DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 41P-19

DIST. 14 REGION

W.P. No. 196-88-02

CONT. No. 92-450

W. O. No.

STR. SITE No. 46-18

HWY. No. 560

LOCATION Hwy 560 & West Montreal River

No of PAGES - —

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATION INVESTIGATION REPORT

CONTRACT NO. 92-450

Ontario

Ministry of
Transportation

INDEX

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

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 (R Q D), 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

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

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
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

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

REPORT ON
FOUNDATION INVESTIGATION
FOR PROPOSED
WEST MONTREAL RIVER BRIDGE
WP-196-88-02: SITE 46-18
DIST. 14 REG. NORTHERN

1. INTRODUCTION

B.P. Walker Associates Limited, Consulting Geotechnical, Inspection and Testing Engineers, was authorized by the Ministry of Transporation, Ontario to conduct a geotechnical investigation at the site of the proposed West Montreal River Bridge. The new structure will be located approximately 50m north of the existing bridge location. Conceptual design data regarding the project were transmitted to us by the Ministry.

The purpose of the geotechnical investigation was to explore the subsurface conditions by means of boreholes for the design and construction of the foundations for the bridge. This report presents a brief account of the procedures followed in the investigation, the field and laboratory test results, and our interpretation of the findings.

2. THE SITE AND GEOLOGY

The site is located on the West Montreal River at the proposed Highway 560 relocation near the Town of Shining Tree. The area is part of the Canadian Shield and the rock formation is classified as Precambrian. The bedrock, except at outcrop locations, is mostly covered with a thin mantle of drift which includes ground moraine, silt and talus.

The topography of the area is gently rolling with infrequent bedrock outcrops. The glacio-lacustrine deposits in the river bed consist of sand, gravels and silt and have been deposited following the last glaciation.

3. FIELD WORK

Two boreholes, numbered 1 and 2, were drilled as shown on the borehole location plan, Drawing 1968802-A*. In addition, dynamic cone penetration tests were carried out at two locations, also shown on the drawing, to estimate probable bedrock elevation.

Borehole 1 was drilled on May 5, 1990, to a depth of 4.0m. Borehole #2 could not be drilled during that period as the sandbar at the location of proposed west abutment was under water and the water current was too strong for conventional drill equipment to be used. Borehole #2 and dynamic cone penetration tests were carried out on August 8 and 9, 1990. A bombardier mounted drilling rig, equipped with solid stem augers and BXC core for coring the bedrock were used for advancing the holes. The boreholes were advanced to refusal using continuous flight augers. Below the refusal depth the borehole was advanced using diamond drilling. The drilling, sampling and the field testing procedures were supervised and the borings were logged by an experienced geotechnical engineer from our office.

Dynamic cone penetration tests were performed on the sand bar to estimate the probable elevation of the bedrock.

Samples of overburden at the sand bar, borehole 2, were taken with a 51mm o.d. split spoon (SS) in accordance with ASTM D 1586-84, Standard Method for PENETRATION TEST AND SPLIT BARREL SAMPLING OF SOILS. Although the recovered samples are disturbed, they are representative of the stratum from which they were obtained and the STANDARD PENETRATION RESISTANCE (N-values) indicates the relative density or consistency of the sampled soil. In the dynamic cone penetration test a 50mm diameter cone is driven with the same driving energy as in the Standard Penetration Test.

* SHEET NO 96 OF THE CONTRACT DWG'S

4. SUBSURFACE CONDITIONS

(a) East Abutment - The overburden on the bedrock at this location consisted of 0.3m of peat followed by 0.5m of sandy silt, trace clay and gravel with some organics.

(b) West Abutment - The west abutment of the proposed bridge is on an existing sandbar. The overburden at this location consists of 0.5m of peat over a deposit of sand with gravel, trace silt and contains layers of organics. Pebbles and boulders were encountered at a depth of 2.7m below the ground surface. Refusal to auger was encountered at a depth of 3.5m, probably on a boulder. Bedrock contact was made at a depth of 4.1m below the ground surface.

