GEOCRES No. 31L-71

DIST. 54 REGION

W.P. No. 398-91-00

CONT. No.

W. O. No.

STR. SITE No.

HWY. No. 17

LOCATION MOSQUITO CREEK CULVERT

No of PAGES -

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

G.I.-30 SEPT. 1976

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Golder Associates

REPORT ON

FOUNDATION INVESTIGATION AND DESIGN
MOSQUITO CREEK CULVERT REPLACEMENT
NORTH BAY TO STURGEON FALLS
HIGHWAY 17, SITE 43-272
DISTRICT 54, SUDBURY
G.W.P. 398-91-00

Submitted to:

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June 2000

991-1164

GEOCRES NO. 31L-71

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PART A

FIELD INVESTIGATION
FOUNDATION INVESTIGATION AND DESIGN
MOSQUITO CREEK CULVERT REPLACEMENT
NORTH BAY TO STURGEON FALLS
HIGHWAY 17, SITE 43-272
DISTRICT 54, SUDBURY
G.W.P. 398-91-00

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by McCormick Rankin Corporation (McCormick Rankin) to carry out a foundation investigation for the proposed culvert replacement at Mosquito Creek, located on Highway 17 between North Bay and Sturgeon Falls, Ontario (Site 43-272). The new culvert is being installed as part of a Highway 17 widening project

The purpose of the investigation is to determine the subsurface conditions at the culvert location by drilling boreholes, carrying out in-situ tests and performing laboratory tests on selected samples. Based on our interpretation of the data obtained, recommendations on the geotechnical aspects of the proposed new culvert are provided.

The plan and profile of the proposed Highway 17 alignment at Mosquito Creek were provided to Golder by McCormick Rankin. The centreline and stations of the proposed alignment were surveyed by others prior to commencing the foundation investigation program.

The terms of reference for the scope of work are outlined in Golder's proposal P91-1225, dated June 1999 which forms part of the Consultant's Agreement (Number P.O. 5005-A-000016) for this project. The work was carried out in accordance with Golder's Quality Control Plan for this project.

2.0 SITE DESCRIPTION

The project area covered by this report extends along the proposed Highway 17 widening route, from approximately Stations 17+100 to 17+200 in the Township of Pedley. The site is situated west of North Bay, Ontario between Highways 64 and 11.

The existing Highway 17 centerline road is at about Elevation 204 m at the culvert location. The elevation of the top of the existing culvert at the north and south sides are 202.3 m and 202.2 m, respectively. The existing culvert is an open culvert design and is approximately 25 m in length.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out on September 7, 1999 at which time, two boreholes (Boreholes 99-1 and 99-2) were advanced at the location of the existing Mosquito Creek culvert. The investigated locations are shown in plan on Figure 1.

The investigation was carried out using a bombardier mounted CME 55 drill rig supplied and operated by Marathon Drilling Co. Ltd. of Ottawa, Ontario. The boreholes were advanced using 208 mm outside diameter (O.D.) continuous flight hollow stem augers. Soil samples were obtained at regular intervals of depth using a 50 mm O.D. split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures. Boreholes 99-1 and 99-2 were sampled to depths of 5.2 m and 8.2 m, respectively. In order to determine the depth to a dense / very stiff stratum or refusal, a dynamic cone penetration test was carried out from the base of Borehole 99-1 to a depth of 27.4 m. The dynamic cone did not encounter a dense / very stiff stratum at this depth. The groundwater conditions in the open boreholes were observed during drilling operations and the groundwater level in a piezometer installed in Borehole 99-1 was obtained on September 29, 1999 to determine stabilized level at that time.

The field work was supervised throughout by a member of our engineering staff, who located the boreholes, supervised the drilling, sampling and in-situ testing operations, logged the boreholes, and examined and cared for the soil samples. The soil samples were identified in the field, placed in containers, labelled and transported to our Mississauga laboratory. Laboratory testing on selected samples included natural water content determinations and grain size analyses. The results of laboratory testing are given on the Record of Borehole sheets and on Figure 2.

The investigation locations were surveyed using the NAD 83 MTM (Zone 12) co-ordinate system and the geodetic datum for elevation. The surveying was carried out by MF Tulloch Inc. of Thessalon, Ontario.

4.0 SUBSURFACE CONDITIONS

The detailed subsurface conditions encountered in the boreholes advanced during this investigation are presented on the Record of Borehole sheets and by the laboratory test results. It should be noted that the stratigraphic boundaries indicated on the borehole records are inferred from non-continuous sampling, observations of drilling progress, results of Standard Penetration Tests (SPTs) and dynamic cone penetration values. These boundaries typically represent transitions from one soil type to another and should not be regarded as exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations.

The ground surface at the borehole locations varies from Elevation 201.1 m to 202.9 m. In general, the subsurface consists of 150 mm to 210 mm of topsoil underlain by deposits of silty sand to sand and gravel fills further underlain by a native deposit of sandy silt to silt.

4.1 Fill

In Borehole 99-2, brown sand to silty sand fill was encountered below 150 mm of topsoil to a depth of about 2.1 m. SPT 'N' values measured in this deposit range from 4 blows to 9 blows per 0.3 m of penetration indicating a loose state of packing. The measured water content of one sample from this deposit is about 22 percent. Below the sand fill in Borehole 99-2, at about Elevation 200.8 m, a brown sand and gravel fill was encountered. This deposit is about 2.2 m thick. The state of packing of this deposit is loose to compact as indicated by SPT 'N' values measured between 6 blows and 18 blows per 0.3 m of penetration. These silty sand to sand and gravel deposits are likely backfill material placed during construction of the existing culvert.

4.2 Sandy Silt to Silt

Below the sand and gravel (at about Elevation 198.6 m) in Borehole 99-2, and below 210 mm of topsoil (at about Elevation 200.9 m) in Borehole 99-1, a deposit of brown to grey silt was encountered. This silt deposit is generally sandy in Borehole 99-1, and grades to a silt containing only trace sand and trace clay in Borehole 99-2 (see Figure 2). SPT 'N' values measured in the native silts range from 2 blows to 6 blows per 0.3 m of penetration indicating a very loose to loose state of packing. Measured water contents of four samples from this deposit range from about 28 percent to 37 percent.

In Borehole 99-1, a dynamic cone penetration test was advanced to a depth of about 27.4 m (Elevation 173.6 m). Dynamic penetration blows were less than 7 blows per 0.3 m of penetration to a depth of about 10.4 m (Elevation 190.7 m). Below this depth, the blow counts rapidly increased to over 20 blows per 0.3 m of penetration, and remained between about 20 blows and 30 blows per 0.3 m of penetration to the end of the test at depth 27.4 m (Elevation 173.6 m).

4.3 Groundwater Conditions

A piezometer was installed in Borehole 99-1. The water level measured in the piezometer was at Elevation 199.6 m (about 1.5 m below the existing ground surface). Information provided by McCormick Rankin indicates that the water level in Mosquito Creek was at about Elevation 199.8 m. It should be noted that the groundwater level is subject to seasonal fluctuations.

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B

PART B

FOUNDATION DESIGN
FOUNDATION INVESTIGATION AND DESIGN
MOSQUITO CREEK CULVERT REPLACEMENT
NORTH BAY TO STURGEON FALLS
HIGHWAY 17, SITE 43-272
DISTRICT 54, SUDBURY
G.W.P. 398-91-00

5.0 ENGINEERING RECOMMENDATIONS

This section of the report provides our interpretation of the factual geotechnical data obtained during the investigation. The recommendations provided are intended for the guidance of the design engineer only. The data may not be sufficient for construction and where comments are made on construction, they are provided only in order to highlight aspects of construction which could affect the design of the project. Contractors bidding on or undertaking the works must make their own interpretation of the subsurface information provided as it affects their proposed construction methods, costs, equipment selection, scheduling and the like.

We understand that the existing culvert (concrete open design on shallow foundation) at Mosquito Creek will be removed and replaced with a new concrete rigid frame box structure. We also understand that that the dimensions for the proposed new culvert are approximately 6 m wide by 3 m high by 27 m long; and that the proposed north and south inverts for the new culvert are at Elevations 199.30 m and 199.13 m, respectively. The existing road surface at the culvert location is at about Elevation 204 m. We understand that the vertical grade of the highway will be raised by about 300 mm.

