THURBER ENGINEERING LTD.

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 417 – 14 CULVERTS
CITY OF OTTAWA, ONTARIO
GWP No. 4074 - 11 - 00

GEOCRES No. 31G5-262

SUBMITTED TO

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GWP 4074-11-00

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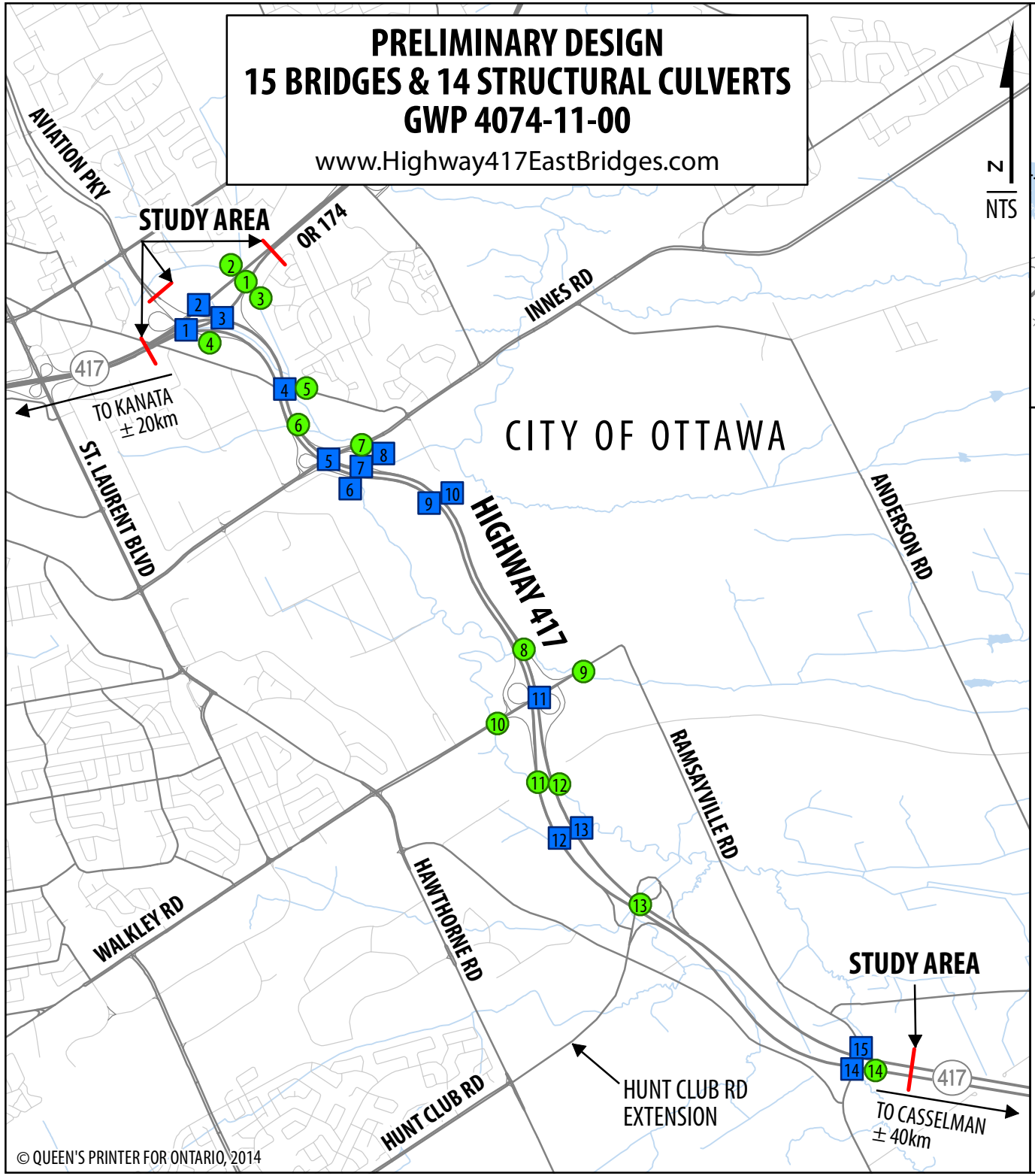

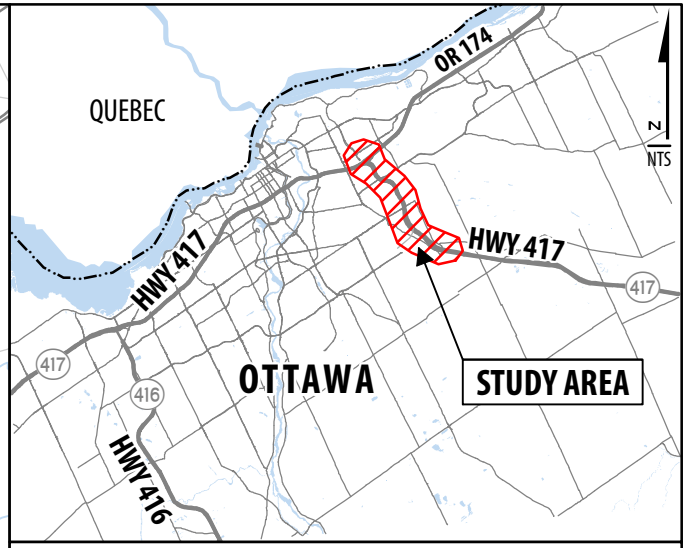

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Report Summary Table GWP 4074-11-00 GEOCRES No. 31G5-262

