

G.I.-30 SEPT. 1976

GEOCRES No. _____

DIST. 41 REGION _____W.P. No. 273-96-00

CONT. No. _____

W. O. No. _____

STR. SITE No. _____

HWY. No. 401LOCATION Culvert Extension
BancroftNo. of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. _____

REMARKS: _____

- L&S testing not to standard terms of reference

DRAFT FOUNDATION INVESTIGATION REPORT

W.P. 271-96-00

HWY 401, STA. 16+180 CULVERT EXTENSION

W.P. 273-96-00

**HWY 401, STA. 14+569 RETAINING WALL AT CULVERT
DISTRICT 43, BANCROFT**

MINISTRY OF TRANSPORTATION ONTARIO

SUBMITTED TO

MINISTRY OF TRANSPORTATION ONTARIO

BY

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PROJECT NO. 11258

DRAFT FOUNDATION INVESTIGATION REPORT

TO

MINISTRY OF TRANSPORTATION ONTARIO

ON

W.P. 271-96-00

HWY 401, STA. 16+180 CULVERT EXTENSION

WP. 273-96-00

HWY 401, STA. 14+569 RETAINING WALL AT CULVERT

DISTRICT 43, BANCROFT

MINISTRY OF TRANSPORTATION ONTARIO

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October 19, 1999



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FOUNDATION INVESTIGATION REPORT

for

W.P. 271-96-00

Culvert Extension - HWY 401, STA. 16+180

and

W.P. 273-96-00

Retaining Wall at Culvert - HWY 401, STA. 14+569

District 43, Bancroft

1.0 INTRODUCTION

This report presents the results of a geotechnical foundation investigation carried out for the proposed extension of the culvert at 16+180, Hope Township, and for the proposed retaining wall to be constructed at the north end of the culvert located at 14+569, Hope Township. The work was carried out in general accordance with our proposal dated September 1, 1999, and proposal revision dated September 10, 1999. Authorization to proceed was provided by Mr. Stuart Jones, P.Eng. of MTO.

This report has been prepared specifically and solely for the project described herein. It contains factual information obtained from this investigation pertaining to the subsurface conditions.

2.0 SITE DESCRIPTION AND GEOLOGY

The culverts are located within two separate MTO project limits:

W.P. 271-96-00	Hwy 401 from Durham Regional Boundary to Wesleyville Road
W.P. 273-96-00	Hwy 401 from Wesleyville Road to Highway 2

The culverts and interchanges within the limits of the investigation area are summarized in the following table.



not clear - implies 5 culverts not 2

Station	Culvert	Proposed Work
10+000	Durham Regional Boundary	-
14+568.75	Port Britain Creek Tributary A	Retaining wall on north side
15+190	Wesleyville Road	-
16+180	Port Britain Creek	Culvert extension both ends
16+861	Deer Park Road Overpass	-
19+937	Highway 2	-

The site location is shown on the Key Plan provided in Appendix 1 (Drawing No. 11258-1).

Both culverts are located within roadway fill sections. The fill heights vary from approximately 7 m to 8 m. The side slopes are approximately 2H:1V and are covered with vegetation. A plan view and a cross section of each culvert location is shown on Drawing No. 11258-2 and 11258-3, provided in Appendix 1.

Drainage in the immediate area is provided by highway ditches. Physiographically, both culvert sites lie within the area known as the Iroquois Plain. This area was formed by a body of water known as Lake Iroquois and is characterized by lacustrine deposits of sand, silts and clays. Along Highway 401, within the project limits, the principal overburden consists of the high shoreline of Lake Iroquois consisting of sands and silts, with occasional drumlins. Ontario Geological Survey Map P.2715 "Physiography of Southern Ontario" (Chapman and Putman) indicates that the overburden in the vicinity of the two culverts consists of a clay plain.

direction
velocity

Describe culverts

Size
type

Condition

length

age

flow volume

depth of
overburden

Describe topography
of surrounding area



3.0 PROCEDURE

3.1 Field Investigation

The site soil conditions were investigated through a borehole drilling investigation and laboratory testing. The drilling was carried out using a track-mounted CME-55 drill rig. The field work for this investigation was carried out on September 30, 1999.

A total of three (3) boreholes, designated as 99-1 through 99-3, were put down during the field investigation. Boreholes 99-1 and 99-2 were put down at the proposed culvert extension locations on the south and north sides of the culvert located at 16+180, respectively. The third borehole (99-3) was put down on the north side of the Hwy 401 WBL near the location of the proposed retaining wall. The proposed retaining wall is to be located on the east side of the culvert, however, due to the steep slopes, the borehole was put down on the west side of the culvert. A hand auger hole was carried out to a depth of 1.5 m at the actual retaining wall location to assess the soil conditions that will be encountered directly behind the retaining wall.

The boreholes were advanced to a minimum depth of 6.7 m using hollow-stem augers. The subsurface conditions were identified in the field by our personnel while carrying out Standard Penetration Tests (SPT) (ASTM D1586). The SPT were carried out at regular intervals (760 mm) and the recovered soil samples were returned to our laboratory. The subsurface conditions are described in detail in the Borehole Records presented in Appendix 1.

All soil samples recovered were stored in moisture proof containers and were returned to our laboratory for detailed classification and testing.

Prior to completing the investigation, the boreholes were backfilled by replacing (and tamping in layers) the augered material.

3.2 Survey

Borehole locations were established in the field by Jacques Whitford personnel relative to the existing culverts. The ground surface elevations at the borehole locations were surveyed relative to the tops of the existing culverts.



3.3 Laboratory Testing

afterberg limits

All samples returned to the laboratory were subjected to detailed visual classification by a geotechnical engineer. Selected samples were tested for moisture content and grain size distribution. One representative soil sample from each of the culvert locations was submitted for pH, sulphate and chloride testing to assess the potential for corrosion of buried steel and the potential for sulphate attack on buried concrete. All soil samples will be stored for a period of one year after issuance of the final report. Unless otherwise directed, the stored samples will be disposed of after this period.

4.0 ~~RESULTS OF THE INVESTIGATION~~

Subsurface Conditions

4.1 Subsurface Profile

The subsurface conditions observed in the boreholes are presented in detail on the Borehole Records provided in Appendix 2. An explanation of the symbols and terms used to describe the Borehole Records is also provided. The general subsurface conditions observed at each of the culvert locations is described in the following sections.

~~refers to stratigraphical profile of B.H. locations~~

4.1.1 Culvert at Sta. 16+180, Hope Township

A borehole location plan and a cross section of the soils encountered within the boreholes at Sta. 16+180 is shown on Drawing No. 11258-2.

why in case
p223

The overburden soils encountered at the south end of the culvert (Borehole 99-1) consisted of silty clay fill overlying a deposit of glacial till. The silty clay fill extended to a depth of 1.7 m and contained some sand and trace amounts of gravel and organic matter. The moisture contents of the two samples tested were 21 % and 23 %. The silty clay fill generally had a firm consistency. The glacial till deposit consisted of sandy silt with a trace amount of gravel and was in a very dense state. The moisture content of three samples tested ranged from 7 % to 8 %. The borehole was terminated within the very dense glacial till deposit.

based on what

The overburden soils encountered at the north end of the culvert (Borehole 99-2) consisted of sand overlying sand with gravel, overlying a silt deposit. The sand deposit extends to a depth of 2.3 m and contains some silt and trace clay. SPT N-values within the sand were no greater than 1, indicating a very loose deposit. The very loose sand is underlain by a deposit of coarse sand with gravel. SPT N-values within this deposit varied from 19 to 40, indicating a compact to dense material. The moisture contents of two samples tested were 10 %. A grain size analysis carried out on a sample of this material indicated that it contained 33 % gravel, 55 % sand and 12 % fines. The coarse sand with gravel extended to a depth of 4.6 m and was

based on what



underlain by a very dense silt deposit. The silt was greyish-brown in colour and contained some sand. SPT N-values were all greater than 100. The moisture contents of the two samples tested were 12 % and 19 %. The borehole was terminated within the silt deposit.