The description of the soils encountered at the two boreholes is given in the Record of Borehole Drawings. The estimated stratigraphy profile shown on Drawing 1968802-A* is based on this information. From ground level downwards, the subsurface conditions in detail are as follows:

Peat

Peat varying in thickness from 0.5m to 0.8m was encountered at boreholes 1 and 2 respectively. At borehole #1, the peat is fibrous, black and compressible. At borehole #2, the peat is fibrous but has layers of very fine to fine sand.

Sandy Silt

The overburden of borehole #1, consists of a deposit of sandy silt, trace clay and gravel and contains some organics.

* SHEET NO 96 OF THE CONTRACT DWG'S

Sand with Gravel, Trace Silt

The overburden at borehole #2 consists of a deposit of fine to medium grained sand and gravel, trace silt and contains layers of organics. The denseness of this deposit, based on the N-values, is very loose to loose. The high N-value below the depth of 3.0m is probably due to boulders or cobbles in the deposit.

Boulders

At borehole #2, refusal to augers was encountered below the sand and gravel deposit at a depth of 3.5m below the ground surface. Core drilling was started from the refusal depth. Cuttings from the drilling showed a mixture of sand and rock powder and the core recovery was minimal indicating boulders mixed with sand. The elevation of the bedrock was estimated below the depth where no sand was noticed in the core cutting.

Bedrock

The quality of bedrock was found to vary from poor to fair at the west abutment, Borehole 2. At the east abutment, Borehole 1, the bedrock quality is fair to excellent. The bedrock type, recovery and the RQD values at each borehole are as follows:

Borehole 1 - East Abutment - The bedrock at this borehole location is sound pink quartzite. The core recovery at this location was 100%. The RQD values varied from 62% to 100% indicating fair to excellent quality bedrock. Bedrock was exposed at the water level west of the proposed abutment footing. Based on our observations at the site we believe that the difference in elevation of the bedrock, under the proposed footing, will be small.

Borehole 2 - West Abutment - The bedrock at this borehole location is sound greyish pink quartzite and is fractured to a depth of 5.9m below the ground surface. The core recovery at this location varied from 98% to 100%. The RQD values varied from 8.7% to 52.8% indicating poor to fair quality bedrock.

The conclusions given in this report are based on information determined at the borehole locations. The soil stratigraphy and groundwater conditions between and beyond the boreholes may differ from those encountered at the borehole locations and subsurface conditions may become apparent during construction which could not be detected or anticipated from the site investigation. Also, depending on seasonal factors, the water level in the West Montreal River could be at a different level than at the time of the field work.

Note: The preceding report is a copy of the factual information from the Foundation Report prepared by B.P. WALKER ASSOCIATES LTD. (consulting geotechnical engineers for this project), under the technical supervision of the M.T.O. Foundation Design Section.

Dr. B. Iyer, P. Eng.
Senior Foundation Engineer

M.S. Devata, P. Eng.
Chief Foundation Engineer

INDEX

Ministry of Transportation Ontario

10

RECORD OF BOREHOLE No 1

METRIC

W P 196 88 02 LOCATION STN. 161+066; o/s 2m Lt. Ø HWY 560 ORIGINATED [illegible]

DIST 14 HWY 560 BOREHOLE TYPE BXC ROCK CORE COMPILED [illegible]

DATUM GEODETIC DATE May 5, 1990 CHECKED [illegible]

SOIL PROFILE ELEV (DEPTH)	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 2 4 6 8 10	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	WATER CONTENT (%) W P W Wl	'γ'	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
348.4	GROUND SURFACE											
0.0 348.1	PEAT											
0.3 347.9	SANDY SILT [illegible] and gravel, some organics					*	348					
0.8	BEDROCK- [illegible]		1	BXC RC	REC 100%		347					RQD 62%
			2	BXC RC	REC 100%		345					RQD 84%
			3	BXC RC	REC 100%		345					RQD 100%
4.0 344.4	END OF BOREHOLE *Water level not established											