Site No.	Site	Location	Structure Type	Available Site Information	Subsurface	Soil Properties	OHSA Soil Type	Seismic Profile & Liquefaction Susceptible	Existing Culvert				
									Foundation	Embankment			
										Height Invert to Finished Grade m	Geometry	Stability Issues	Settlement Issues
1	**3-734/C**	Hwy 174 Median 1 km west of Hwy 174 / Blair Road Interchange	Based on MTO Inspection report: concrete rigid frame Length = 12 m; span = 5.5 m; height = 1.8 m	Regional Geology Review No GEOCRES reports or construction drawings available	0.8 m organic silt 2.7 to 3.2 m compact to dense sand & gravel Billings formation shale bedrock Based on GEOCRES Report No. 31G5-86 for Structure 3-304/1	γ = 20 kN/m^3 ϕ = 32°	Type 3 above GW Type 4 below GW	Soil Profile Type I Site is not susceptible to liquefaction	Likely founded on bedrock	< 2.5	≈ 2H:1V	NA	NA
2	**3-733/C**	Hwy 174 WB 1 km west of Hwy 174 / Blair Road Interchange	Based on MTO Inspection report: concrete rigid frame Length = 51.8 m; span = 5.5 m; height = 4 m at north inlet transitioning to a height of 1.8 m at south outlet	Regional Geology Review No GEOCRES reports or construction drawings available	1 to 4 m sand & clay till Billings formation shale bedrock	Till γ = 20 kN/m^3 ϕ = 32°	Till Type 3 above GW Type 4 below GW	Soil Profile Type I Site is not susceptible to liquefaction	Likely founded on bedrock	< 6	≈ 2H:1V	NA	NA
3	**3-735/C**	Hwy 174 EB 1 km west of Hwy 174 / Blair Road Interchange	Based on MTO Inspection report: concrete rigid frame Length = 53.3 m; span = 5.5 m; height = 1.8 m	Regional Geology Review No GEOCRES reports or construction drawings available	0.8 m organic silt 2.7 to 3.2 m compact to dense sand & gravel Billings formation shale bedrock Based on GEOCRES Report No. 31G5-86 Boreholes 1 & 3	γ = 20 kN/m^3 ϕ = 32°	Type 3 above GW Type 4 below GW	Soil Profile Type I Site is not susceptible to liquefaction	Likely founded on bedrock	≈ 3.5	≈ 2H:1V	NA	NA
4	**3-442/C**	Hwy 417 EB At the Hwy 417 / Hwy 174 Interchange	Based on MTO Inspection report: concrete rigid frame Length = 120 m; span = 3.7 m; height = 1.5 m	Regional Geology Review No GEOCRES reports or construction drawings available	0.9 to 1.1 m very stiff clayey silt 3 to 3.4 m compact to dense sand and gravel 1.1 m very dense till Billings formation shale bedrock Based on GEOCRES Report No. 31G5-86 for Structure 3-304/1 & 3-304/2 Boreholes 10 & 11	Clayey Silt γ = 19 kN/m^3 ϕ = 29° Sand & Gravel γ = 19 kN/m^3 ϕ = 30° Till γ = 20 kN/m^3 ϕ = 32°	Native soils Type 3 above GW Type 4 below GW	Soil Profile Type I Site is not susceptible to liquefaction	Founded on either sand & gravel, till or bedrock	3	-	NA	NA
5	**3-732/C**	Cyrville Road 600 m north of Hwy 417 / Innes Road Interchange	Based on MTO Inspection report: concrete rigid frame Length = 49.5 m; span = 5.5 m; height = 2.1 m	GEOCRES Report No. 31G5-114	1.5 to 2.4 m loose to dense sand 0.2 to 2.3 m very dense till Billings formation shale bedrock Based on GEOCRES Report No. 31G5-114 Boreholes 9 & 11	Silty Sand γ = 19 kN/m^3 ϕ = 30° Till γ = 20 kN/m^3 ϕ = 32°	Till Type 3 above GW Type 4 below GW	Soil Profile Type I Site is not susceptible to liquefaction	Likely founded on weathered shale bedrock	4.2	-	NA	NA
6	**3-443/C**	Hwy 417 EB & WB 320 m northwest of Hwy 417 / Innes Road Interchange	Based on historic General Layout Drawings: concrete open bottom Length = 114.6 m; width = 4.9 m; height = 1.8 m	GEOCRES Report No. 31G5-266	1.8 to 2.2 m compact to dense fill 0.1 m silty sand Billings formation shale bedrock Based on current investigation results GEOCRES Report No. 31G5-266 Boreholes 1 to 3	Fill γ = 20 kN/m^3 ϕ = 30° Silty Sand γ = 19 kN/m^3 ϕ = 30°	Embankment Fill Type 3 Silt Sand Type 3 above GW Type 4 below GW Weathered Shale Type 3	Soil Profile Type I Site is not susceptible to liquefaction	Founded on weathered shale bedrock	2.5 to 3.0	≈ 4H:1V	NA	NA
7	**3-762/C**	Innes Road & Hwy 417 Ramps 225 m northeast north of Hwy 417 / Innes Road Interchange	Based on MTO Inspection report: concrete box culvert Length = 80 m; span = 6 m; height = 2.4 m	Regional Geology Review No GEOCRES reports or construction drawings available	3.7 m loose to compact silty sand Billings formation shale bedrock Based on GEOCRES Report No. 31G5-85 Borehole 1	Silty Sand γ = 19 kN/m^3 ϕ = 30°	Silty Sand Type 3 above GW Type 4 below GW	Soil Profile Type I Site is not susceptible to liquefaction	Likely founded on silty sand	≈ 4	-	NA	NA
8	**3-730/C**	Hwy 417 EB & WB 340 m north of Hwy 417 / Walkley Road Interchange	Based on historic General Layout Drawings: concrete closed bottom Length = 115.8 m; width = 3.0 m; height = 2.4 m	GEOCRES Report No. 31G5-91	4.4 to 5.2 m very stiff to firm silty clay 2.1 to 2.7 m dense to very dense silt & sand till with gravel & clay Carlsbad formation shale bedrock Based on GEOCRES Report No. 31G5-91 Boreholes 3 to 5	Clay γ = 17 kN/m^3 ϕ = 27°	Clay Type 3	Soil Profile Type III Site is not susceptible to liquefaction	Founded on silty clay. Culvert was designed with a 86 kPa allowable bearing as per GEOCRES Report	2.7 of cover	-	NA	NA