4.1.2 Culvert at Sta. 14+569, Hope Township

A borehole location plan and a cross section of the soils encountered within the borehole located at the north end of the culvert at Sta. 14+569 is shown on Drawing No. 11258-3.

The stratigraphy consisted of granular fill overlying a silt and clay deposit overlying glacial till. The granular fill consists of sandy silt with trace amounts of clay and gravel and extends to a depth of approximately 1.5 m. The moisture content of the sample of fill tested was 14 %. SPT N-values ranged from 3 to 8 indicating a generally loose deposit. The fill was underlain by a silt and clay deposit that extended to a depth of 3.1 m. The silt and clay contained trace amounts of sand, was dark brown and grey in colour and had a stiff consistency. The moisture content of the sample tested was 19 %. The silt and clay was underlain by a glacial till deposit. The glacial till varied from clayey silt with sand, trace gravel to sandy silt, trace clay and gravel. SPT N-values ranged from 40 to 165, indicating a dense to very dense deposit. The moisture content of seven samples tested ranged from 11 % to 15 % with an average of 12 %. A grain size analysis carried out on one sample of the glacial till indicated that it contained 22 % sand, 55 % silt and 23 % clay particles. The borehole was terminated at a depth of 9.0 m, within the glacial till deposit.

4.2 Groundwater

Groundwater levels were observed to be approximately equal to the water level in the creeks at all borehole locations. Water was present in all culverts at the time of the investigation. Fluctuations in the groundwater level due to seasonal variations or in response to a particular precipitation event should be anticipated.

Sign & seal



FOUNDATION INVESTIGATION AND DESIGN REPORT

for

W.P. 271-96-00

Culvert Extension - HWY 401, STA. 16+180

and

W.P. 273-96-00

Retaining Wall at Culvert - HWY 401, STA. 14+569

District 43, Bancroft

5.0 DISCUSSION AND RECOMMENDATIONS

5.1 Proposed Development

It is understood that the Ministry of Transportation of Ontario (MTO) plans to construct a median tall wall barrier and to widen both the EBL and WBL of Highway 401 from two to three lanes within the full limits of W.P. 271-96-00 and W.P. 273-96-00. To accommodate the proposed widening, the culvert located at Sta. 16+180 will need to be extended by 1.8 m on the north side and 3.0 m on the south side. At Sta. 14+569, on the north side of Hwy 401, a 5.0 m long by 3.0 m tall concrete retaining wall is to be constructed. It is understood that construction of the retaining wall will prevent the toe of the highway side slopes from encroaching into the creek to accommodate the proposed widening.

Based on drawings of the culvert locations, the embankment geometry is as follows:

Culvert Location	Height of Fill Over Culvert (m)	Height of Fill Over Culvert Invert (m)	Sideslopes
14+569	4.8	6.3	2H:1V
16+180	5.0	8.0	2H:1V

5.2 Geotechnical Assessment

It is anticipated that the culvert replacements will be constructed to match the existing culvert structures (i.e. same type of culvert and same founding elevation). This will require removal of existing fill and /or very loose sand material. The proposed grade raise and embankment loading will result in increased stresses in



the soil beneath and immediately surrounding the existing culverts. It is anticipated that the retaining wall at the base of the slope will be founded on a spread footing.

5.3 Foundation Recommendations

5.3.1 Culvert at Sta. 16+180, Hope Township

The existing culvert consists of a double 4.88 m by 3.0 m concrete box culvert founded at approximately elevation 98.0 m (north side). Very loose sand and fill were encountered beneath the proposed founding elevations on the north and south sides, respectively. These materials will need to be removed and replaced with structural fill. Subexcavation in the order of 2 m should be expected.

*is sub ex below ised
if so is protection
required*

what is structural fill

*explicitly state foundation
level*

The following design parameters may be used for spread footings founded on structural fill overlying the native glacial till or coarse sand with gravel:

	North Side	South Side
Factored Bearing Pressure at ULS	425 kPa	600 kPa
Bearing Pressure at SLS	225 kPa	275 kPa

Sliding resistance between the concrete and the structural fill should be calculated in accordance with Section 6-8.4.3 of the OHBDC using an unfactored friction coefficient of 0.55.

$$\mu = \tan \phi$$
$$\phi = 28.8^\circ$$

It is anticipated that the structures may encounter differential settlements due to the varying overburden depths. The culvert should be designed and constructed to minimize possible damages associated with total and differential settlements.

how - construction joint

All spread footings should be protected from frost action by a minimum soil cover of 1.4 m or equivalent insulation.

or bunks designed to accommodate frost pressure

5.3.2 Retaining Wall at Culvert - Sta. 14+569, Hope Township

The existing culvert is founded at elevation 126.5 m. It is anticipated that the proposed retaining wall will be constructed at the same founding elevation. Loose granular fill was encountered to a depth of 1.5 m (approximately elevation 126.0 m) in Borehole 99-3. The fill will need to be removed and replaced with structural fill.

how without disturbing culvert



The following design parameters may be used for spread footings founded on the native silt and clay or on structural fill overlying the native silt and clay: *state elev.*

Factored Bearing Pressure at ULS	130 kPa
Bearing Pressure at SLS	100 kPa

too high

The effects of inclined loads should be accounted for in accordance with Section 6-8.4.2 of the OHBDC.

Sliding resistance between the concrete and the structural fill should be calculated in accordance with Section 6-8.4.3 of the OHBDC using an unfactored friction coefficient of 0.55.

not rise for clay

All spread footings should be protected from frost action by a minimum soil cover of 1.4 m or equivalent insulation.

what about RSS

not required for

5.4 Lateral Earth Pressures

5.4.1 Lateral Earth Pressures on Culverts

The walls of the box culvert may be considered as a fully restrained structure and lateral earth pressures corresponding to the at-rest condition should be used for design. The unfactored soil parameters presented in the table below may be used for design.

Parameter	OPSS Granular A	OPSS Granular B	Native Soil / Earth Fill
Bulk Unit Weight, γ (kN/m ³)	22.5	21	19
Effective Friction Angle, ϕ	35°	32°	30°
At-rest Earth Pressure Coefficient, K_0	0.43	0.47	0.50

The properties of the native soil/earth fill should be used to determine the lateral earth pressure unless the interface between the granular backfill and the native soil/earth fill is flatter than 45 degrees, in which case the properties of the granular backfill may be used. The earth pressure should have a triangular distribution with the apex at the ground surface.

The effects of compaction should be accounted for by applying a compaction surcharge as shown in Figure 6-7.4.3 of the OHBDC 3rd Edition.



