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STR. SITE No. 48E-46

HWY. No. 17

LOCATION Hwy 17 & McKellar Creek

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

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FOUNDATION DESIGN SECTION

foundation investigation and design report

F.

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 195-87-01 DIST 18

HWY 17 STR SITE 48E-46

McKellar Creek Culvert at Highway 17

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GEOCRES 42D-15 DATE APR 25 1991

FOUNDATION INVESTIGATION REPORT

For

McKellar Creek Culvert at Highway 17

W.P. 195-87-01, Site 48 E - 46

District 18, Sault Ste. Marie

INTRODUCTION

This report summarizes the results of a foundation investigation conducted for the proposed replacement for McKellar Creek Culvert at Highway 17. The new culvert will be located under a new alignment of Highway 17 about 75 m maximum to the north of the existing.

SITE DESCRIPTION

The site is located at the Highway 17 crossing of McKellar Creek, approximately 34.5 km east of Terrace Bay in the Township of Walsh, District of Sault Ste. Marie. The existing culvert is of 2 m x 2 m boxes and is a tie crib with little bracing. The culvert has shown signs of distress at places. The existing embankment is about 6 m high and at a gradient of 1.25:1 approximately.

According to the Geological Map S265 in Ontario Geological Survey Report GR 164, the site consists largely of deposits of varved or massive clay and silt and bare bedrock.

INVESTIGATION PROCEDURES

The field investigation for this project was conducted between 90 08 20 and 90 08 22 and consisted of three (3) sampled boreholes accompanied by dynamic cone penetration tests and two (2) dynamic cone penetration tests, conducted along the proposed culvert location. A continuous flight track mounted drilling machine equipped with hollow stem augers was used to auger the boreholes. A bulldozer was also employed to remove surficial boulders for advancement of some boreholes.

The locations of the boreholes are shown on Drawing No. 1958701-A.In BH's 1 to 3, soil samples were taken generally at regular intervals in conjunction with standard penetration tests using split spoon samplers. Field vane tests and dynamic cone penetration tests were also carried out to determine the strength of the soil at various depths. The boreholes were advanced to depths of 9.5 to 15.1 m (elevation 177.9 to 183.2 m) where the cone tests were carried out down to refusals at 10.8 to 18.6 m depths (elevation 172.1 to 181.9 m). Only dynamic cone penetration tests were carried out at BH 4 and BH 5 locations. They were carried down to refusals at 11.0 and 14.9 m depths (elevation 182.3 m and 176.4 m respectively).

The following laboratory tests were carried out on representative samples to identify and determine the physical properties of the overburden.

- Grain Size Distribution Analysis
- Natural Moisture Content Determinations
- Atterberg Limits Determinations
- Consolidation Test

SUBSURFACE CONDITIONS

The Record of Borehole sheets in the Appendix illustrate the subsurface conditions at the borehole locations. The locations and elevations of the boreholes, along with stratigraphical profiles based on the borehole data are shown on Drawing No. 1958701-A.

The subsurface stratigraphy typically comprises silty clay overlying silty sand. The silt clay stratum was absent in BH 1.

Silty Clay

This cohesive deposit was encountered in BH's 2 and 3 below a 1 to 2 m thick layer of boulders and granular materials. It is described as silty clay with trace of sand. The consistency of the material is soft to firm. The silty clay stratum extended to a depth of 4.1 to 7.8 m (elevation 188.6 and 182.9 m respectively).

The results of the laboratory testing carried out on the samples retrieved from BH's 2 and 3 are as follows:

Property	Range
Natural Moisture Content (w%)	34 to 51
Liquid Limit (w_L%)	35.5 to 54.5
Plastic Limit (w_P%)	18 to 24.5
Grain Size Distribution (%)	
- Gravel	0
- Sand	0.5 to 1.5
- Silt	22 to 50
- Clay	50 to 78

A consolidation test carried out on a silty clay sample indicated a void ratio of 1.423 and a compression index of 0.153.

Field vane tests carried out on the silty clay material indicated undrained shear strengths of 20 to 45 kPa, but typically between 20 and 25 kPa.

Silty Sand

This non-cohesive deposit was contacted in all boreholes underlying the silty clay stratum except in BH 1 where the silty clay layer was absent. The material is described as a silty sand with trace of clay. It was generally in a loose to compact state but become dense to very dense below a depth of 9 to 15 m, as determined by Standard Penetration tests and Dynamic Cone tests. The deposit was not penetrated at the termination depths of the boreholes.

The results of the laboratory testing carried out on this material are as follows:

Property	Range
Natural Moisture Content (w%)	23
Grain Size Distribution (%)	
- Gravel	0 to 9
- Sand	71 to 92
- Silt	5 to 33
- Clay	2 to 8

GROUNDWATER CONDITIONS

Groundwater levels was measured in open boreholes after completion of the investigation. The groundwater table was found to be at about 1 m below the ground surface, typically between elevations 190 m to 192 m. Seasonal variation is expected.

