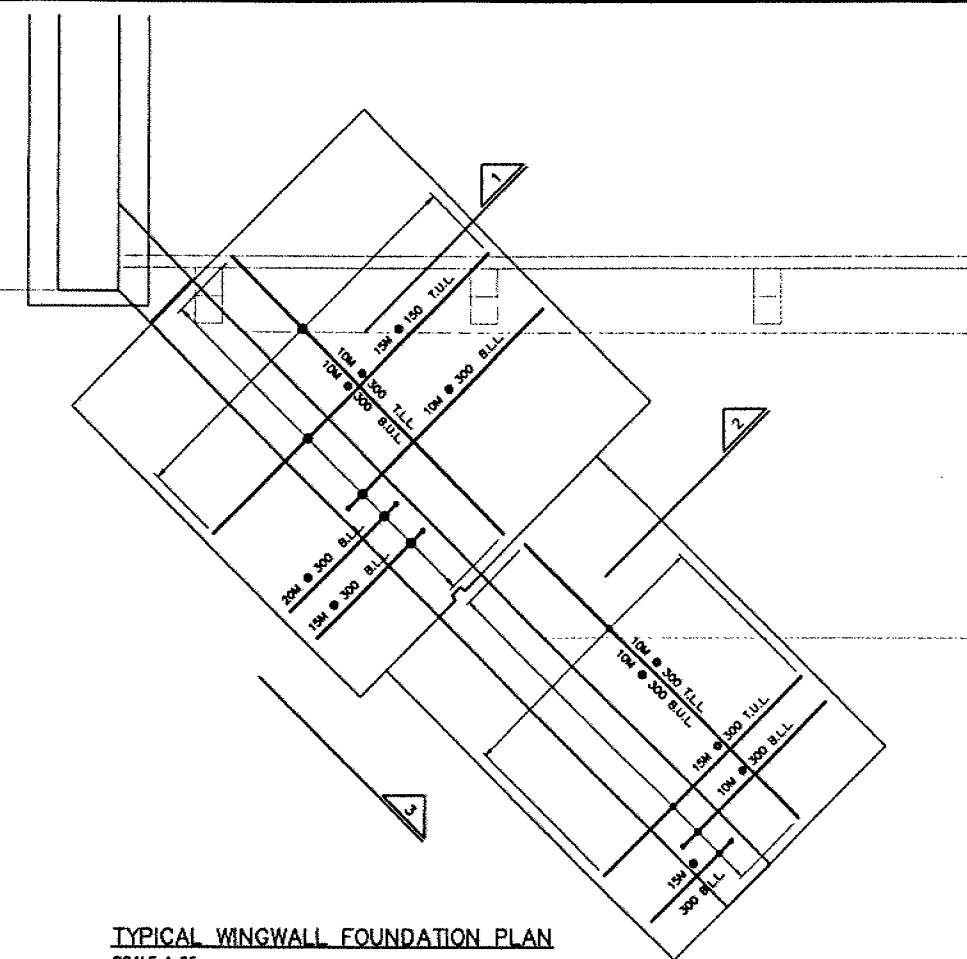
why triangular symbol

Sliding resistance assumed

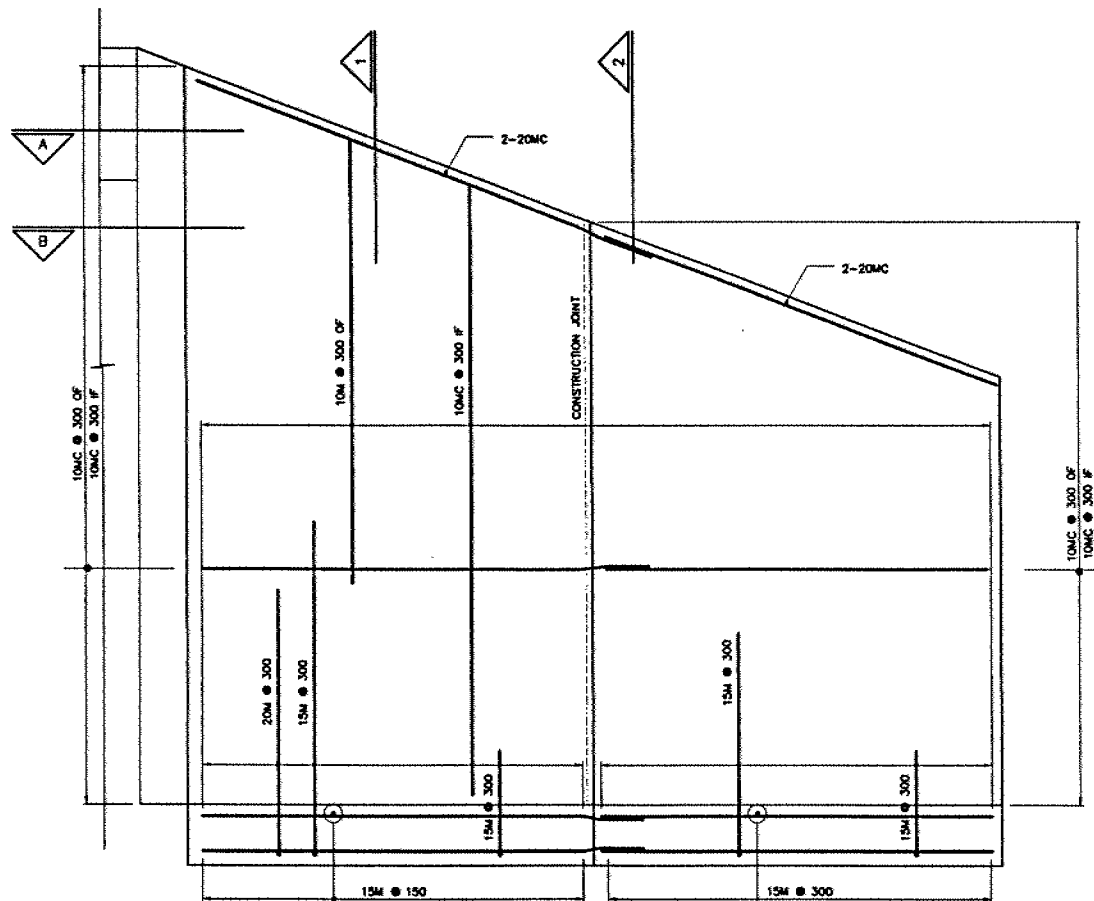
DRAWINGS NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

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DESIGN	J.F.J.	CHK J.F.J.	CODE CHDCC 91 ROAD CHB
DRAWN	P.W.	CHK J.F.J.	SITE 31-20 STRUCT SCHEME DWG 16

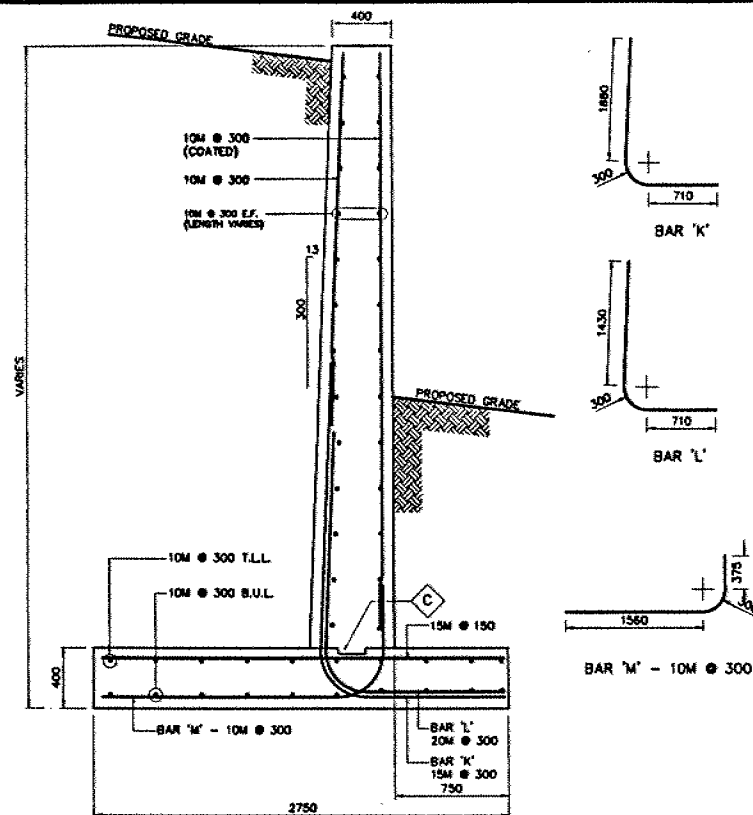
C:\DATA\3074\DWG\3074-17 Web Nbr 12 16 51:34 1997



TYPICAL WINGWALL FOUNDATION PLAN
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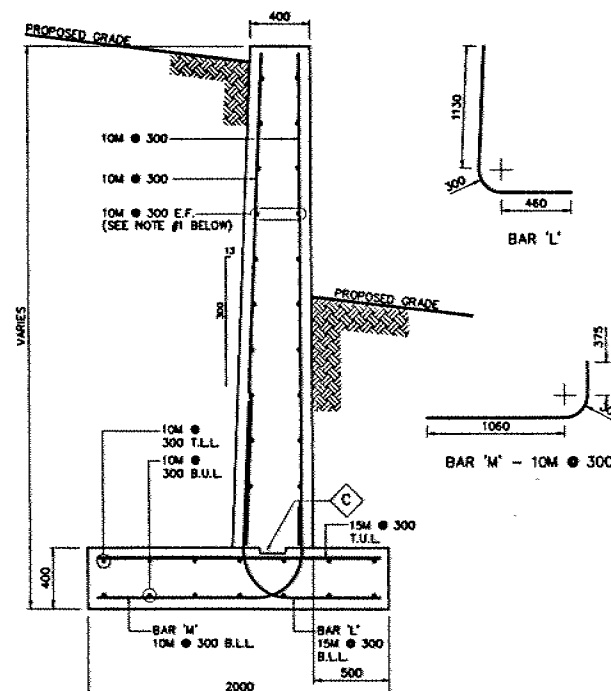


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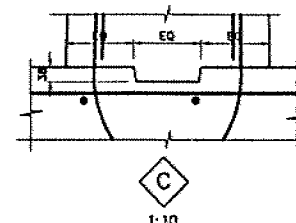
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SECTION
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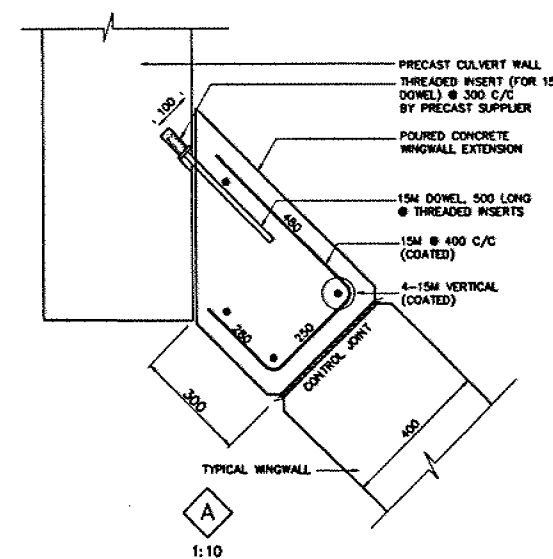
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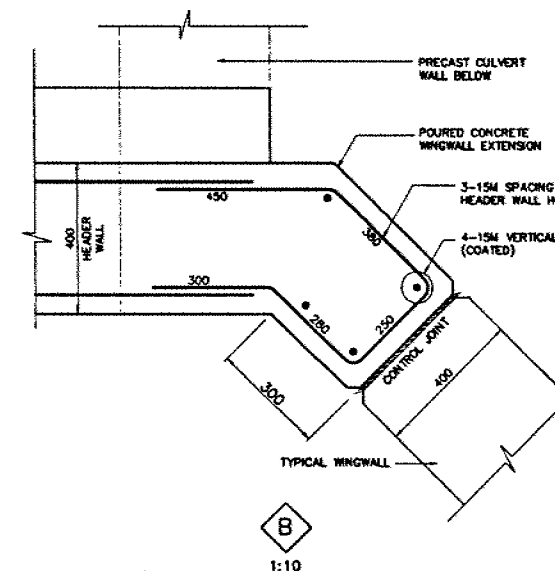


SCALE 1:10

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AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



SCALE 1:10



SCALE 1:10

PLATE No. 388-34 / 101-0
CONT No 97-18
WP No 317-94-01

RIGAUD RIVER BRIDGE
WINGWALL DETAILS

SHEET
16

Cumming Cockburn Limited
Consulting Engineers and Planners



NOTES:
RETAINING WALL DESIGNED BY OHIO CODE.
EQUIVALENT FLUID PRESSURE AS PER OHIO CODE CL.6.1.2.2.
DESIGNED FOR 800mm SURCHARGE.
LOAD FACTORS FOR EARTH PRESSURE:
O_L = 1.25 LATERAL PRESSURE
O_L = 1.25 STEM & BASE SLAB
O_L = 0.80 STABILITY
CLASS OF CONCRETE 30MPa
YIELD STRENGTH OF STEEL 400MPa
CLEAR COVER TO REINFORCING STEEL 70 ± 20mm EXCEPT AS NOTED
ANALYSIS ON THE BASIS OF 1m WIDE STRIP
ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SPECIFIED
R₁ = REDUCTION FACTOR FOR BEARING CAPACITY DUE TO INCLINATION OF LOAD, CL.6.7.3.3.

ALT. DENOTES ALTERNATE
I.F. DENOTES INSIDE FACE
O.F. DENOTES OUTSIDE FACE
E.F. DENOTES EACH FACE
C DENOTES COATED IN 15M/C

DRAWINGS NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION
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2	31-20	INJECT	SCHEME
3	31-20	INJECT	SCHEME
4	31-20	INJECT	SCHEME
5	31-20	INJECT	SCHEME
6	31-20	INJECT	SCHEME
7	31-20	INJECT	SCHEME
8	31-20	INJECT	SCHEME
9	31-20	INJECT	SCHEME
10	31-20	INJECT	SCHEME

METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

PLATE No. 388-34 / 101-0
CONF No 97-18
WP No 317-94-01

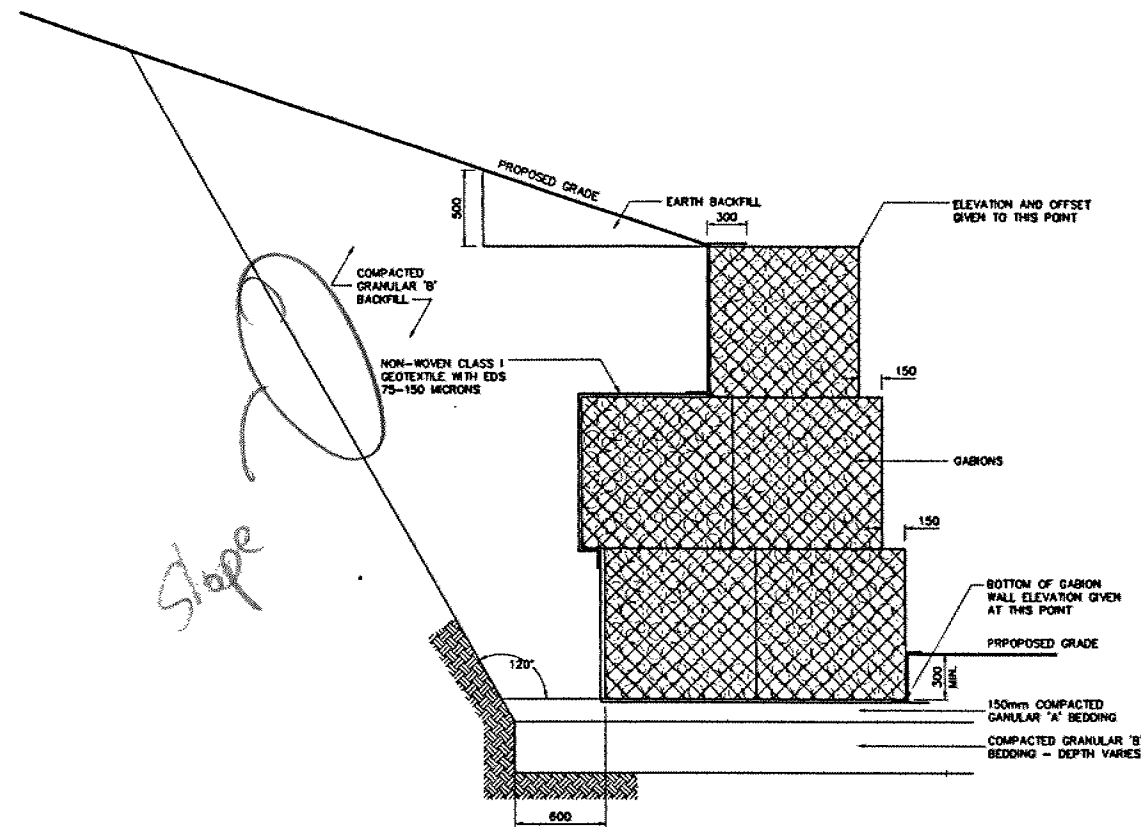
RIGAUD RIVER BRIDGE
GABION WALL
ELEVATION & SECTIONS

SHEET
19

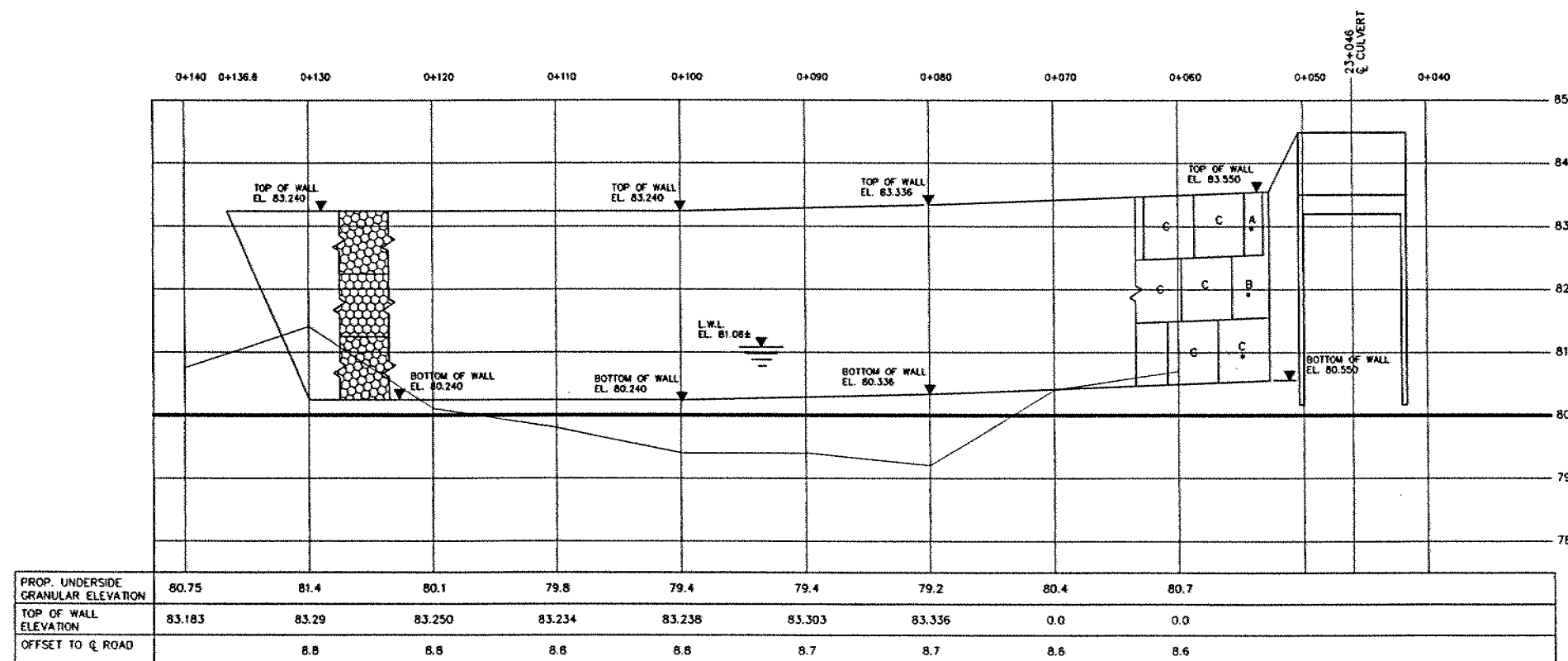
 Cumming Cockburn Limited
Consulting Engineers and Planners

NOTES:

1. ALL GABIONS TO BE "SEA-TYPE" POLYVINYL CHLORIDE COATED WIRE BASKETS.
 2. ALL EARTH AND BACKFILL SURFACES WHICH ABUT GABIONS TO BE LINED WITH GEOTEXTILE.
 2. LEGEND (LENGTH, WIDTH, DEPTH IN METRES)
 - (A) $2 \times 1 \times 1$
 - (B) $3 \times 1 \times 1$
 - (C) $4 \times 1 \times 1$
 - (D) $2 \times 1 \times .3$
 - (E) $3 \times 1 \times .3$
 - (F) $4 \times 1 \times .3$
- NOTE: LOWER TWO LAYERS
ARE 2m DEEP
* INDICATES CRIMPED BASKET



TYPICAL GABION WALL SECTION
SCALE 1:25



GABION WALL ELEVATION
HOR. SCALE 1:250
VERT SCALE 1:50

DRAWINGS NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REVISIONS												
	DATE		BY		DESCRIPTION							
	PERSON	J.F.J.	HQ	OFF	CODE	ORBBDE	71	LOAD	OTHER	PAIR	MAN	1907
	DRAWN	N6	AIR	FF	GIE	31-20	PRODUCT			FILM	WG	70

FILE COPY

**Rigaud River Bridge Replacement
WP 317-94-00
MTO Site #31-20**

CONT 40-97-15

Geocres No 31G-216

Trow Consulting Engineers Ltd.

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Brampton, Ontario L6T 4V1
Telephone: (905) 793-9800
Facsimile: (905) 793-0641

BR-10697-A/G
December 12, 1996

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Appendices

Appendix A: Photographs

Appendix B: Plan Location of Boreholes & Borehole Logs

Appendix C: Stratigraphies Beneath Bridge Abutments & Temporary Detour

Appendix D: Laboratory Results

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PART 1 Foundation Investigation

1. Introduction

This submission presents the results of a geotechnical investigation completed by Trow Consulting Engineers Ltd. (Trow) for the Rigaud River Bridge Replacement, WP 317-94-00, Site number 31-20. The project consists of two parts, namely: (i) construction of a temporary culvert and roadway (detour) around the existing Rigaud River Bridge and (ii) removal of the existing 10.06 m single span concrete rigid frame bridge and construction of a replacement. It is understood that the replacement options are either a rigid frame structure similar to the existing bridge or a twin cell box culvert with an opening width of 8 m situated along the existing alignment.

2. Site Description and Geological Setting

2.1 Site Description

The site is located on Highway 34 between stations $22 + 800 \pm$ and $23 + 350 \pm$ in the county of Stormont, Dundas and Glengarry. Physiographically, the site lies within the Glengarry Till Plain which has generally flat to moderately undulating terrain. The terrain in the immediate area of the project site is relatively flat.

Between stations $23+056 \pm$ and $23+120 \pm$, the Rigaud River flows from north to south and is situated to the west of Highway 34. At station $23+047 \pm$, the river begins to flow in an easterly direction crossing from the west side of Highway 34 to the east side. The existing Rigaud River Bridge is a rigid frame concrete structure with a span of $10.0 \pm$ m located at station $23+046.7$. Highway 34 is a two lane highway and both north and south approaches to the bridge are straight.

Photograph 1 in Appendix A shows the existing Rigaud River Bridge from a location just east of the proposed temporary culvert/detour alignment while Photograph 2 in Appendix A shows the existing bridge from the south approach.

2.2 Geological Setting

According to the OGS Map 2556, the overburden soils at the site consist of till which is predominantly sandy silt to silt and often rich in clay. Intervening glaciomarine and marine deposits (comprised of silts and clay) and muskegs may also occur in the area. The underlying bedrock in the area is from the Rockcliffe Formation (OGS Map 2544) which consists of inter-bedded shaly bioclastic limestone, dark grey to maroon shales, and light grey, fine grained, calcareous to non-calcareous quartz sandstone.

3. Investigative Procedures

3.1 General

Part 1 of this report describes the investigative procedures adopted for the geotechnical assessment of the Rigaud River Bridge Replacement. Properties of the overburden soils at the site were obtained by in situ and laboratory testing and the procedures employed during the investigation are described below.

3.2 Field Investigation

3.2.1 Rigaud River Bridge Replacement

The field work for the investigation related to the replacement of the existing Rigaud River Bridge was carried out on October 21 and 22, 1996, and consisted of four (4) boreholes (Boreholes 1 to 4) which were advanced to depths ranging from 7.9 metres to 8.6 metres. Two (2) boreholes were drilled near each of the north and south abutments. The borehole locations are shown on Drawing 1 in Appendix B and all elevations are reference to MTO Temporary Benchmark (El. 86.904) at station 22+951 of King's Highway 34.

The boreholes were advanced through the overburden soils on the site using a truck mounted CME-55 drill rig equipped with solid and hollow stem augers. Soil samples were obtained using a split spoon sampler in conjunction with Standard Penetration Tests (ASTM D1586) at approximately 0.75 metre and 1.5 metre intervals. The Standard Penetration (N) values were recorded and used to provide an assessment of the relative denseness of the overburden soils at the site and the soil samples were used for identification and laboratory testing.

At each of the four (4) boreholes, conventional rock coring techniques were used to advance the boreholes approximately 3.0 metres into the underlying bedrock. Standard NQ size core barrels and casings were used and core samples of the bedrock were retrieved for rock quality determinations and classification purposes.

3.2.2 Temporary Detour and Culvert

The field work for the investigation related to the proposed temporary detour and culvert was carried out on October 25, 1996, and consisted of six (6) boreholes which were advanced to depths ranging from 2 metres to 6.1 metres. Two (2) boreholes were drilled near the north and south abutments of the proposed culvert and two (2) boreholes were drilled along each of the alignment of the north and south approaches to the culvert. Drawing 1 in Appendix B shows the locations of the boreholes drilled along the temporary detour alignment (see Boreholes 5 to 10 on Drawing 1).

The boreholes were advanced through the overburden soils on the site using a track mounted CME-55 drill rig equipped with solid and hollow stem augers. Soil samples were obtained using a split spoon sampler in conjunction with Standard Penetration Tests (ASTM D1586) at approximately 0.75 metre and 1.5 metre intervals. The Standard Penetration (N) values were recorded and used to provide an assessment of the relative denseness of the overburden soils at the site and the soil samples were used for identification and laboratory testing. A groundwater sample was obtained from Borehole 7 for pH and sulphate analysis.

At Borehole 8 located near the north culvert abutment, conventional rock coring techniques were used to advance the boreholes approximately 3.0 metres into the underlying bedrock. Standard NQ size core barrels and casings were used and rock core samples of the bedrock were retrieved for rock quality determinations and classification purposes.

3.3 Laboratory

The laboratory testing program for select soil samples consisted of the following:

- Atterberg Limits
- Natural Moisture Contents
- Unit Weights
- Grain Size Distributions

The laboratory test results are summarized on the attached Borehole Logs in Appendix B. pH and sulphate analyses was performed on a groundwater sample taken from Borehole 7 and the results are contained in Appendix D. Appendix D also contains grain size distributions for soil samples from boreholes 2 and 9, respectively.

4. Subsurface Conditions

4.1 Existing Bridge Location

As previously indicated, the Borehole locations are shown on Drawing 1 of Appendix B and the results of the geotechnical investigation near the existing bridge location are summarized on the attached Borehole Logs number 1, 2, 3, and 4 in Appendix B. Asphaltic concrete and concrete were found overlying fill in Boreholes 1, 2, 3 and 4 adjacent to the north and south bridge abutments. The fill ranged in thickness from 4.5 m to 4.8 m and was underlain by a thin silt and gravel till layer. The silt and gravel layer (glacial till) was found to range in thickness from approximately 0.4 m to 0.8 m and was underlain by bedrock consisting of inter-layered shaly limestone and shale. Drawing 1 in Appendix C shows the summarized stratigraphic profile for both the north and south bridge abutments.

4.1.1 Asphaltic Concrete and Concrete

Approximately 150 mm of asphalt was found overlying 200 mm of concrete at Boreholes 2, 3, and 4. The asphaltic concrete and concrete encountered in Borehole 1 were found to be slightly thicker (200 mm and 280 mm, respectively).

4.1.2 FILL

Underlying the asphaltic concrete and concrete, fill was encountered. The fill was predominantly clayey silt (ML-CL) with some gravel and coarse sand, and occasional zones with organic material. Based on Standard Penetration N-values, the consistency of the fill was found to be highly variable ranging from soft to very stiff. The Standard Penetration N-values ranged from 3 blows/300mm to 27 blows/300mm and the natural moisture content ranged from approximately 10% to 80%.

The large range of natural moisture content is due in part to the organic materials present in portions of the fill. It was generally observed that the Penetration resistance of the fill was inversely proportional to the moisture content. For example, natural moisture contents in excess of 40% generally coincided with low blow counts in the order of 3 to 4 (blows/300 mm). Moisture contents in the order of 20%± generally coincided with blow counts of 10 or greater.

4.1.3 SILT and GRAVEL till (ML-GL)

A thin layer of compact to dense silt and gravel till (ML-CL) with sand and a trace of clay was found beneath the fill in Boreholes 1, 2, 3 and 4. The silt and gravel till layer (ML-GL) ranged in thickness from approximately 0.4 to 0.8 m. Standard Penetration N-values in this layer ranged from 27 blows/300mm to 60 blows/130 mm and natural moisture contents varied from approximately 10% to 14.5%. Grain size analysis on Split Spoon Sample 5 from Borehole 2 (see Figure 1 in Appendix D) indicated 22% gravel, 38% sand, 38 % silt and 3 % clay.

4.1.4 BEDROCK

The bedrock was proven in Boreholes 1, 2, 3 and 4 by obtaining NQ cores which were used for subsequent classification of the rock. The bedrock at the bridge site is relatively flat ranging in Elevation from 78.66 m to 79.30 m.

Detailed descriptions of the rock are included on the attached Borehole Logs in Appendix B. The upper 1.0 to 2.0 metres of the bedrock cores was classified as shaly limestone. The rock was grey, fine to medium grained, weak to medium strong with very close to moderately close fracture spacing. The lower portions of the rock cores obtained from Boreholes 1, 2, 3, and 4 were found to consist of grey to dark grey shale with shaly limestone and mudstone seams (50 - 200 mm thick).

Rock core recovery ranged from 50% to 100% and Rock Quality Designation (RQD) values ranged from 0% in the upper core run of Borehole 4 (El. 79.30 m to 77.80 m) to 72% in the lower core run of Borehole 3 (El. 77.12 m to 75.62 m). In generally, the Rock Mass Quality was found to be very poor to poor in the upper 0.3 to 0.4 metres of bedrock for Boreholes 1 and 2. Below the upper 0.3 to 0.4 metre zone of highly fractured rock, the Rock Mass Quality improves to fair with an average RQD of approximately 60%.

4.2 Temporary Detour and Culvert Alignment

The results of the geotechnical investigation for the temporary detour and culvert are summarized on Borehole logs 5, 6, 7, 8, 9 and 10 in Appendix B. An organic clayey silt root mat (CL-OL) varying in thickness from 0.18 metres to 1.3 metres was encountered overlying silty clay (CL-CH). The silty clay (CL-CH) was found to be greater than 1.8 metres thick at Borehole 10 and was absent in Boreholes 6 and 8. Silt and gravel till (ML-GL) was encountered below the silty clay (CL-CH) in Boreholes 5, 6, 7, and 8 and bedrock was encountered in Borehole 8 at an Elevation of 78.94 metres. Boreholes 9 and 10 were terminated within the upper silty clay (ML-CL) deposit. A summary of the inferred stratigraphical profile along the proposed alignment of the temporary detour and culvert is shown on Drawing 2 in Appendix C.

4.2.1 ORGANIC CLAYEY SILT (root mat) over SILTY CLAY

An organic clayey silt layer (OL-CL) was encountered in all boreholes drilled along the proposed alignment of the temporary detour and culvert. The thickness of the organic layer (root mat) varied from 0.18 metres in Borehole 5 to 1.8 metres in Borehole 7. Moisture contents for this subsurface layer typically ranged from 50% to 60% and Standard Penetration N-values varied from 2 to 8 blows/300mm. The consistency of this deposit is soft to firm based on the Penetration resistance.

The upper root mat was underlain by a similar soil deposit ranging from soft to stiff SILTY clay (no significant root fibers). The average moisture content of this overburden layer was approximately 36% and Standard Penetration N-values varied from 2 to 10 blows/300mm.

4.2.2 SILT and GRAVEL till (ML-GL)

Compact to dense silt and gravel till (ML-CL) with sand and a trace of clay was found below the upper clayey silt layers in Boreholes 5, 6, 7 and 8. The silt and gravel till (ML-GL) layer was penetrated completely by Borehole 8 only. The thickness of the layer at Borehole 8 was found to be approximately 1.6 metres. Standard Penetration N-values in this layer ranged from 23 to 47 blows/300mm and natural moisture contents varied from approximately 10% to 20%.

4.2.3 BEDROCK

The bedrock was proven in Borehole 8 by obtaining NQ rock cores which were used for subsequent classification of the rock. The bedrock was encountered at an Elevation of 78.9 m.

Detailed description of the rock is included on the attached Borehole log for Borehole 8 in Appendix B. The upper 1.9 metres of the bedrock core was classified as shaly limestone. The rock was grey, fine to medium grained, weak to medium strong with very close to moderately close fracture spacing. The lower portion of the bedrock core obtained from Borehole 8 was found to consist of grey to dark grey shale with shaly limestone and mudstone seams (50 - 100 mm thick).

Rock core recovery ranged from 81 to 90% and Rock Quality Designation (RQD) values were general good ranging from 81% in the upper core run of Borehole 8 (El. 78.94 m to 77.42 m) to 90% in the lower core run of Borehole 8 (El. 77.42 m to 75.89 m). Generally, the Rock Mass Quality was found to be fair to good below the upper 0.3 metres of the Bedrock.

5. Groundwater Conditions

At the time of the investigation, the water level in the Rigaud River was measured to be 81.2 metres (Geodetic Elevation). Information regarding the groundwater levels at the site was obtained by measuring the water levels in the open boreholes after the completion of drilling. No free standing water was observed in Boreholes 1 to 5 and 8 to 10. For Boreholes 6 and 7, water was encountered in the open boreholes at an Elevation of $81.6 \pm$ m as indicated on Borehole logs 6 and 7 in Appendix B. It is, however, unlikely that sufficient time was allowed for these water levels to stabilize. Based on the above noted observations and relatively flat terrain in the vicinity of the bridge, the groundwater levels at the site can be expected to closely follow the Elevation of the water level in the Rigaud River. As such, ground water tables will be subject to seasonal fluctuations and the prevailing hydraulics of the river.

pH and sulphate tests were performed on a groundwater sample taken from Borehole 7 and the results are shown in Appendix D. The pH was found to be 7.27 and the sulphate test showed 23.5 mg/ml of sulphate.