5.1 Foundations

The culvert can be supported on a 300 mm Granular 'A' bed placed at about Elevation 198.3 m. The subsurface condition at these elevations consists of loose to very loose grey sandy silt containing trace clay which grades with depth into a silt containing trace sand and clay. As indicated in the dynamic penetration cone test results from Borehole 99-1, this loose to very loose deposit extends to about Elevation 191 m, where a more compact / stiff soil stratum was encountered. The loose to very loose sandy silt / silt deposit is considered suitable to support foundations for the proposed culvert.

A rigid frame concrete box structure relies on its concrete bottom to act as a spread footing. It is similar to a raft foundation. For a closed box 6 m wide structure at this location, a factored bearing resistance at ultimate limit states (ULS) of 500 kPa and a bearing resistance at serviceability limit state (SLS), corresponding to 25 mm of settlement, of 40 kPa may be assumed for design. The ULS value is based on a culvert embedment depth of about 5.5 m below the road surface. The SLS value of 40 kPa corresponds to additional net loading (i.e., over and above the loading experienced by the existing culvert). An example of net loading is increase in vertical grade of the highway at this location.

The culvert should be designed to withstand the appropriate weight of fill and traffic loadings, and frost pressures (where adequate frost cover is not provided). The culvert should be founded on properly prepared subgrade, and the base of the excavation should be inspected after reaching the design level. The culvert walls should be designed using a triangular pressure distribution, a coefficient of lateral earth pressure of 0.5 and a soil unit weight of 21 kN/m^3. Water pressure should be taken into account as appropriate.

5.2 Excavations

It is understood that excavations for construction of the new culvert will extend to about Elevation 198 m. The excavations are expected to extend through the silty sand to sand and gravel fill materials and, depending on the extent of fill around the existing culvert, into the native silt deposit. The excavation may extend about 0.5 m to 1 m below the groundwater level which was measured at Elevation 199.6 m in the piezometer in Borehole 99-2. The groundwater level should be measured prior to excavation to determine its location at that time.

Conventional excavation equipment should be suitable for excavation through the on-site soils. The fills and native silts are classified as Type 3 and Type 4 soils, respectively, according to the Occupational Health and Safety Act (Ont. Reg. 213/91). All excavations must be carried out in accordance with the latest edition of the Ontario Occupation Health and Safety Act and Regulations for Construction Projects.

Provided that adequate groundwater control is maintained, temporary unsupported excavation side slopes should be cut no steeper than 2 horizontal to 1 vertical (2H:1V). When the excavation reaches the groundwater table and / or very loose to loose, wet silts, the excavated slopes may experience localized instability in the form of surficial sloughing.

A temporary groundwater control system should be installed and operated before the excavation reaches the groundwater table. The groundwater table should be lowered by at least 0.5 m below the required depth of excavation. Due to the fine-grained nature of the native soils encountered at this site, the groundwater is expected to respond slowly to hydraulic gradients induced by pumping Therefore, the groundwater control system should be installed and operated sufficiently in advance of the excavation and field subgrade preparation. In addition, surface water should be directed away from the excavation.

It is considered that control of the groundwater during construction may be achieved by either pumping from a perimeter interceptor ditch or by utilizing a properly filtered well-point system. The services of a specialist groundwater control firm / contractor should be utilized to design and install the temporary groundwater control system within the silt subsoil. The proposed groundwater control system should be reviewed.

The perimeter interceptor ditch should be extended to a depth of at least 1 m below the required depth of excavation. The ditch should be constructed using a filter cloth wrapped weeping tile surrounded with well graded coarse sand. In addition, to prevent the migration of fine particles, the ditches should be lined and covered with an appropriate filter fabric. Due to the expected sloughing behaviour of the native silts, some difficulty in constructing the ditches should be expected. A trench box to temporarily support the ditch sides and to allow for placement of the filter fabric, weeping tile and sand; and staged construction of relatively short lengths (in the order of 3 m), may be required. It is considered that the collected water can be handled with properly filtered sump pumps.

If a well point system is utilized, the wells must be properly filtered, and should be installed and operated well in advance of the excavation and field subgrade preparation. Based on the fine gradation of the subsoil, a vacuum well point system may be required.

The groundwater level should be confirmed prior to excavation to ensure it has been lowered to an acceptable elevation.

5.3 Bedding and Backfill

Despite the lowered groundwater table to be provided by the groundwater control system, the native silts will likely remain saturated and will, therefore, be subject to disturbance. To preserve the integrity of the subgrade, methods of subgrade preparation that do not require traffic on the subgrade by equipment or labour should be used.

The proposed bedding for the rigid frame concrete box culvert consists of 300 mm of Granular 'A' underlain by a geotextile. It should be noted that compaction of this bedding material with vibratory compaction equipment may disturb the native silts and cause "pumping" at the excavation base. If this method is chosen, the Granular 'A' should be compacted to at least 95 percent of the material's Standard Proctor maximum dry density using non-vibratory (static) equipment only. The bedding material should be placed as soon as practicable after reaching the base of excavation and following completion of inspection.

As an alternative, consideration could be given to using a material conforming to the gradation specifications of HL8 coarse aggregate (OPSS 1003) as the bedding material. The 300 mm thick layer of HL8 aggregate should be completely wrapped in a suitable filter geotextile using sewen overlaps. To provide a workable base, a mud coat should be applied over the geotextile wrapped aggregate layer. The advantages of this bedding system is that no compaction of the HL8 aggregate is required, a workable base is provided for construction of the culvert, and risk of disturbance of the native silt subgrade is minimized.

Backfill arrangements around the culvert should be carried out as per OPSD 803.01. Backfill to the culvert should consist of free-draining, non-frost susceptible granular materials such as OPSS Granular 'A' or 'B'. All granular fill should be placed in loose lifts not exceeding 200 mm thick and be compacted to at least 95 percent of its Standard Proctor maximum dry density. The first lift of backfill material should be compacted with non-vibratory equipment to avoid disturbance of the native silt deposit below the bedding material.

Heavy compaction equipment should not be used adjacent to the walls and roof of the culvert. The height of backfill to the culvert walls should be maintained equal on both sides of the structure during all stages of backfill placement.

Temporary diversion of surface water flow would be required during culvert installation. Adequate erosion protection should be provided as appropriate. Consideration could be given to use of suitable non-woven geotextiles and rip-rap as required to provide erosion protection based on hydraulic requirements. An upstream clay seal and / or a cut-off wall could be used if it is necessary to control seepage through the bedding below the culvert. The material specification for a "clay" seal should be as per OPSS1205. In addition, sediment control such as silt fences, erosion control blankets may be required during construction and diversion of the creek to mitigate migration of fine soil particles into the creek.

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LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO	Drive open
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:
The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.).

Dynamic Penetration Resistance; N_d:
The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH:	Sampler advanced by hydraulic pressure
PM:	Sampler advanced by manual pressure
WH:	Sampler advanced by static weight of hammer
WR:	Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT):
An electronic cone penetrometer with a 60° conical tip and a projected end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	N Blows/300 mm or Blows/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

Consistency	c_u, s_u kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, G_S)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane test (LV-laboratory vane test)
γ	unit weight

Note:
1. Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π = 3.1416
ln x, natural logarithm of x
$\log_{10}$ x or log x, logarithm of x to base 10
g acceleration due to gravity
t time
F factor of safety
V volume
W weight

II. STRESS AND STRAIN

γ shear strain
Δ change in, e.g. in stress: $\Delta\sigma$
ε linear strain
ε_v volumetric strain
η coefficient of viscosity
ν Poisson's ratio
σ total stress
σ' effective stress ($\sigma' = \sigma - u$)
σ'_{vo} initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$ principal stresses (major, intermediate, minor)
σ_{oct} mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ shear stress
u porewater pressure
E modulus of deformation
G shear modulus of deformation
K bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$ bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$ dry density (dry unit weight)
$\rho_w(\gamma_w)$ density (unit weight) of water
$\rho_s(\gamma_s)$ density (unit weight) of solid particles
γ' unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R relative density (specific gravity)of solid particles ($D_R = \rho_s/\rho_w$) (formerly G_s)
e void ratio
n porosity
S degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)

(a) Index Properties (con't.)

w water content
w_l liquid limit
w_p plastic limit
I_P plasticity Index = $(w_l - w_p)$
w_S shrinkage limit
I_L liquidity index = $(w - w_p)/I_p$
I_C consistency index = $(w_l - w)/I_p$
e_{max} void ratio in loosest state
e_{min} void ratio in densest state
I_D density index = $(e_{max} - e)/(e_{max} - e_{min})$ (formerly relative density)

(c) Hydraulic Properties

h hydraulic head or potential
q rate of flow
v velocity of flow
i hydraulic gradient
k hydraulic conductivity (coefficient of permeability)
j seepage force per unit volume