DISCUSSION AND RECOMMENDATIONS

It is proposed to replace the existing timber box culvert with a new 5.0 m x 2.5 m x 76 m concrete box culvert. The new culvert will be located under a new alignment of Highway 17 about 75 m maximum to the north of the existing alignment.

The recommendations below are limited to the culvert structure only. As indicated in our memo date 90 11 23 to Structural Section of Northwestern Region, there are potential stability and settlement problems on the approaches that require attention. The Northwestern Region Geotechnical Section has requested us to carry out an investigation on the approaches and the recommendations pertaining to this will be under a separate report.

Foundation

Various types of foundations have been considered. Since the Structural Section has indicated in their memo dated 90 12 11 the importance of this highway and the expected long design life, we have ruled out the floating foundation alternative. Two methods of support are recommended as follows:

Shallow Foundation (footings on engineered fill)

It is recommended to remove the soft silty clay in order to minimize consolidation settlements. The existing ground level at the proposed culvert location ranges from 191 to 193.5. Excavation should be carried down to the native loose to compact silty sand, and be then brought up to the design culvert founding elevation with compacted Granular 'A' or rockfill material. The minimum thickness of this pad should be 1 m. The estimated bottom of excavation is given in Table 1.

Table 1

(Hwy. 17 Sta. 14+736) Culvert Sta.	Estimated Bottom of Excavation Elevation
9+963	190.0
9+980	190.0
10+000	188.0
10+020	187.0
10+039	183.5

Excavation limits may be interpolated between these points.

Removal of the soft silty clay can be done by subexcavation and displacement method. Excavation is carried down to remove as much of the soft material as possible, starting from the upstream end of the proposed culvert in order to create the optimum geometry to facilitate displacement of any remaining clay. The maximum depth of excavation may be limited to approximately 6 m due to limitations in equipment. The remaining soft material will have to be displaced by the weight of the backfill. Rockfill should be placed concurrently as the subexcavation advances. It is recommended a surcharge be applied by placing an additional 2 m of rockfill above final grade as a rolling surcharge that would be advanced as the concurrent subexcavation/backfilling operation progressed. The rolling surcharge should be over the full width of the excavation, extending 6 m from the advancing crest. The weight of the backfill will displace the soft clay as the operation advances to the other end of the culvert. The "mudwaves" generated should be removed so that displacement is not impeded. The length of the excavation should extend at both ends to allow for an assumed 1:1 load distribution gradient, as shown in Figures 1a and 1b.

As the existing groundwater table is close to the ground surface, excavation will be carried out down to considerable depth (3 to 7 m) below the groundwater table. In order to eliminate disturbance to the subsoil, one of the following alternative measures has to be taken.

Subexcavation and Displacement with partial dewatering.

Subexcavation and displacement of soft material by a rolling surcharge of rockfill as described above is carried out without dewatering. When the rockfill pad is formed to the design elevation of the base of he proposed culvert, dewatering will be carried out by sump pumping in a perimeter drainage system to provide a dry founding base for placement of concrete. The bearing surface of the rockfill should be chinked with low slump concrete to provide a working mat.

Subexcavation and Displacement in the dry:

Two methods of dewatering may be employed.

1. Well-points - A series of well-points may be installed around the perimeter of the excavation to drawdown the groundwater prior to excavation. Temporary construction slopes may be cut to as steep as 1H:1V. At wet areas or seepage zones, flatter gradient will probably be required. Backfilling and compaction in dry may be controlled to achieve a high compactness of the granular pad.

2. Sheetpiling - Sheetpiles can also be used to support the excavation and cut off the groundwater seepage. For dewatering purposes, the minimum depth of penetration of the sheetpile below the base of the excavation should be 0.75 times the height of the prevailing groundwater above the base of the cut. Earth pressure stability would still require analysis using parameters provided below. Cross braking or rakes may be required for support.

Silty Clay	Silty Sand
ϕ=0°, C_u=20 kPa	ϕ=30°, C=0
bulk unit weight=20 kN/m^3	bulk unit weight=20 kN/m^3

(assume that the groundwater is at ground surface)

Both of the above methods can provide good site control over excavation and backfilling operations. However, they would also be quite costly to implement. In our opinion, the first scheme which involves subexcavation and displacement with only partial dewatering is strongly recommended.

The bearing capacities recommended as per the O.H.B.D.C. are as follows:

Granular 'A' engineered fill

Factored Bearing Capacity at U.L.S. = 900 kPa
Bearing Capacity at S.L.S. Type II* = 350 kPa

Rockfill

Factored Bearing Capacity at U.L.S. = 675 kPa
Bearing Capacity at S.L.S. Type II* = 250 kPa

*Settlement of the structure constructed in accordance with the above recommendations is anticipated to be in the order of 150 mm. It is therefore recommended that the culvert be constructed with a 300 mm mid-span camber and fall towards the outlet, to provide for the possible future settlements. An articulated joint should be constructed at the camber location.