Part 2 Engineering Discussions and Recommendations

6.1 General

The following subsections address geotechnical considerations pertaining to the Rigaud River Bridge replacement. It is understood that the replacement options are either a similar rigid frame structure or a twin cell box culvert with an opening width of 8 m situated along the existing alignment. A temporary detour which will cross the Rigaud River will be required during construction and it is understood that approximately three (3) 1.0 metre diameter CSP culverts are proposed to carry the expected river flows. The proposed location of the temporary culvert is 23+060± which will involve temporary diversion of the river.

6.2 Foundations - Rigaud Bridge Replacement

6.2.1 North Abutment Location

At the location of the north abutment, there is approximately 4.7 to 4.8 metres of clayey silt fill overlying approximately 0.6 to 0.8 metres of compact to dense silt and gravel till (ML-GL). Bedrock was encountered at an elevation of approximately 78.7 m in both Boreholes 1 and 2. Given the relatively thin overburden of fill and silt and gravel till, placement of new footings directly on Bedrock is recommended. For the purpose of design based on the Ontario Highway Bridge Design Code, the following bearing capacities can be used for spread footings placed directly on bedrock subject to inspection by a qualified geotechnical engineer:

Factored Bearing Resistance at ULS = 3000 kPa

Factored Bearing Resistance at SLS = 3000 kPa

The above Factored Bearing Resistance at U.L.S. applies to spread footings subjected to vertical loads, and placed directly on rock with a Fair Rock Mass Quality (50% < RQD < 75%, Canadian Foundation Engineering Manual). For the north abutment area, Boreholes 1 and 2 indicate that this would require excavation and removal of approximately 0.3 metres of loose rock. The footing base must be cleared of all loose materials prior to placement of concrete and inspected by a qualified geotechnical engineer to verify the Rock Mass Quality.

As per section 6-8.4.2 of the Ontario Highway Bridge design code, a reduction factor shall be applied to the Ultimate Bearing Resistance at ULS (3000 kPa) to account for the effects of inclined loading. Table 1 contains a summary of reduction factors for inclined loads.

Table 1 Reduction Factors to Account for the Effects of Inclined Loads on the Ultimate Bearing Resistance at ULS

Ratio of Horizontal to Vertical Load	Reduction Factor
0.1	0.87
0.2	0.75
0.3	0.66
0.4	0.57

Note: The structural engineer can refer to Figure 6-8.4.2 of the Ontario Highway Bridge Design Code for reduction factors corresponding to ratios of horizontal to vertical loads which are not listed above. The reduction factors for cohesive soil or rock shall be applied.

6.2.2 South Abutment Location

The subsurface conditions for the south abutment are similar to those discussed for the north abutment. As a result, spread footings placed directly on bedrock are also recommended for the south abutment given the relative thin overburden of fill and silt and gravel till (ML-CL). Bedrock was encountered at elevations ranging from 78.7 m in Borehole 3 to 79.3 m in Borehole 4. For the purpose of design base on the Ontario Highway Bridge Design Code, the following bearing capacities can be used for footings placed directly on bedrock subject to geotechnical inspection:

Factored Bearing Resistance at ULS = 3000 kPa

Factored Bearing Resistance at SLS = 3000 kPa

The above Factored Bearing Resistance at ULS applies to spread footings subjected to vertical loads, and placed directly on rock with a Fair Rock Mass Quality (50% < RQD < 75%, Canadian Foundation Engineering Manual). For the south abutment area, Boreholes 3 and 4 indicate that this would require excavation and removal of approximately 0.4 metres of loose rock. As per section 6-8.4.2 of the Ontario Highway Bridge design code, a reduction factor shall be applied to the Factored Bearing Resistance at ULS (3000 kPa) to account for the effects of inclined loading. The reduction factors contained in Table 1 and discussed in Section 6.2.1 also apply to the south abutment foundation.

6.2.3 Anticipated Footing Elevations

The following Table summarizes the location and estimated footing elevations at which a Factored Bearing Capacity (at U.L.S.) is applicable:

Table 2:
Location and Estimated Elevation of Footing Bases for Bridge Abutments.

Location	Description	Approximate Elevation (m)
Sta 23 + 058	Boreholes 1 and 2 near north abutment	78.3
Sta 23 + 038	Boreholes 3 and 4 near south abutment	78.3 to 78.8

The above elevations are for preliminary purposes and were estimated based on the factual borehole data at two locations near the north and south abutments respectively. Interpolation between boreholes is approximate, and as such, actual footing elevations will depend on the conditions encountered at the time of construction. The rock surface at the footing base must be cleared of all loosened or highly fractured rock and be inspected by a qualified geotechnical engineer to verify the Rock Mass Quality prior to placement of concrete.

6.2.4 Twin Cell Culvert

As indicated in the introduction to this report, a twin cell box culvert with an opening width of 8 metres situated along the existing alignment is being considered. Contract drawings for the original Rigaud River Bridge (Contract 82-13) supplied by the client indicate that the existing bridge is founded on bedrock at Elevation 79.0 m \pm . Bedrock is inferred from the bedrock Elevations measured during this geotechnical investigation. In view of the above evidence, founding the twin box culverts on the silt and gravel till layer is not recommended since this subsurface soil layer may have been significantly disturbed during excavation and construction of the existing bridge footings.

It is recommended to sub-excavate down to bedrock at an elevation of 78.3 m \pm to 78.8m \pm and backfill to 81.0 m \pm with Granular 'A' (or equivalent) compacted to 100% Standard Proctor Maximum Dry Density. The granular pad should extend a minimum of 1.0 metres beyond the plan limits of the footing and have side slopes no steeper than 1 horizontal to 1 vertical. In addition, the bedrock should be cleared of all loose material and inspected by a qualified geotechnical engineer prior to placement of the Granular 'A' pad.

The bearing capacities recommended for the culvert design based on the Ontario Highway Bridge Design Code are as follows:

Factored Bearing Resistance at ULS = 400 kPa

Factored Bearing Resistance at SLS = 200 kPa

In the absence of detailed information pertaining to the structural design of the culvert, the Factored Bearing Resistance at SLS presented above has been calculated based on a maximum permissible displacement of 25 mm and total differential settlements of 19 mm.

6.2.5 Frost Protection

Frost cover is not required for footings placed directly on bedrock.

6.2.6 Sliding Resistance

The computation of the sliding resistance of the foundation shall be carried out in accordance with of O.H.B.D.C. An friction angle, ϕ' , of 32 degrees can be used for sliding along discontinuities within the bedrock and at the interface between the bedrock and footing base.

If the factored resistance against sliding failure based on friction alone is inadequate, then a passive resistance key should be excavated into the bedrock. A coefficient of passive earth pressure, K_p' , equal to 4.2 can be used for design of the passive resistance key in conjunction with applicable resistance factors as outlined in Section 6-6.2.2 of the Ontario Highway Bridge Design Code.

6.3 Foundations - Temporary Detour and Culvert

The elevation of the creek bed at the Rigaud River Bridge was surveyed during the investigation to be $81.2 \pm$ metres. It is expected that the invert elevation of the culverts will be set at or slightly below this elevation. Based on a minimum bedding thickness of 200 mm for CSP culverts (O.H.B.D.C. 7-8.4), the anticipated foundation Elevation is $81.0 \pm$ metres. Referring to Drawing 2 in Appendix C, the expected foundation soils will consist of approximately 0.5 metres of clayey silt (CL-CH) overlying compact silt and gravel till at Elevation $80.5 \pm$. Placement of the temporary culvert on 200 mm bedding founded on the clayey silt soil layer is not expected to present any significant problems with respect to bearing capacity related failure of the foundations soils provided that the temporary culverts are designed and constructed as outlined in the Ontario Highway Bridge Design Code and recommendations regarding backfill materials are strictly adhered to.

6.4 Backfill

6.4.1 Location of Bridge Replacement

Backfill to abutments or retaining walls should consist of free draining granular materials such as Granular 'A' and Granular 'B' or rock fill. Computation of earth pressures shall be in accordance with Section 6.7.4 of the Ontario Highway Bridge Design Code. Unfactored properties for backfill materials are provided in the following table:

Table 3:
Material Types and Unfactored Properties.

Material	Friction Angle, ϕ'	γ (kN/m ³)	K_a	K_p	K_o
Granular A	35 degrees	22.5	0.27	3.7	0.43
Granular B	30 degrees	21.5	0.33	3.0	0.50
Rock Fill	35 degrees	20.0	0.27	3.7	0.43

Note: K_a is the earth pressure coefficient corresponding to the active state
 K_o is the earth pressure coefficient at rest
 K_p is the earth pressure coefficient corresponding to the passive state.

6.4.2 Location of Temporary Detour and Culvert

Backfill for the temporary culvert and approach roadways at the site should not be compacted with heavy vibratory equipment in the vicinity of the culverts (as per Section 7-8.6 of the O.H.B.D.C.) and in areas where the upper surface crust (root mat) has been excavated. The later precaution is due to the sensitive nature of the predominantly silty overburden soils at the site. Free draining granular materials such as Granular 'A' and Granular 'B' or rock fill can be used for structural backfill provided that adequate compaction as specified in the Ontario Highway Bridge Design Code can be achieved. If clear stone or rock fill is placed directly on the subgrade soils at the site, a geotextile separator must be applied between the subgrade soils and the granular soil to prevent pumping of the subgrade soils into the granular sub-base.

Unfactored properties for backfill materials are provided in the following table:

Table 4:
Material Types and Unfactored Properties

Material	Friction Angle, ϕ'	γ (kN/m ³)	K_a	K_p	K_o
Granular A	35 degrees	22.5	0.27	3.7	0.43
Granular B	30 degrees	21.5	0.33	3.0	0.50
(20 mm nominal size) Clear Stone	35 degrees	21.0	0.33	3.7	0.43
Rock Fill	35 degrees	20.0	0.27	3.7	0.43

Note: K_a is the earth pressure coefficient corresponding to the active state

K_o is the earth pressure coefficient at rest

K_p is the earth pressure coefficient corresponding to the passive state.

6.5 Excavations

6.5.1 Location of Bridge Replacement

Excavations in the clayey silt fill (ML-CL) and silt and gravel till (ML-GL) will be required to construct the abutment footings on Bedrock. The overburden fill and silt and gravel till (ML-GL) are classified as Type 3 soils and the maximum depth of excavation anticipated at the site is approximately 5 metres. As such, excavations in accordance with the Occupational Health and Safety Regulations for Construction Projects for Type 3 soils will be adequate.

The walls of excavations in the fill and silt and gravel till (ML-GL) do not require a support system provided that the walls are sloped from the bottom of the excavation and with a minimum slope gradient of one horizontal to one vertical.

If zones of soft soil (not encountered during the investigation) or areas of significant water seepage are encountered during excavation, it is recommended that side slopes be cut back locally to a 1.5:1 (horizontal to vertical) slope gradient.

Some de-watering of excavations below the ground water table may be required. Due to the relatively low permeability of the overburden soils at the site, groundwater flow is expected to occur predominantly within the upper highly fractured zones of bedrock. Flows are expected to be small and of a quantity which can be managed using conventional sump pumping techniques in conjunction with perimeter drainage ditches. Excavation work should start from the downstream ends of the excavation to facilitate drainage and enhance the excavation procedures.

6.5.2 Location of Temporary Detour and Culvert

Excavations in the clayey silt (CL-CH) and silt and gravel till (ML-GL) will be required to construct the temporary culvert. The overburden soils are classified as Type 3 soils, and as such, excavations in accordance with the Occupational Health and Safety Regulations for Construction Projects for Type 3 soils should be sufficient given the anticipated depths of excavation. The walls of excavations do not require a support system provided that the walls are sloped from the bottom of the excavation with a minimum slope gradient of one horizontal to one vertical.

Some de-watering of excavations below the ground water table may be required. Due to the relatively low permeability of the overburden soils at the site, groundwater flow is expected to be minimal and of a quantity which can be managed using conventional sump pumping techniques.

6.6 Culvert Treatment

For culvert protection, the two treatment zones to be considered include the embankment and the channel. Adequate protection against scour and erosion is required to ensure the geotechnical integrity of both the temporary and permanent culverts. Adequate protection, such as rock rip rap, must be designed (in accordance with M.T.O. specifications) to withstand the design shear stresses and the hydraulic conditions expected to prevail during the lifetime of the structure. These conditions depend on the type of culvert, configuration of the river, configuration of the river diversion, the river hydraulics etc. which are beyond the scope of this investigation and must be addressed at a later stage in the project before tendering and construction.

7. General

The information presented in this report is based on a limited investigation designed to provide information to support an overall assessment of the current geotechnical conditions at the site of the proposed Rigaud River Bridge Replacement. The conclusions presented in this report reflect site conditions existing at the time of the investigation. It is noted that the soil boundaries indicated on the borehole logs are inferred from discontinuous sampling and observations during drilling. These boundaries are intended to reflect transition zones for the purpose of geotechnical design and should not be interpreted as exact planes of geological change.


This report has been prepared by Sean Hinchberger and reviewed by S.E. Gonsalves and Peter Chan. Peter Chan coordinated the field investigation and Clement Chow performed the fieldwork.

We trust this report is satisfactory for your purposes. Should you have any questions, please do not hesitate to contact this office.

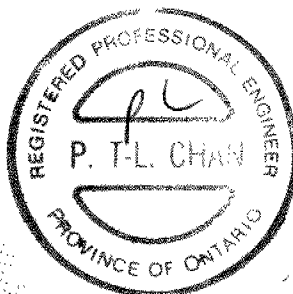
Trow Consulting Engineers Ltd.



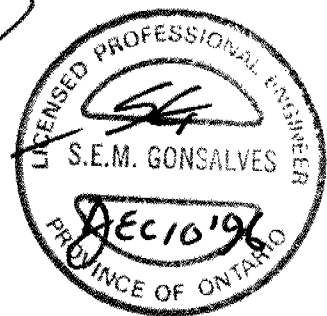
S. Hinchberger, Ph.D.



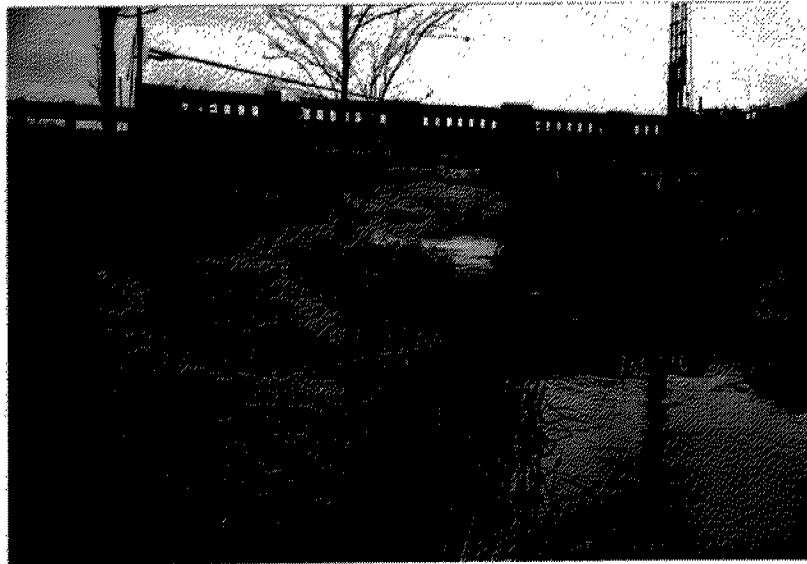
Peter Chan, P.Eng.



S. E. Gonsalves, P.Eng.



Appendix A: Photographs

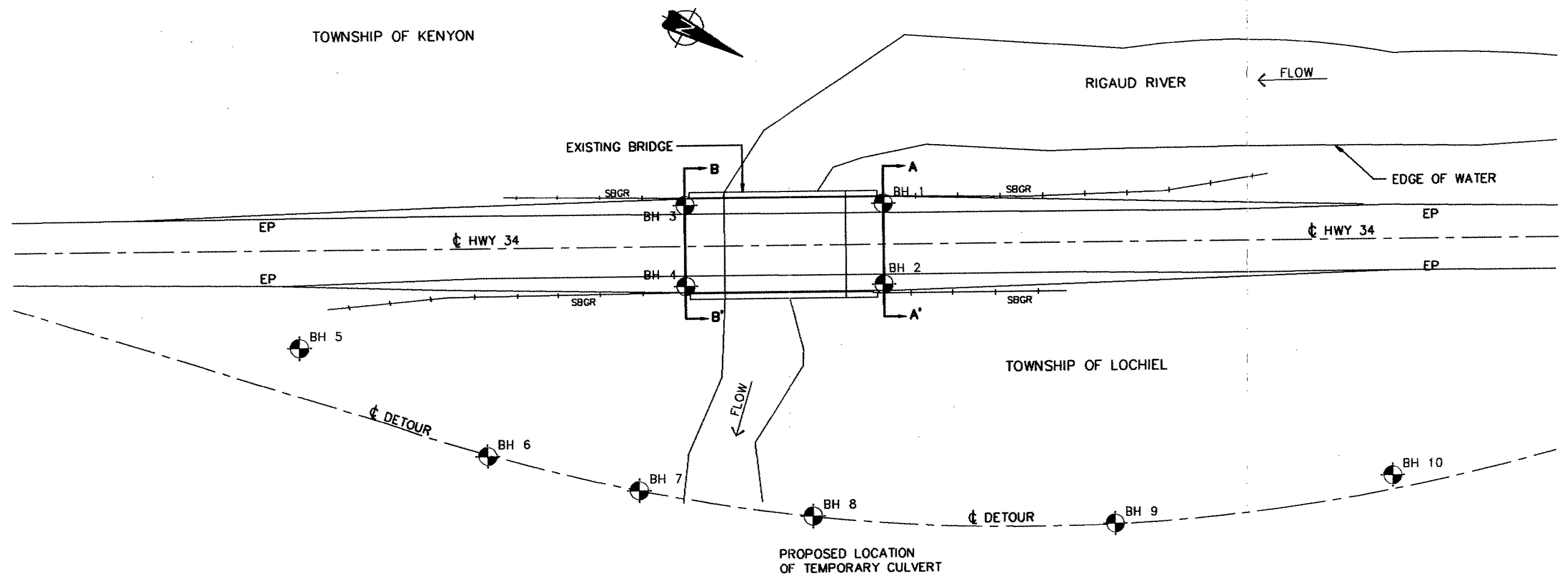


PHOTOGRAPH 1 View of Existing Rigid Frame Bridge from the Location of the Proposed Temporary Culvert - Rigaud River and Hwy 34.