+3, ×5 : Numbers refer to Sensitivity

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

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 2

METRIC

W P 106-88-02 LOCATION STN. 16+014; o/s 2.5m Rt. of Hwy.560 ORIGINATED BY T.O

DIST 14 HWY 560 BOREHOLE TYPE SOLID STEM AUGERS & BXC ROCK CORE COMPILED BY B.G.S

DATUM GEODETIC DATE August 8, 1990 CHECKED BY B.S.S

ELEV (DEPTH)	SOIL PROFILE DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT N	SHEAR STRENGTH (kPa) ○ UNDISTURBED ● REMOULDED + FIELD VANE × LAB VANE	WATER CONTENT (%) Wp W Wl 25 50 75	γ	REMARKS & RATE OF PENETRATION (Y)
346.1	GROUND SURFACE						346					
0.0	PEAT - sand, dark brown, soft		1	SS	1							
345.7												
0.6	SAND WITH GRAVEL, trace silt, organic seams, very loose to very dense		2	SS	2		345					
			3	SS	1							
	Boulders and pebbles below 3.7m.		4	SS	6		344					
	Refusal to auger at 3.7m		5	SS	6½		343					
342.8												
4.1	BOULDERS - mixed with sand		6	BXC RC	REC 0%		342					
342.2												
4.1	BEDROCK - greyish pink quartzite, fractured to depth of 7.0m, sound to massive		7	BXC RC	REC 100%							RQD 21.8%
			8	BXC RC	REC 100%		341					RQD 8.7%
			9	BXC RC	REC 98%		340					RQD 52.8%
338.8							339					
7.3	END OF BOREHOLE											

OFFICE REPORT ON SOIL EXPLORATION

+3, x5 ; Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 3 METRIC

W P 196-88-02 LOCATION STN. 16+030.0, o/s 6.0m Lt. ORIGINATED BY T.O.

DIST 14 HWY 560 BOREHOLE TYPE DYNAMIC CONE TEST COMPILED BY D.D.S.

DATUM GEODETIC DATE August 9, 1990 CHECKED BY D.D.S.

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT Wp	NATURAL MOISTURE CONTENT W	LIQUID LIMIT WL	WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
146.0															
0.2															
142.1															
3.9	PROBABLE BEDROCK														

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 4

METRIC

W P 196-88-02 LOCATION STN. 16+028.5, o/s 3.0m RT. ORIGINATED BY T.C.

DIST 14 HWY 560 BOREHOLE TYPE DYNAMIC CONE TEST COMPILED BY H.G.S.

DATUM GEODETIC DATE August 9, 1990 CHECKED BY H.G.S.

SOIL PROFILE: ELEV (DEPTH)	DESCRIPTION	STRATA PLOT	SAMPLES: NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	WATER CONTENT (%) W_P W W_L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
346.2	WATER SURFACE											
346.0 / 0.2												
344.0												
2.2	PROBABLE BEDROCK											

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

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

B.P. WALKER
Associates Limited

REPORT ON
FOUNDATION INVESTIGATION
FOR PROPOSED
WEST MONTREAL RIVER BRIDGE
WP-196-88-02: SITE 45-18
DIST. 14 REG. NORTHERN

CONT 92-450

Consulting Geotechnical
Inspection and
Testing Engineers

B.P.Walker Associates Ltd.

Consulting Geotechnical, Inspection and Testing Engineers

101 Amber Street, Suite 2, Markham, Ontario, L3R 3B2 (416) 491-4075 Fax. # 475-5376

REPORT ON

FOUNDATION INVESTIGATION

FOR PROPOSED

WEST MONTREAL RIVER BRIDGE

WP-196-88-02: SITE 46-18

DIST. 14 REG. NORTHERN

CONT. 92-A50

Prepared for:

Ministry of Transporation

Foundation Design Section

1201 Wilson Avenue

Downsview, Ontario

M3M 1J8

GEOCRES # 41P-19

Project No. 2340-0590

September 17, 1990

1. INTRODUCTION

B.P. Walker Associates Limited, Consulting Geotechnical, Inspection and Testing Engineers, was authorized by the Ministry of Transporation, Ontario to conduct a geotechnical investigation at the site of the proposed West Montreal River Bridge. The new structure will be located approximately 50m north of the existing bridge location. Conceptual design data regarding the project were transmitted to us by the Ministry.