The minimum earth cover required for frost protection is 2.2 m, unless if the box culvert is structurally designed to withstand frost pressures.

Backfill to the culvert may consist of rockfill and granular material. Reference is made to OPSD 803 standards for details. Only free draining granular material should be used below the groundwater table. If rockfill is used as backfill and bedding to the culvert, consideration should be given to specifying a 500 mm cushion around the culvert consisting of well graded rockfill with particle sizes less than 300 mm.

Deep Foundation (H-piling)

Deep foundation in the form of H-piles can be used to support the culvert structure. Piles driven to bedrock or into the competent stratum at about 9 to 18 m below the proposed invert elevations of the culvert would be capable of supporting the structure with minimal settlements.

This alternative of support is provided only because it was specifically requested by the Structural Section. In our opinion, it is not the most practical alternative from a geotechnical point of view due to concerns about stability of the approach embankments, necessity to design stable slopes even at the culvert abutment locations, and the probability of differential settlements between the culvert and its approaches.

Table 2

(Hwy. 17 Sta. 14+736) Culvert Sta.	Estimated Pile Tip Elevation (m)
9+963	172
9+980	179
10+000	182
10+020	177
10+039	172

During the field investigation it was not anticipated that deep foundations would be considered, and hence the boreholes were terminated above the end bearing strata. Furthermore, the subsurface conditions are extremely variable with respect to bedrock elevation and end bearing strata and that it would be difficult to accurately predict pile tip elevations. The intent is to drive piles to bedrock. However, for piles hung up above bedrock, the behaviour of the pile during driving, as measured by the Hiley formula, will have to serve as the criteria for pile lengths. The pile tip elevations, given in Table 2, are for estimating purposes only.

For piles ending above bedrock, pile driving should be controlled by the Hiley Formula as per MTO Standards SS103-10 or SS103-11, assuming ultimate capacities as indicated below.

Ultimate Capacities for Hiley Formula

HP310x79	HP310x110
2460 kN/pile	3450 kN/pile

The layer of soft silty clay, if not removed, will undergo consolidation and create a downdrag force due to negative skin friction. This will reduce the net pile capacity. For design purposes, the following values according to the O.H.B.D.C. are recommended.

Soft Silty Clay not removed (with negative skin friction)

Pile Type	Factored Capacity at U.L.S.	Capacity at S.L.S. Type II
HP310x79	750 kN/pile	500 kN/pile
HP310x110	1200 kN/pile	830 kN/pile

Field investigation has revealed a layer of cobbles/boulders up to 1 m thick at the surface on the northern half of the proposed culvert. It is advisable to strip off this layer of boulders prior to pile driving.

Dewatering will be required in the granular subsoil for pile cap construction below the prevailing groundwater table. This may be done by an enclosed sheet pile cofferdam driven to a sufficient depth to control disturbance of the underlying soil as described in the preceding section.

Culvert Treatment

It is noted from the E-plan that the proposed culvert intercepts McKellar Creek at a sharp angle. Protection works against outter channel erosion in the form of gabions would be required in order to maintain the proposed rerouted channel.

For granular backfill, a seal of cohesive material (CI-CH Clay) with a minimum thickness of 0.6 m should be constructed at the culvert inlet. The intent of the clay seal is to protect the granular backfill. The seal should extend a minimum of 1 m on each side of any granular backfill at culvert inlet, and from the high water level down to 1 m below the base of the culvert or 2 m along the creek bottom as a cutoff. The culvert inlet should be protected with 0.6 m of rock protection extending a minimum of 1 m beyond the clay seal. Assuming the embankment will be rockfill, seal and rock protection would not be required at the inlet.

The culvert outlet should be protected with 0.6 m rock protection as per OPSD 810.01 Type 'A'. The treatment should extend for 15 m along the channel to prevent undercutting of the bed. If the embankment is rockfill, rock protection on the embankemnt will not be required but the protection along the channel will still be needed.

Transition Zone

As an integral part of the culvert design, the stability of the embankment in the immediate vicinity of the culvert should also be considered. This transition zone is taken to be 15 m on both sides of the culvert. The soft clay under the plan limits of the embankment in this area should be removed/displaced as described above. The embankment should be formed at 2H:1V gradient with a 1 m wide berm incorporated at 9 m for embankment heights above 9 m to a maximum height of 18 m. The design of the approaches, which is outside the scope of the current study, should take into consideration a smooth tie-in with this transition zone.

MISCELLANEOUS

The fieldwork for this investigation was carried out by B. Lane, Engineering Trainee. The drilling equipment was owned and operated by Dominion Soil Investigation Ltd. The report was prepared by Mr. D. Kwok, Project Foundation Engineer, under the general supervision of Mr. D. Dundas, Senior Foundation Engineer. The report was reviewed and approved by Mr. M. Devata, Chief foundation Engineer.