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Report Summary Table GWP 4074-11-00 GEOCRES No. 31G5-262

Site No.	Site	Recommendation								Additional Investigation Work
		New Foundation					Embankment			
		Founding Level / Foundation Type	Vertical Geotechnical Resistance at ULS kPa	Vertical Geotechnical Reaction at SLS kPa	Unfactored Coefficient of Friction Concrete Cast-in-Place / Precast	Special Concerns	Geometry	Stability Issues	Settlement Issues	
1	3-734/C	Removal Option: Area to be re-vegetated as part of construction in general accordance with OPSS 804	NA	NA	NA	Removal of vegetative ground surface cover will promote erosion. Cutting and clearing should be maintained to the minimum necessary	New creek banks 3H:1V	NA	NA	Additional investigations should be carried out if the culvert is replaced or extended or if geometry of the embankments is modified. Investigation should include monitoring wells for developing dewatering plans and bedrock sampling and chemical testing to determine pyritic heave potential
		Replacement Option: Sound shale bedrock (Any new foundations for extensions or wing walls should match existing)	1500	NA	0.50 / 0.45	Billings formation shale is susceptible to heaving if exposed during construction	2H:1V	NA	NA	
2	3-733/C	Sound shale bedrock (Any new foundations for extensions or wing walls should match existing)	1500	NA	0.50 / 0.45	Billings formation shale is susceptible to heaving if exposed during construction	2H:1V	NA	NA	Additional investigations should be carried out if the culvert is replaced or extended or if geometry of the embankments is modified. Investigation should include monitoring wells for developing dewatering plans and bedrock sampling and chemical testing to determine pyritic heave potential
3	3-735/C	Sound shale bedrock (Any new foundations for extensions or wing walls should match existing)	1500	NA	0.50 / 0.45	Billings formation shale is susceptible to heaving if exposed during construction	2H:1V	NA	NA	Additional investigations should be carried out if the culvert is replaced or extended or if geometry of the embankments is modified. Investigation should include monitoring wells for developing dewatering plans and bedrock sampling and chemical testing to determine pyritic heave potential
4	3-442/C	Strip footings on sand & gravel or Till: 1.8 m embedment	350	225	0.45 / 0.40	Billings formation shale is susceptible to heaving if exposed during construction	2H:1V	NA	NA	Additional investigations should be carried out if the culvert is replaced or extended or if geometry of the embankments is modified. Investigation should include monitoring wells for developing dewatering plans and bedrock sampling and chemical testing to determine pyritic heave potential
		Sound shale bedrock	1500	NA	0.50 / 0.45					
5	3-732/C	Footings on weathered shale bedrock	1000	NA	0.45 / 0.40	Billings formation shale is susceptible to heaving if exposed during construction	2H:1V	NA	NA	Additional investigations should be carried out if the culvert is replaced or extended or if geometry of the embankments is modified. Investigation should include monitoring wells for developing dewatering plans and bedrock sampling and chemical testing to determine pyritic heave potential
6	3-443/C	Footings on weathered shale bedrock	1000	NA	0.45 / 0.40	Billings formation shale is susceptible to heaving if exposed during construction	2H:1V	NA	NA	Additional investigations should be carried out if the culvert is replaced or extended or if geometry of the embankments is modified. Investigation should include monitoring wells for developing dewatering plans and bedrock sampling and chemical testing to determine pyritic heave potential
7	3-762/C	Strip footings on silty sand: 1 to 2 m wide, 1.8 m embedment	150	100	0.40 / 0.35	Billings formation shale is susceptible to heaving if exposed during construction	2H:1V	NA	NA	Additional investigations should be carried out if the culvert is replaced or extended or if geometry of the embankments is modified. Investigation should include monitoring wells for developing dewatering plans and bedrock sampling and chemical testing to determine pyritic heave potential
		6 m wide box culvert on Sand	150	85	0.40 / 0.35					
8	3-730/C	Strip footings on silty clay: 1 to 2 m wide, 1.8 m embedment	120	100	0.35 / 0.30	-	2H:1V	NA	NA	Additional investigations should be carried out if the culvert is replaced or extended or if geometry of the embankments is modified. Investigation should include piezometer installations for developing dewatering plans
		Strip footings on Till: 1 to 2 m wide, 1.8 m embedment	375	250	0.45 / 0.40					
		4 m wide box culvert on Silty Clay: 1.8 m embedment	150	85	0.35 / 0.30					