The purpose of the geotechnical investigation was to explore the subsurface conditions by means of boreholes for the design and construction of the foundations for the bridge. This report presents a brief account of the procedures followed in the investigation, the field and laboratory test results, and our interpretation of the findings.

2. THE SITE AND GEOLOGY

The site is located on the West Montreal River at the proposed Highway 560 relocation near the Town of Shining Tree. The area is part of the Canadian Shield and the rock formation is classified as Precambrian. The bedrock, except at outcrop locations, is mostly covered with a thin mantle of drift which includes ground moraine, silt and talus.

The topography of the area is gently rolling with infrequent bedrock outcrops. The glacio-lacustrine deposits in the river bed consist of sand, gravels and silt and have been deposited following the last glaciation.

3. FIELD WORK

Two boreholes, numbered 1 and 2, were drilled as shown on the borehole location plan, Drawing 1968802-A. In addition, dynamic cone penetration tests were carried out at two locations, also shown on the drawing, to estimate probable bedrock elevation.

Borehole 1 was drilled on May 5, 1990, to a depth of 4.0m. Borehole #2 could not be drilled during that period as the sandbar at the location of proposed west abutment was under water and the water current was too strong for conventional drill equipment to be used. Borehole #2 and dynamic cone penetration tests were carried out on August 8 and 9, 1990. A bombardier mounted drilling rig, equipped with solid stem augers and BXC core for coring the bedrock were used for advancing the holes. The boreholes were advanced to refusal using continuous flight augers. Below the refusal depth the borehole was advanced using diamond drilling. The drilling, sampling and the field testing procedures were supervised and the borings were logged by an experienced geotechnical engineer from our office.

Dynamic cone penetration tests were performed on the sand bar to estimate the probable elevation of the bedrock.

Samples of overburden at the sand bar, borehole 2, were taken with a 51mm o.d. split spoon (SS) in accordance with ASTM D 1586-84, Standard Method for PENETRATION TEST AND SPLIT BARREL SAMPLING OF SOILS. Although the recovered samples are disturbed, they are representative of the stratum from which they were obtained and the STANDARD PENETRATION RESISTANCE (N-values) indicates the relative density or consistency of the sampled soil. In the dynamic cone penetration test a 50mm diameter cone is driven with the same driving energy as in the Standard Penetration Test.

4. SUBSURFACE CONDITIONS

(a) East Abutment - The overburden on the bedrock at this location consisted of 0.3m of peat followed by 0.5m of sandy silt, trace clay and gravel with some organics.

(b) West Abutment - The west abutment of the proposed bridge is on an existing sandbar. The overburden at this location consists of 0.5m of peat over a deposit of sand with gravel, trace silt and contains layers of organics. Pebbles and boulders were encountered at a depth of 2.7m below the ground surface. Refusal to auger was encountered at a depth of 3.5m, probably on a boulder. Bedrock contact was made at a depth of 4.1m below the ground surface.

The description of the soils encountered at the two boreholes is given in the Record of Borehole Drawings. The estimated stratigraphy profile shown on Drawing 1968802-A is based on this information. From ground level downwards, the subsurface conditions in detail are as follows:

Peat

Peat varying in thickness from 0.5m to 0.8m was encountered at boreholes 1 and 2 respectively. At borehole #1, the peat is fibrous, black and compressible. At borehole #2, the peat is fibrous but has layers of very fine to fine sand.

Sandy Silt

The overburden of borehole #1, consists of a deposit of sandy silt, trace clay and gravel and contains some organics.

Sand with Gravel, Trace Silt

The overburden at borehole #2 consists of a deposit of fine to medium grained sand and gravel, trace silt and contains layers of organics. The denseness of this deposit, based on the N-values, is very loose to loose. The high N-value below the depth of 3.0m is probably due to boulders or cobbles in the deposit.