LICENSED PROFESSIONAL ENGINEER
W. D. KWOK
PROVINCE OF ONTARIO

D. Kwok, P.Eng.
Project Foundation Engineer

M. Devata, P.Eng.
Chief Foundation Engineer

APPENDIX

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 $\tilde{N}$.

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/0.3 m)	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

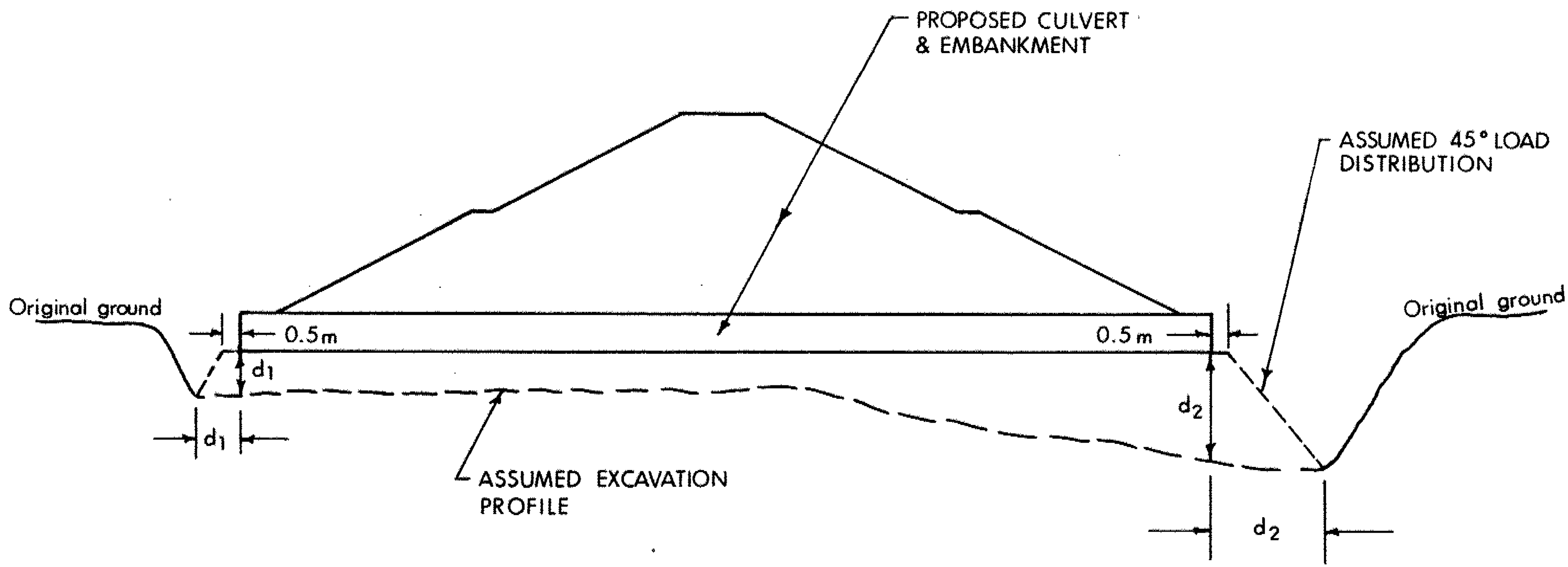

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FIG 1a-LONGITUDINAL SECTION SHOWING SUBEXCAVATION PROFILE

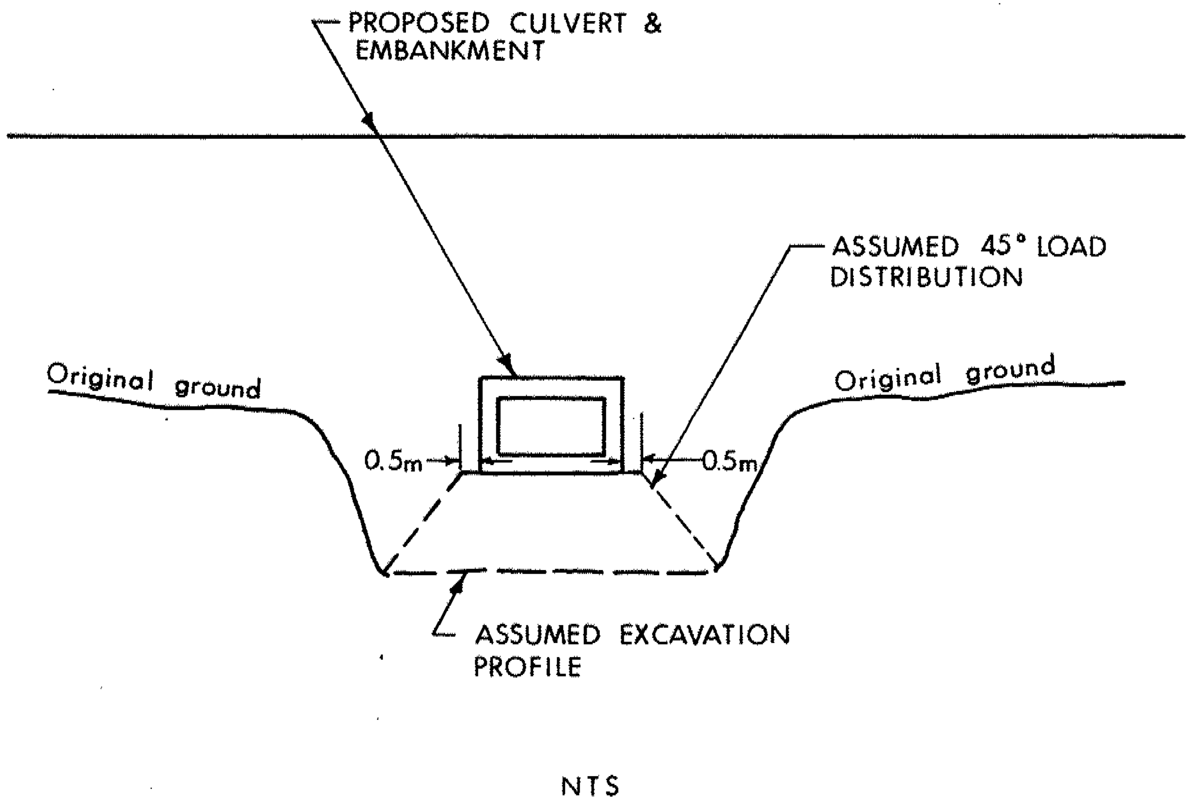

FIG 1b - CROSS SECTION SHOWING SUBEXCAVATION PROFILE

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RECORD OF BOREHOLE No 1

METRIC

W.P. 195-87-01 LOCATION Sta. 14 + 738.0, 24.4 LT. Line B ORIGINATED BY BL

DIST 18 HWY 17 BOREHOLE TYPE Cone Test, Hollow-Stem Auger, N Casing COMPILED BY BL

DATUM Geodetic DATE 90 08 21 CHECKED BY DD

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.0	Ground Surface						
0.0	Frequent Cobbles And Boulders Very Dense	1	CS	*			
		2	CS	*	▼	192	
	Silty Sand, Trace Clay, Very Loose	3	CS	*			
		4	SS	2		190	
		5	SS	2			9 71 15 5
		6	SS	2			
		7	SS	2		188	0 88 9 3
		8	SS	2			
	Loose To Compact	9	SS	12			
		10	SS	9		186	
		11	SS	6		184	
		12	SS	4			0 92 (8)
						182	