5.4.2 Lateral Earth Pressures on Retaining Wall

It is understood that the proposed retaining wall is to be 5 m long and 3 m tall. Based on the contract drawings, the highway sideslopes are understood to be no steeper than 2H:1V. A backfill slope of 2H:1V behind the retaining wall should be assumed for design purposes. Computation of earth pressures should be in accordance with Section 6-7 of the OHBDC 3rd Edition.

The following unfactored soil parameters may be used for the design of retaining walls with a granular backfill inclined at 2H:1V:

Parameter	OPSS Granular A	OPSS Granular B	Native Soil / Earth Fill
Bulk Unit Weight, γ (kN/m ³)	22.5	21	19
Effective Friction Angle, ϕ	35°	32°	30°
Coulomb Active Earth Pressure Coefficient, K_a	0.4	0.47	0.54

The resultant force calculated from the Coulomb active earth pressure coefficient provided in the table above acts horizontally and intersects the wall at a point equal to one third of the height of the wall from the base of the wall. The earth pressure should have a triangular distribution with the apex at the ground surface.

The properties of the native soil/earth fill should be used to determine the lateral earth pressure unless the interface between the granular backfill and the native soil/earth fill is flatter than 45 degrees, in which case the properties of the granular backfill may be used.

The effects of compaction should be accounted for by applying a compaction surcharge as shown in Figure 6-7.4.3 of the OHBDC 3rd Edition.

near backfill / weeping hole reqs

5.5 General Construction Recommendations

Site Grading and Preparation

All organic soils, and other deleterious materials must be removed from beneath the proposed culvert extensions and retaining wall foundations. Where deleterious materials are encountered, the material should be excavated, wasted and replaced with structural fill. The lateral extent of such excavation should include all deleterious material within an imaginary line drawn at an angle of 1 horizontal to 1 vertical, downward and away from the vertical edges of the culvert, to the competent native soil.

what about deleterious material in wedge



Stripping of deleterious materials should be inspected by geotechnical personnel to ensure that all unsuitable materials are removed prior to placement of structural fill. Structural fill should consist of OPSS Granular A or Granular B, Type I or II, placed in lifts no greater than 300 mm thick and compacted to at least 98 % standard Proctor maximum dry density.

If required for grading purposes, earth fill should consist of Select Subgrade Material (SSM), placed in lifts no greater than 300 mm and compacted to at least 95 % Standard Proctor Maximum Dry Density (SPMDD).

Excavation and Backfill

Excavation and backfill for the concrete box culverts should conform to OPSD-803.01 or OPSD-803.02. Rockfill can be used as backfill provided that within a lateral distance of 600 mm on each side and over the culvert, granular backfill such as OPSS Granular B or Granular A material be used to avoid high stress points on the culvert. This material should be placed in lifts no greater than 300 mm thick and compacted to at least 95 % SPMDD.

Excavation and backfill behind the proposed concrete retaining wall should conform to OPSD 3504.00

Side slopes for open cut excavations should conform to Occupational Health and Safety Act and Regulations for Construction Projects. The soils to be excavated range from a Type 3 to a Type 4 soil, as defined in the act. Therefore, relatively flat slopes or shoring may be required. Should shoring be proposed, the soil parameters provided in Sections 5.4.2 (Lateral Earth Pressures on Retaining Walls) may be used.

A depth of frost treatment, f , of 1.4 m should be used at these sites.

Dewatering and Protection of Founding Level

The proposed founding elevations for the culverts and the retaining wall were below the water table at the time of this investigation. Dewatering will likely be required during construction. The use of sump pumps and coffer dams may be used during construction of the culvert replacements.

A layer of free draining granular material such as clean crushed stone should be placed immediately beneath the culvert for levelling and support purposes. This will also serve to protect the base from disturbance and softening prior to culvert construction.



Cement Type and Corrosion Protection

Two representative soil sample were submitted to Accutest Laboratories in Nepean, Ontario for analysis of pH and water soluble sulphate and chloride, in order to determine cement type and reinforcing steel protection requirements. The results are summarized in the table below.

Location	Borehole	Sample	pH	Soluble Chloride (%)	Soluble Sulphate (%)
Station 16+180	99-2	SS4	8.7	0.009	0.03
Station 14+569	HA-3	BS3	8.6	0.032	0.02

Both water soluble sulphate results were below 0.10 %, indicating that a negligible degree of sulphate attack is expected for concrete in contact with the site soils. Therefore, a normal Type 10 Portland cement should be suitable for use in concrete at these sites.

The soil pH level and concentration of water soluble chloride give an indication to the level of potential attack on buried steel objects such as reinforcing steel. The pH levels are within the normally acceptable range of 5.8 to 9, indicating no special corrosion potential problems. The water soluble chloride concentration result from the sample taken from Sta. 14+569 was greater than 0.025%, indicating an environment that is favorable for corrosion of buried steel. In addition, high levels of chloride may be present in the ditches and creek water at certain times of the year due to roadway deicing, therefore consideration should be given to providing some form of corrosion protection for the reinforcing steel.

- need res for inlet channel protection
and outlet.

6.0 CLOSURE

The recommendations made in this report are in accordance with our present understanding of the project. We request that we be permitted to review our recommendations when the drawings and specifications are complete.

A soil investigation is a limited sampling of a site. The conclusions given herein are based on information gathered at the specific borehole locations and can only be extrapolated to an undefined limited area around these locations. The extent of the limited area depends on the soil and groundwater conditions, as well as the history of the site reflecting natural, construction, and other activities. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information and its effects on the above conclusions.

We trust the information presented herein meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

Yours very truly,

JACQUES, WHITFORD LIMITED

Paul Carnaffan, M.Eng., P.Eng.