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Site No.	Site	Location	Structure Type	Available Site Information	Subsurface	Soil Properties	OHSA Soil Type	Seismic Profile & Liquefaction Susceptible	Existing Culvert				
									Foundation	Embankment			
										Height Invert to Finished Grade m	Geometry	Stability Issues	Settlement Issues
9	**3-736/C**	Walkley Road 360 m east of Hwy 417 / Walkley Road Interchange	Based on historic General Layout Drawings: concrete closed bottom Length = 36.6 m; width = 3.0 m; height = 2.4 m	GEOCRES Report No. 31G5-91	4.8 to 5.5 m loose to dense sand 1.5 to 2.3 m dense silt and sand till with gravel & clay Carlsbad formation shale bedrock Based on GEOCRES Report No. 31G5-91 Boreholes 1 & 2	Sand γ = 19 kN/m^3 ϕ = 30°	Sand Type 3 above GW Type 4 below GW	Soil Profile Type III Sand layer above elevation 59.5 m is susceptible to liquefaction. Till is not susceptible to liquefaction	Founded on sand. Culvert was designed with a 57 kPa allowable bearing as per GEOCRES Report	3	≈ 2H:1V	NA	NA
10	**3-312/C**	Walkley 350 m west of Hwy 417 / Walkley Road Interchange	Based on historic General Layout Drawings: twin circular steel pipe culverts Length = 66.5 m; internal diameter = 5.5 m	GEOCRES Report No. 31G5-87	6.4 to 7.6 m very stiff to firm silty clay 3 to 3.4 m very loose to compact silt 4.3 to 4.6 m compact to very dense till silt, sand and clay Carlsbad formation shale bedrock Based on GEOCRES Report No. 31G5-87 Boreholes 1 to 4	Silty Clay γ = 17 kN/m^3 ϕ = 27°	Silty Clay Type 3	Soil Profile Type III Silt layer between elevations 55 & 60 m is susceptible to liquefaction. Clay and till is not susceptible to liquefaction	Founded on sand. Culvert was designed with a 48 kPa allowable bearing as per GEOCRES Report	3.6	-	NA	NA
11	**3-313/C1**	Hwy 417 EB 600 m south of Hwy 417 / Walkley Road Interchange	Based on historic General Layout Drawings: twin circular steel pipe culverts Length = 74.5 m; internal diameter = 5.5 m	GEOCRES Report No. 31G5-89	6.1 to 8.8 m silty clay very stiff to firm 4.4 to 4.6 m loose to compact till silt, sand, gravel some clay Carlsbad formation shale bedrock Based on GEOCRES Report No. 31G5-87 Boreholes 1 and 3	Silty Clay γ = 17 kN/m^3 ϕ = 27°	Silty Clay Type 3	Soil Profile Type III Site is not susceptible to liquefaction	Founded on silty clay Culvert was designed with a 100 kPa allowable bearing as per GEOCRES Report	6.7 to 10	≈ 2H:1V	NA	Predicted settlement of 125 mm Culvert was designed with a 100 mm camber
12	**3-313/C2**	Hwy 417 WB 600 m south of Hwy 417 / Walkley Road Interchange	Based on historic General Layout Drawings: twin circular steel pipe culverts Length = 74.5 m; internal diameter = 5.5 m	GEOCRES Report No. 31G5-89	5.8 to 7.0 m silty clay very stiff to firm 3.4 to 3.5 m loose to compact till silt, sand, gravel some clay Carlsbad formation shale bedrock Based on GEOCRES Report No. 31G5-87 Boreholes 4 and 6	Silty Clay γ = 17 kN/m^3 ϕ = 27°	Silty Clay Type 3	Soil Profile Type III Site is not susceptible to liquefaction	Founded on silty clay Culvert was designed with a 100 kPa allowable bearing as per GEOCRES Report	8.7 to 11	≈ 2H:1V	NA	Predicted settlement of 125 mm Culvert was designed with a 150 mm camber
13	**3-315/C**	Hwy 417 EB & WB At the Hwy 417 / Hunt Club Road Interchange	Based on historic General Layout Drawings: concrete closed bottom Length = 74.2 m; width = 6.1 m; height = 3.7 m	GEOCRES Report Nos. 31G5-90, 31G5-237, 31G5-240, & 31G5-267	150 mm of asphalt 2.0 m compact to dense fill sand and gravel 3.9 m firm to stiff silty clay 2.6 m very dense silt till Carlsbad formation shale bedrock Based on current investigation GEOCRES Report No. 31G5-267 Boreholes 4	Embankment Fill γ = 20 kN/m^3 ϕ = 30° Silty Clay γ = 17 kN/m^3 ϕ = 27° Silt Till γ = 19 kN/m^3 ϕ = 30°	Silty Clay Type 3	Soil Profile Type I Site is not susceptible to liquefaction	Founded on silty clay Culvert was designed with a 71 kPa allowable bearing as per GEOCRES Report	2.1 to 4.5	-	NA	NA
14	**3-444/C**	Hwy 417 EB Ramsayville Road overpass 2 km west of Anderson Road Structure No. 3-265/1	Based on historic General Layout Drawings: steel pipe arch Length = 52 m; span = 6.2 m; height = 3.9 m	GEOCRES Report No. 31G5-71	33.5 m silty clay firm to stiff 11.8 m compact to very dense till clayey silt, some sand & gravel Carlsbad formation shale bedrock Based on GEOCRES Report No. 31G5-71 Boreholes 6	Silty Clay γ = 17 kN/m^3 ϕ = 27°	Silty Clay Type 3	Soil Profile Type III Site is not susceptible to liquefaction	Founded on silty clay Culvert was designed with a 72 kPa allowable bearing as per GEOCRES Report	5.7	2H:1V to 4H:1V	NA	Predicted settlement of 75 mm