Boulders

At borehole #2, refusal to augers was encountered below the sand and gravel deposit at a depth of 3.5m below the ground surface. Core drilling was started from the refusal depth. Cuttings from the drilling showed a mixture of sand and rock powder and the core recovery was minimal indicating boulders mixed with sand. The elevation of the bedrock was estimated below the depth where no sand was noticed in the core cutting.

Bedrock

The quality of bedrock was found to vary from poor to fair at the west abutment, Borehole 2. At the east abutment, Borehole 1, the bedrock quality is fair to excellent. The bedrock type, recovery and the RQD values at each borehole are as follows:

Borehole 1 - East Abutment - The bedrock at this borehole location is sound pink quartzite. The core recovery at this location was 100%. The RQD values varied from 62% to 100% indicating fair to excellent quality bedrock. Bedrock was exposed at the water level west of the proposed abutment footing. Based on our observations at the site we believe that the difference in elevation of the bedrock, under the proposed footing, will be small.

Borehole 2 - West Abutment - The bedrock at this borehole location is sound greyish pink quartzite and is fractured to a depth of 5.9m below the ground surface. The core recovery at this location varied from 98% to 100%. The RQD values varied from 8.7% to 52.8% indicating poor to fair quality bedrock.

5. DISCUSSION AND RECOMMENDATIONS

5.1 Project

The proposed structure is approximately 50m north of the existing bridge. According to the conceptual layout drawings, obtained from MTO, the top of the bridge will be at an elevation of approximately 353.0m at the center of the bridge.

The proposed structure will be of single span construction with a span of approximately 32.0m.

5.2 Foundations

Spread Footings on Bedrock

(a) East Abutment (Borehole 1) - Spread footings on bedrock will require excavation to an elevation of 347.6m. For footings placed on sound bedrock, the Factored Bearing Capacity at Ultimate Limit State (qf) is 4000 kPa. The bearing capacity at Serviceability Limit State Type II (qs) need not be considered.

We recommend that all lateral forces along the footing base for east abutment be resisted by a key cut into the sound bedrock below the footing or by dowels, grouted into the sound bedrock. The minimum depth of the key should be 0.5m. Provided that concrete is placed against the 'undisturbed' rock face the key should provide a resisting pressure of 2000 kPa against lateral forces.

Driven Piles to Bedrock

(b) West Abutment - (Borehole 2, Cones 3 & 4) - The proposed abutment founding elevation is estimated to be about El. 350.0m. The existing ground surface at this location is at an elevation of 346.3m and will require an addition of more than 4.0m of fill, after removal of the peat layer, to bring the existing ground surface to the estimated founding elevation.

The bedrock elevation at this location is estimated at elevation varying from 342.2m to 344.0m, approximately 2.2m to 4.0m below the existing water level. Excavation for footings on bedrock will require extensive dewatering. A cofferdam using sheet piles or equivalent will have to be constructed for dewatering. It is our opinion that driving sheet piles to the bedrock will be difficult and complete dewatering might not be achieved due to a layer of boulders immediately above the bedrock.

In view of these conditions we believe that driven piles will be the most suitable foundation type for this abutment.

We recommend that peat and any organic material be removed from the road alignnment and the west abutment location. The west approach to the bridge should be constructed in accordance with the current Ministry of Transportation of Ontario Specification to the proposed footing elevation of the abutment. This will enable the piles to be driven from a dry platform.

HP310X100 piles, equipped with reinforced tip and driven with a suitable pile driving hammer to refusal on the bedrock, should be designed for a Factored Capacity of 2700 kN at Ultimate Limit States (qf). The bearing capacity at Serviceability Limit State Type II (qs) need not be considered.

Caissons or spread footings founded on sound bedrock are other foundation alternatives. These alternatives would require extensive dewatering. They will also be expensive and difficult to install due to the layer of boulders immediately above the bedrock.

The total and differential settlement of the bridge foundations constructed as recommended above will be negligible.

5.3 Bridge Approaches

The depth of fill at the east and west bridge approaches will be approxiamtely 4.5m and 7.0m, respectively. We recommend that all peat and organic material be removed from the road alignment prior to placing the fill.