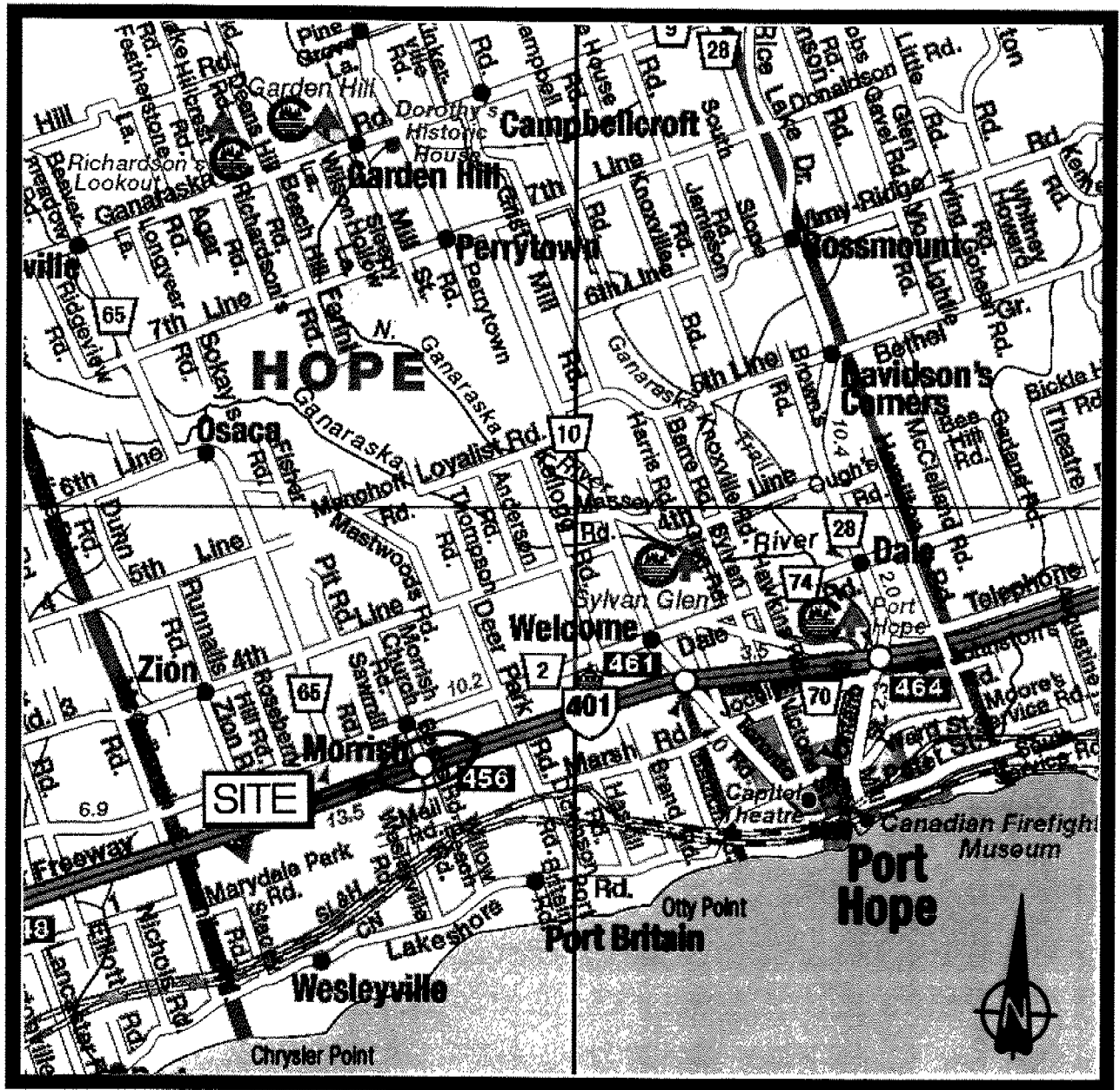
J.G.A. Raymond Haché, M.Sc., P.Eng.
Manager, Geotechnical Services.