(d) Consolidation (one-dimensional)

C_c compression index (normally consolidated range)
C_r recompression index (overconsolidated range)
C_S swelling index
C_α coefficient of secondary consolidation
m_v coefficient of volume change
c_v coefficient of consolidation
T_v time factor (vertical direction)
U degree of consolidation
σ'_p pre-consolidation pressure
OCR Overconsolidation ratio $=\sigma'_p/\sigma'_{vo}$

(e) Shear Strength

τ_p, τ_r peak and residual shear strength
ϕ' effective angle of internal friction
δ angle of interface friction
μ coefficient of friction = $\tan\delta$
c' effective cohesion
c_u, s_u undrained shear strength ($\phi = 0$ analysis)
p mean total stress $(\sigma_1 + \sigma_3)/2$
p' mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q $(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u compressive strength $(\sigma_1 - \sigma_3)$
S_t sensitivity

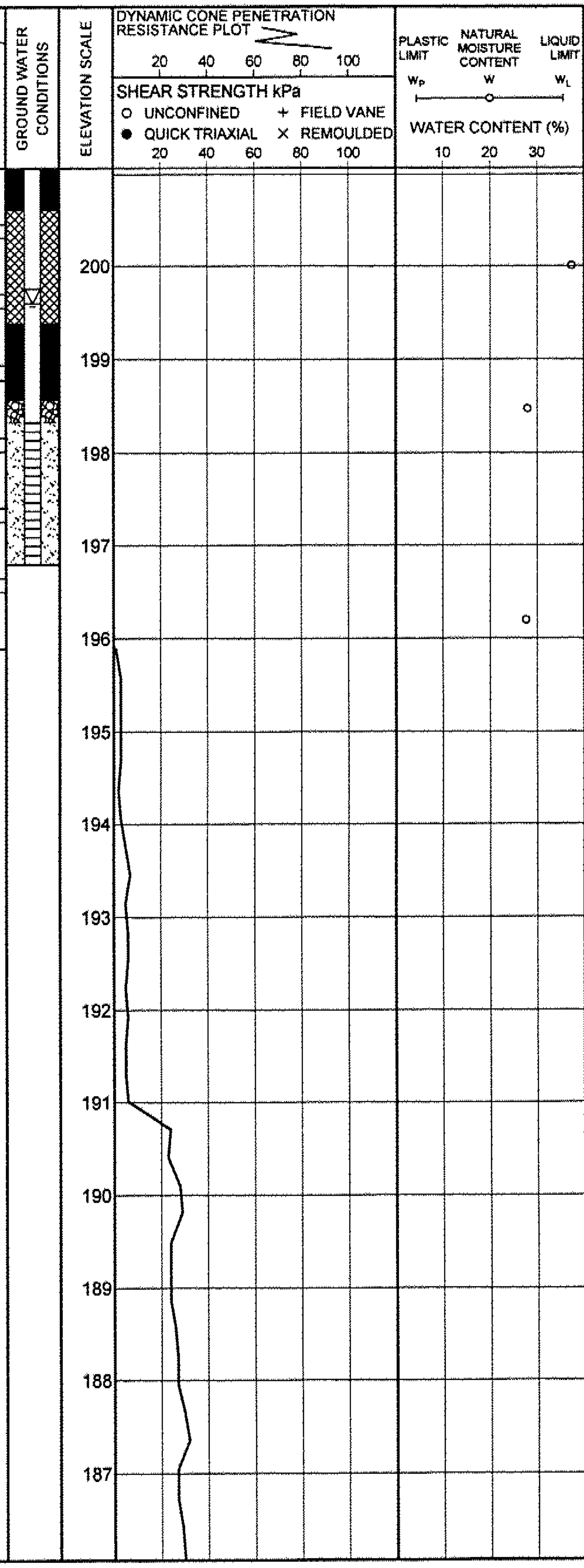
Notes: 1. $\tau = c' + \sigma' \tan\phi'$
2. Shear strength = (Compressive strength)/2

RECORD OF BOREHOLE No 99-1

METRIC

PROJECT 991-1164			
W.P. 398-91-00	LOCATION N 5136511.51; E 282398.30 (Mosquito Creek, Site 43-272)	ORIGINATED BY MSB	
DIST 54	HWY 17	BOREHOLE TYPE Bombardier CME-55	COMPILED BY BVB
DATUM Geodetic	DATE 9/7/1999	CHECKED BY DEB	

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
201.07	GROUND SURFACE									
200.86	Topsoil									
0.21	Sandy Silt, trace clay Loose to very loose Brown to Grey	1	50 DO	2						
		2	50 DO	2	200	~33	0	26	72	2
		3	50 DO	2	199					
		4	50 DO	5		~28				
		5	50 DO	5	198					
		6	50 DO	6	197					
195.89		7	50 DO	3	196	~28				
5.18	Start of Dynamic Cone Penetration Test at 5.2m depth. Note: Water in piezometer at Elev. 199.6m on Sept.29,1999.				195 – 187					



Continued Next Page

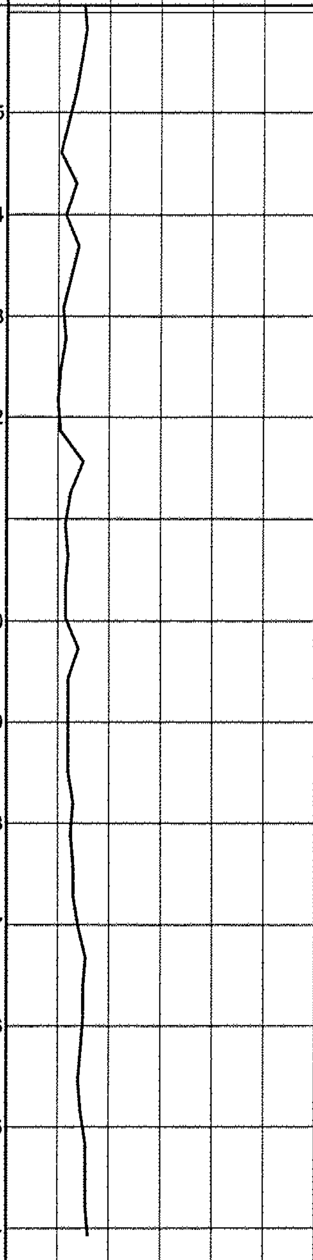
+3, X3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 99-1

METRIC

PROJECT 991-1164
W.P. 398-91-00
LOCATION N 5136511.51; E 282398.30 (Mosquito Creek, Site 43-272)
ORIGINATED BY MSB
DIST 54 HWY 17
BOREHOLE TYPE Bombardier CME-55
COMPILED BY BVB
DATUM Geodetic
DATE 9/7/1999
CHECKED BY DEB

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, × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L; WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	— CONTINUED FROM PREVIOUS PAGE —										
							185				
							184				
							183				
							182				
							181				
							180				
							179				
							178				
							177				
							176				
							175				
							174				
173.64 / 27.43	END OF BOREHOLE										



$+^3, \times^3$: Numbers refer to Sensitivity
$O^{3\%}$ STRAIN AT FAILURE

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No 99-2

METRIC

PROJECT 991-1164
W.P. 398-91-00
LOCATION N 5136539.48; E 282408.31 (Mosquito Creek, Site 43-272)
ORIGINATED BY MSB
DIST 54 HWY 17
BOREHOLE TYPE Bombardier CME-55
COMPILED BY BVB
DATUM Geodetic
DATE 9/7/1999
CHECKED BY DEB

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%) (natural moisture, w)	GR	SA	SI	CL
202.85	GROUND SURFACE									
0.00	Topsoil									
0.15	Sand, trace silt to silty Loose Brown (Fill)	1	50 DO	4						
		2	50 DO	6	202	o				
		3	50 DO	9	201					
200.78 2.07	Sand and Gravel Loose to compact Brown (Fill)	4	50 DO	6	200					
		5	50 DO	10						
		6	50 DO	18	199					
198.58 4.27	Silt, sandy to trace sand, trace clay Loose to very loose Grey	7	50 DO	6	198					
					197					
		8	50 DO	4	196	o	0	1	91	8
		9	50 DO	2	195					
194.62 8.23	END OF BOREHOLE									