The fill for the east approach to the bridge will be placed on top of a thin layer of sandy silt over bedrock and the settlement of the embankment will be minor.

The subsoil under the west approach to the bridge is a very loose to loose sand, with thin organic layers and the height of the embankment will be more than 7.0m.

We believe that any settlement of the existing soil will take place during construction of the embankment.

We recommend that the side slopes of the embankment not be steeper than 2 horizontal and 1 vertical and that MTO Standard details and procedures be followed in material selection and placement of fill.

5.4 Backfill

Rigid walls of the bridge abutments should be designed to withstand the at-rest earth pressures which can be approximated using the following equivalent fluid pressures:

At Ultimate Limit State	10 kPa/m
At Serviceability Limit State, Type II	8.5 kPa/m

When using the above values, it is assumed that the slope of the backfill behind the retaining structure is approximately level.

As an alternative to the "equivalent fluid pressure method" the earth pressures can also be calculated using the analytical approach, assuming that backfill to the abutments will consist of Granular 'A' or 'B' type aggregates.

In this case, backfill for the structures should consist of granular materials, in accordance with MTO Standard Special Provision No. 121, dated October, 1983. Earth pressures acting on the wall may be computed in accordance with Section 6.6.1.2.1 of the O.H.B.D.C. assuming a non-yielding foundation where the "at rest" condition applies. The physical properties to be assumed for the backfill are as follows:

Granular "A" - ϕ = 35°, γ = 22.8 kN/m^3 Ko = 0.43
Granular "B" - ϕ = 30°, γ = 21.2 kN/m^3 Ko = 0.50

If some movement of the abutment or the cantilevered wing walls can be tolerated, the earth pressure acting on the wall may be computed using the following active pressure coefficients:

Granular "A" - ϕ = 35°, γ = 22.8 kN/m^3, Ka = 0.27
Granular "B" - ϕ = 30°, γ = 21.2 kN/m^3, Ka = 0.33

Construction joints should be provided between those portions of structure which can yield and those which are rigidly restrained.

Care should be given to avoid the development of large horizontal pressures when compacting the backfill behind the abutments. Vibratory compaction equipment, for use behind retaining structures, must be restricted in size as per current M.T.O. specifications.

6. CLOSURE

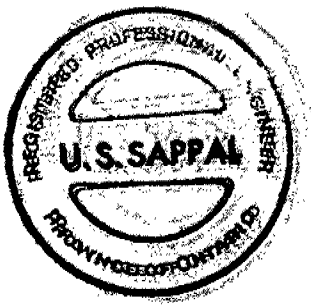
The conclusions and recommendations given in this report are based on information determined at the borehole locations. The soil stratigraphy and groundwater conditions between and beyond the boreholes may differ from those encountered at the borehole locations and subsurface conditions may become apparent during construction which could not be detected or anticipated from the site investigation. Also, depending on seasonal factors, the water level in the West Montreal River could be at a different level than at the time of the field work.

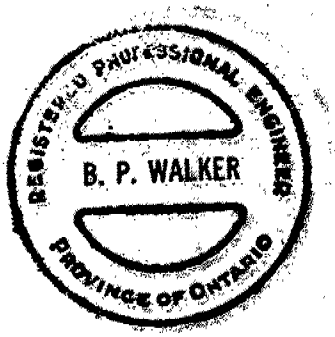
The recommendations given in this report are applicable only to the project described in the text and then only if constructed in accordance with the general principles stated in the report.

Yours very truly,
B.P. WALKER ASSOCIATES LTD.

U.S. Sappal, P.Eng.

Dr. B.P. Walker, P.Eng.
/lb





OVERSIZE DRAWING

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 1

METRIC

W P 196-88-02 LOCATION STN. 16+066; o/s 2m Lt. ℄ HWY 560 ORIGINATED BY T.O.

DIST 14 HWY 560 BOREHOLE TYPE BXC ROCK CORE COMPILED BY U.S.S.