P:\1999\10000\11258\Foundation Report.wpd



APPENDIX 1

Hwy 401



WP 271-96-00

Hwy 401, Sta 16+180 Culvert Extension

WP 273-96-00

Hwy 401, Sta 14+569 Retaining Wall at Culvert



District 43, Bancroft

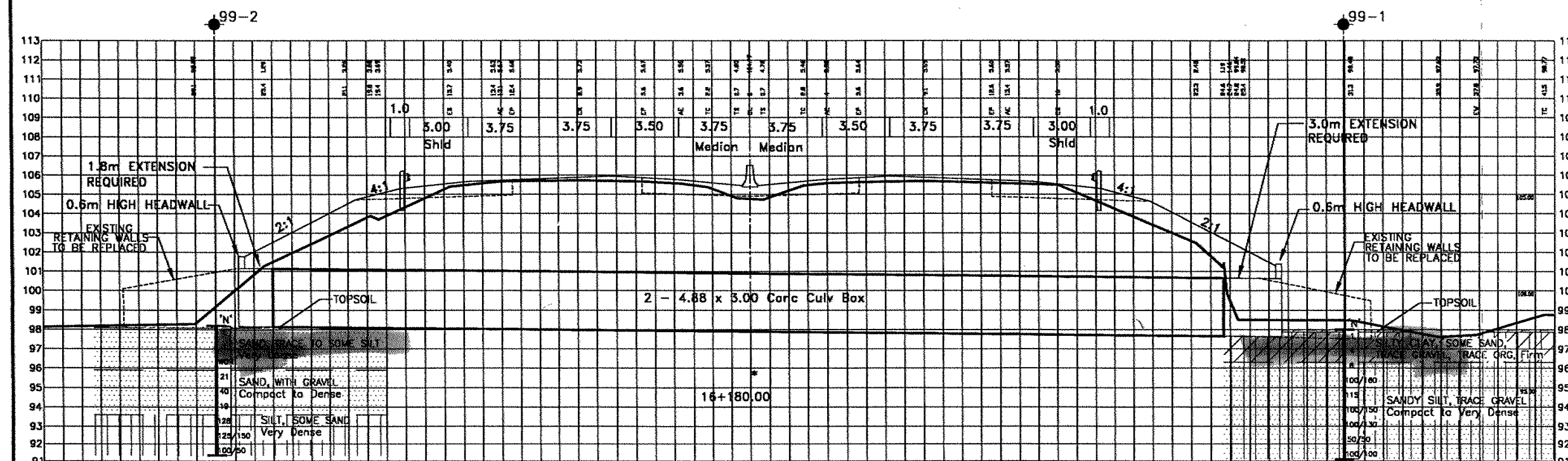
Township of Hope

KEY PLAN

Not to Scale









PLATE No DRAWING No CONT No WP No 273-96-00	
HWY 401 - CULVERT E11 STA 16+180.27	SHEET 1
JACQUES, WHITFORD LIMITED	
	



SCALE

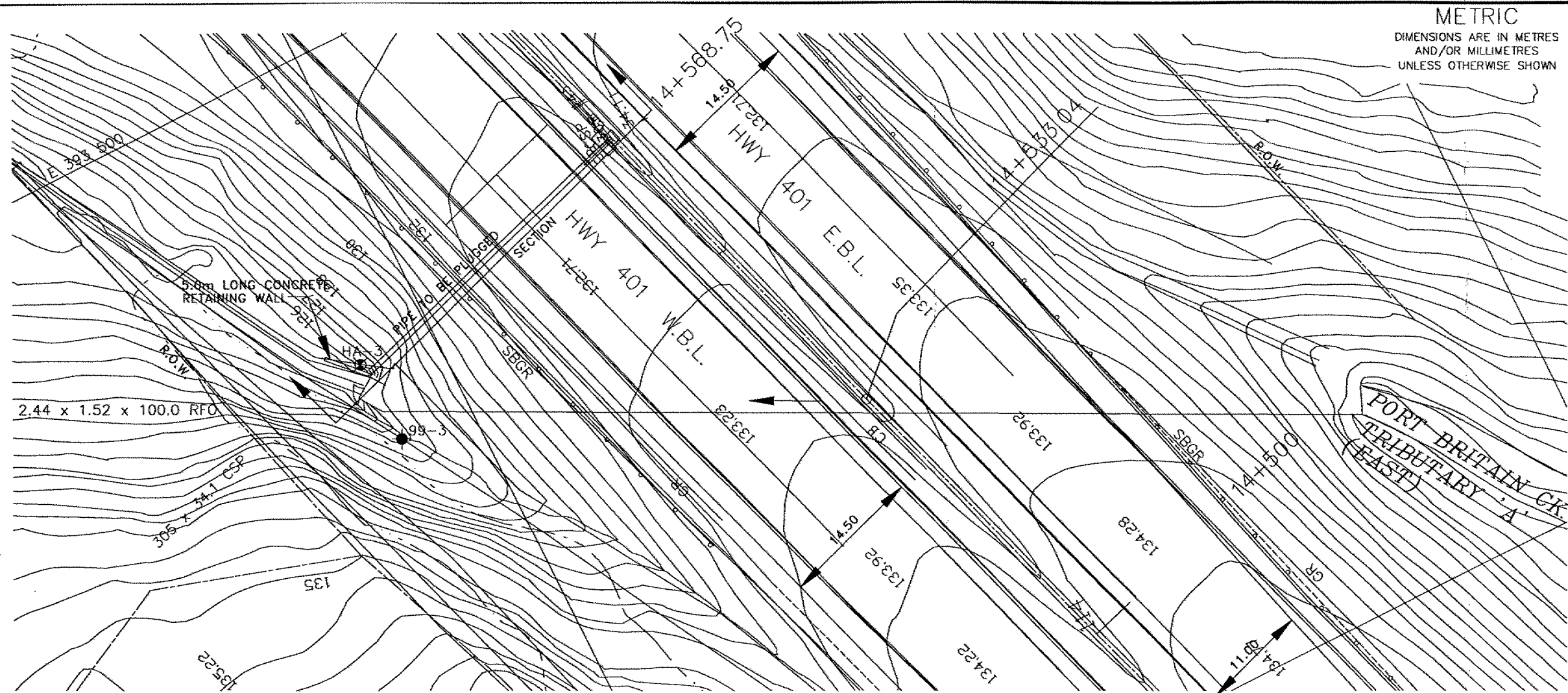
2.5m 0 2.5m

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)		
	WL at time of investigation 97 07		
	WL in Piezometer		
	Piezometer		
No	ELEVATION	COORDINATES	
		NORTH	EAST
99-1	98.0	-	-
99-2	98.2	-	-

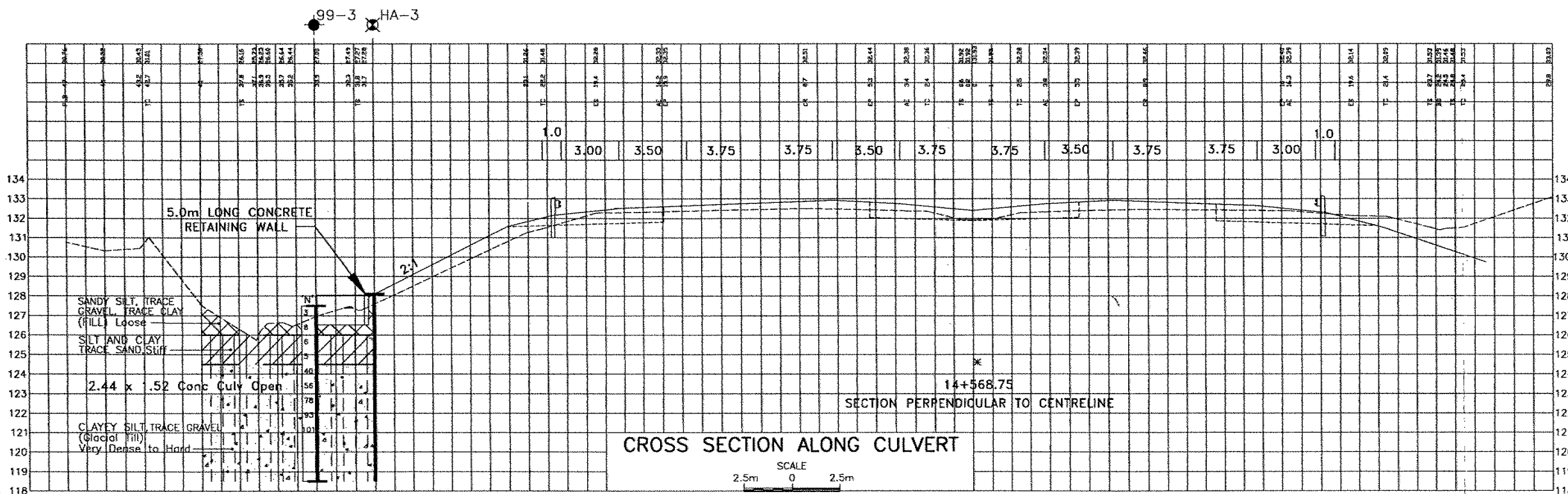
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore holes the boundaries are assumed from geological evidence.

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.

REC				
	DATE	BY	DESCRIPTION	
GEOCONS Na				
HWY No 401			DIST 4.3	
SUBM'D	PC	CHECKED	DATE 199-10-12	SITE
DRAWN	GBB	CHECKED	APPROVED	DWG 11258-2



PLAN
SCALE
5m 0 5m



CROSS SECTION ALONG CULVERT

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

PLATE No	SHEET 2
DRAWING No	
CONT No	
WP No 273-96-00	
HWY 401 - CULVERT E9	
STA 14+533.04	
TOWNSHIP OF HOPE, ONTARIO	
JACQUES, WHITFORD LIMITED	

- LEGEND
- Bore Hole
 - ⊕ Dynamic Cone Penetration Test (Cone)
 - ⊙ Bore Hole & Cone
 - ⊗ Hand Auger
 - N Blows/0.3m (Std Pen Test, 475 J/blow)
 - CONE Blows/0.3m (60° Cone, 475 J/blow)
 - WL at time of investigation 97 07

No	ELEVATION	COORDINATES NORTH	EAST
99-3	127.5	-	-

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

HWY No 401	DIST 43
SUBM'D PC	CHECKED
DRAWN GBB	CHECKED
DATE 199-10-18	SITE
APPROVED	DWG 11258-3

Dwg File : 11258-3.dwg

APPENDIX 2

SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

<i>Topsoil</i>	-	mixture of soil and humus capable of supporting good vegetative growth
<i>Peat</i>	-	fibrous aggregate of visible and invisible fragments of decayed organic matter
<i>Till</i>	-	unstratified glacial deposit which may range from clay to boulders
<i>Fill</i>	-	any materials below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

<i>Desiccated</i>	-	having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
<i>Fissured</i>	-	having cracks, and hence a blocky structure
<i>Varved</i>	-	composed of regular alternating layers of silt and clay
<i>Stratified</i>	-	composed of alternating successions of different soil types, e.g. silt and sand
<i>Layer</i>	-	> 75 mm
<i>Seam</i>	-	2 mm to 75 mm
<i>Parting</i>	-	< 2 mm
<i>Well Graded</i>	-	having wide range in grain sizes and substantial amounts of all intermediate particle sizes
<i>Uniformly Graded</i>	-	predominantly of one grain size

Terminology describing soils on the basis of grain size and plasticity is based on the Unified Soil Classification System (USCS) (ASTM D-2488). The classification excludes particles larger than 76 mm (3 inches). This system provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter, construction debris) is based upon the proportion of these materials present:

<i>Trace, or occasional</i>	Less than 10%
<i>Some</i>	10-20%

The standard terminology to describe cohesionless soils includes the compactness (formerly "relative density"), as determined by laboratory test or by the Standard Penetration Test 'N' - value.

Relative Density	'N' Value	Compactness %
<i>Very Loose</i>	< 4	< 15
<i>Loose</i>	4-10	15-35
<i>Compact</i>	10-30	35-65
<i>Dense</i>	30-50	65-85
<i>Very Dense</i>	> 50	> 85

The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by insitu vane tests, penetrometer tests, unconfined compression tests, or occasionally by standard penetration tests.