	Occ. Gravel Compact To Dense	13	SS	25			
		14	SS	12		180	
177.9		15	SS	36		178	
15.1	End of Borehole						
176.8 / 16.2	End of Cone Test						

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

SHEAR STRENGTH kPa: o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

* Grab sample taken by backhoe

$+^3$, $\times^5$: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

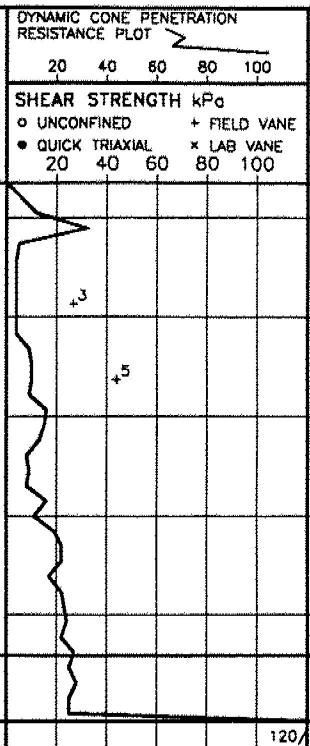
Foundation Design

RECORD OF BOREHOLE No 2

METRIC

W.P. 195-87-01 LOCATION Sta. 14 + 736.0, C/L Line B ORIGINATED BY BL
DIST 18 HWY 17 BOREHOLE TYPE Cone Test, Hollow-Stem Auger, N Casing COMPILED BY BL
DATUM Geodetic DATE 90 08 20 CHECKED BY DD

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%) (w_P – w – w_L)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
192.7	Ground Surface								
0.0	Occ. Cobbles And Boulders	1	CS	*					
	Silty Clay, Trace Sand, Soft To Firm	2	SS	9	▼	192			
		3	SS	4					0 2 34 64
						190			
		4	SS	2					
188.6 / 4.1	Silty Sand, Trace Clay, Loose To Compact	5	SS	9		188			0 87 5 8
		6	SS	7					
		7	SS	7		186			0 81 15 4
		8	SS	17					
	Occ. Gravel, Very Dense					184			
183.2		9	SS	63	/21cm				
9.5	End of Borehole								
181.9 / 10.8	End of Cone Test, Probable Bedrock								