DATUM GEODETIC DATE May 5, 1990 CHECKED BY U.S.S.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT W_p / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_l — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
348.4	GROUND SURFACE										
0.0 348.1	PEAT										
0.3 347.6	SANDY SILT-trace clay and gravel, some organics					*	348				
0.8	BEDROCK- pink quartzite, massive, sound		1	BXC RC	REC 100%		347				RQD=62%
			2	BXC RC	REC 100%		345				RQD=84%
			3	BXC RC	REC 100%		345				RQD=100%
344.4 4.0	END OF BOREHOLE *Water level not established										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 2

METRIC

W P 196-88-02 LOCATION STN. 16+034; o/s 2.5m Rt. ℄ Hwy.560 ORIGINATED BY T.O.

DIST 14 HWY 560 BOREHOLE TYPE SOLID STEM AUGERS & BXC ROCK CORE COMPILED BY D.S.S.

DATUM GEODETIC DATE August 8, 1990 CHECKED BY D.S.S.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
346.3	GROUND SURFACE										
0.0 / 345.7	PEAT-sand, dark brown, soft		1	SS	1		346				
0.6	SAND WITH GRAVEL-trace silt, organic seams, very loose to very dense		2	SS	2						
	Boulders and pebbles below 2.7m.		3	SS	1		345				
			4	SS	6		344				
	Refusal to Auger at 3.5m		5	SS	65		343				
4.1 / 342.2	BOULDERS-mixed with sand		6	BXC RC	REC 0%						
4.1	BEDROCK-greyish pink quartzite, fractured to depth of 5.9m, sound massive		7	BXC RC	REC 100%		342				RQD 21.8%
			8	BXC RC	REC 100%		341				RQD 8.7%
			9	BXC RC	REC 98%		340				RQD 52.8%
338.8							339				
7.5	END OF BOREHOLE										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 3

METRIC

W P 196-88-02 LOCATION STN. 16+030.0, o/s 6.0m Lt. ORIGINATED BY T.O.

DIST 14 HWY 560 BOREHOLE TYPE DYNAMIC CONE TEST COMPILED BY U.S.B.

DATUM GEODETIC DATE August 9, 1990 CHECKED BY U.S.B.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100 — SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE			
346.2											
346.0 / 0.2											
342.3 / 3.9	PROBABLE BEDROCK										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 4 METRIC

W P 196-88-02 LOCATION STN. 16+028.5, o/s 3.0m Rt. ORIGINATED BY T.O.

DIST 14 HWY 560 BOREHOLE TYPE DYNAMIC CONE TEST COMPILED BY U.S.S.

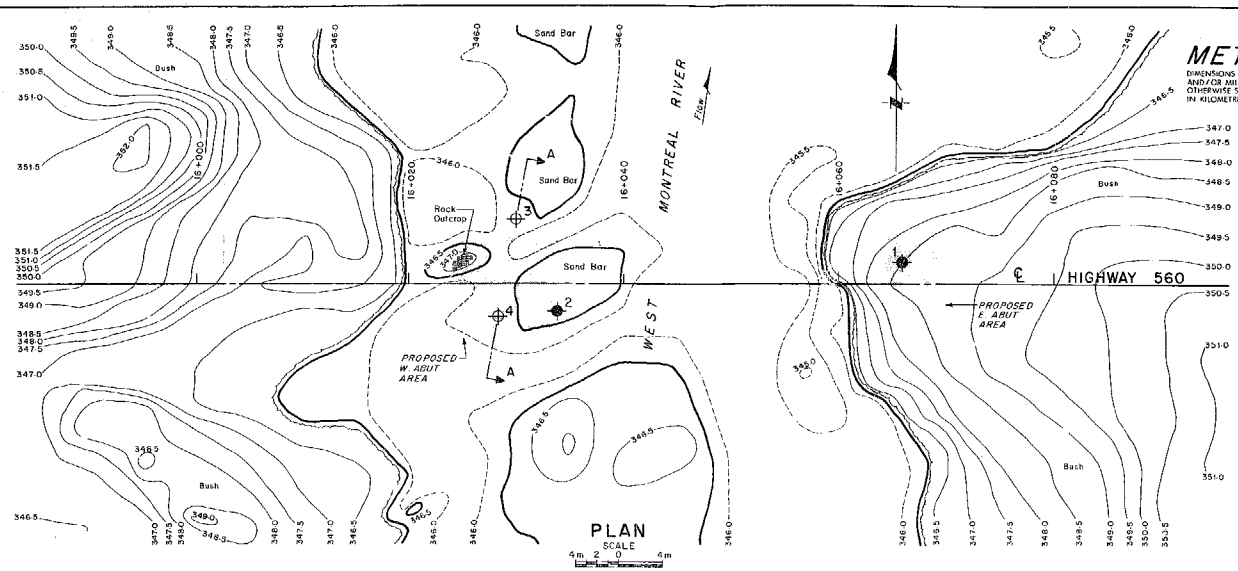
DATUM GEODETIC DATE August 9, 1990 CHECKED BY U.S.S.