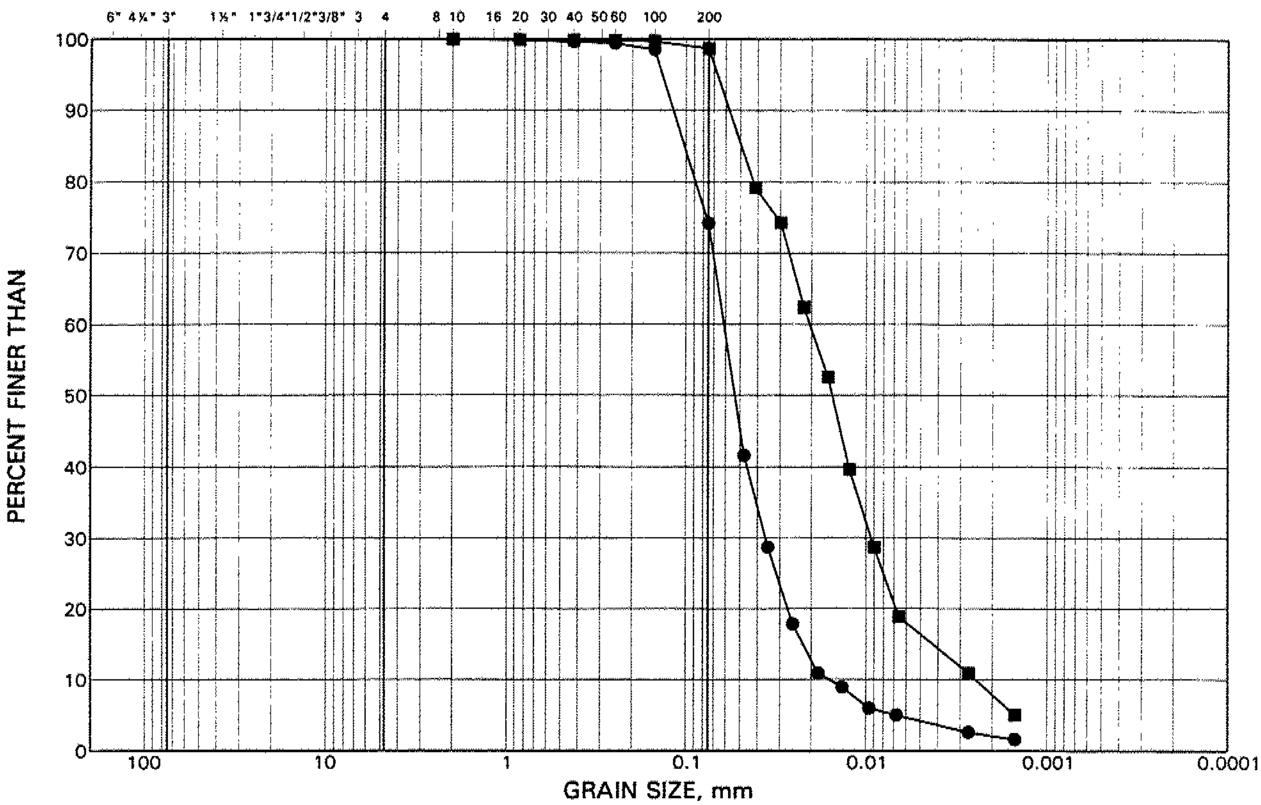
Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT w LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

ON_MOT 9911164.GPJ ON_MOT.GDT 27/6/00

$+^3, \times^3$: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

OVERSIZE DRAWING(S)

GRAIN SIZE DISTRIBUTION
Sandy Silt, trace clay; Silt, trace clay



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	99-1	2	1.4
■	99-2	8	6.7

Golder Associates Ltd.

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REPORT ON

FOUNDATION INVESTIGATION
MOSQUITO CREEK CULVERT REPLACEMENT
NORTH BAY TO STURGEON FALLS
HIGHWAY 17, SITE 43-272
DISTRICT 54, SUDBURY
G.W.P. 398-91-00

FACTUAL ONLY

Submitted to:

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June 2000

991-1164

GEOCRES NO. 31L-71

TABLE OF CONTENTS

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by McCormick Rankin Corporation (McCormick Rankin) to carry out a foundation investigation for the proposed culvert replacement at Mosquito Creek, located on Highway 17 between North Bay and Sturgeon Falls, Ontario (Site 43-272). The new culvert is being installed as part of a Highway 17 widening project

The purpose of the investigation is to determine the subsurface conditions at the culvert location by drilling boreholes, carrying out in-situ tests and performing laboratory tests on selected samples. Based on our interpretation of the data obtained, recommendations on the geotechnical aspects of the proposed new culvert are provided.

The plan and profile of the proposed Highway 17 alignment at Mosquito Creek were provided to Golder by McCormick Rankin. The centreline and stations of the proposed alignment were surveyed by others prior to commencing the foundation investigation program.

The terms of reference for the scope of work are outlined in Golder's proposal P91-1225, dated June 1999 which forms part of the Consultant's Agreement (Number P.O. 5005-A-000016) for this project. The work was carried out in accordance with Golder's Quality Control Plan for this project.

2.0 SITE DESCRIPTION

The project area covered by this report extends along the proposed Highway 17 widening route, from approximately Stations 17+100 to 17+200 in the Township of Pedley. The site is situated west of North Bay, Ontario between Highways 64 and 11.

The existing Highway 17 centerline road is at about Elevation 204 m at the culvert location. The elevation of the top of the existing culvert at the north and south sides are 202.3 m and 202.2 m, respectively. The existing culvert is an open culvert design and is approximately 25 m in length.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out on September 7, 1999 at which time, two boreholes (Boreholes 99-1 and 99-2) were advanced at the location of the existing Mosquito Creek culvert. The investigated locations are shown in plan on Figure 1.

The investigation was carried out using a bombardier mounted CME 55 drill rig supplied and operated by Marathon Drilling Co. Ltd. of Ottawa, Ontario. The boreholes were advanced using 208 mm outside diameter (O.D.) continuous flight hollow stem augers. Soil samples were obtained at regular intervals of depth using a 50 mm O.D. split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures. Boreholes 99-1 and 99-2 were sampled to depths of 5.2 m and 8.2 m, respectively. In order to determine the depth to a dense / very stiff stratum or refusal, a dynamic cone penetration test was carried out from the base of Borehole 99-1 to a depth of 27.4 m. The dynamic cone did not encounter a dense / very stiff stratum at this depth. The groundwater conditions in the open boreholes were observed during drilling operations and the groundwater level in a piezometer installed in Borehole 99-1 was obtained on September 29, 1999 to determine stabilized level at that time.

The field work was supervised throughout by a member of our engineering staff, who located the boreholes, supervised the drilling, sampling and in-situ testing operations, logged the boreholes, and examined and cared for the soil samples. The soil samples were identified in the field, placed in containers, labelled and transported to our Mississauga laboratory. Laboratory testing on selected samples included natural water content determinations and grain size analyses. The results of laboratory testing are given on the Record of Borehole sheets and on Figure 2.

The investigation locations were surveyed using the NAD 83 MTM (Zone 12) co-ordinate system and the geodetic datum for elevation. The surveying was carried out by MF Tulloch Inc. of Thessalon, Ontario.

4.0 SUBSURFACE CONDITIONS

The detailed subsurface conditions encountered in the boreholes advanced during this investigation are presented on the Record of Borehole sheets and by the laboratory test results. It should be noted that the stratigraphic boundaries indicated on the borehole records are inferred from non-continuous sampling, observations of drilling progress, results of Standard Penetration Tests (SPTs) and dynamic cone penetration values. These boundaries typically represent transitions from one soil type to another and should not be regarded as exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations.

The ground surface at the borehole locations varies from Elevation 201.1 m to 202.9 m. In general, the subsurface consists of 150 mm to 210 mm of topsoil underlain by deposits of silty sand to sand and gravel fills further underlain by a native deposit of sandy silt to silt.

4.1 Fill

In Borehole 99-2, brown sand to silty sand fill was encountered below 150 mm of topsoil to a depth of about 2.1 m. SPT 'N' values measured in this deposit range from 4 blows to 9 blows per 0.3 m of penetration indicating a loose state of packing. The measured water content of one sample from this deposit is about 22 percent. Below the sand fill in Borehole 99-2, at about Elevation 200.8 m, a brown sand and gravel fill was encountered. This deposit is about 2.2 m thick. The state of packing of this deposit is loose to compact as indicated by SPT 'N' values measured between 6 blows and 18 blows per 0.3 m of penetration. These silty sand to sand and gravel deposits are likely backfill material placed during construction of the existing culvert.