* Grab sample taken by backhoe

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

RECORD OF BOREHOLE No 3

 METRIC

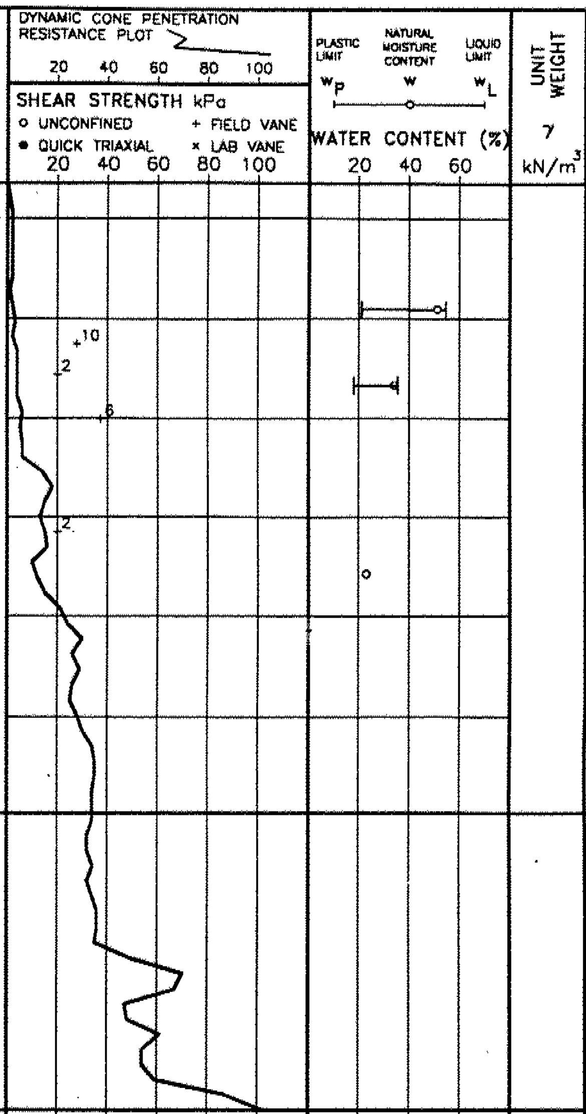
W.P. 195-87-01 LOCATION Sta. 14 + 720.0, 47.0 RT, Line B ORIGINATED BY BL

DIST 18 HWY 17 BOREHOLE TYPE Cone Test, Hollow-Stem Auger COMPILED BY BL

DATUM Geodetic DATE 90 08 22 CHECKED BY DD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
190.7	Ground Surface							
0.0	Silty Sand, Occ. Organics, Compact		1	CS	*	▼		
			2	SS	12		190	
	Silty Clay, Trace Sand, Soft To Firm		3	TW	PH			
			4	TW	PH		188	0 0 72 28
			5	TW	PH			
			6	SS	2			0 1 50 49
							186	
			7	SS	9			
			8	SS	2		184	
182.9 / 7.8	Silty Sand, Trace Clay, Compact		9	SS	6			0 65 33 2
							182	
			10	SS	10			
			11	SS	6		180	
178.1 / 12.6	End of Borehole		12	SS	10			3 79 12 6
172.1 / 18.6	End of Cone Test							

* Grab sample taken by backhoe



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

RECORD OF BOREHOLE No 4

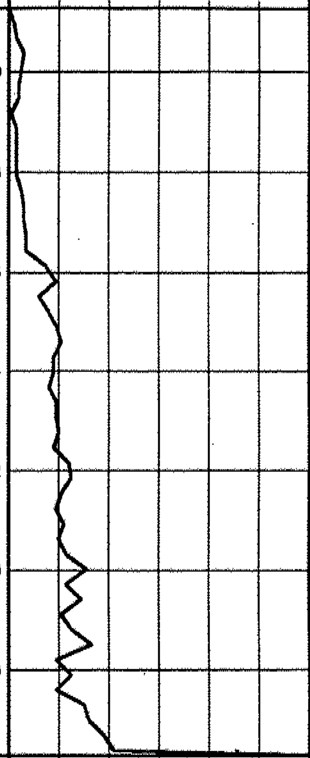
METRIC

W.P. 195-87-01 LOCATION Sta. 14 + 727.6, 23.6 RT. Line B ORIGINATED BY BL

DIST 18 HWY 17 BOREHOLE TYPE Cone Test COMPILED BY BL

DATUM Geodetic DATE 90 08 22 CHECKED BY DD

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
191.3	Ground Surface										
0.0	Probable Silty Clay Soft To Firm						190 188				
186.4 4.9	Probable Silty Sand Loose To Compact						186 184 182 180 178				
176.4 14.9	End of Cone Test							120/10cm			