PHOTOGRAPH 2 View of Existing Rigaud River Bridge from the South Approach.

Appendix B: Plan Location of Boreholes & Borehole Logs



General Notes

- 1) The boundaries and soil types have been established only at Borehole locations. Between boreholes they are assumed and may be subject to considerable error.
- 2) Soil samples will be retained in storage for 1 year and then destroyed unless client advises that an extended time period is required.
- 3) Topsoil quantities should not be established from the information provided at the borehole locations.
- 4) This drawing forms part of the report, project number as referenced, and should be used only in conjunction with this report.

Geocres No 31G - 216

0m 4m 8m 12m 16m
SCALE 1:400

METRIC

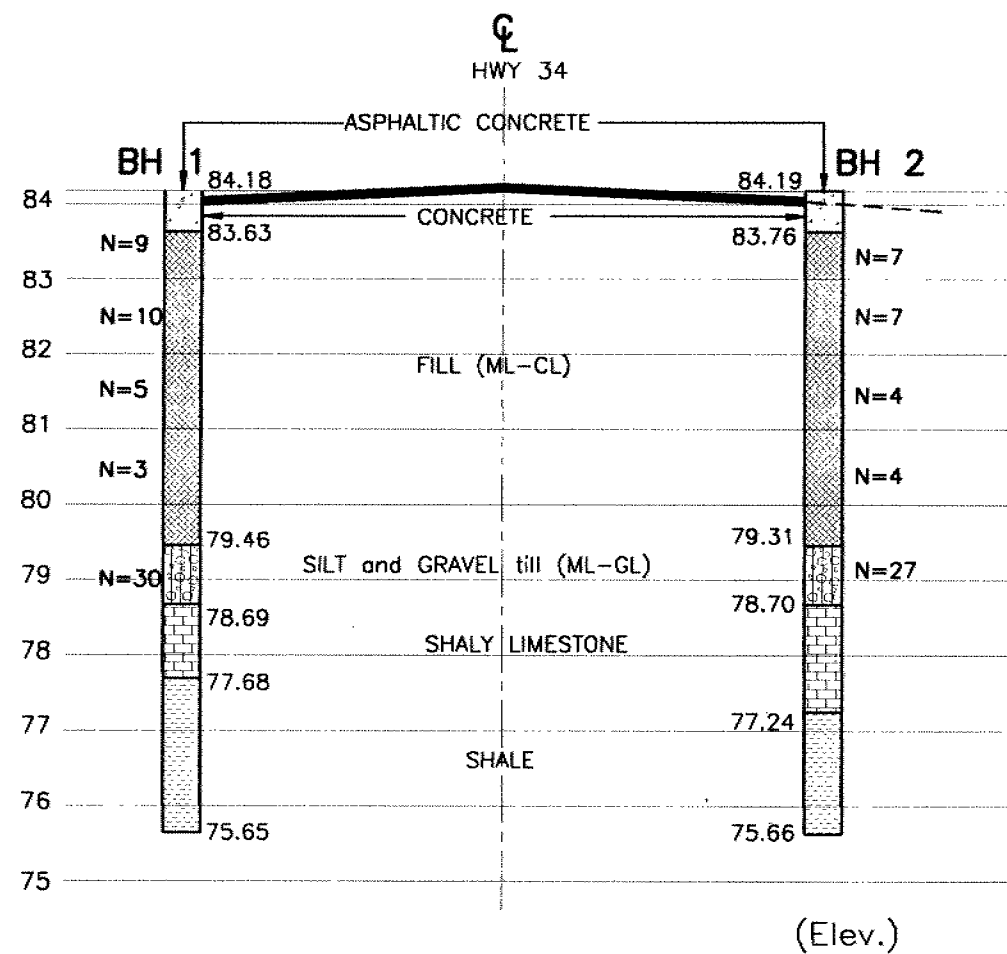


TROW CONSULTING ENGINEERS LTD.
BRAMPTON BRANCH

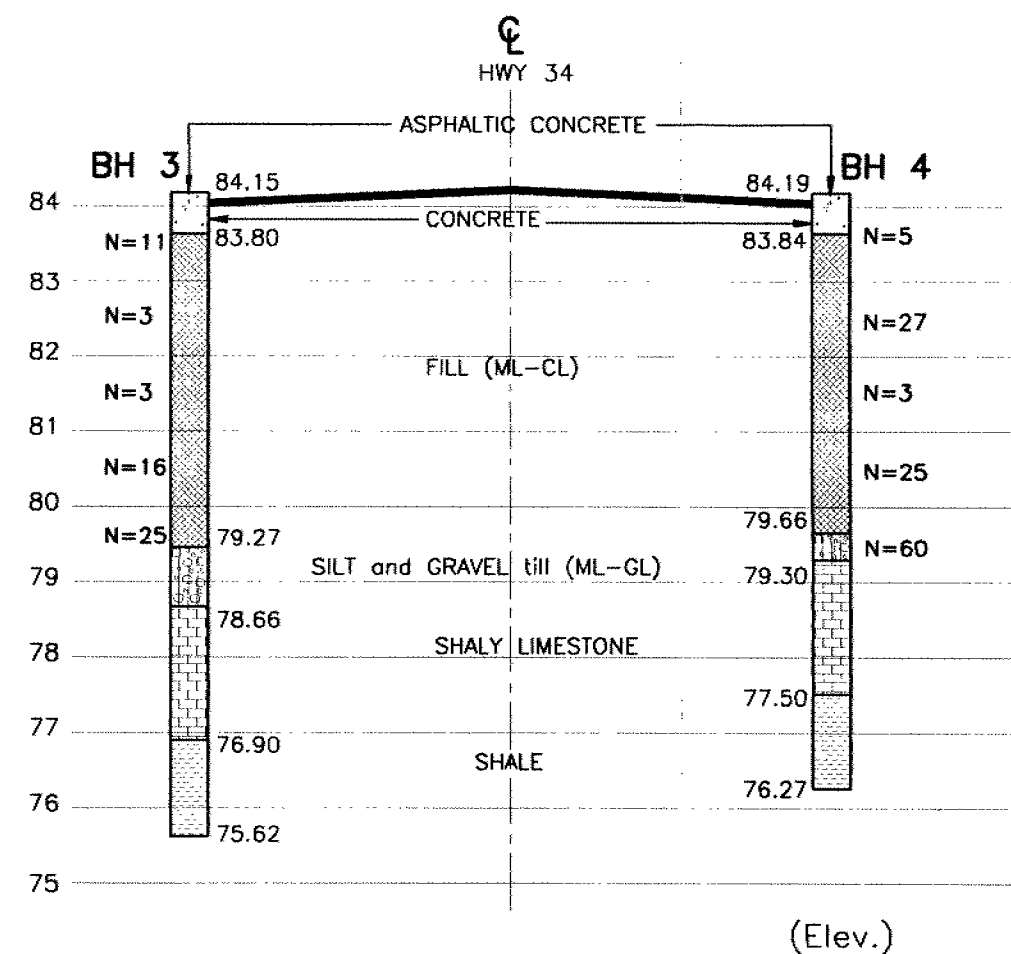
BOREHOLE LOCATION PLAN
PROPOSED CROSSING AT KING'S
HIGHWAY 34 AND RIGAUD RIVER
LOT 1 CONCESSION 7 TWP KENYON
LOT 38 CONCESSION 6 TWP LOCHIEL
LAGGAN ONTARIO

PROJECT NO.:	BR-10697-A
SCALE:	1:400
DRAWN BY:	JF
CHECKED BY:	SDH
DATE:	OCTOBER 1996
DRAWING NO.:	1

Appendix C: Stratigraphies Beneath Bridge Abutments & Temporary Detour



SECTION A-A' (NORTH ABUTMENT)



SECTION B-B' (SOUTH ABUTMENT)

SOIL STRATIGRAPHY BELOW NORTH AND SOUTH BRIDGE ABUTMENT

Geocres No 31G-216

METRIC



TROW CONSULTING ENGINEERS LTD.
BRAMPTON BRANCH

GEOTECHNICAL INVESTIGATION
RIGAUD RIVER
BRIDGE REPLACEMENT

LAGGAN

ONTARIO

PROJECT NO.: BR-10697-A
SCALE: 1:100
DRAWN BY: VB
CHECKED BY: SDH
DATE: NOVEMBER 1996
DRAWING NO.: 1

RECORD OF BOREHOLE 1

1 OF 1

METRIC

W.P. 317-94-00

LOCATION N 5027.9810km E 210.4610km

ORIGINATED BY S.D.H.

DIST 23+059 HWY 34

BOREHOLE TYPE H.S. Augers, NQ Core Barrel, SPT

COMPILED BY S.D.H.

DATUM Geodetic

DATE 1996 October 21

CHECKED BY S.E.G.

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT wp	NATURAL MOISTURE CONTENT w	LIQUID LIMIT wl	UNIT WEIGHT kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE			10	20	30	40					
84.18	GROUND SURFACE														
0.00	200mm ASPHALTIC CONCRETE														
83.93	280mm CONCRETE														
0.25															
83.63															
0.55	FILL - predominantly clayey silt (ML-CL) with some gravel and coarse sand, some zones of organic material, moist to very moist, grey and brown, soft to firm.		1	SPT	9									19.20	
			2	SPT	10										
			3	SPT	5										
			4	SPT	3									22.50	
79.46															
4.72	SILT and GRAVEL till (ML-GL) - with sand, trace of clay, wet, grey, dense.		5	SPT	30									73.7	
78.69															
5.49	SHALY LIMESTONE - grey, fine to medium grain, medium strong. Fracture spacing: moderately close, Fracture Orientation: 85-90 deg. to core axis. Fair Rock Mass Quality.		1	NQ											REC 100% RQD 60%
77.68															
6.50	SHALE - occasional shaly limestone seams (50-100 mm thick), dark grey, fine grain, weak. Fracture spacing: moderate to close. Fracture Orientation: 85-90 deg. to core axis. Fair Rock Mass Quality.		2	NQ											REC 100% RQD 65%
75.65															
8.53	End of Borehole														

RECORD OF BOREHOLE 2

1 OF 1

METRIC

W.P. 317-94-00 LOCATION N 5027.9850km E 210.4670km ORIGINATED BY S.D.H.
 DIST 23+059 HWY 34 BOREHOLE TYPE H.S. Augers, NQ Core Barrel, SPT COMPILED BY S.D.H.
 DATUM Geodetic DATE 1996 October 22 CHECKED BY S.E.G.

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT wp	NATURAL MOISTURE CONTENT w	LIQUID LIMIT wl	UNIT WEIGHT kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE			10	20	30	40					
84.19	GROUND SURFACE														
84.00	150 mm ASPHALTIC CONCRETE														
0.15	280 MM CONCRETE														
83.78	FILL - predominantly clayey silt (ML-CL) with some gravel and coarse sand, some zones of organic material, moist to very moist, grey and brown, soft to firm.														
0.43			1	SPT	7										
			2	SPT	7								21.50		
			3	SPT	4										
			4	SPT	4										
79.31	SILT and GRAVEL till (ML-GL) - with sand, trace of clay, wet, grey, dense.														
4.88			5	SPT	27									22 38 38 2	
78.70	SHALY LIMESTONE - grey, fine to medium grain, medium strong. Fracture spacing: very close in upper 0.3 m, close for remainder. Fracture Orientation: 85-90 deg. to core axis. Poor Rock Mass Quality.														
5.49			1	NQ										REC 100% RQD 28%	
77.24	SHALE - occasional shaly limestone seams (50-100 mm thick), dark grey, fine grained, medium strong. Fracture spacing: moderately close. Fracture Orientation: 85-90 deg. to core axis. Poor Rock Mass Quality.														
6.95			2	NQ										REC 100% RQD 48%	
75.66	End of Borehole														
8.53															

RECORD OF BOREHOLE 3

1 OF 1

METRIC

W.P. 317-94-00

LOCATION N 5027.9640km E 210.4700km

ORIGINATED BY S.D.H.

DIST 23+037 HWY 34


BOREHOLE TYPE H.S. Auger, NQ Core Barrel, SPT

COMPILED BY S.D.H.

DATUM Geodetic

DATE 1996 October 22

CHECKED BY S.E.G.

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT			NATURAL MOISTURE CONTENT			UNIT WEIGHT kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION				
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE			BLOWS/0.3m					wp ——— w ——— wl			WATER CONTENT (%)			GR	SA	SI	CL	
								10	20	30	40	10	20	30	40							
84.15	GROUND SURFACE																					
84.00	150 mm ASPHALTIC CONCRETE																					
83.80	200 mm CONCRETE																					
83.80	FILL - predominantly clayey silt (ML-CL) with some gravel and coarse sand, some zones of organic material, moist to very moist, grey and brown, soft to firm.		1	SPT	11																	
83.65																						
83.50																						
83.35																						
83.20																						
83.05			2	SPT	3												78.8					
82.90																						
82.75																						
82.60			3	SPT	3													68				
82.45																						
82.30																						
82.15																						
82.00																						
81.85			4	SPT	16													75.7				
81.70																						
81.55																						
81.40																						
81.25																						
81.10																						
80.95			5	SPT	25																	
80.80																						
80.65																						
80.50																						
80.35																						
80.20																						
80.05																						
79.90																						
79.75																						
79.60																						
79.45																						
79.30																						
79.15																						
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69.85																						
69.70																						
69.55																						
69.40																						
69.25																						
69.10																						
68.95																						
68.80																						
68.65																						
68.50																						

METRIC

CHECKED BY S.E.G.

MTD 10697 96/12/10



RECORD OF BOREHOLE 5

1 OF 1

METRIC

W.P. 317-94-00

LOCATION N 5027.9380km E 210.5000km

ORIGINATED BY S.D.H.

DIST 23+002 HWY 34

BOREHOLE TYPE H.S. Augers, SPT

COMPILED BY S.D.H.

DATUM Geodetic

DATE 1996 October 25

CHECKED BY S.E.G.

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT		UNIT WEIGHT kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION			
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE			BLOWS/0.3m	10	20	30	40	wp	w	wl							
								SHEAR STRENGTH: Cu, KPa							WATER CONTENT (%)						
							● UNCONFINED QUICK TRIAXIAL	⊗ FIELD VANE LAB VANE													
							20	40	60	80	10 20 30 40										
84.13	GROUND SURFACE																				
0.00 83.99 0.18	ORGANIC CLAYEY SILT (CL-OL) - root fibres, some fine sand, moist, brown, firm to stiff.		1	SPT	8		84	⊗													
	SILTY CLAY (CL) - some fine sand, moist, brown, firm to stiff		2	SPT	10		83	⊗													
82.73 1.40	SILT and GRAVEL till (ML-GL) - with sand, trace of clay, grey, wet, dense.		3	SPT	38				⊗												
82.15 1.98	End of Borehole																				

RECORD OF BOREHOLE 6

1 OF 1

METRIC

W.P. 317-94-00

LOCATION N 5027.9590km E 210.5000km

ORIGINATED BY S.D.H.

DIST 23+017 HWY 34



BOREHOLE TYPE H.S. Auger, STP

COMPILED BY S.D.H.

DATUM Geodetic

DATE 1996 October 25

CHECKED BY S.E.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT		UNIT WEIGHT kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION			
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS/0.3m			10 20 30 40				wp		w		wl			GR	SA	SI	CL
								SHEAR STRENGTH: Cu, KPa ● UNCONFINED QUICK TRIAXIAL * FIELD VANE LAB VANE 20 40 60 80				WATER CONTENT (%) 10 20 30 40										
82.11	GROUND SURFACE																					
0.00	ORGANIC CLAYEY SILT (CL-OL) - root fibres, some fine sand, moist, brown, firm to stiff		1	SPT	3												66	16.40				
81.54																						
0.57	SILT and GRAVEL till (ML-GL) - with sand, trace of clay, wet, grey, dense.		2	SPT	23																	
			3	SPT	26																	
80.13																						
1.98	End of Borehole																					

RECORD OF BOREHOLE 7

1 OF 1

METRIC

W.P. 317-94-00

LOCATION N 5027.9740km E 210.4960km

ORIGINATED BY S.D.H.

DIST 23+033 HWY 34








BOREHOLE TYPE H.S. Auger, SPT

COMPILED BY S.D.H.

DATUM Geodetic

DATE 1996 October 25

CHECKED BY S.E.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT			NATURAL MOISTURE CONTENT			LIQUID LIMIT			UNIT WEIGHT kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION			
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS/0.3m			10 20 30 40				wp — w — wl			WATER CONTENT (%)			10 20 30 40							
								SHEAR STRENGTH: Cu, KPa				UNCONFINED QUICK TRIAXIAL			FIELD VANE LAB VANE										
82.20	GROUND SURFACE																								
0.00	ORGANIC CLAYEY SILT (CL-OL) - root fibres, some fine sand, very wet, brown, soft to firm.		1	SPT	4		82													16.00					
80.90			2	SPT	2		81																		
1.30	SILTY CLAY (CH) - high plasticity, sensitive, very wet, grey, soft to firm		3	SPT	4																				
80.20			4	SPT	42		80																		
2.00	SILT and GRAVEL till (ML-GL) - with sand, trace of clay, wet, grey, dense		5	SPT	82																				
78.75	Probable Bedrock						79																		
3.45	End of Borehole Notes: 1. Borehole terminated on probable bedrock.																								