4.2 Sandy Silt to Silt

Below the sand and gravel (at about Elevation 198.6 m) in Borehole 99-2, and below 210 mm of topsoil (at about Elevation 200.9 m) in Borehole 99-1, a deposit of brown to grey silt was encountered. This silt deposit is generally sandy in Borehole 99-1, and grades to a silt containing only trace sand and trace clay in Borehole 99-2 (see Figure 2). SPT 'N' values measured in the native silts range from 2 blows to 6 blows per 0.3 m of penetration indicating a very loose to loose state of packing. Measured water contents of four samples from this deposit range from about 28 percent to 37 percent.

In Borehole 99-1, a dynamic cone penetration test was advanced to a depth of about 27.4 m (Elevation 173.6 m). Dynamic penetration blows were less than 7 blows per 0.3 m of penetration to a depth of about 10.4 m (Elevation 190.7 m). Below this depth, the blow counts rapidly increased to over 20 blows per 0.3 m of penetration, and remained between about 20 blows and 30 blows per 0.3 m of penetration to the end of the test at depth 27.4 m (Elevation 173.6 m).

4.3 Groundwater Conditions

A piezometer was installed in Borehole 99-1. The water level measured in the piezometer was at Elevation 199.6 m (about 1.5 m below the existing ground surface). Information provided by McCormick Rankin indicates that the water level in Mosquito Creek was at about Elevation 199.8 m. It should be noted that the groundwater level is subject to seasonal fluctuations.

GOLDER ASSOCIATES LTD.

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Designated MTO Contact

BVB/DEB/FJH/bvb/clg
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LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π = 3.1416
ln x, natural logarithm of x
$\log_{10}$ x or log x, logarithm of x to base 10
g acceleration due to gravity
t time
F factor of safety
V volume
W weight

II. STRESS AND STRAIN

γ shear strain
Δ change in, e.g. in stress: $\Delta\sigma$
ε linear strain
ε_v volumetric strain
η coefficient of viscosity
ν Poisson's ratio
σ total stress
σ' effective stress ($\sigma' = \sigma - u$)
σ'_{vo} initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$ principal stresses (major, intermediate, minor)
σ_{oct} mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ shear stress
u porewater pressure
E modulus of deformation
G shear modulus of deformation
K bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$ bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$ dry density (dry unit weight)
$\rho_w(\gamma_w)$ density (unit weight) of water
$\rho_s(\gamma_s)$ density (unit weight) of solid particles
γ' unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R relative density (specific gravity)of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e void ratio
n porosity
S degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)

(a) Index Properties (con't.)

w water content
w_l liquid limit
w_p plastic limit
I_P plasticity Index = $(w_l - w_p)$
w_S shrinkage limit
I_L liquidity index = $(w - w_p) / I_p$
I_C consistency index = $(w_l - w) / I_p$
e_{max} void ratio in loosest state
e_{min} void ratio in densest state
I_D density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(c) Hydraulic Properties

h hydraulic head or potential
q rate of flow
v velocity of flow
i hydraulic gradient
k hydraulic conductivity (coefficient of permeability)
j seepage force per unit volume

(d) Consolidation (one-dimensional)

C_c compression index (normally consolidated range)
C_r recompression index (overconsolidated range)
C_S swelling index
C_α coefficient of secondary consolidation
m_v coefficient of volume change
c_v coefficient of consolidation
T_v time factor (vertical direction)
U degree of consolidation
σ'_p pre-consolidation pressure
OCR Overconsolidation ratio $= \sigma'_p / \sigma'_{vo}$

(e) Shear Strength

τ_p, τ_r peak and residual shear strength
ϕ' effective angle of internal friction
δ angle of interface friction
μ coefficient of friction = $\tan\delta$
c' effective cohesion
c_u, S_u undrained shear strength ($\phi = 0$ analysis)
p mean total stress $(\sigma_1 + \sigma_3)/2$
p' mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q $(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u compressive strength $(\sigma_1 - \sigma_3)$
S_t sensitivity

Notes: 1. $\tau = c' + \sigma' \tan\phi'$
2. Shear strength = (Compressive strength)/2

RECORD OF BOREHOLE No 99-1

METRIC

PROJECT	991-1164		
W.P.	398-91-00	LOCATION	N 5136511.51; E 282398.30 (Mosquito Creek, Site 43-272)
DIST 54	HWY 17	BOREHOLE TYPE	Bombardier CME-55
DATUM	Geodetic	DATE	9/7/1999

ORIGINATED BY MSB
COMPILED BY BVB
CHECKED BY DEB

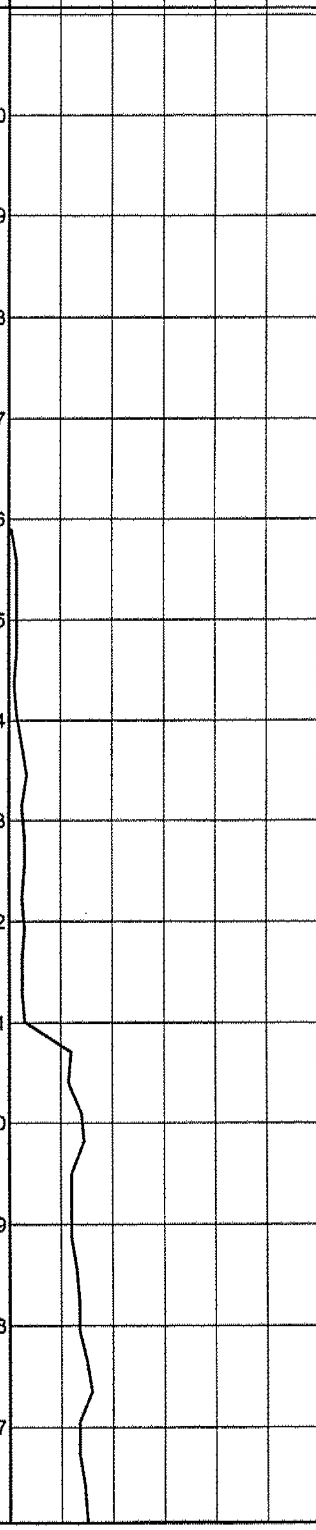
SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
201.07	GROUND SURFACE
200.86 / 0.21	Topsoil
	Sandy Silt, trace clay Loose to very loose Brown to Grey
195.89 / 5.18	Start of Dynamic Cone Penetration Test at 5.2m depth. Note: Water in piezometer at Elev. 199.6m on Sept.29,1999.

SAMPLES

NUMBER	TYPE	"N" VALUES	Natural moisture content	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	50 DO	2		
2	50 DO	2	~37 (plotted)	0 26 72 2
3	50 DO	2		
4	50 DO	5	~28 (plotted)	
5	50 DO	5		
6	50 DO	6		
7	50 DO	3	~28 (plotted)	

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; ELEVATION SCALE 200 to 187.



Continued Next Page

+3, ×3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

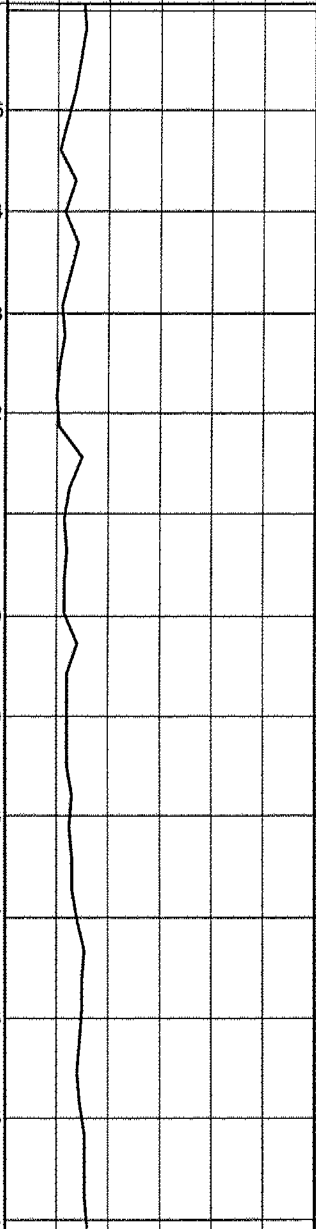
Ministry of Transportation Ontario

RECORD OF BOREHOLE No 99-1

METRIC

PROJECT	991-1164		
W.P.	398-91-00	LOCATION	N 5136511.51; E 282398.30 (Mosquito Creek, Site 43-272)
DIST 54	HWY 17	BOREHOLE TYPE	Bombardier CME-55
DATUM	Geodetic	DATE	9/7/1999