$+^3$, $\times^5$: Numbers refer to Sensitivity

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

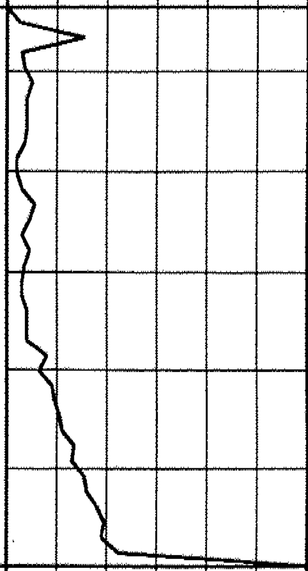
Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 5

METRIC

W.P. 195-87-01 LOCATION Sta. 14 + 740.0, 14.0 LT. Line B ORIGINATED BY BL
DIST 18 HWY 17 BOREHOLE TYPE Cone Test COMPILED BY BL
DATUM Geodetic DATE 90 08 22 CHECKED BY DD

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.3	Ground Surface										
0.0	Probable Occ. Cobbles And Boulders										
	Probable Silty Clay Soft To Firm						192				
							190				
189.2 / 4.1	Probable Silty Sand Loose To Compact						188				
							186				
							184				
182.3 / 11.0	End of Cone Test — Probable Bedrock							120/25cm			