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Site No.	Site	Recommendation								Additional Investigation Work
		New Foundation					Embankment			
		Founding Level / Foundation Type	Vertical Geotechnical Resistance at ULS kPa	Vertical Geotechnical Reaction at SLS kPa	Unfactored Coefficient of Friction Concrete Cast-in-Place / Precast	Special Concerns	Geometry	Stability Issues	Settlement Issues	
9	**3-736/C**	Strip footings on Sand: 1 to 2 m wide, 1.8 m embedment	200	100	0.40 / 0.35	-	2H:1V	NA	NA	Additional investigations should be carried out if the culvert is replaced or extended or if geometry of the embankments is modified. Investigation should include piezometer installations for developing dewatering plans.
		Strip footings on Till: 1 to 2 m wide, 1.8 m embedment	375	250	0.45 / 0.40					
		3.6 m wide box culvert on Sand: 1.8 m embedment	200	90	0.40 / 0.35					
10	**3-312/C**	Strip footings on silty clay: 1 to 2 m wide, 1.8 m embedment	120	100	0.35 / 0.30 0.25 steel	-	2H:1V	NA	NA	Additional investigations should be carried out if the culverts is replaced or extended or if geometry of the embankments is modified. Investigation should include piezometer installations for developing dewatering plans.
		Strip footings on silt: 1 to 2 m wide, 1.8 m embedment	150	< 50	0.35 / 0.30 0.25 steel					
		5.5 m wide box culvert on silty clay	150	85	0.35 / 0.30					
11	**3-313/C1**	Strip footings on silty clay: 1 to 2 m wide, 1.8 m embedment	150	100	0.35 / 0.30 0.25 steel	-	2H:1V	NA	Minimum additional settlement if culvert is replaced like-for-like	Additional investigations should be carried out if the culvert is replaced or extended or if geometry of the embankments is modified. Investigation should include piezometer installations for developing dewatering plans.
		6.2 m wide box culvert on silty clay 1.8 m embedment	120	70	0.35 / 0.30					
12	**3-313/C2**	Strip footings on silty clay: 1 to 2 m wide, 1.8 m embedment	150	100	0.35 / 0.30 0.25 steel	-	2H:1V	NA	Minimum additional settlement if culvert is replaced like-for-like	Additional investigations should be carried out if the culvert is replaced or extended or if geometry of the embankments is modified. Investigation should include piezometer installations for developing dewatering plans.
		6.2 m wide box culvert on silty clay 1.8 m embedment	120	70	0.35 / 0.30					
13	**3-315/C**	Strip footings on silty clay: 1 to 2 m wide, 1.8 m embedment	120	100	0.35 / 0.30	-	2H:1V	NA	NA	Not likely required
		Strip footings on silt till: 1 to 2 m wide, 1.8 m embedment	-	150	-					
		6.9 m wide box culvert on silty clay 1.8 m embedment	150	85	0.35 / 0.30					
14	**3-444/C**	Strip footings on silty clay: 1 to 2 m wide, 1.8 m embedment	150	100	0.35 / 0.30 0.25 steel	Staged Excavation	2H:1V to 4H:1V	NA	Minimum additional settlement if culvert is replaced like-for-like	Additional investigations should be carried out if the culvert is replaced or extended or if geometry of the embankments is modified. Investigation should include piezometer installations for developing dewatering plans and structural evaluation of unbalance forces on Pier 3 for structure 3-265/1. Also additional slope stability and settlement analysis if culvert is replaced
		6.2 m wide box culvert on silty clay 1.8 m embedment	120	70	0.35 / 0.30					

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APPENDIX 1

SITE 3-734/C

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MEMORANDUM

To: Laura Donaldson, P.Eng.
McIntosh Perry Consulting Engineers

Date: July 17, 2015

From: Kenton Power, M.A.Sc., P.Eng.
(Reviewed by Fred Griffiths, P.Eng. and P.K. Chatterji, P.Eng.)

File: 19-3405-3

PRELIMINARY FOUNDATION DESIGN
CULVERT STRUCTURE (SITE 3-734/C)
GWP 4074-11-00 GEOCRES 31G5-262

PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This memo presents a brief summary of the factual findings from a foundation review carried out for the culvert structure located between the east and westbound lanes of Highway 174 in Ottawa, Ontario. It also presents preliminary geotechnical recommendations for potential culvert extensions or replacement. It is noted that the proposed construction options for this site are not yet defined. The preliminary recommendations provided below are for assistance in developing and evaluating the options and will need to be refined during subsequent design stages.