ORIGINATED BY MSB
COMPILED BY BVB
CHECKED BY DEB

SOIL PROFILE			SAMPLES						DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X REMOULDED (20 40 60 80 100)	PLASTIC LIMIT W_p / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE					
	— CONTINUED FROM PREVIOUS PAGE —						185, 184, 183, 182, 181, 180, 179, 178, 177, 176, 175, 174					
173.64 / 27.43	END OF BOREHOLE											

+3, X3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

ON_MOT 9911164.GPJ ON_MOT.GDT 27/6/00

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 99-2

METRIC

PROJECT 991-1164			
W.P. 398-91-00	LOCATION N 5136539.48; E 282408.31 (Mosquito Creek, Site 43-272)	ORIGINATED BY MSB	
DIST 54	HWY 17	BOREHOLE TYPE Bombardier CME-55	COMPILED BY BVB
DATUM Geodetic	DATE 9/7/1999	CHECKED BY DEB	

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
202.85	GROUND SURFACE												
0.00	Topsoil												
0.15	Sand, trace silt to silty Loose Brown (Fill)		1	50 DO	4								
			2	50 DO	6		202	~21					
			3	50 DO	9		201						
200.78 2.07	Sand and Gravel Loose to compact Brown (Fill)		4	50 DO	6		200						
			5	50 DO	10								
			6	50 DO	18		199						
198.58 4.27	Silt, sandy to trace sand, trace clay Loose to very loose Grey		7	50 DO	6		198						
							197						
			8	50 DO	4			~26		0	1	91	8
							196						
			9	50 DO	2		195						
194.62 8.23	END OF BOREHOLE												

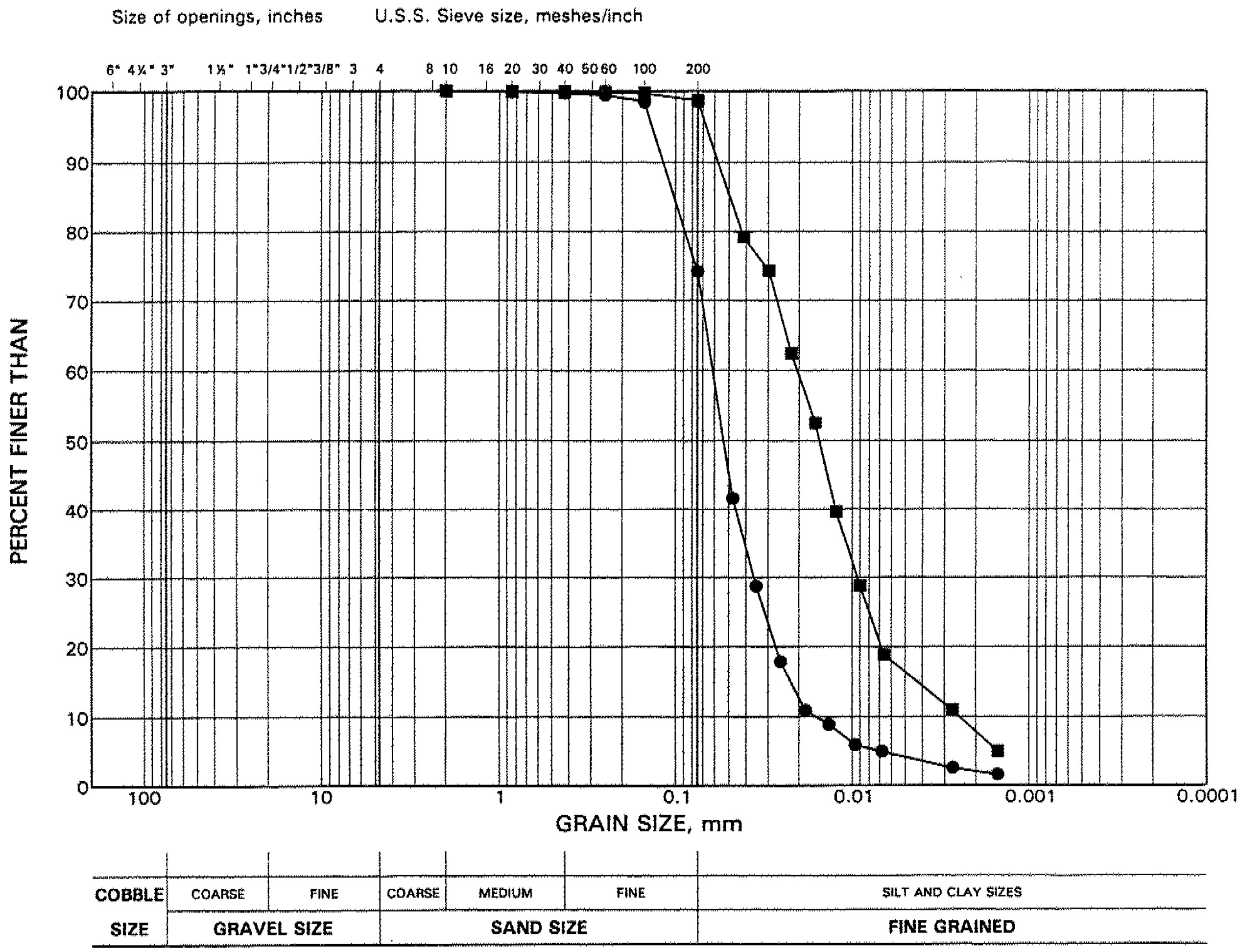
Column headings also include: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa — O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (10, 20, 30); REMARKS & GRAIN SIZE DISTRIBUTION (%).

$+^3, \times^3$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

OVERSIZE DRAWING(S)

GRAIN SIZE DISTRIBUTION
Sandy Silt, trace clay; Silt, trace clay

FIGURE 2



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	99-1	2	1.4
■	99-2	8	6.7

Project 991-1164

Golder Associates

METRIC

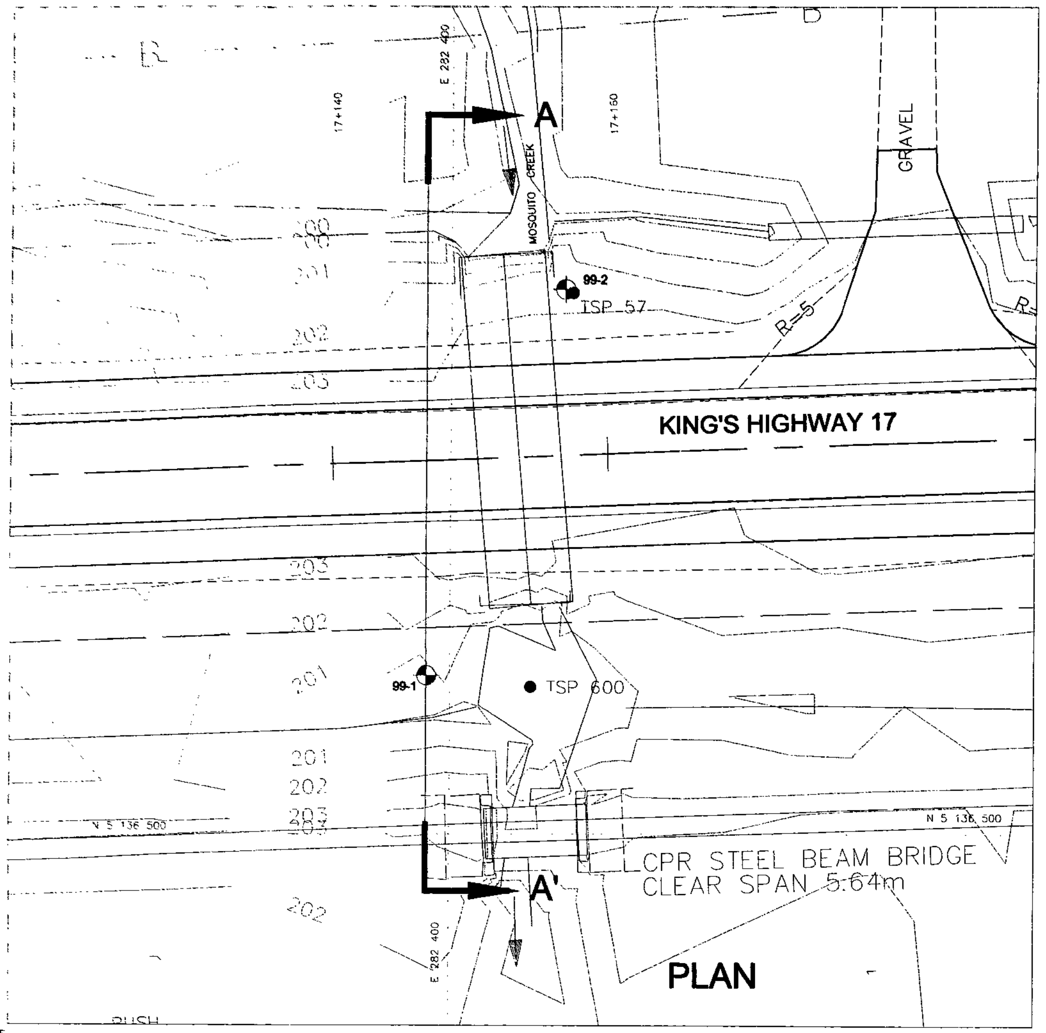
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT. No. 2000-0218
WP No. 398-91-00