$+^3$, $\times^5$: Numbers refer to Sensitivity

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

METRIC

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

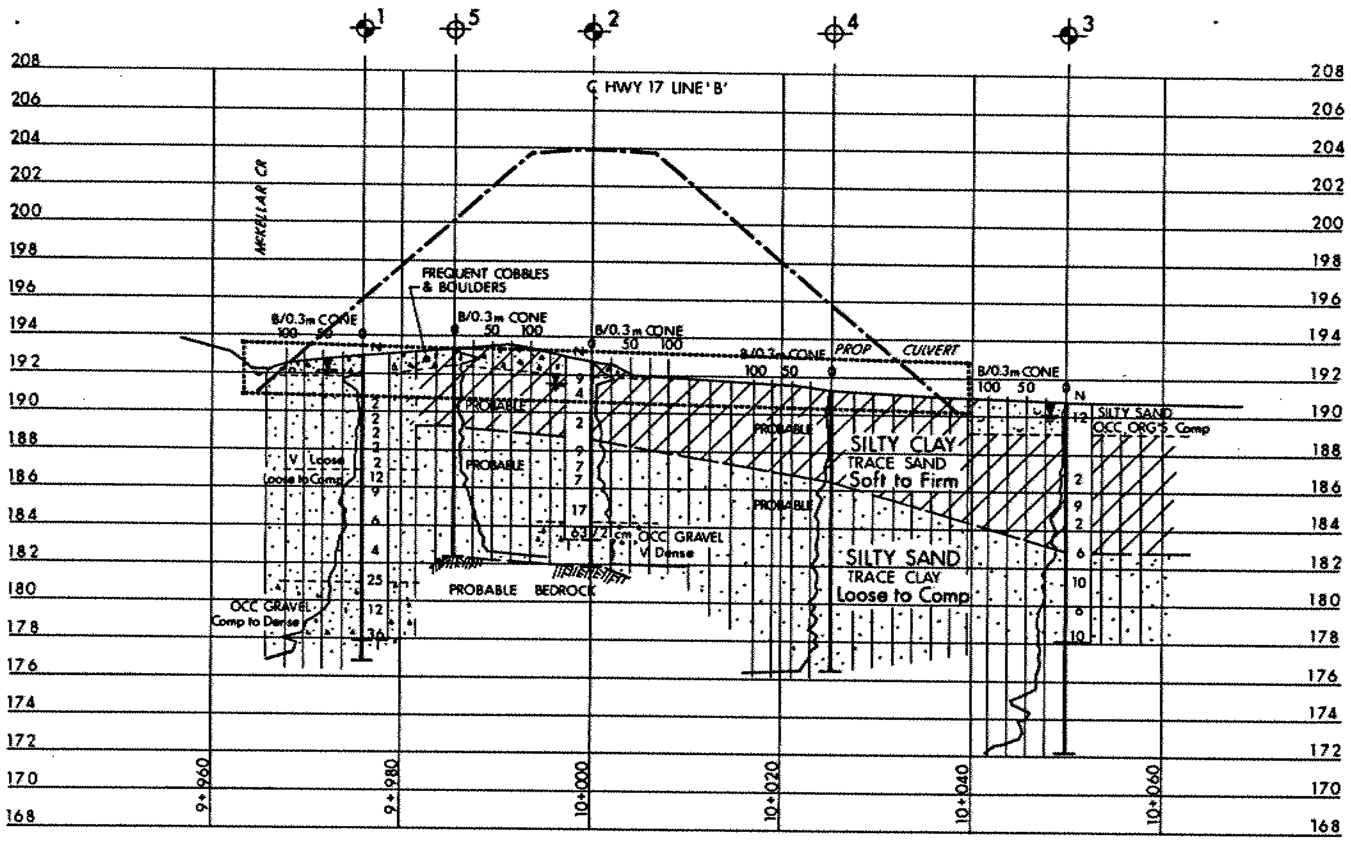
CONT No

WP No 195-87-01

McKELLAR CREEK

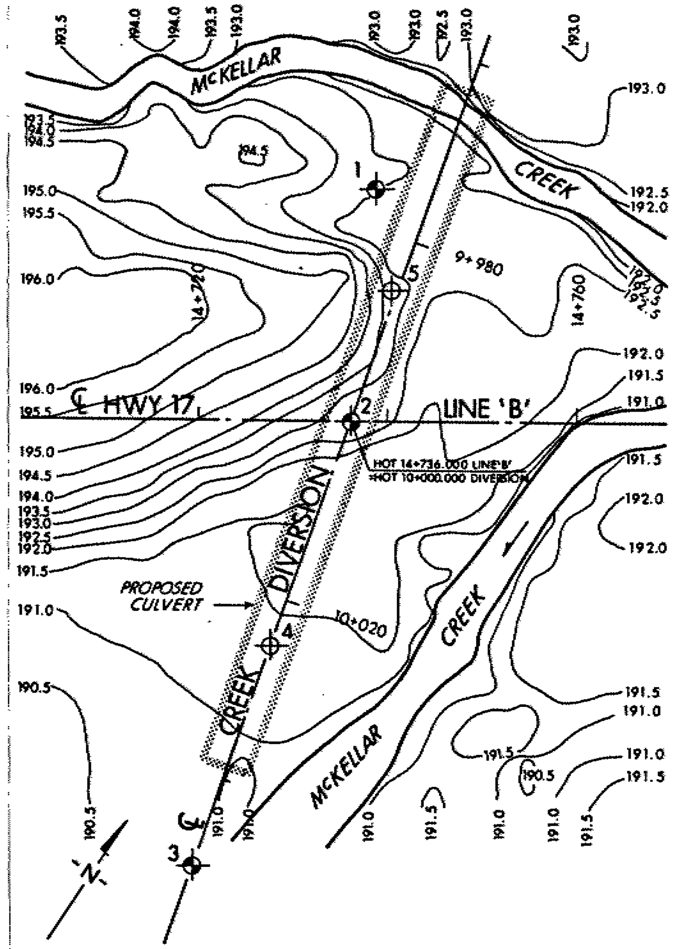
BORE HOLE LOCATIONS & SOIL STRATA

SHEET



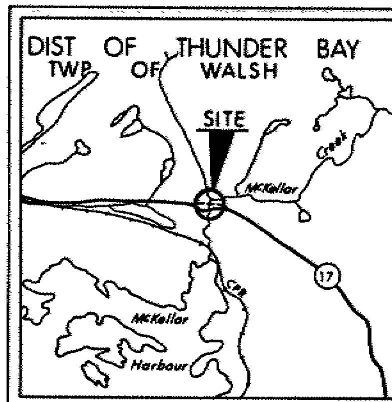
℄ PROFILE CREEK DIVERSION

SCALE 8m 4 0 8m Hor; 4m 2 0 4m Vert



PLAN

SCALE 8m 4 0 8m



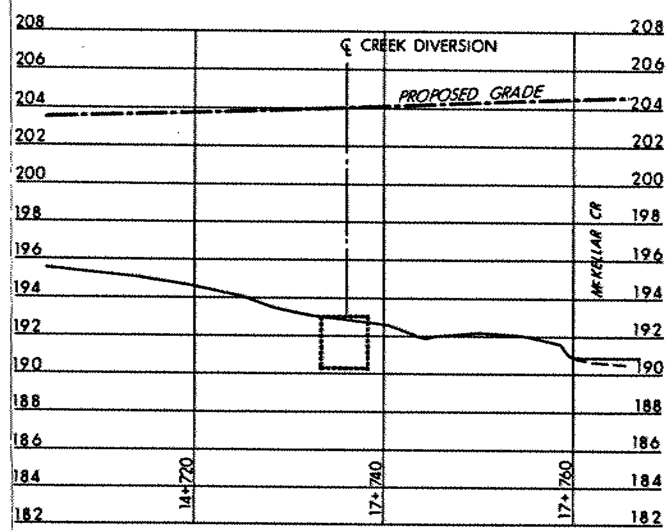
KEY PLAN

SCALE 1km 0.5 0 1km

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	193.0	14+738.0	24.4 m LT
2	192.7	14+736.0	℄
3	190.7	14+720.0	47.0 m RT
4	191.3	14+727.6	23.6 m RT
5	193.3	14+740.0	14.0 m LT



℄ PROFILE LINE 'B'

SCALE 8m 4 0 8m Hor; 4m 2 0 4m Vert

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 42D-15

HWY No 17 LINE 'B'			DIST 18
SUBM'D DK	CHECKED	DATE 1991 04 05	SITE 48E-46
DRAWN SQ	CHECKED	APPROVED	DWG 1958701-A

REF NO E-868-17-3 1990 02