Consistency	Undrained Shear Strength		'N' Value
	kips/sq. ft.	kPa	
<i>Very Soft</i>	<0.25	<12.5	<2
<i>Soft</i>	0.25-0.5	12.5-25	2-4
<i>Firm</i>	0.5-1.0	25-50	4-8
<i>Stiff</i>	1.0-2.0	50-100	8-15
<i>Very Stiff</i>	2.0-4.0	100-200	15-30
<i>Hard</i>	>4.0	>200	>30

ROCK DESCRIPTION

Rock Quality Designation (RQD)

The classification is based on a modified core recovery percentage in which all pieces of sound core over 100 mm long are counted as recovery. The smaller pieces are considered to be due to close shearing, jointing, faulting, or weathering in the rock mass and are not counted. RQD was originally intended to be done on NW core; however, it can be used on different core sizes if the bulk of the fractures caused by drilling stresses are easily distinguishable from *in situ* fractures.

RQD

ROCK QUALITY

90-100	Excellent, intact, very sound
75-90	Good, massive, moderately jointed or sound
50-75	Fair, blocky and seamy, fractured
25-50	Poor, shattered and very seamy or blocky, severely fractured
0-25	Very poor, crushed, very severely fractured

Terminology describing rock mass:

Spacing (mm)	Bedding, Laminations, Bands	Discontinuities
2000-6000	<i>Very Thick</i>	<i>Very Wide</i>
600-2000	<i>Thick</i>	<i>Wide</i>
200-600	<i>Medium</i>	<i>Moderate</i>
60-200	<i>Thin</i>	<i>Close</i>
20-60	<i>Very Thin</i>	<i>Very Close</i>
<20	<i>Laminated</i>	<i>Extremely Close</i>
<6	<i>Thinly Laminated</i>	

Strength Classification	Uniaxial Compressive Strength (MPa)
<i>Very Low</i>	1-25
<i>Low</i>	25-50
<i>Medium</i>	50-100
<i>High</i>	100-200
<i>Very High</i>	>200

Terminology describing weathering:

Slight

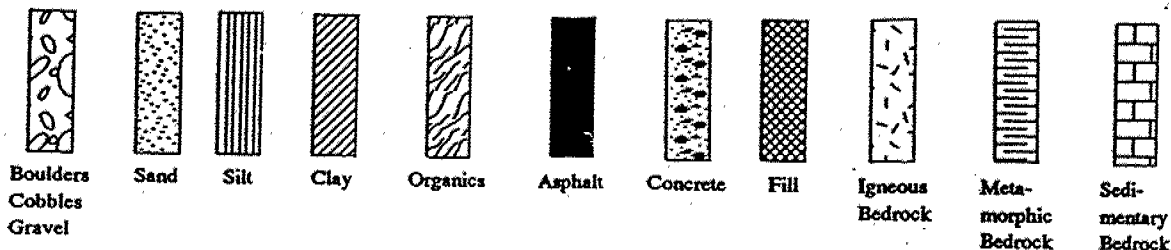
Weathering limited to the surface of major discontinuities. Typically iron stained.

Moderate
High

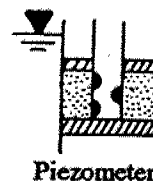
- Weathering extends throughout rock mass. Rock is not friable.
- Weathering extends throughout rock mass. Rock is friable.

STRATA PLOT

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols:



WATER LEVEL MEASUREMENT



SAMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)	BS	Bulk sample
ST	Shelby tube or thin wall tube	WS	Wash sample
PS	Piston sample	HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond drilling bits.


N - VALUE

Numbers in this column are the results of the Standard Penetration Test: the number of blows of a 140 pound (64 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (305 mm) into the soil. For split spoon samples where insufficient penetration was achieved and 'N' values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75).

OTHER TESTS

S	Sieve analysis	H	Hydrometer analysis
G _s	Specific gravity of soil particles	γ	Unit weight
k	Permeability (cm/sec)	C	Consolidation
↓	Single packer permeability test; test interval from depth shown to bottom of borehole	CD	Consolidated drained triaxial
	Double packer permeability test; test interval as indicated	CU	Consolidated undrained triaxial with pore pressure measurements
○	Falling head permeability test using casing	UU	Unconsolidated undrained triaxial
▽	Falling head permeability test using well point or piezometer	DS	Direct shear
		Q _u	Unconfined compression
		I _p	Point Load Index (I _p on Borehole Record equals I _p (50); the index corrected to a reference diameter of 50 mm)

METRIC

ELEV DEPTH	SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w_p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w_L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE							
98.0								20 40 60 80 100								

Depth (m)	Description	Soil Type	Grain Size	Moisture (%)	Plasticity (%)	Unit Weight (kN/m³)	Void Ratio	Compression Index	Swelling Pressure (kPa)	Other Data
0.0 - 0.1	125 mm TOPSOIL Firm, brown SILTY CLAY, some sand, trace gravel, trace organic matter (Fill)	SS	1							
0.1 - 96.3	Compact to very dense, grey SANDY SILT, trace gravel (glacial till)	SS	4							
96.3 - 91.3	End of Borehole	SS	6							
91.3 - 6.7	End of Borehole	SS	100/180							
6.7 - 5.31	End of Borehole	SS	115							
5.31 - 3.1	End of Borehole	SS	100/150							
3.1 - 1.64	End of Borehole	SS	100/130							
1.64 - 0.85	End of Borehole	SS	50/50							
0.85 - 0.0	End of Borehole	SS	100/100							

+ 3, X 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH 99-2

1 OF 1

METRIC

W.P. 273-96-00 LOCATION Highway 401 Culvert Investigation ORIGINATED BY RL
DIST 43 HWY 401 BOREHOLE TYPE Hollow stem augers COMPILED BY PC
DATUM Geodetic DATE 30.09.99 CHECKED BY JGARH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL × LAB VANE						
98.2							20	40	60	80	100	10	20	30	GR SA SI CL	
98.1	125 mm TOPSOIL		1	SS	1	▽	98								33 55 12	
	Very loose, grey SAND, trace to some silt, trace clay (Wet)		2	SS	1		97									
			3	SS	WOR		96									
95.9	- trace gravel		4	SS	21		95									
2.3	Compact to dense, grey, coarse SAND with gravel		5	SS	40		94									
			6	SS	19		93									
93.6	Very dense, grey SILT, some sand		7	SS	128	92										
4.6	- brownish grey		8	SS	125/150											
			9	SS	100/50											
91.5	End of Borehole															
6.7	WOR = weight of rod															