N = 82/254mm

RECORD OF BOREHOLE 8

1 OF 1

METRIC

W.P. 317-94-00

LOCATION N 5027.9790km E 210.4900km

ORIGINATED BY S.D.H.

DIST 23+049 HWY 34

BOREHOLE TYPE H.S. Auger, NQ Core Barrel, SPT

COMPILED BY S.D.H.

DATUM Geodetic

DATE 1996 October 25

CHECKED BY S.E.G.

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION	
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE			BLOWS/0.3m	TEST (N Value)								
								10	20	30						40
81.99	GROUND SURFACE															
0.00	ORGANIC CLAYEY SILT (CL-OL) - root fibres, some fine sand, moist, brown, firm to stiff.		1	SPT	3									16.10		
			2	SPT	6											
80.47																
1.52	SILT and GRAVEL till (ML-GL) - some sand, trace of clay, wet, grey, dense.		3	SPT	23											
			4	SPT	47											
78.94																
3.05	SHALY LIMESTONE - grey, fine to medium grain, medium strong. Fracture spacing: close to moderate close. Fracture Orientation: 85-90 deg. to core axis. Poor to Fair Rock Mass Quality.		1	NQ											REC 81% RQD 55%	
77.04																
4.95	SHALE - occasional shaly limestone seams (50- 100 mm thick), dark grey, fine grain, weak. Fracture spacing: moderate close. Fracture Orientation: 85-90 deg. to core axis. Fair to Good Rock Mass Quality.		2	NQ											REC 90% RQD 78%	
75.89																
6.10	End of Borehole															

RECORD OF BOREHOLE 9

1 OF 1

METRIC

W.P. 317-94-00

LOCATION N 5028.0150km E 210.4770km

ORIGINATED BY S.D.H.

DIST 23+079 HWY 34



BOREHOLE TYPE H.S. Auger, SPT

COMPILED BY S.D.H.

DATUM Geodetic

DATE 1996 October 25

CHECKED BY S.E.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT wp	NATURAL MOISTURE CONTENT w	LIQUID LIMIT wl	UNIT WEIGHT kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION							
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS/0.3m			SHEAR STRENGTH: Cu, KPa								WATER CONTENT (%)				GR	SA	SI	CL
								UNCONFINED QUICK TRIAXIAL	FIELD VANE LAB VANE	10	20					30	40	10	20				
82.57	GROUND SURFACE																						
0.00	ORGANIC CLAYEY SILT (CL-OL) - root fibres, some fine sand, moist, brown, stiff		1	SPT	6																		
82.37																							
0.20																							
	SILTY CLAY (CL-CH) - some fine sand, moist, brown, firm becomming soft below El. 81.2 m		2	SPT	7																		
			3	SPT	2																		
80.59	End of Borehole																						
1.98																							

RECORD OF BOREHOLE 10

1 OF 1

METRIC

W.P. 317-94-00

LOCATION N 5028.0370km E 210.4600km

ORIGINATED BY S.D.H.

DIST 23+105 HWY 34

BOREHOLE TYPE H.S. Auger, SPT

COMPILED BY S.D.H.

DATUM Geodetic

DATE 1996 October 25

CHECKED BY S.E.G.

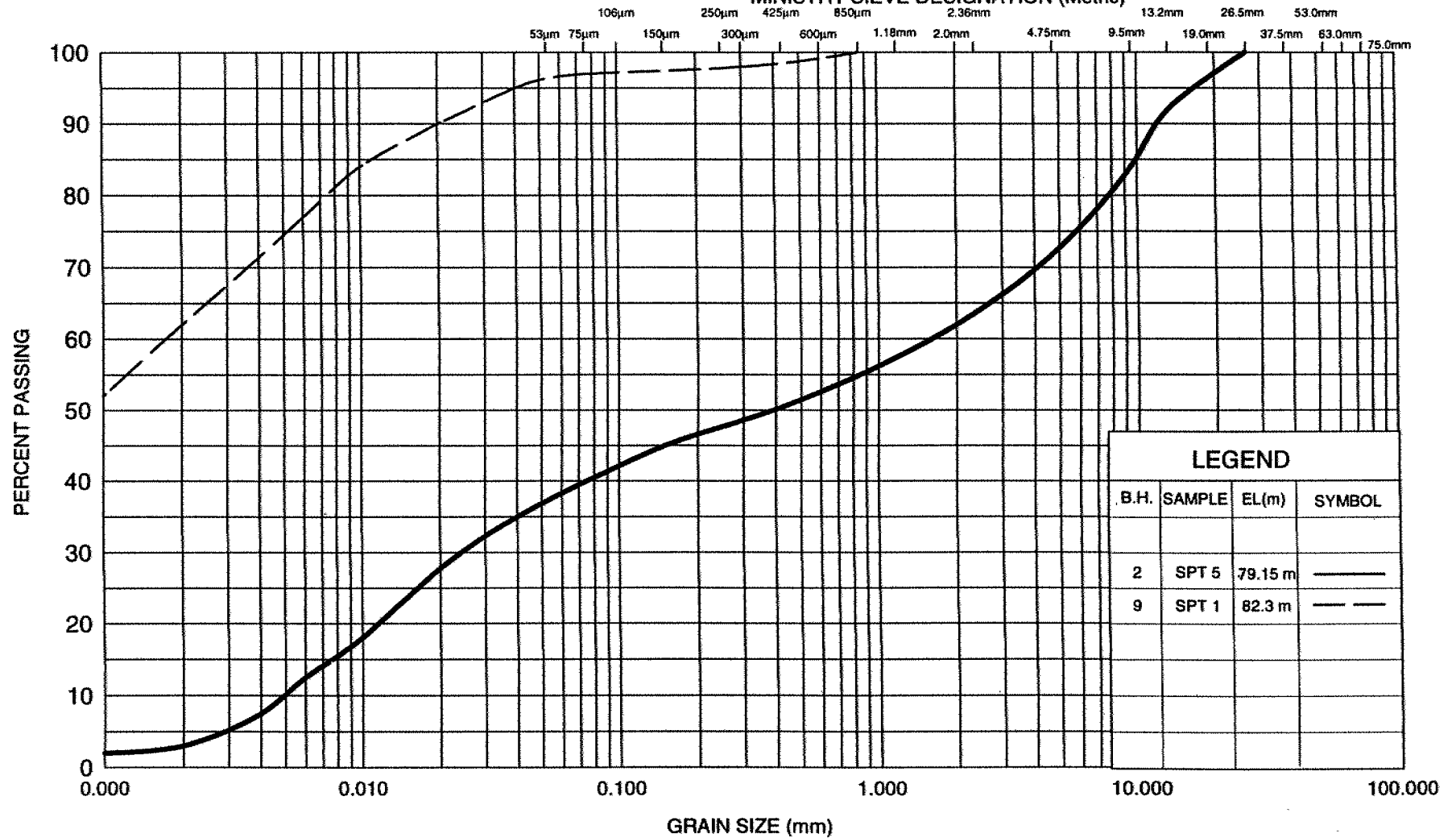
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION GR SA SI CL	
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS/0.3m			SHEAR STRENGTH: Cu, KPa				WATER CONTENT (%)					
								UNCONFINED QUICK TRIAXIAL		FIELD VANE LAB VANE							
82.87	GROUND SURFACE							10	20	30	40	wp	w	wl			
0.00	ORGANIC CLAYEY SILT (CL-OL)		1	SPT	8			20	40	60	80						
82.67	- root fibres, some fine sand, moist, brown, stiff																
0.20	SILTY CLAY (CL-CH) - some fine sand, moist, brown, firm to stiff.																
			2	SPT	12		82										
			3	SPT	8		81										
80.89	End of Borehole																
1.98																	

Appendix D: Laboratory Results

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT	SAND			GRAVEL	
	FINE	MEDIUM	COARSE	FINE	COARSE

MINISTRY SIEVE DESIGNATION (Metric)



LEGEND

B.H.	SAMPLE	EL(m)	SYMBOL
2	SPT 5	79.15 m	————
9	SPT 1	82.3 m	- - - -

Ministry of
Transportation

METRIC

GRAIN SIZE DISTRIBUTION

B.H. 2 - SAMPLE 5: SILT and GRAVEL till (ML-GL) - with sand and a trace of clay.
B.H. 9 - SAMPLE 1: SILTY CLAY (CH)

FIGURE 1

W.P. 317-94-00


Client: Trow Markham
 Attention: Clement Chow
 Project: BR 10697 A
 P.O.:
 Sample Type: Water
 Date Received: Oct 28/96
 Date Reported: Oct 30/96

ENTECH

A Division of Agri-Service Lab Inc.
 6820 Kilmist Rd., Unit #4
 Mississauga, ONT L5N 6M3
 TEL: (905) 821-1112
 FAX: (905) 821-2095

MISC. SAMPLE TEST

PARAMETER	Units	Method Detection Limit (ug/ml)	CONTROL SAMPLE			SAMPLE DATA				
			Expected (ug/ml)	Found (ug/ml)	Recovery %	24558 BH3				
pH	-	-	9.08	8.91	98	7.27				
Sulphate	ug/ml	0.2	400	412.5	103	23.5				


 Sam Sanyal, M.Sc., C. Chem

G.I-30 SEPT. 1976

GEOCRES No. 31G-216

DIST. 42 REGION

W.P. No. 317-94-00

CONT. No.

W. O. No.

STR. SITE No. 31-20

HWY. No. 34

LOCATION RIGAUD RIVER

No. of PAGES -

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

**Rigaud River Bridge Replacement
WP 317-94-00
MTO Site #31-20**

GEOCRES # 31G-216

Trow Consulting Engineers Ltd.

1595 Clark Boulevard
Brampton, Ontario L6T 4V1
Telephone: (905) 793-9800
Facsimile: (905) 793-0641

BR-10697-A/G
December 12, 1996

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Appendix A: Photographs

Appendix B: Plan Location of Boreholes & Borehole Logs

Appendix C: Stratigraphies Beneath Bridge Abutments & Temporary Detour

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PART 1 Foundation Investigation

1. Introduction

This submission presents the results of a geotechnical investigation completed by Trow Consulting Engineers Ltd. (Trow) for the Rigaud River Bridge Replacement, WP 317-94-00, Site number 31-20. The project consists of two parts, namely: (i) construction of a temporary culvert and roadway (detour) around the existing Rigaud River Bridge and (ii) removal of the existing 10.06 m single span concrete rigid frame bridge and construction of a replacement. It is understood that the replacement options are either a rigid frame structure similar to the existing bridge or a twin cell box culvert with an opening width of 8 m situated along the existing alignment.

2. Site Description and Geological Setting

2.1 Site Description

The site is located on Highway 34 between stations $22 + 800 \pm$ and $23 + 350 \pm$ in the county of Stormont, Dundas and Glengarry. Physiographically, the site lies within the Glengarry Till Plain which has generally flat to moderately undulating terrain. The terrain in the immediate area of the project site is relatively flat.

Between stations $23+056 \pm$ and $23+120 \pm$, the Rigaud River flows from north to south and is situated to the west of Highway 34. At station $23+047 \pm$, the river begins to flow in an easterly direction crossing from the west side of Highway 34 to the east side. The existing Rigaud River Bridge is a rigid frame concrete structure with a span of $10.0 \pm$ m located at station $23+046.7$. Highway 34 is a two lane highway and both north and south approaches to the bridge are straight.

Photograph 1 in Appendix A shows the existing Rigaud River Bridge from a location just east of the proposed temporary culvert/detour alignment while Photograph 2 in Appendix A shows the existing bridge from the south approach.

2.2 Geological Setting

According to the OGS Map 2556, the overburden soils at the site consist of till which is predominantly sandy silt to silt and often rich in clay. Intervening glaciomarine and marine deposits (comprised of silts and clay) and muskegs may also occur in the area. The underlying bedrock in the area is from the Rockcliffe Formation (OGS Map 2544) which consists of inter-bedded shaly bioclastic limestone, dark grey to maroon shales, and light grey, fine grained, calcareous to non-calcareous quartz sandstone.

3. Investigative Procedures

3.1 General

Part 1 of this report describes the investigative procedures adopted for the geotechnical assessment of the Rigaud River Bridge Replacement. Properties of the overburden soils at the site were obtained by in situ and laboratory testing and the procedures employed during the investigation are described below.

3.2 Field Investigation

3.2.1 Rigaud River Bridge Replacement

The field work for the investigation related to the replacement of the existing Rigaud River Bridge was carried out on October 21 and 22, 1996, and consisted of four (4) boreholes (Boreholes 1 to 4) which were advanced to depths ranging from 7.9 metres to 8.6 metres. Two (2) boreholes were drilled near each of the north and south abutments. The borehole locations are shown on Drawing 1 in Appendix B and all elevations are reference to MTO Temporary Benchmark (El. 86.904) at station 22+951 of King's Highway 34.

The boreholes were advanced through the overburden soils on the site using a truck mounted CME-55 drill rig equipped with solid and hollow stem augers. Soil samples were obtained using a split spoon sampler in conjunction with Standard Penetration Tests (ASTM D1586) at approximately 0.75 metre and 1.5 metre intervals. The Standard Penetration (N) values were recorded and used to provide an assessment of the relative denseness of the overburden soils at the site and the soil samples were used for identification and laboratory testing.

At each of the four (4) boreholes, conventional rock coring techniques were used to advance the boreholes approximately 3.0 metres into the underlying bedrock. Standard NQ size core barrels and casings were used and core samples of the bedrock were retrieved for rock quality determinations and classification purposes.

3.2.2 Temporary Detour and Culvert

The field work for the investigation related to the proposed temporary detour and culvert was carried out on October 25, 1996, and consisted of six (6) boreholes which were advanced to depths ranging from 2 metres to 6.1 metres. Two (2) boreholes were drilled near the north and south abutments of the proposed culvert and two (2) boreholes were drilled along each of the alignment of the north and south approaches to the culvert. Drawing 1 in Appendix B shows the locations of the boreholes drilled along the temporary detour alignment (see Boreholes 5 to 10 on Drawing 1).

The boreholes were advanced through the overburden soils on the site using a track mounted CME-55 drill rig equipped with solid and hollow stem augers. Soil samples were obtained using a split spoon sampler in conjunction with Standard Penetration Tests (ASTM D1586) at approximately 0.75 metre and 1.5 metre intervals. The Standard Penetration (N) values were recorded and used to provide an assessment of the relative denseness of the overburden soils at the site and the soil samples were used for identification and laboratory testing. A groundwater sample was obtained from Borehole 7 for pH and sulphate analysis.

At Borehole 8 located near the north culvert abutment, conventional rock coring techniques were used to advance the boreholes approximately 3.0 metres into the underlying bedrock. Standard NQ size core barrels and casings were used and rock core samples of the bedrock were retrieved for rock quality determinations and classification purposes.

3.3 Laboratory

The laboratory testing program for select soil samples consisted of the following:

- Atterberg Limits
- Natural Moisture Contents
- Unit Weights
- Grain Size Distributions

The laboratory test results are summarized on the attached Borehole Logs in Appendix B. pH and sulphate analyses was performed on a groundwater sample taken from Borehole 7 and the results are contained in Appendix D. Appendix D also contains grain size distributions for soil samples from boreholes 2 and 9, respectively.

4. Subsurface Conditions

4.1 Existing Bridge Location

As previously indicated, the Borehole locations are shown on Drawing 1 of Appendix B and the results of the geotechnical investigation near the existing bridge location are summarized on the attached Borehole Logs number 1, 2, 3, and 4 in Appendix B. Asphaltic concrete and concrete were found overlying fill in Boreholes 1, 2, 3 and 4 adjacent to the north and south bridge abutments. The fill ranged in thickness from 4.5 m to 4.8 m and was underlain by a thin silt and gravel till layer. The silt and gravel layer (glacial till) was found to range in thickness from approximately 0.4 m to 0.8 m and was underlain by bedrock consisting of inter-layered shaly limestone and shale. Drawing 1 in Appendix C shows the summarized stratigraphic profile for both the north and south bridge abutments.

4.1.1 Asphaltic Concrete and Concrete

Approximately 150 mm of asphalt was found overlying 200 mm of concrete at Boreholes 2, 3, and 4. The asphaltic concrete and concrete encountered in Borehole 1 were found to be slightly thicker (200 mm and 280 mm, respectively).

4.1.2 FILL

Underlying the asphaltic concrete and concrete, fill was encountered. The fill was predominantly clayey silt (ML-CL) with some gravel and coarse sand, and occasional zones with organic material. Based on Standard Penetration N-values, the consistency of the fill was found to be highly variable ranging from soft to very stiff. The Standard Penetration N-values ranged from 3 blows/300mm to 27 blows/300mm and the natural moisture content ranged from approximately 10% to 80%.

The large range of natural moisture content is due in part to the organic materials present in portions of the fill. It was generally observed that the Penetration resistance of the fill was inversely proportional to the moisture content. For example, natural moisture contents in excess of 40% generally coincided with low blow counts in the order of 3 to 4 (blows/300 mm). Moisture contents in the order of 20%± generally coincided with blow counts of 10 or greater.

4.1.3 SILT and GRAVEL till (ML-GL)

A thin layer of compact to dense silt and gravel till (ML-CL) with sand and a trace of clay was found beneath the fill in Boreholes 1, 2, 3 and 4. The silt and gravel till layer (ML-GL) ranged in thickness from approximately 0.4 to 0.8 m. Standard Penetration N-values in this layer ranged from 27 blows/300mm to 60 blows/130 mm and natural moisture contents varied from approximately 10% to 14.5%. Grain size analysis on Split Spoon Sample 5 from Borehole 2 (see Figure 1 in Appendix D) indicated 22% gravel, 38% sand, 38 % silt and 3 % clay.

4.1.4 BEDROCK

The bedrock was proven in Boreholes 1, 2, 3 and 4 by obtaining NQ cores which were used for subsequent classification of the rock. The bedrock at the bridge site is relatively flat ranging in Elevation from 78.66 m to 79.30 m.