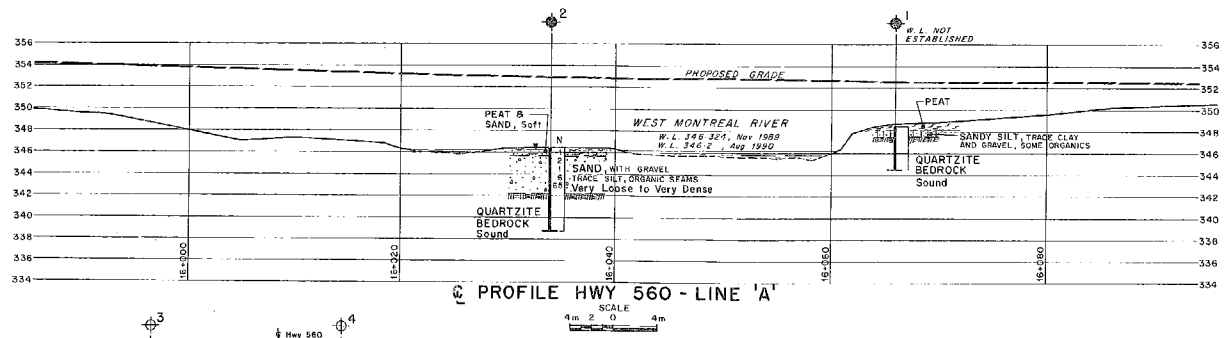
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
346.2	WATER SURFACE										
346.0 / 0.2											
344.0 / 2.2	PROBABLE BEDROCK										

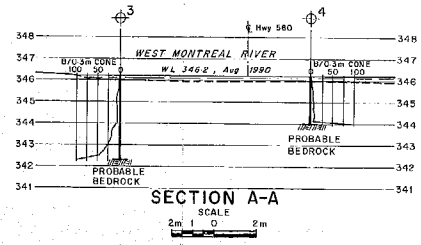
OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

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







METRIC

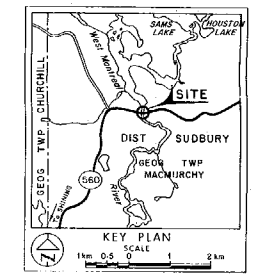
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No
WP No 196-88-02

WEST MONTREAL RIVER | SHEET

BORE HOLE LOCATIONS & SOIL STRATA

B. P. Walker Associates Ltd.



LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0·3m (Std Pen Test, 475 J/blow)
- CONE Blows/0·3m (60° Cone, 475 J/blow)
- W.L at time of investigation 1990 08

No.	ELEVATION	STATION	OFFSET
1	348·4	16+066·0	2·0m Lt
2	346·3	16+034·0	2·5m Rt
3	346·2	16+030·0	6·0m Lt
4	346·2	16+028·5	3·0m Rt

=NOTE=

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV.	DATE	BY	DESCRIPTION

Geocres No 41P-19

HWY No. 560			DIST 14
SUBMD U.S	CHECKED	DATE Sept 27,'90	SITE 46-18
DRAWN P.S	CHECKED	APPROVED	DWG 1968802-A

MINISTRY OF TRANSPORTATION, ONTARIO