2 SITE DESCRIPTION

The site is located in eastern Ottawa, in the Township of Gloucester approximately 1 km west of the Highway 174 / Blair Road interchange. Currently no roadway or traffic is carried over Culvert 3-734/C. The culvert is part of series of three culverts that carries the Cyrville Drain flow below the east and westbound lanes of Highway 174. Based on results of the MTO inspection report the culvert is a rigid frame, concrete structure with a span of 5.5 m and a height of 1.8 m. Creek flow through the culvert is from north to south. The terrain in the vicinity of the inlet and outlet of the culvert is generally flat and is brush and grass covered. Site photos showing the general site conditions are attached.

3 SUBSURFACE CONDITIONS

There were no as-built drawings or GEOGRES reports specific to this structure available at the time of preparing this memo. A review of publically available data was undertaken to develop a generalized soil and bedrock stratigraphy model for this site. Also the relevant data from the GEOCRES Report No. 31G5-86 for nearby Structure 3-304/1 was reviewed and is presented below.

3.1 Background Review – Sources of Information

The following resources were reviewed to provide a general understanding of the subsurface conditions at this site:

- The Physiography of Southern Ontario, by Chapman and Putnam (1984)
- The Geological Survey of Canada, Map 1506A Surficial Geology of Ottawa, by Department of Energy, Mines and Resources (1982)
- The Geological Survey of Canada, Map 1508A Generalized Bedrock Geology of Ottawa-Hull, by Department of Energy, Mines and Resources (1979)
- Ontario Ministry of the Environment (MOE) Water Well Record database
- Ontario Geological Survey (OGS) Borehole Record database
- GEOCRES Report No. 31G5-86

3.2 REGIONAL GEOLOGY

3.2.1 Overburden

The site is situated within the physiographic region identified as the Ottawa Valley Clay Plains, as reported by Chapman and Putnam (1984). This physiographic region generally consists of clay plains interrupted by ridges of rock or sand.

Geological Survey of Canada, Map 1506A Surficial Geology of Ottawa, indicates that the overburden in the region consists predominantly of till plain deposits with drift thickness less than 5 m.

A review of the OGS borehole database identified two boreholes within approximately 300 m of the culvert location. The borehole records reported that the overburden materials at the site consist predominantly of a sand and silt till with thicknesses less than 10 m underlain by a shale bedrock.

3.2.2 Bedrock

The Generalized Bedrock Geology of Ottawa-Hull, Map 1508A, indicates that the bedrock underlying the site belongs to the Billings Formation of Ordovician age and consists of black shale. It should be noted that Billings Formation shale is susceptible to heaving if allowed to weather in the presence of oxygen.

The MOE water well records indicated that shale bedrock within the vicinity of the site was encountered at depths of less than 5 m below grade.

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3.3 Results from GEOCRES Report No. 31G5-86

A site investigation was carried out by the MTO Foundations Office for the Highway 417 / Highway 174 interchange Structures 3-303, 3-304/1 and 3-304/2; GEOCRES Report No. 31G5-86 dated December 1972. The investigation consisted of sixteen sampled boreholes that were designated 1 to 16.

Based on Thurber's review of the 1972 Foundation Investigation Report, Boreholes 1 and 3, which were advanced as part of the investigation for Bridge 3-304/1, were located approximately 275 m from Culvert 3-734/C. Drawing No. 72-11083A (copy attached) illustrates the locations of the investigation boreholes, as well as the soil strata plot for the 1972 investigation. The stratigraphy at this site is generally characterized by a thin layer of organic silt, overlaying a sand and gravel deposit, underlain by shale bedrock.

3.3.1 Organic Silt

An organic silt stratum 0.8 m in thickness was reported at the ground surface in Borehole 1. The top of this stratum was at 66.8 m in elevation. The standard penetration test (SPT) 'N' values were not recorded for this stratum. The estimated undrained shear strength based on in-situ field vane tests ranged from 23 kPa to 33 kPa indicating a soft to firm consistency.

3.3.2 Sand and Gravel

A sand and gravel stratum was reported below the organic silt material in Borehole 1 and below the surface cover at Borehole 3. The top of this stratum ranged from 66.0 m to 66.8 m in elevation. It had a thickness from 2.7 m to 3.2 m. The SPT 'N' values range from 11 to 60 blows per 0.3 m of penetration; indicating a compact to very dense condition.

The results of grain size analysis tests completed on two samples of this material indicated a gravel content of 15% and 53%, sand content of 39% and 64%, and a fines content (combined silt and clay size particles) between 8% and 21%.

The moisture content of the samples tested was 5% and 19%.

3.3.3 Bedrock

A grey shale bedrock was encountered beneath the sand and gravel stratum of both boreholes as proven by BX size coring. Both boreholes were terminated in bedrock. The bedrock surface elevation ranged from 63.3 m to 63.6 m. Bedrock core recovery was recorded as 100% in both boreholes. The bedrock was described to be in sound condition. Geological mapping suggests the bedrock at this site is shale of the Billings Formation.

3.4 Groundwater

Groundwater levels were measured in the open boreholes prior to backfilling at elevations of 65.3 m and 66.1 m.