1 OF 1

METRIC

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

APPENDIX 3

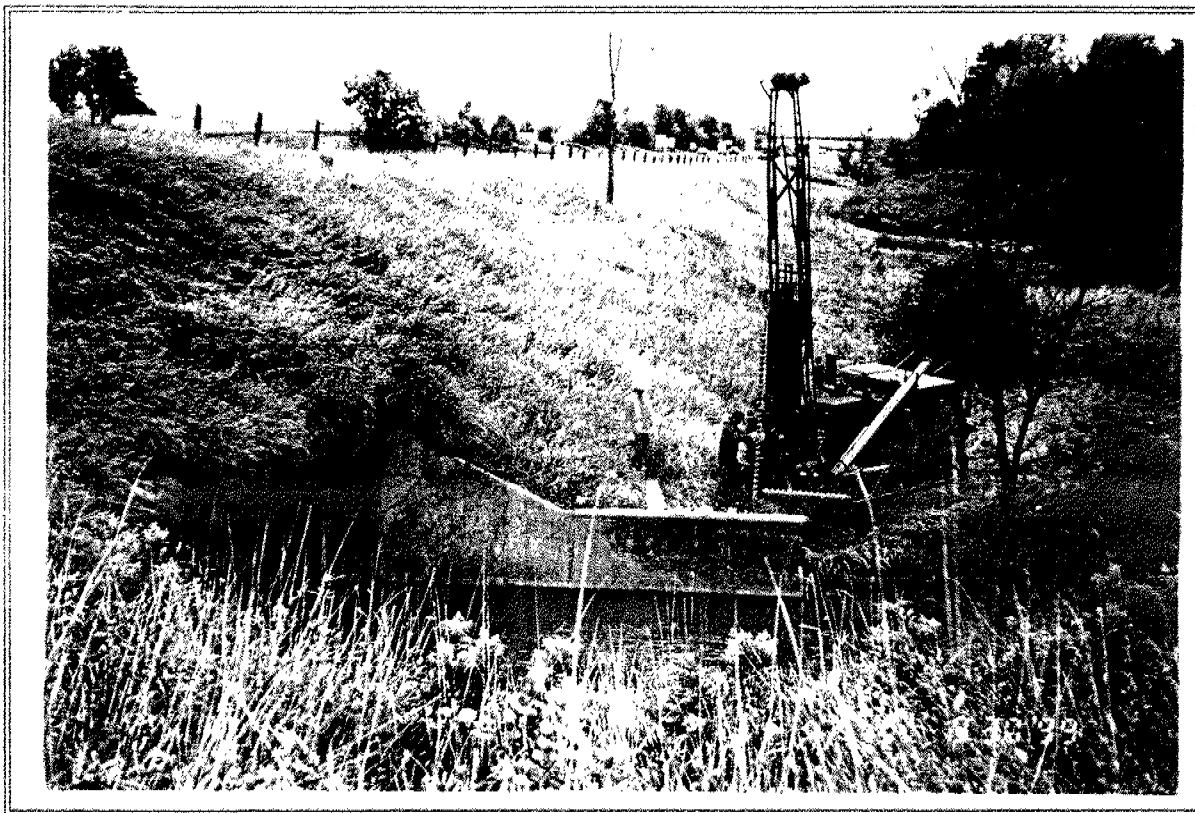


Photo 1: Hwy 401, Sta. 16+180, Hope Township.
Drill Rig at Borehole BH 99-1.



Photo 2: Hwy 401, Sta. 16+180, Hope Township.
Drill rig at Borehole BH 99-2.



Photo 3: Hwy 401, Sta. 14+569, Hope Township.
Access to Borehole BH 99-3.

Tomy

Dec - 8/99

I have reviewed and concurred
with comments or responses
by J-W but suggest we check
items 14 & 17 in final report.
FYI & FILING Doe

**Jacques,
Whitford
Limited**
Consulting Engineers
Environmental Scientists
Risk Consultants

Ontario • Saskatchewan • Alberta • British Columbia • Nova Scotia • New Brunswick • Prince Edward Island • Newfoundland & Labrador • Quebec
Maine • New Hampshire • Vermont • Trinidad • Russia • Argentina

December 3, 1999

Mr. Stuart Jones, P.Eng.
Highway Engineering, Eastern Region
Ministry of Transportation Ontario
355 Counter Street, Postal Bag 4000
Kingston, ON K7L 5A3

Dear Mr. Jones:

Re: Response to Evaluation of Draft Foundation Investigation & Design Report
Hwy 401, Bancroft: WP 271-96-00 and WP 273-96-00

Thank you for MTO's comments on our Draft Foundation Investigation and Design Report for the following sites:

WP 271-96-00, Culvert Extension, Station 16+180
WP 273-96-00, Retaining Wall at Culvert, Station 14+569

The purpose of this letter is to respond to the comments provided by Mr. Dave Dundas, P.Eng., MTO Senior Foundation Engineer, in his letter dated November 18, 1999. Jacques Whitford offers the following responses to MTO's comments:

- 1) A description of the direction, velocity and flow should be provided for the culverts.

Subsequent to receiving MTO's comments we have requested and received this information. The information will be included in the final report.

- 2) A description of the size, length, age and condition of the existing culverts should be provided.

Jacques Whitford did not have information regarding the age and condition of the culverts at the time that the Draft Report was prepared. This information has since been obtained from MTO. This information will be included in the final report.



Mr. S. Jones
December 3, 1999

JWL File No. 11258
Page 2 of 5

- 3) Site number is not indicated.

Jacques Whitford has contacted MTO and requested the site numbers. It is understood from discussions with the structural engineer for the project, that the site number for the culvert located at Station 16+180 is 21-369. There does not appear to be a site number for the culvert located at Station 14+569. The site numbers, where available from MTO, will be included in the final report.

- 4) Lab testing does not meet requirements (Atterberg Limits for cohesive samples).

A thin cohesive deposit was encountered in Borehole 99-3. Two split spoon samples were taken within this deposit. Atterberg limit testing has been carried out on Sample No. 3. The liquid limit and plastic limit were determined to be 25.8 % and 14.5 %, respectively. Test results will be included in the text and logs of the final report.

- 5) Section 4 'Results of Investigation' should be titled 'Subsurface Conditions'.

This formatting error will be rectified in the final report.

- 6) Each strata should be discussed under its own subtitle.

This formatting error will be rectified in the final report.

- 7) An explanation of why no vane tests were conducted in cohesive deposits should be provided.

No vane tests were carried out in the cohesive deposits (SILT and CLAY and silty clay FILL). Based on field observations of the split spoon samples, the SILT and CLAY material contained sufficient sand to influence the test results and was determined to be too stiff to carry out in-situ shear vane tests. The silty clay FILL contained varying amounts of sand, gravel and organic matter. These materials would have influenced the test results (likely providing artificially high shear strengths) and may have damaged the vane blades.

- 8) Foundation Investigation (portion of) Report not signed and sealed separately as required.

This has not been done by Jacques Whitford on past MTO assignments, however, we agree that this would be a good idea since the report will be split up before being provided to the contractor. We will gladly comply with this request for this and all future assignments.



Mr. S. Jones
December 3, 1999

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- 9) For culvert, the founding elevation for the extension should be explicitly stated. If subexcavation below the foundation of the existing culvert is required, recommendations should be provided to ensure its stability.

Exact foundation elevations were not known at the time that the draft report was prepared. It was understood that the culvert extensions were to maintain the existing grades (i.e. invert elevations were to match at the connection between the existing culvert and the proposed extensions). The thickness of the box culvert extensions has since been determined by the structural engineer, and founding elevations based on the desired invert elevations and the culvert geometry will be provided in the final report

Subexcavation below the founding elevation of the box culvert will be required. In front of the existing culvert, the subexcavation is expected to extend to the base of the existing cut-off walls located at the ends of the culverts. The existing cut-off walls are to remain in place and will prevent loss of material from beneath the existing culvert. Some loss of material may be experienced during removal of the existing wing walls. If this should occur, it is expected that it would be over a short length (no greater than 1.5 m) and overall stability of the existing culvert foundations will therefore not be compromised. If this does occur, the soil beneath the existing box culvert should be reinstated using unshrinkable fill.