Detailed descriptions of the rock are included on the attached Borehole Logs in Appendix B. The upper 1.0 to 2.0 metres of the bedrock cores was classified as shaly limestone. The rock was grey, fine to medium grained, weak to medium strong with very close to moderately close fracture spacing. The lower portions of the rock cores obtained from Boreholes 1, 2, 3, and 4 were found to consist of grey to dark grey shale with shaly limestone and mudstone seams (50 - 200 mm thick).

Rock core recovery ranged from 50% to 100% and Rock Quality Designation (RQD) values ranged from 0% in the upper core run of Borehole 4 (El. 79.30 m to 77.80 m) to 72% in the lower core run of Borehole 3 (El. 77.12 m to 75.62 m). In generally, the Rock Mass Quality was found to be very poor to poor in the upper 0.3 to 0.4 metres of bedrock for Boreholes 1 and 2. Below the upper 0.3 to 0.4 metre zone of highly fractured rock, the Rock Mass Quality improves to fair with an average RQD of approximately 60%.

4.2 Temporary Detour and Culvert Alignment

The results of the geotechnical investigation for the temporary detour and culvert are summarized on Borehole logs 5, 6, 7, 8, 9 and 10 in Appendix B. An organic clayey silt root mat (CL-OL) varying in thickness from 0.18 metres to 1.3 metres was encountered overlying silty clay (CL-CH). The silty clay (CL-CH) was found to be greater than 1.8 metres thick at Borehole 10 and was absent in Boreholes 6 and 8. Silt and gravel till (ML-GL) was encountered below the silty clay (CL-CH) in Boreholes 5, 6, 7, and 8 and bedrock was encountered in Borehole 8 at an Elevation of 78.94 metres. Boreholes 9 and 10 were terminated within the upper silty clay (ML-CL) deposit. A summary of the inferred stratigraphical profile along the proposed alignment of the temporary detour and culvert is shown on Drawing 2 in Appendix C.

4.2.1 ORGANIC CLAYEY SILT (root mat) over SILTY CLAY

An organic clayey silt layer (OL-CL) was encountered in all boreholes drilled along the proposed alignment of the temporary detour and culvert. The thickness of the organic layer (root mat) varied from 0.18 metres in Borehole 5 to 1.8 metres in Borehole 7. Moisture contents for this subsurface layer typically ranged from 50% to 60% and Standard Penetration N-values varied from 2 to 8 blows/300mm. The consistency of this deposit is soft to firm based on the Penetration resistance.

The upper root mat was underlain by a similar soil deposit ranging from soft to stiff SILTY clay (no significant root fibers). The average moisture content of this overburden layer was approximately 36% and Standard Penetration N-values varied from 2 to 10 blows/300mm.

4.2.2 SILT and GRAVEL till (ML-GL)

Compact to dense silt and gravel till (ML-CL) with sand and a trace of clay was found below the upper clayey silt layers in Boreholes 5, 6, 7 and 8. The silt and gravel till (ML-GL) layer was penetrated completely by Borehole 8 only. The thickness of the layer at Borehole 8 was found to be approximately 1.6 metres. Standard Penetration N-values in this layer ranged from 23 to 47 blows/300mm and natural moisture contents varied from approximately 10% to 20%.

4.2.3 BEDROCK

The bedrock was proven in Borehole 8 by obtaining NQ rock cores which were used for subsequent classification of the rock. The bedrock was encountered at an Elevation of 78.9 m.

Detailed description of the rock is included on the attached Borehole log for Borehole 8 in Appendix B. The upper 1.9 metres of the bedrock core was classified as shaly limestone. The rock was grey, fine to medium grained, weak to medium strong with very close to moderately close fracture spacing. The lower portion of the bedrock core obtained from Borehole 8 was found to consist of grey to dark grey shale with shaly limestone and mudstone seams (50 - 100 mm thick).

Rock core recovery ranged from 81 to 90% and Rock Quality Designation (RQD) values were general good ranging from 81% in the upper core run of Borehole 8 (El. 78.94 m to 77.42 m) to 90% in the lower core run of Borehole 8 (El. 77.42 m to 75.89 m). Generally, the Rock Mass Quality was found to be fair to good below the upper 0.3 metres of the Bedrock.

5. Groundwater Conditions

At the time of the investigation, the water level in the Rigaud River was measured to be 81.2 metres (Geodetic Elevation). Information regarding the groundwater levels at the site was obtained by measuring the water levels in the open boreholes after the completion of drilling. No free standing water was observed in Boreholes 1 to 5 and 8 to 10. For Boreholes 6 and 7, water was encountered in the open boreholes at an Elevation of $81.6 \pm$ m as indicated on Borehole logs 6 and 7 in Appendix B. It is, however, unlikely that sufficient time was allowed for these water levels to stabilize. Based on the above noted observations and relatively flat terrain in the vicinity of the bridge, the groundwater levels at the site can be expected to closely follow the Elevation of the water level in the Rigaud River. As such, ground water tables will be subject to seasonal fluctuations and the prevailing hydraulics of the river.

pH and sulphate tests were performed on a groundwater sample taken from Borehole 7 and the results are shown in Appendix D. The pH was found to be 7.27 and the sulphate test showed 23.5 mg/ml of sulphate.

Part 2 Engineering Discussions and Recommendations

6.1 General

The following subsections address geotechnical considerations pertaining to the Rigaud River Bridge replacement. It is understood that the replacement options are either a similar rigid frame structure or a twin cell box culvert with an opening width of 8 m situated along the existing alignment. A temporary detour which will cross the Rigaud River will be required during construction and it is understood that approximately three (3) 1.0 metre diameter CSP culverts are proposed to carry the expected river flows. The proposed location of the temporary culvert is 23+060± which will involve temporary diversion of the river.

6.2 Foundations - Rigaud Bridge Replacement

6.2.1 North Abutment Location

At the location of the north abutment, there is approximately 4.7 to 4.8 metres of clayey silt fill overlying approximately 0.6 to 0.8 metres of compact to dense silt and gravel till (ML-GL). Bedrock was encountered at an elevation of approximately 78.7 m in both Boreholes 1 and 2. Given the relatively thin overburden of fill and silt and gravel till, placement of new footings directly on Bedrock is recommended. For the purpose of design based on the Ontario Highway Bridge Design Code, the following bearing capacities can be used for spread footings placed directly on bedrock subject to inspection by a qualified geotechnical engineer:

Factored Bearing Resistance at ULS = 3000 kPa

Factored Bearing Resistance at SLS = 3000 kPa

The above Factored Bearing Resistance at U.L.S. applies to spread footings subjected to vertical loads, and placed directly on rock with a Fair Rock Mass Quality (50% < RQD < 75%, Canadian Foundation Engineering Manual). For the north abutment area, Boreholes 1 and 2 indicate that this would require excavation and removal of approximately 0.3 metres of loose rock. The footing base must be cleared of all loose materials prior to placement of concrete and inspected by a qualified geotechnical engineer to verify the Rock Mass Quality.

As per section 6-8.4.2 of the Ontario Highway Bridge design code, a reduction factor shall be applied to the Ultimate Bearing Resistance at ULS (3000 kPa) to account for the effects of inclined loading. Table 1 contains a summary of reduction factors for inclined loads.

Table 1 Reduction Factors to Account for the Effects of Inclined Loads on the Ultimate Bearing Resistance at ULS

Ratio of Horizontal to Vertical Load	Reduction Factor
0.1	0.87
0.2	0.75
0.3	0.66
0.4	0.57

Note: The structural engineer can refer to Figure 6-8.4.2 of the Ontario Highway Bridge Design Code for reduction factors corresponding to ratios of horizontal to vertical loads which are not listed above. The reduction factors for cohesive soil or rock shall be applied.

6.2.2 South Abutment Location

The subsurface conditions for the south abutment are similar to those discussed for the north abutment. As a result, spread footings placed directly on bedrock are also recommended for the south abutment given the relative thin overburden of fill and silt and gravel till (ML-CL). Bedrock was encountered at elevations ranging from 78.7 m in Borehole 3 to 79.3 m in Borehole 4. For the purpose of design base on the Ontario Highway Bridge Design Code, the following bearing capacities can be used for footings placed directly on bedrock subject to geotechnical inspection:

Factored Bearing Resistance at ULS = 3000 kPa

Factored Bearing Resistance at SLS = 3000 kPa

The above Factored Bearing Resistance at ULS applies to spread footings subjected to vertical loads, and placed directly on rock with a Fair Rock Mass Quality (50% < RQD < 75%, Canadian Foundation Engineering Manual). For the south abutment area, Boreholes 3 and 4 indicate that this would require excavation and removal of approximately 0.4 metres of loose rock. As per section 6-8.4.2 of the Ontario Highway Bridge design code, a reduction factor shall be applied to the Factored Bearing Resistance at ULS (3000 kPa) to account for the effects of inclined loading. The reduction factors contained in Table 1 and discussed in Section 6.2.1 also apply to the south abutment foundation.

6.2.3 Anticipated Footing Elevations

The following Table summarizes the location and estimated footing elevations at which a Factored Bearing Capacity (at U.L.S.) is applicable:

Table 2:
Location and Estimated Elevation of Footing Bases for Bridge Abutments.

Location	Description	Approximate Elevation (m)
Sta 23 + 058	Boreholes 1 and 2 near north abutment	78.3
Sta 23 + 038	Boreholes 3 and 4 near south abutment	78.3 to 78.8

The above elevations are for preliminary purposes and were estimated based on the factual borehole data at two locations near the north and south abutments respectively. Interpolation between boreholes is approximate, and as such, actual footing elevations will depend on the conditions encountered at the time of construction. The rock surface at the footing base must be cleared of all loosened or highly fractured rock and be inspected by a qualified geotechnical engineer to verify the Rock Mass Quality prior to placement of concrete.

6.2.4 Twin Cell Culvert

As indicated in the introduction to this report, a twin cell box culvert with an opening width of 8 metres situated along the existing alignment is being considered. Contract drawings for the original Rigaud River Bridge (Contract 82-13) supplied by the client indicate that the existing bridge is founded on bedrock at Elevation 79.0 m \pm . Bedrock is inferred from the bedrock Elevations measured during this geotechnical investigation. In view of the above evidence, founding the twin box culverts on the silt and gravel till layer is not recommended since this subsurface soil layer may have been significantly disturbed during excavation and construction of the existing bridge footings.

It is recommended to sub-excavate down to bedrock at an elevation of 78.3 m \pm to 78.8m \pm and backfill to 81.0 m \pm with Granular 'A' (or equivalent) compacted to 100% Standard Proctor Maximum Dry Density. The granular pad should extend a minimum of 1.0 metres beyond the plan limits of the footing and have side slopes no steeper than 1 horizontal to 1 vertical. In addition, the bedrock should be cleared of all loose material and inspected by a qualified geotechnical engineer prior to placement of the Granular 'A' pad.

The bearing capacities recommended for the culvert design based on the Ontario Highway Bridge Design Code are as follows:

Factored Bearing Resistance at ULS = 400 kPa

Factored Bearing Resistance at SLS = 200 kPa

In the absence of detailed information pertaining to the structural design of the culvert, the Factored Bearing Resistance at SLS presented above has been calculated based on a maximum permissible displacement of 25 mm and total differential settlements of 19 mm.

6.2.5 Frost Protection

Frost cover is not required for footings placed directly on bedrock.

6.2.6 Sliding Resistance

The computation of the sliding resistance of the foundation shall be carried out in accordance with of O.H.B.D.C. An friction angle, ϕ' , of 32 degrees can be used for sliding along discontinuities within the bedrock and at the interface between the bedrock and footing base.

If the factored resistance against sliding failure based on friction alone is inadequate, then a passive resistance key should be excavated into the bedrock. A coefficient of passive earth pressure, K_p' , equal to 4.2 can be used for design of the passive resistance key in conjunction with applicable resistance factors as outlined in Section 6-6.2.2 of the Ontario Highway Bridge Design Code.

6.3 Foundations - Temporary Detour and Culvert

The elevation of the creek bed at the Rigaud River Bridge was surveyed during the investigation to be $81.2 \pm$ metres. It is expected that the invert elevation of the culverts will be set at or slightly below this elevation. Based on a minimum bedding thickness of 200 mm for CSP culverts (O.H.B.D.C. 7-8.4), the anticipated foundation Elevation is $81.0 \pm$ metres. Referring to Drawing 2 in Appendix C, the expected foundation soils will consist of approximately 0.5 metres of clayey silt (CL-CH) overlying compact silt and gravel till at Elevation $80.5 \pm$. Placement of the temporary culvert on 200 mm bedding founded on the clayey silt soil layer is not expected to present any significant problems with respect to bearing capacity related failure of the foundations soils provided that the temporary culverts are designed and constructed as outlined in the Ontario Highway Bridge Design Code and recommendations regarding backfill materials are strictly adhered to.

6.4 Backfill

6.4.1 Location of Bridge Replacement

Backfill to abutments or retaining walls should consist of free draining granular materials such as Granular 'A' and Granular 'B' or rock fill. Computation of earth pressures shall be in accordance with Section 6.7.4 of the Ontario Highway Bridge Design Code. Unfactored properties for backfill materials are provided in the following table:

Table 3:
Material Types and Unfactored Properties.

Material	Friction Angle, ϕ'	γ (kN/m ³)	K_a	K_p	K_o
Granular A	35 degrees	22.5	0.27	3.7	0.43
Granular B	30 degrees	21.5	0.33	3.0	0.50
Rock Fill	35 degrees	20.0	0.27	3.7	0.43

Note: K_a is the earth pressure coefficient corresponding to the active state
 K_o is the earth pressure coefficient at rest
 K_p is the earth pressure coefficient corresponding to the passive state.

6.4.2 Location of Temporary Detour and Culvert

Backfill for the temporary culvert and approach roadways at the site should not be compacted with heavy vibratory equipment in the vicinity of the culverts (as per Section 7-8.6 of the O.H.B.D.C.) and in areas where the upper surface crust (root mat) has been excavated. The later precaution is due to the sensitive nature of the predominantly silty overburden soils at the site. Free draining granular materials such as Granular 'A' and Granular 'B' or rock fill can be used for structural backfill provided that adequate compaction as specified in the Ontario Highway Bridge Design Code can be achieved. If clear stone or rock fill is placed directly on the subgrade soils at the site, a geotextile separator must be applied between the subgrade soils and the granular soil to prevent pumping of the subgrade soils into the granular sub-base.

Unfactored properties for backfill materials are provided in the following table:

Table 4:
Material Types and Unfactored Properties

Material	Friction Angle, ϕ'	γ (kN/m ³)	K_a	K_p	K_o
Granular A	35 degrees	22.5	0.27	3.7	0.43
Granular B	30 degrees	21.5	0.33	3.0	0.50
(20 mm nominal size) Clear Stone	35 degrees	21.0	0.33	3.7	0.43
Rock Fill	35 degrees	20.0	0.27	3.7	0.43

Note: K_a is the earth pressure coefficient corresponding to the active state

K_o is the earth pressure coefficient at rest

K_p is the earth pressure coefficient corresponding to the passive state.

6.5 Excavations

6.5.1 Location of Bridge Replacement

Excavations in the clayey silt fill (ML-CL) and silt and gravel till (ML-GL) will be required to construct the abutment footings on Bedrock. The overburden fill and silt and gravel till (ML-GL) are classified as Type 3 soils and the maximum depth of excavation anticipated at the site is approximately 5 metres. As such, excavations in accordance with the Occupational Health and Safety Regulations for Construction Projects for Type 3 soils will be adequate.

The walls of excavations in the fill and silt and gravel till (ML-GL) do not require a support system provided that the walls are sloped from the bottom of the excavation and with a minimum slope gradient of one horizontal to one vertical.

If zones of soft soil (not encountered during the investigation) or areas of significant water seepage are encountered during excavation, it is recommended that side slopes be cut back locally to a 1.5:1 (horizontal to vertical) slope gradient.

Some de-watering of excavations below the ground water table may be required. Due to the relatively low permeability of the overburden soils at the site, groundwater flow is expected to occur predominantly within the upper highly fractured zones of bedrock. Flows are expected to be small and of a quantity which can be managed using conventional sump pumping techniques in conjunction with perimeter drainage ditches. Excavation work should start from the downstream ends of the excavation to facilitate drainage and enhance the excavation procedures.

6.5.2 Location of Temporary Detour and Culvert

Excavations in the clayey silt (CL-CH) and silt and gravel till (ML-GL) will be required to construct the temporary culvert. The overburden soils are classified as Type 3 soils, and as such, excavations in accordance with the Occupational Health and Safety Regulations for Construction Projects for Type 3 soils should be sufficient given the anticipated depths of excavation. The walls of excavations do not require a support system provided that the walls are sloped from the bottom of the excavation with a minimum slope gradient of one horizontal to one vertical.

Some de-watering of excavations below the ground water table may be required. Due to the relatively low permeability of the overburden soils at the site, groundwater flow is expected to be minimal and of a quantity which can be managed using conventional sump pumping techniques.

6.6 Culvert Treatment

For culvert protection, the two treatment zones to be considered include the embankment and the channel. Adequate protection against scour and erosion is required to ensure the geotechnical integrity of both the temporary and permanent culverts. Adequate protection, such as rock rip rap, must be designed (in accordance with M.T.O. specifications) to withstand the design shear stresses and the hydraulic conditions expected to prevail during the lifetime of the structure. These conditions depend on the type of culvert, configuration of the river, configuration of the river diversion, the river hydraulics etc. which are beyond the scope of this investigation and must be addressed at a later stage in the project before tendering and construction.

7. General

The information presented in this report is based on a limited investigation designed to provide information to support an overall assessment of the current geotechnical conditions at the site of the proposed Rigaud River Bridge Replacement. The conclusions presented in this report reflect site conditions existing at the time of the investigation. It is noted that the soil boundaries indicated on the borehole logs are inferred from discontinuous sampling and observations during drilling. These boundaries are intended to reflect transition zones for the purpose of geotechnical design and should not be interpreted as exact planes of geological change.