4 SITE OBSERVATIONS

A structure inspection was conducted by MTO in August 2010 for Culvert 3-734/C with the report issued December 2010. Condition data outlined in the report for the culvert structure ranged from poor to good but typically the culvert was rated in good condition.

The site was inspected by Thurber Engineering staff during the week of July 14th, 2014. Several photographs of the site are attached.

At the time of the inspection, the following observations were made:

North Inlet:

- No erosion protection measures were observed at the inlet
- Erosion of the embankment was observed on both sides of the culvert
- Embankment slope above the culvert was measured at 26°; approximately 2H:1V (Horizontal:Vertical)
- Vegetation was noted on the side slopes and over the culvert
- No wing walls were present at the inlet

South Outlet:

- No erosion protection measures were observed at the outlet
- Erosion of the embankment was observed on both sides of the culvert
- Embankment slope above the culvert was measured at 26°; approximately 2H:1V
- Vegetation was noted on the side slopes and over the culvert
- No wing walls were present at the outlet

It should be noted that exposed bedrock was observed along the southwest creek bank at Culvert 3-735/C located approximately 75 m southeast of Culvert 3-734/C.

5 GEOTECHNICAL ASSESSMENT

5.1 Frost Considerations

The frost penetration depth at this site is 1.8 m (OPSD 3090.101).

5.2 Seismic Considerations

This site is classified as a Soil Profile Type I in accordance with Section 4.4.6 of the Canadian Highway Bridge Design Code (CHBDC). The zonal acceleration ratio for this site is 0.20 as per Table A3.1.1 of the CHBDC.

Based on the anticipated presence and density of the sand and gravel stratum this material is classified as “not susceptible” to liquefaction during the design earthquake event.

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5.3 Existing Foundations

The results of the MTO inspection report indicate that the Culvert 3-734/C is a rigid frame concrete culvert that is 12.0 m long, with a span of 5.5 m and a height of 1.8 m.

Based on the frost cover requirement and the anticipated shallow bedrock depth at this site it is likely that the culvert is founded within the shale bedrock or within the compact to dense sand and gravel overburden.

PART 2: ENGINEERING DISCUSSION AND PRELIMINARY RECOMMENDATIONS

6 GEOTECHNICAL RECOMMENDATIONS

Based on the available data regarding the ground conditions at this site, the following sections present preliminary geotechnical recommendations for the assessment of the existing culvert and for preliminary design for potential culvert extensions, replacement, or removal and the construction of new wing walls, end sections and/or headwall structures, if required. It is noted that the proposed construction options for this site are not yet defined. The preliminary recommendations provided below are for assistance in developing and evaluating options and will need to be refined during subsequent design stages.

The existing culvert is a concrete rigid frame open-footing culvert likely founded on bedrock. For culvert extensions, it is preferred that type of foundations and founding elevation match the existing arrangement so as not to undermine the existing foundation. From a foundation perspective for a culvert replacement, a concrete rigid-frame open-footing culvert is preferred, however, a closed box culvert may also be feasible. The geometry of the culvert may not be suitable for a CSP.

6.1 Shallow Foundations

Although spread footings within the overburden are possible, effective dewatering of the sand and gravel strata would be required. Given the relatively shallow depth to the shale bedrock (which must be confirmed by drilling boreholes during the detailed design stage) and the higher geotechnical resistance offered by the bedrock, spread footings within the overburden are not recommended. In addition, footings for potential culvert extensions should match the elevation of the existing foundation element, i.e. be founded on bedrock.

The factored vertical geotechnical resistance of 1500 kPa at ULS may be used for the preliminary design of shallow foundations, founded on or in sound shale bedrock. The SLS condition will not govern for footings in or on the bedrock. The design of any new foundations on bedrock would need to consider interactions with the existing foundations and potential for undermining of the existing structural elements.

Resistance to lateral forces and sliding resistance between concrete and underlying materials should be evaluated using an unfactored coefficient of friction of 0.5 for cast-in-place concrete and 0.45 for pre-cast concrete on sound shale bedrock.

Based on current geological mapping, the shale present at this site may be from the Billings Formation which is susceptible to heaving if allowed to weather in the presence of oxygen. The general mechanism is that oxidation of pyrite within the shale produces sulfuric acid, which in turn reacts with calcite in the shale to form gypsum crystals, which occupy a larger volume than the original materials. A by-product of this chain of reactions also tends to increase sulphate levels which can attack buried concrete structures.

The potentially detrimental effects of shale heaving can be avoided by preventing exposure of the shale to oxygen both during construction and long term. This is typically achieved by limiting exposure of the shale to no more than one day prior to covering with a protective layer such as shotcrete or a concrete mud slab. Sulphate resistant cement should be used in such applications.

6.2 Excavations, Bedding and Backfilling

All excavations must be conducted in accordance with the requirements of the Occupational Health & Safety Act & Regulations (OHSA) for Construction Projects. The anticipated native soils at the site should be classified Type 3 soils above and Type 4 below the groundwater table in accordance with OHSA.

Where excavations will extend below the groundwater level prevailing at the time of construction, the contractor will need to implement groundwater control and ground support systems as are required to carry out the construction in a safe, stable, and unwatered excavation.