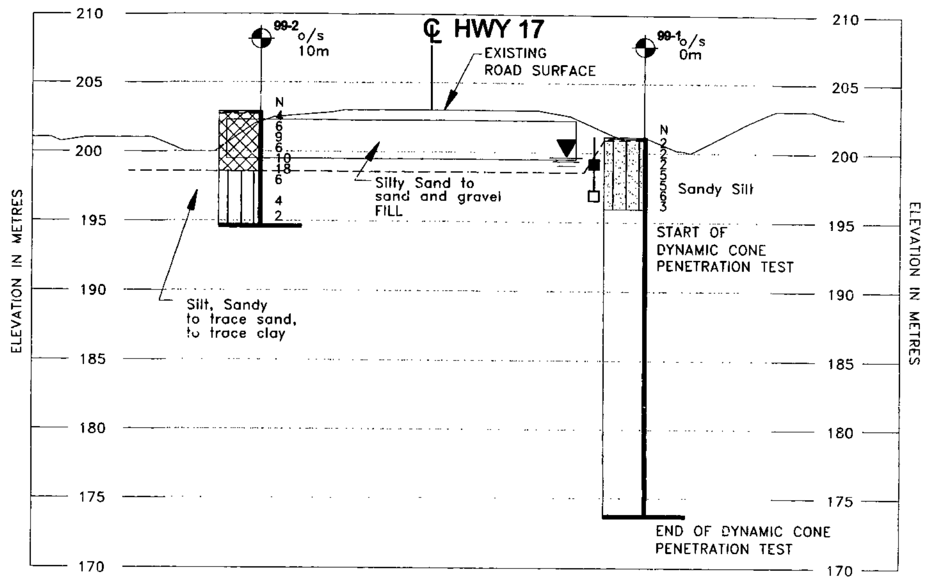
SHEET

MOSQUITO CREEK CULVERT
STA. 17+140 TO STA. 17+160
BOREHOLE LOCATIONS & SOIL STRATA

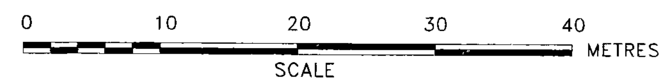
Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA

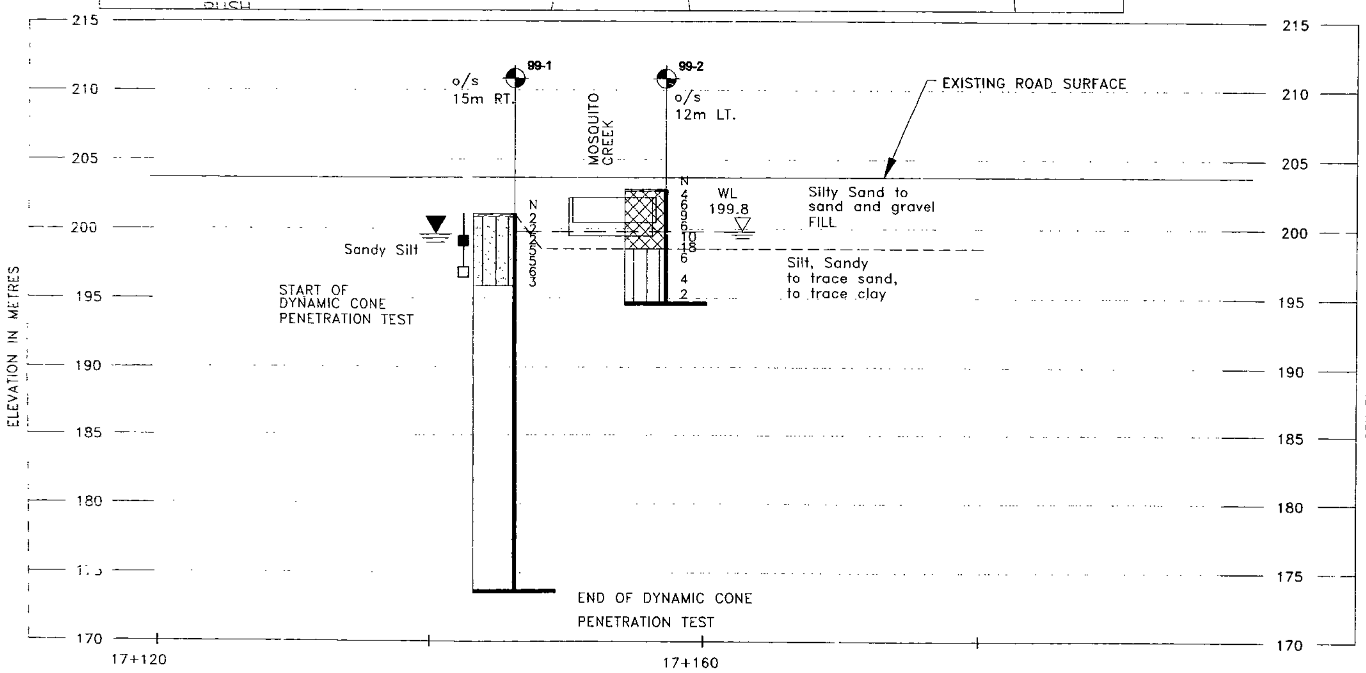


PLAN



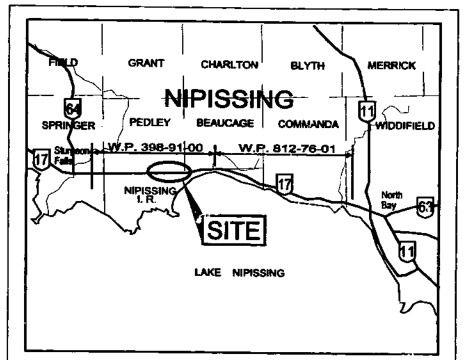
SECTION A-A'





CHAINAGE ALONG CENTERLINE

PROFILE ALONG HWY 17 CENTERLINE



KEY PLAN

LEGEND

- Borehole
- Seal
- Piezometer
- N — Blows/0.3m (Std. Pen. Test, 475 j/blow)
- WL in piezometer on Sept. 29, 1999
- WL in Mosquito Creek

No.	ELEVATION	LOCATION NORTHING	LOCATION EASTING
99-1	201.07	5136511.51	282398.30
99-2	202.85	5136539.48	282408.31

NOTES

The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REFERENCE

This figure was prepared using digital files provided by McCormick Rankin Corp.

NO.	DATE	BY	REVISION

Geocres No. 31L - 71

HWY. No. 17		PROJECT NO.: 991-1164	DIST. 54
SUBM'D. BVB	CHKD: DEB	DATE: 1999 10 12	SITE 43-272
DRAWN: JFC	CHKD. BVB	APPD.	FIGURE 1