This report has been prepared by Sean Hinchberger and reviewed by S.E. Gonsalves and Peter Chan. Peter Chan coordinated the field investigation and Clement Chow performed the fieldwork.

We trust this report is satisfactory for your purposes. Should you have any questions, please do not hesitate to contact this office.

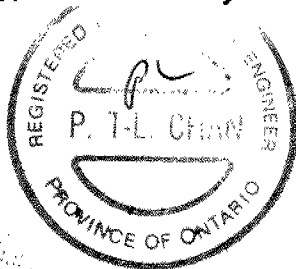
Trow Consulting Engineers Ltd.



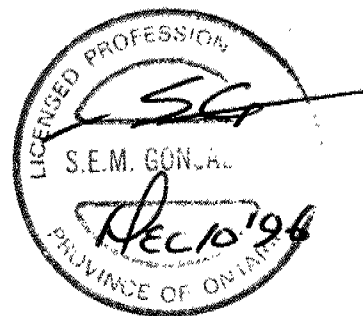
S. Hinchberger, Ph.D.



Peter Chan, P.Eng.



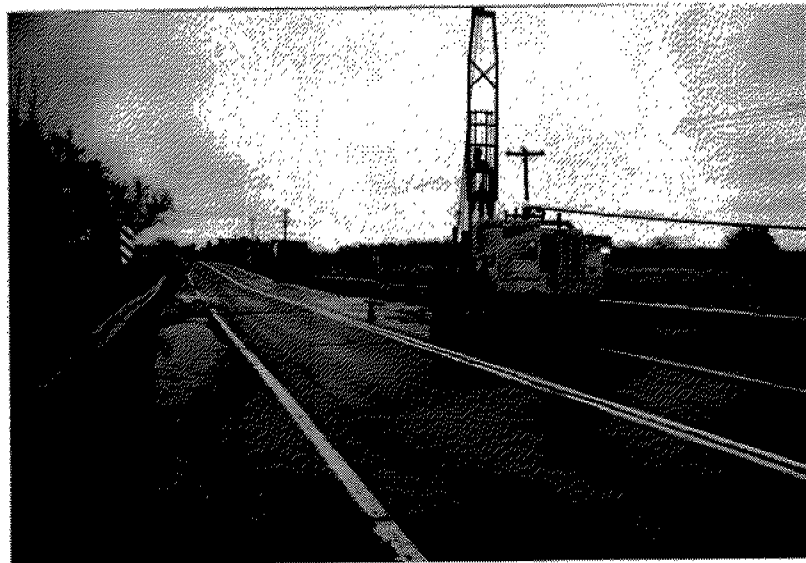
S. E. Gonsalves, P.Eng.



Appendix A: Photographs

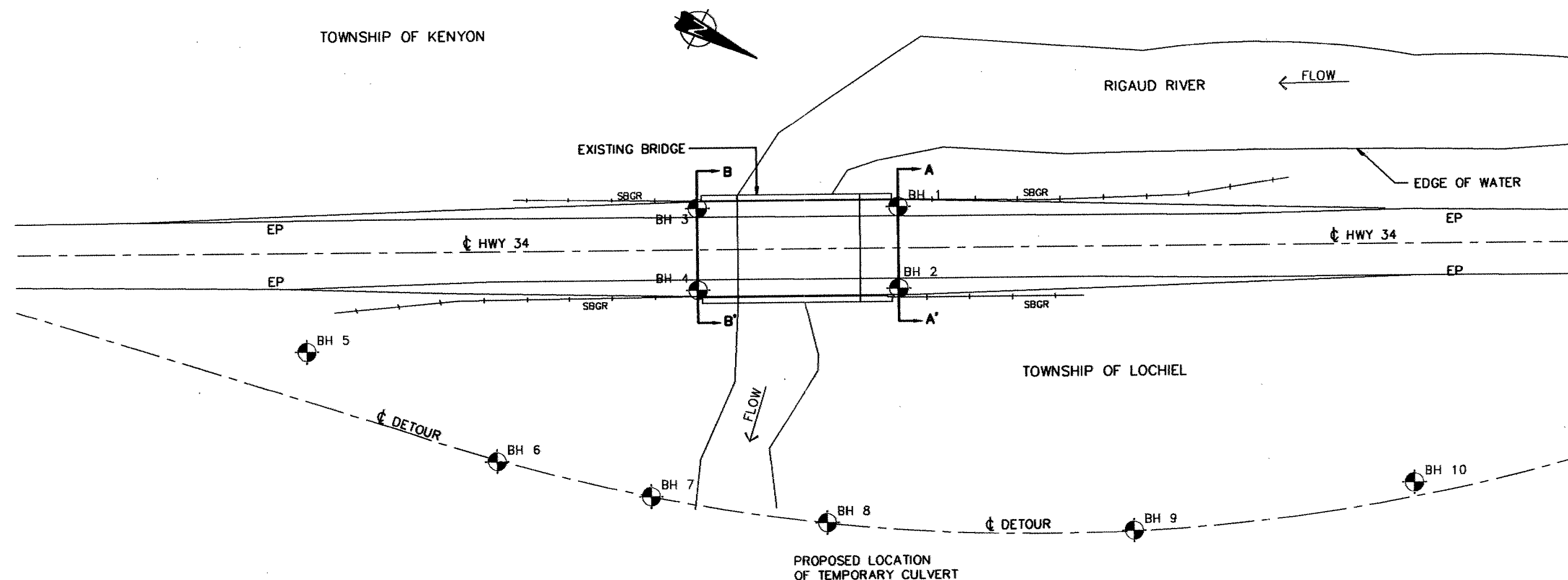


PHOTOGRAPH 1 View of Existing Rigid Frame Bridge from the Location of the Proposed Temporary Culvert - Rigaud River and Hwy 34.



PHOTOGRAPH 2 View of Existing Rigaud River Bridge from the South Approach.

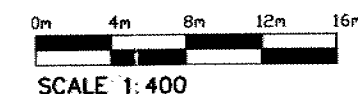
Appendix B: Plan Location of Boreholes & Borehole Logs



General Notes

- 1) The boundaries and soil types have been established only at Borehole locations. Between boreholes they are assumed and may be subject to considerable error.
- 2) Soil samples will be retained in storage for 1 year and then destroyed unless client advises that an extended time period is required.
- 3) Topsoil quantities should not be established from the information provided at the borehole locations.
- 4) This drawing forms part of the report, project number as referenced, and should be used only in conjunction with this report.

GEOCRES # 31G-216



METRIC

SCALE 1:400



TROW CONSULTING ENGINEERS LTD.
BRAMPTON BRANCH

BOREHOLE LOCATION PLAN
PROPOSED CROSSING AT KING'S
HIGHWAY 34 AND RIGAUD RIVER
LOT 1 CONCESSION 7 TWP KENYON
LOT 38 CONCESSION 6 TWP LOCHIEL
LAGGAN ONTARIO

PROJECT NO.: BR-10697-A
SCALE: 1:400
DRAWN BY: JI
CHECKED BY: SDH
DATE: OCTOBER 1996
DRAWING NO.: 1

RECORD OF BOREHOLE 1

1 OF 1

METRIC

W.P. 317-94-00

LOCATION N 5027.9810km E 210.4610km

ORIGINATED BY S.D.H.

DIST 23+059 HWY 34

BOREHOLE TYPE H.S. Augers, NQ Core Barrel, SPT

COMPILED BY S.D.H.

DATUM Geodetic

DATE 1996 October 21

CHECKED BY S.E.G.

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE			10	20	30	40					
84.18	GROUND SURFACE														
0.00	200mm ASPHALTIC CONCRETE														
83.93	280mm CONCRETE														
0.25															
83.63															
0.55	FILL - predominantly clayey silt (ML-CL) with some gravel and coarse sand, some zones of organic material, moist to very moist, grey and brown, soft to firm.		1	SPT	9										
			2	SPT	10									19.20	
			3	SPT	5										
			4	SPT	3									22.50	
79.46															
4.72	SILT and GRAVEL till (ML-GL) - with sand, trace of clay, wet, grey, dense.		5	SPT	30										
78.69															
5.49	SHALY LIMESTONE - grey, fine to medium grain, medium strong. Fracture spacing: moderately close. Fracture Orientation: 85-90 deg. to core axis. Fair Rock Mass Quality.		1	NQ											REC 100% RQD 60%
77.68															
6.50	SHALE - occasional shaly limestone seams (50-100 mm thick), dark grey, fine grain, weak. Fracture spacing: moderate to close. Fracture Orientation: 85-90 deg. to core axis. Fair Rock Mass Quality.		2	NQ											REC 100% RQD 65%
75.65															
8.53	End of Borehole														

RECORD OF BOREHOLE 2

1 OF 1

METRIC

W.P. 317-94-00

LOCATION N 5027.9850km E 210.4670km

ORIGINATED BY S.D.H.

DIST 23+059 HWY 34

BOREHOLE TYPE H.S. Augers, NQ Core Barrel, SPT

COMPILED BY S.D.H.

DATUM Geodetic

DATE 1996 October 22

CHECKED BY S.E.G.




SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE			10	20	30	40					
84.19	GROUND SURFACE														
84.00	150 mm ASPHALTIC CONCRETE														
0.18	280 MM CONCRETE														
83.76	FILL - predominantly clayey silt (ML-CL) with some gravel and coarse sand, some zones of organic material, moist to very moist, grey and brown, soft to firm.		1	SPT	7									21.50	
83.43			2	SPT	7										
			3	SPT	4										
			4	SPT	4										
79.31	SILT and GRAVEL till (ML-GL) - with sand, trace of clay, wet, grey, dense.		5	SPT	27									22 38 38 2	
4.88															
78.70	SHALY LIMESTONE - grey, fine to medium grain, medium strong. Fracture spacing: very close in upper 0.3 m, close for remainder. Fracture Orientation: 85-90 deg. to core axis. Poor Rock Mass Quality.		1	NQ										REC 100% RQD 28%	
5.49															
77.24	SHALE - occasional shaly limestone seams (50-100 mm thick), dark grey, fine grained, medium strong. Fracture spacing: moderately close. Fracture Orientation: 85-90 deg. to core axis. Poor Rock Mass Quality.		2	NQ										REC 100% RQD 48%	
6.95															
75.66	End of Borehole														
8.53															

RECORD OF BOREHOLE 3

1 OF 1

METRIC

W.P. 317-94-00 LOCATION N 5027.9640km E 210.4700km ORIGINATED BY S.D.H.
 DIST 23+037 HWY 34 BOREHOLE TYPE H.S. Auger, NQ Core Barrel, SPT COMPILED BY S.D.H.
 DATUM Geodetic DATE 1996 October 22 CHECKED BY S.E.G.

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT wp	NATURAL MOISTURE CONTENT w	LIQUID LIMIT wl	UNIT WEIGHT kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION			
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE			BLOWS/0.3m	10	20	30					40	10	20	30
84.15	GROUND SURFACE																	
84.00	150 mm ASPHALTIC CONCRETE																	
83.80	200 mm CONCRETE																	
83.80	FILL - predominantly clayey silt (ML-CL) with some gravel and coarse sand, some zones of organic material, moist to very moist, grey and brown, soft to firm.		1	SPT	11													
83.60			2	SPT	3													
83.40			3	SPT	3													
83.20			4	SPT	16													
83.00			5	SPT	25													
79.27	SILT and GRAVEL till (ML-GL) - with sand, trace of clay, wet, grey, dense (inferred from drill rates)																	
78.66	SHALY LIMESTONE - grey, fine to medium grain, weak to medium strong. Fracture spacing: close in upper 0.4 m and moderate close for remainder. Fracture Orientation: 85-90 deg. to core axis. Poor to Fair Rock Mass Quality.		1	NQ														REC 100% RQD 53%
76.90	SHALE - occasional shaly limestone and mud stone seams (50-150 mm thick), fine grain. Fracture spacing: medium close. Fracture Orientation: 85-90 deg. to core axis. Fair Rock Mass Quality.		2	NQ														REC 100% RQD 72%
75.62	End of Borehole																	

METRIC

CHECKED BY S.E.G.

MTO 10697 96/12/10

RECORD OF BOREHOLE 5

1 OF 1

METRIC

W.P. 317-94-00

LOCATION N 5027.9380km E 210.5000km

ORIGINATED BY S.D.H.

DIST 23+002 HWY 34

BOREHOLE TYPE H.S. Augers, SPT

COMPILED BY S.D.H.

DATUM Geodetic

DATE 1996 October 25

CHECKED BY S.E.G.

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT wp	NATURAL MOISTURE CONTENT w	LIQUID LIMIT wl	UNIT WEIGHT kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE			10	20	30	40					
84.13	GROUND SURFACE														
0.00	ORGANIC CLAYEY SILT (CL-OL) - root fibres, some fine sand, moist, brown, firm to stiff.		1	SPT	8	84	⊗					○			
83.95 0.18															
	SILTY CLAY (CL) - some fine sand, moist, brown, firm to stiff		2	SPT	10	83	⊗						○		
82.73 1.40	SILT and GRAVEL till (ML-GL) - with sand, trace of clay, grey, wet, dense.		3	SPT	38					⊗		○			
82.15 1.98	End of Borehole														

RECORD OF BOREHOLE 6

1 OF 1

METRIC

W.P. 317-94-00

LOCATION N 5027.9590km E 210.5000km

ORIGINATED BY S.D.H.

DIST 23+017 HWY 34

BOREHOLE TYPE H.S. Auger, STP

COMPILED BY S.D.H.

DATUM Geodetic

DATE 1996 October 25

CHECKED BY S.E.G.

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE			10	20	30	40					
82.11	GROUND SURFACE														
0.00	ORGANIC CLAYEY SILT (CL-OL) - root fibres, some fine sand, moist, brown, firm to stiff		1	SPT	3	82								16.40	
81.54															
0.57	SILT and GRAVEL till (ML-GL) - with sand, trace of clay, wet, grey, dense.		2	SPT	23	81									
			3	SPT	26										
80.13															
1.98	End of Borehole														

RECORD OF BOREHOLE 7

1 OF 1

METRIC

W.P. 317-94-00

LOCATION N 5027.9740km E 210.4960km

ORIGINATED BY S.D.H.

DIST 23+033 HWY 34

BOREHOLE TYPE H.S. Auger, SPT

COMPILED BY S.D.H.

DATUM Geodetic

DATE 1996 October 25

CHECKED BY S.E.G.

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE			10	20	30	40					
82.20	GROUND SURFACE														
0.00	ORGANIC CLAYEY SILT (CL-OL) - root fibres, some fine sand, very wet, brown, soft to firm.		1	SPT	4									16.00	
80.90			2	SPT	2										
1.30	SILTY CLAY (CH) - high plasticity, sensitive, very wet, grey, soft to firm		3	SPT	4										
80.20			4	SPT	42										
2.00	SILT and GRAVEL till (ML-GL) - with sand, trace of clay, wet, grey, dense		5	SPT	82										
78.75	Probable Bedrock														N = 82/254mm
3.45	End of Borehole Notes: 1. Borehole terminated on probable bedrock.														

RECORD OF BOREHOLE 8

1 OF 1

METRIC

W.P. 317-94-00

LOCATION N 5027.9790km E 210.4900km

ORIGINATED BY S.D.H.

DIST 23+049 HWY 34

BOREHOLE TYPE H.S. Auger, NQ Core Barrel, SPT

COMPILED BY S.D.H.

DATUM Geodetic

DATE 1996 October 25

CHECKED BY S.E.G.

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT wp	NATURAL MOISTURE CONTENT w	LIQUID LIMIT wl	WATER CONTENT (%)	UNIT WEIGHT kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE			10	20	30	40						
81.99 0.00	GROUND SURFACE															
	ORGANIC CLAYEY SILT (CL-OL) - root fibres, some fine sand, moist, brown, firm to stiff.		1	SPT	3		⊗								16.10	
			2	SPT	6		81	⊗								
80.47 1.52	SILT and GRAVEL till (ML-GL) - some sand, trace of clay, wet, grey, dense.		3	SPT	23			⊗								
			4	SPT	47				⊗							
78.94 3.05	SHALY LIMESTONE - grey, fine to medium grain, medium strong. Fracture spacing: close to moderate close. Fracture Orientation: 85-90 deg. to core axis. Poor to Fair Rock Mass Quality.		1	NQ												REC 81% RQD 55%
77.04 4.95	SHALE - occasional shaly limestone seams (50- 100 mm thick), dark grey, fine grain, weak. Fracture spacing: moderate close. Fracture Orientation: 85-90 deg. to core axis. Fair to Good Rock Mass Quality.		2	NQ												REC 90% RQD 78%
75.89 6.10	End of Borehole															

RECORD OF BOREHOLE 9

1 OF 1

METRIC

W.P. 317-94-00

LOCATION N 5028.0150km E 210.4770km

ORIGINATED BY S.D.H.

DIST 23+079 HWY 34

BOREHOLE TYPE H.S. Auger, SPT

COMPILED BY S.D.H.

DATUM Geodetic

DATE 1996 October 25

CHECKED BY S.E.G.