- 10) 'Structural Fill' should be defined per MTO material specifications.

'Structural Fill' was defined as per MTO material specifications in Section 5.5 of the Draft Report. Changes will be made to the Final Report so that the MTO material specifications will be used wherever structural fill is discussed.

- 11) Recommendations to accommodate differential settlement with the existing culvert should be provided (construction joint).

Due to the short length of the culvert extensions and sloping backfill, the culverts will be subjected to relatively small post-construction loads - an average of 20 kPa at the north end and 30 kPa at the south end (see attached sketch).

Fill material associated with backfilling of the cut-off walls of the existing culvert and wing walls will need to be removed from beneath the proposed culvert extensions. Therefore the culvert extensions will be constructed on relatively thick pad of structural fill (approximately 800 mm thick).

Based on the anticipated loading, the soil conditions beneath the culvert extensions and the geometry of the culvert extensions, maximum total settlements beneath the culvert



Mr. S. Jones
 December 3, 1999

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extensions are expected to be in the order of 2 to 3 mm at the north end and 3 to 4 mm at the south end. Settlement at the ends of the existing culvert are expected to be in the order of 3 mm at the north end and 4 mm at the south end. Differential settlement between the existing culvert and proposed extensions is therefore expected to be no greater than 1 to 2 mm if the extensions are not rigidly attached. Based on discussions with August Wilkins from Wyllie & Ufnal (the structural engineers), it is understood that the culvert extensions can be constructed in a rigid manner (i.e. dowel connections) and will be able to accommodate the stresses that would be caused by these settlements. A rigid connection would be preferable for controlling differential frost movements.

These items will be discussed in the final report.

- 12) For retaining wall, recommendations are required to ensure stability of existing culvert if excavations extend below culvert foundation level.

Excavation for construction of the proposed retaining wall is expected to extend to a depth of approximately 1.4 m below the invert elevation of the existing culvert. It is noted that a retaining wall is only being constructed on the east side at the north end of the culvert. It is expected that only the northeast corner of the culvert will be undermined during excavation for the construction of the retaining wall foundation. The end of the culvert has less than 1 m of soil cover above it and therefore produces negligible loads on the underlying soils. Temporary loss of soil from beneath this corner of the existing culvert will not result in a loss of stability of the culvert structure. Any soil lost from beneath the culvert structure should be reinstated with unshrinkable fill. This will be recommended in the final report.

- 13) Recommendations for drainage requirements (weep holes, pipe subdrain) are required.

Recommendations for weep holes and subdrains were implied through reference to OPSD 3504.00. These recommendations will be expressed specifically in the final report.

- 14) Specific founding elevations for which bearing resistances apply should be stated. The recommended bearing resistances are higher than typical.

Specific founding elevations for the stated bearing resistances will be provided in the final report. The magnitude of the recommended bearing resistance values are based on standard geotechnical design procedures and are considered appropriate for the soil conditions encountered (a weighted average N-value of 27 within 2B, after subexcavation and replacement).

to be checked



Mr. S. Jones
December 3, 1999

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Page 5 of 5

- 15) Retained Soil Systems should be considered as an alternative.

A Retained Soil System is typically not economical for small wall applications. Based on this and the fact that MTO had specifically indicated that a concrete retaining wall was planned for this site, no comments regarding alternative retaining wall systems were discussed in the report.

OK

- 16) Box culverts can be designed to accommodate frost stresses thus eliminating the need for frost cover.

We have discussed this issue with the project's structural engineer and acknowledge that box culverts are designed to accommodate frost stresses. The requirement for frost cover for the box culvert will be removed from the Final Report.

✓

- 17) Recommendations for inlet/outlet erosion protection for the culvert extension are required.

Recommendations for erosion protection at the inlet and outlet of the extended culvert will be provided in the final report.

to be checked

We thank you for the constructive comments provided by MTO regarding our Draft Foundation Report. We ask that a copy of this letter be provided to the MTO Foundation Section so that we may discuss our responses relating to design issues with them in order to ensure that a consensus has been reached prior to issuance of the Final Report.

Please do not hesitate to contact us if you have any questions.

Yours truly,

JACQUES, WHITFORD LIMITED



Paul Carnaffan, M.Eng., P.Eng.



J.G.A. Raymond Haché, M.Sc., P.Eng.
Manager, Geotechnical Services

P:\1999\10000\11258\Comments on Draft.rpd



MEMORANDUM



To: Stuart Jones
Project Manager
Highway Engineering
Eastern Region

Date: November 4, 1999

From: Pavements and Foundations Section
Room 223, Central Building
1201 Wilson Avenue
Downsview, Ontario

Tel: (416) 235-3731
Fax: (416) 235-5240

Re: Evaluation of Performance of Foundation Engineering Consultant
Jacques Whitford
For
Draft Foundation Investigation and Design Report (dated October 19, 1999)
Culvert Extension Station 16+180
WP 271-96-00
Hwy 401, Bancroft
And
Retaining Wall at Culvert Station 14+569
WP 273-96-00
Hwy 401, Bancroft

We have reviewed the above-noted report to determine the Consultant's performance in providing the deliverables as specified in the Terms of Reference for this assignment. The accuracy of the subsurface information and the adequacy of the technical aspects of the recommendations have not been reviewed and remain the responsibility and liability of the Consultant. The Ministry assumes no responsibility or liability for these aspects of the report.

Based on our review, the report does not conform to the requirements of the Terms of Reference per the following comments:

- 1) A description of the direction, velocity and flow should be provided for the culverts.
- 2) A description of the size, length, age and condition of the existing culverts should be provided.
- 3) Site number is not indicated.
- 4) Lab testing does not meet requirements (Atterberg Limits for cohesive samples).
- 5) Section 4 'Results of Investigation' should be titled 'Subsurface Conditions'.
- 6) Each strata should be discussed under its own subtitle.

- 7) An explanation of why no vane tests were conducted in cohesive deposits should be provided.
- 8) Foundation Investigation (portion of) Report not signed and sealed separately as required.
- 9) For culvert, the founding elevation for the extension should be explicitly stated. If subexcavation below the foundation of the existing culvert is required, recommendations should be provided to ensure its stability.
- 10) 'Structural fill' should be defined per MTO material specifications.
- 11) Recommendations to accommodate differential settlement with the existing culvert should be provided (construction joint).
- 12) For retaining wall, recommendations are required to ensure stability of existing culvert if excavations extend below culvert foundation level.
- 13) Recommendations for drainage requirements (weep holes, pipe subdrain) are required.
- 14) Specific founding elevations for which bearing resistances apply should be stated. The recommended bearing resistances are higher than typical.
- 15) Retained Soil Systems should be considered as an alternative.
- 16) Box culverts can be designed to accommodate frost stresses thus eliminating the need for frost cover.
- 17) Recommendations for inlet/outlet erosion protection for the culvert extension are required.

It is recommended that the consultant should be requested to acknowledge and address our comments.

If there are any questions, please call.

Dave Dundas, P.Eng.
Senior Foundation Engineer