01164MOSQUITO.DWG

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

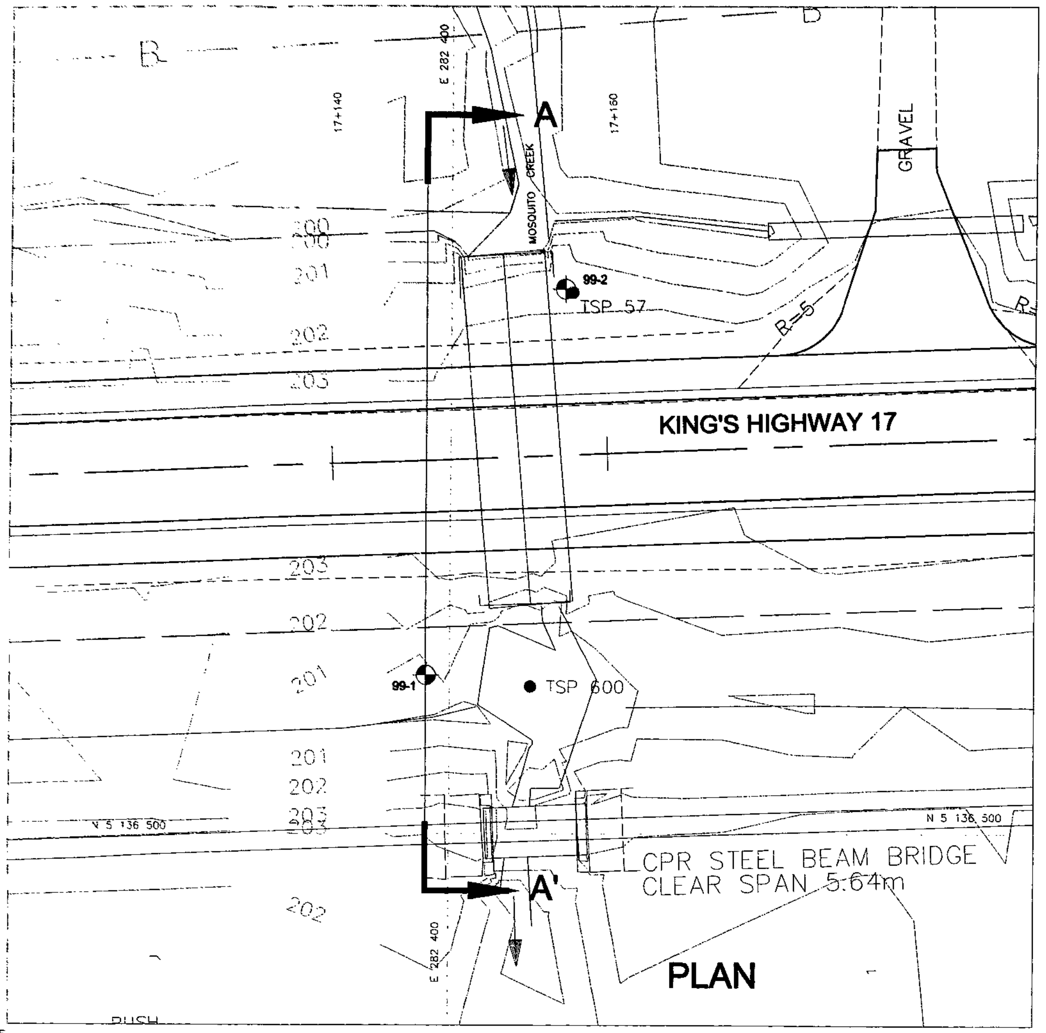
CONT. No. 2000-0218
WP No. 398-91-00

SHEET

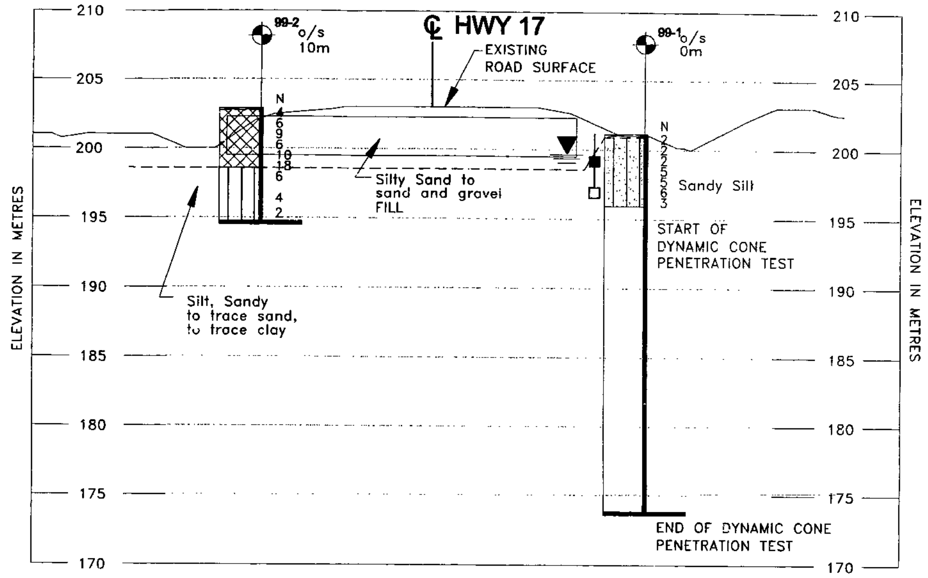
MOSQUITO CREEK CULVERT
STA. 17+140 TO STA. 17+160
BOREHOLE LOCATIONS & SOIL STRATA

Golder Associates

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA

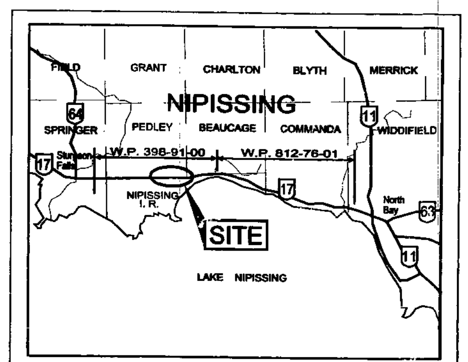


PLAN



SECTION A-A'

0 10 20 30 40 METRES
SCALE



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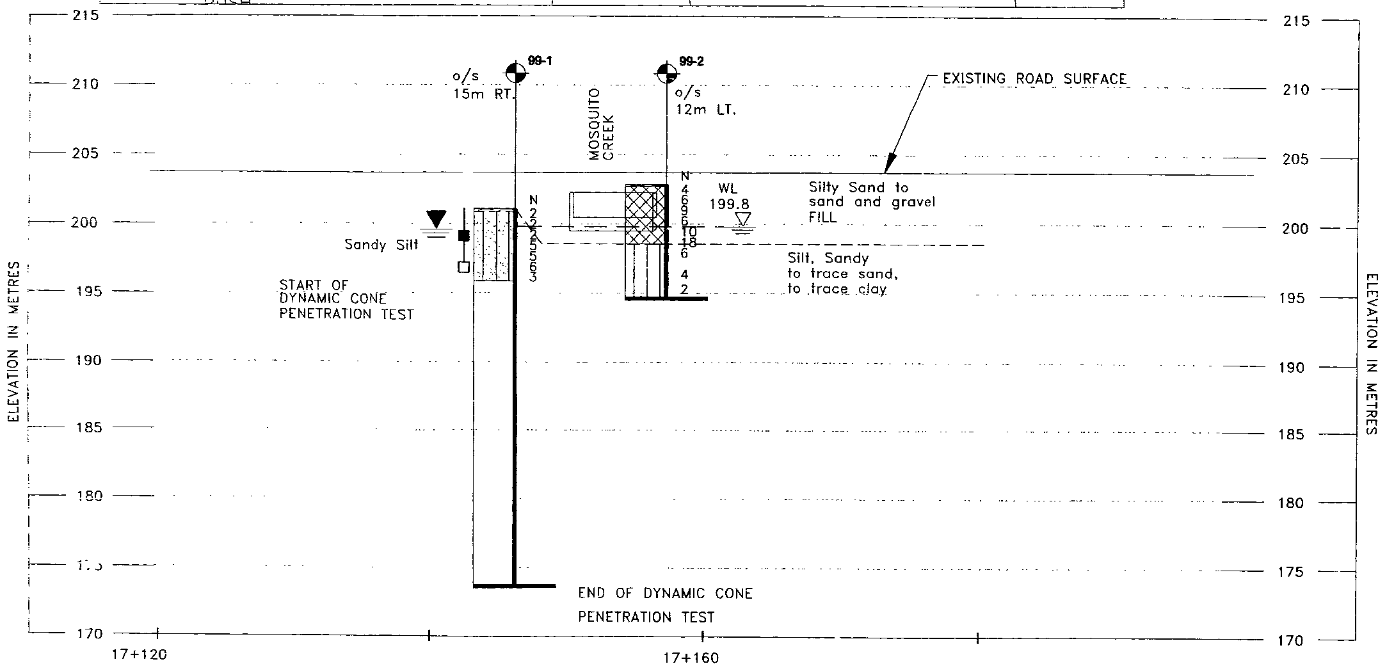

PROFILE ALONG HWY 17 CENTERLINE

NO.	DATE	BY	REVISION

Geocres No. 31L – 71

HWY. No. 17		PROJECT NO.: 991-1164	DIST. 54
SUBM'D. BVB	CHKD: DEB	DATE: 1999 10 12	SITE 43-272
DRAWN: JFC	CHKD. BVB	APPD.	FIGURE 1

01164MOSQUITO.DWG