SOIL PROFILE				SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION										
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS/0.3m			10	20	30	40									SHEAR STRENGTH: Cu, KPa				WATER CONTENT (%)		
								UNCONFINED QUICK TRIAXIAL				FIELD VANE LAB VANE														
82.57	GROUND SURFACE																									
0.00 82.37 0.20	ORGANIC CLAYEY SILT (CL-OL) - root fibres, some fine sand, moist, brown, stiff		1	SPT	6		⊗							○				0	5	35	60					
	SILTY CLAY (CL-CH) - some fine sand, moist, brown, firm becomming soft below El. 81.2 m		2	SPT	7		⊗								○											
			3	SPT	2		⊗								○	59.5										
80.59 1.98	End of Borehole																									

RECORD OF BOREHOLE 10

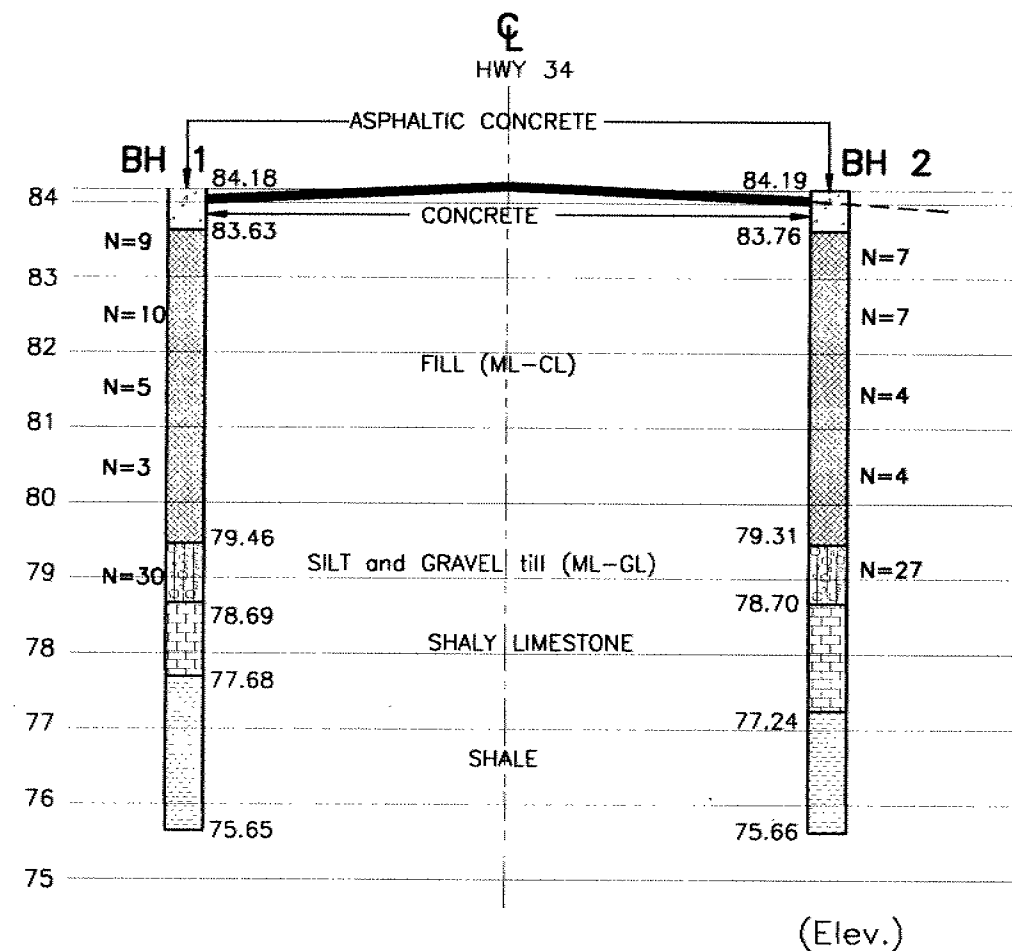
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METRIC

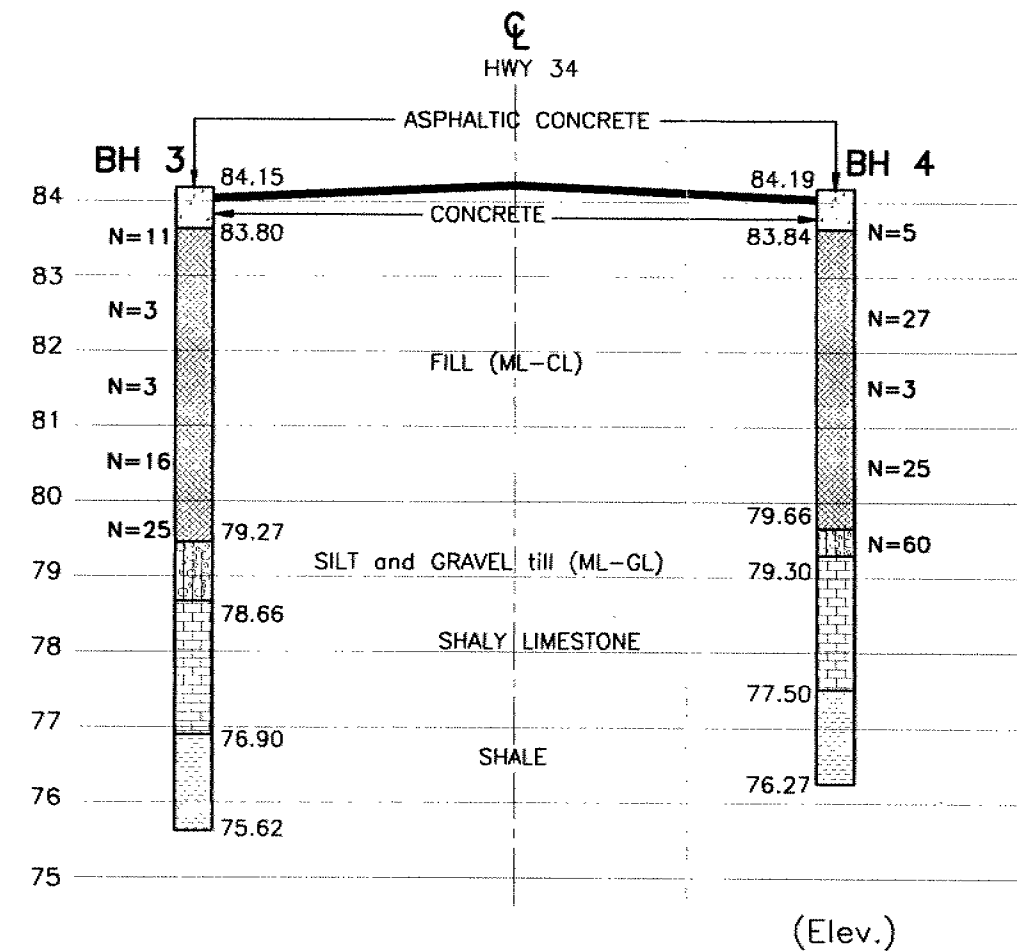
W.P. 317-94-00 LOCATION N 5028.0370km E 210.4600km ORIGINATED BY S.D.H.
 DIST 23+105 HWY 34 BOREHOLE TYPE H.S. Auger, SPT COMPILED BY S.D.H.
 DATUM Geodetic DATE 1996 October 25 CHECKED BY S.E.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE (metres)	STANDARD PENETRATION TEST (N Value)				PLASTIC LIMIT wp	NATURAL MOISTURE CONTENT w	LIQUID LIMIT wl	UNIT WEIGHT kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION GR SA SI CL	
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS/0.3m			10 20 30 40									WATER CONTENT (%)
								SHEAR STRENGTH: Cu, KPa				WATER CONTENT (%)					
								UNCONFINED QUICK TRIAXIAL	FIELD VANE LAB VANE								
								20 40 60 80									
82.87	GROUND SURFACE																
0.00	ORGANIC CLAYEY SILT (CL-OL)		1	SPT	8			⊗									
82.67	- root fibres, some fine sand,																
0.20	moist, brown, stiff																
	SILTY CLAY (CL-CH) - some fine		2	SPT	12		82	⊗									
	sand, moist, brown, firm to stiff.																
			3	SPT	8		81	⊗									
80.89	End of Borehole																
1.98																	

Appendix C: Stratigraphies Beneath Bridge Abutments & Temporary Detour



SECTION A-A' (NORTH ABUTMENT)



SECTION B-B' (SOUTH ABUTMENT)

SOIL STRATIGRAPHY BELOW NORTH AND SOUTH BRIDGE ABUTMENT

GEOCRES # 31G-216

METRIC



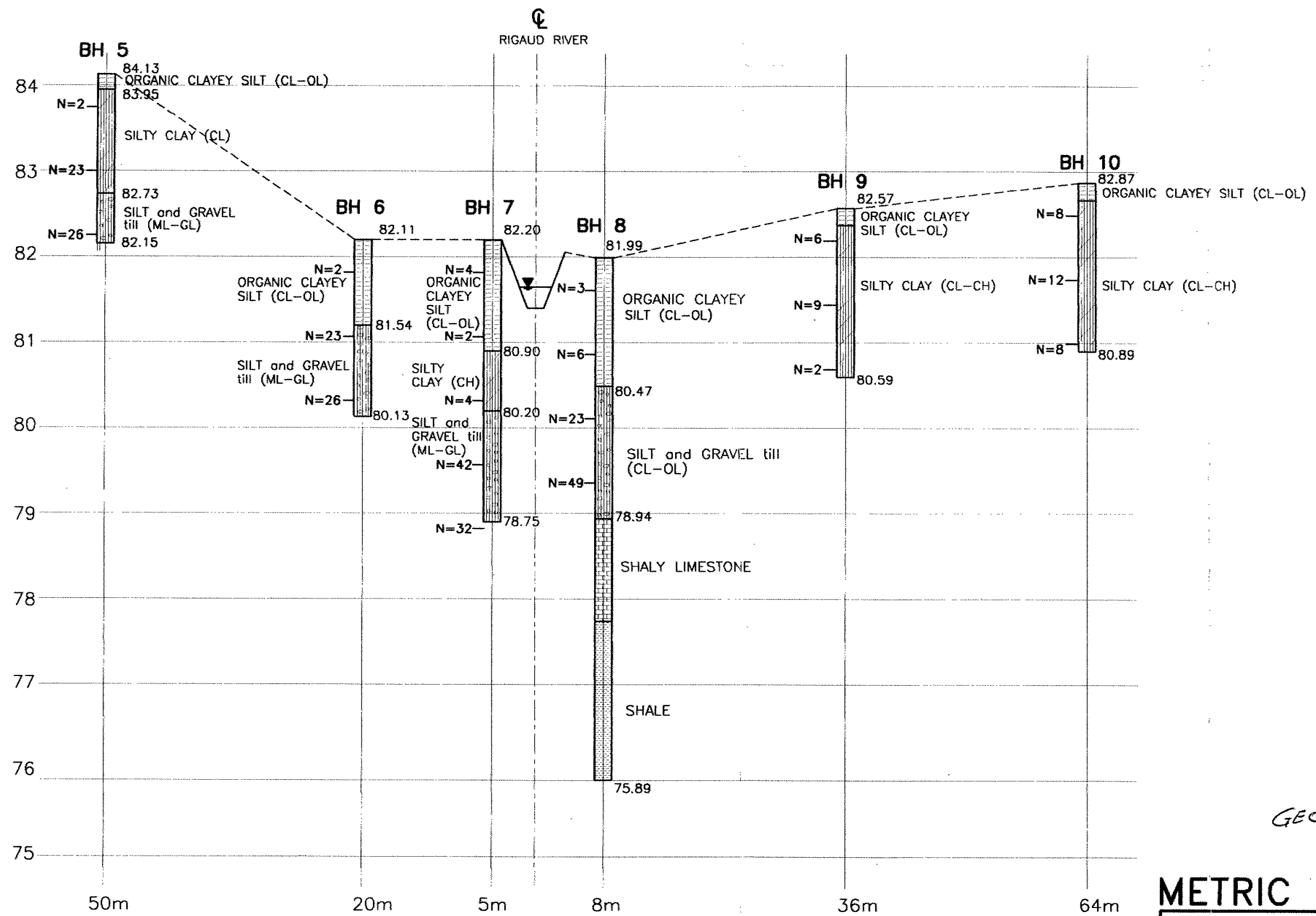
TROW CONSULTING ENGINEERS LTD.
BRAMPTON BRANCH

**GEOTECHNICAL INVESTIGATION
RIGAUD RIVER
BRIDGE REPLACEMENT**

LAGGAN

ONTARIO

PROJECT NO.:	BR-10697-A
SCALE:	1:100
DRAWN BY:	VB
CHECKED BY:	SDH
DATE:	NOVEMBER 1996
DRAWING NO.:	1



SUMMARY OF SOIL STRATIGRAPHY FOR PROPOSED ALIGNMENT
OF TEMPORARY DETOUR AND CULVERT

GEOCPRES # 31G-216

METRIC

TROW CONSULTING ENGINEERS LTD.
BRAMPTON BRANCH

GEOTECHNICAL INVESTIGATION
RIGAUD RIVER
BRIDGE REPLACEMENT

PROJECT NO.:	BR-10697-A
SCALE:	H=1:500, V=1:50
DRAWN BY:	VB
CHECKED BY:	SH
DATE:	NOVEMBER 1996
DRAWING NO.:	2

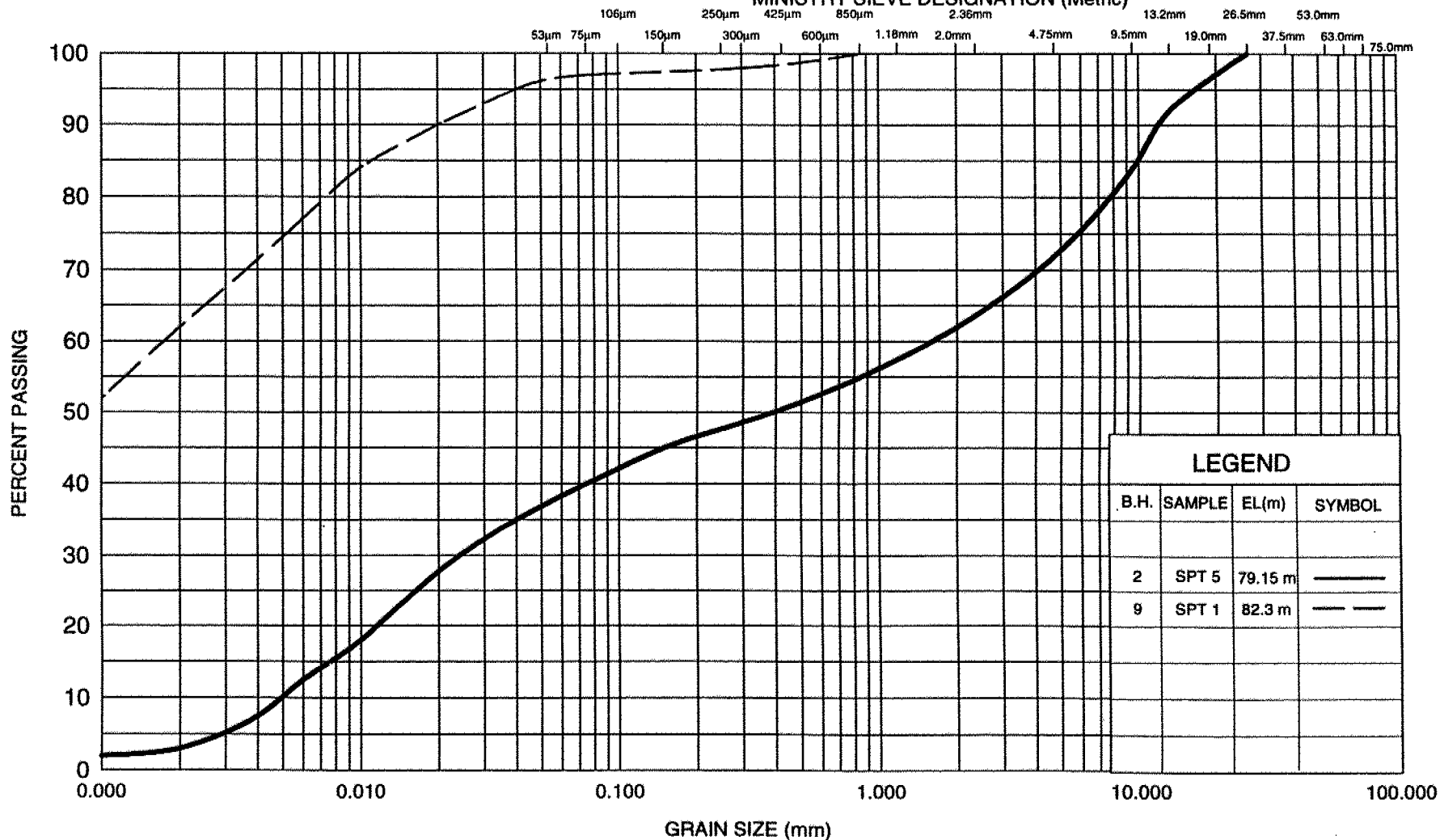
LAGGAN ONTARIO

Appendix D: Laboratory Results

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT	SAND			GRAVEL	
	FINE	MEDIUM	COARSE	FINE	COARSE

MINISTRY SIEVE DESIGNATION (Metric)



Ministry of
Transportation

METRIC

GRAIN SIZE DISTRIBUTION

B.H. 2 - SAMPLE 5: SILT and GRAVEL till (ML-GL) - with sand and a trace of clay.

B.H. 9 - SAMPLE 1: SILTY CLAY (CH)

FIGURE 1

W.P. 317-94-00

Client: **Trow Markham**
 Attention: **Clement Chow**
 Project: **BR 10697 A**
 P.O.:
 Sample Type: **Water**
 Date Received: **Oct 28/96**
 Date Reported: **Oct 30/96**

ENTECH

A Division of Agri-Service Lab Inc.
 6820 Kilmat Rd., Unit #4
 Mississauga, ONT L5N 5M3
 TEL: (905) 821-1112
 FAX: (905) 821-2095

MISC. SAMPLE TEST

PARAMETER	Units	Method	CONTROL SAMPLE			SAMPLE DATA			
		Detection	Expected	Found	Recovery	24558			
		Limit (ug/ml)	(ug/ml)	(ug/ml)	%	BH3			
pH	-	-	9.08	8.91	98	7.27			
Sulphate	ug/ml	0.2	400	412.5	103	23.5			



Sam Sanyal, M.Sc., C. Chem