Excavations, bedding and backfill for rigid frame structures should be in accordance with OPSS 422 and 902. Backfill for the culvert must consist of free draining granular material conforming to OPSS Granular A or B material specifications. The granular material must be placed to the extent shown on OPSD 803.030 or 803.031.

Subgrade preparation and placement of culvert bedding must be carried out in the dry.

6.3 Static Lateral Earth Pressure Coefficients

Lateral earth pressures acting on structures should be computed in accordance with the CHBDC but generally are given by the expression:

$$P_h = K^*(\gamma h + q)$$

where:

P_h = horizontal pressure on the wall (kPa)
K = earth pressure coefficient
γ = unit weight of retained soil

h = depth below top of fill where pressure is computed (m)
q = value of any surcharge (kPa)

The recommended lateral earth pressure parameters for use in the design for both a horizontal and for 2H:1V back-slope are provided in Table A.

For rigid structures such as Culvert 3-734/C, it is recommended that at-rest horizontal lateral earth pressures be used for design. Active pressures should be used for the design of unrestrained walls.

A lateral pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with the Section 6.9.3 of the CHBDC.

The parameters provided in Table A are based on the assumption that the backfill is fully drained so that there are no unbalanced hydrostatic pressures. If adequate drainage cannot be confirmed, the potential for hydrostatic pressures should be considered.

Table A: Static Lateral Earth Pressure Coefficient

Parameter	OPSS Granular A & OPSS Granular B Type II	Native Sand & Gravel Till	OPSS Granular B Type I
Soil Unit Weight, kN/m^3, γ	21	20	20
Angle of Internal Friction, ϕ	35°	32°	30°
Horizontal Back-Slope			
Coefficient of at Rest Earth Pressure, K_o (Restrained Wall)	0.43	0.47	0.50
Coefficient of Active Earth Pressure, K_a (Unrestrained Wall)	0.27	0.31	0.33
2H:1V Back-Slope			
Coefficient of Active Earth Pressure, K_a	0.39	0.47	0.53

6.4 Embankments

It is estimated that there is less than 1.5 m of fill over the existing culvert and that the grade over the culvert is less than 1 m above the surrounding terrain. Given the anticipated shallow bedrock and the soil type prevalent in this area settlement would be minimal for minor widening and/or minor grade increases. Embankment side slopes of 2H:1V are appropriate for preliminary design.

6.5 Erosion Control

6.5.1 Removal of Culvert 3-734/C

Should the removal option be selected for Culvert 3-734/C the limits/quantity of vegetation cutting and clearing should be maintained to the minimum necessary as the disturbance of the

vegetative ground surface cover can be expected to promote erosion. All stripped areas that are not directly included in the construction of the new open channel and related components should be re-vegetated as part of construction in general accordance with OPSS 804. The banks of the new open channel should be constructed with a maximum slope of 3H:1V and erosion protection measures should also be established along the creek banks.

6.5.2 Existing or Replacement of Culvert 3-734/C

Erosion protection should be provided at the culvert inlet and outlet areas. Design of the erosion protection measures must consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field.

Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact. Treatment at the outlets should be in accordance with OPSD 810.010. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS 804.

A concrete cut-off wall or clay seal should be installed at the culvert inlet to minimize the potential for seepage through the granular bedding and backfill material and avoid consequent erosion of these materials. The clay seal should have a minimum thickness of 0.5 m, completely surround the culvert, extend laterally the width of the granular backfill material, and extend above the high water level. The material used for the clay seal should conform to the requirements of OPSS 1205.

7 ADDITIONAL INVESTIGATIONS

Further foundation investigations and analysis must be carried out should the culvert structure be replaced or extended or if the height, geometry, or location of the fills are to be modified for either short-term construction staging or for vertical or horizontal re-alignments. Should excavations be anticipated within the embankment fills to repair or modify the culvert, consideration should be given to drilling foundation boreholes to determine the nature of the fill materials and to allow generation of road way protection design. It is also recommended that monitoring wells be installed to better define the groundwater level as well as the hydraulic conductivity at the site. This information will be required to allow for the design of excavation dewatering systems.

Should the proposed works result in excavations to bedrock, samples of the bedrock should be acquired during the investigation and submitted for chemical testing to determine the pyritic heave potential.

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8 CLOSURE

We trust this information provided in this technical memorandum meets your present purposes. Please let us know if you have any questions or need additional information.

Thurber Engineering Ltd.

Kenton C. Power, P.Eng.
Geotechnical Engineer

Fred Griffiths, P.Eng.
Associate, Senior Geotechnical Engineer

P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact

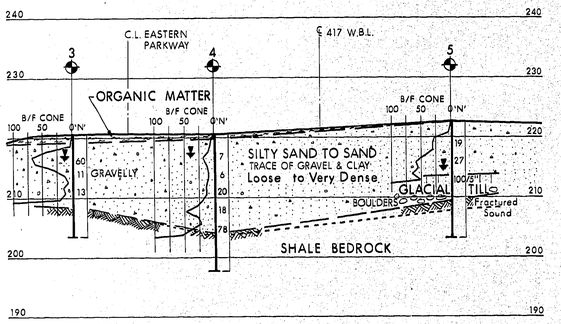
Attachments

Preliminary Foundation Design
W.P. 4312-11-01
Site Photographs

PRELIMINARY FOUNDATION DESIGN
CULVERT STRUCTURE (SITE 3-734/C)

North inlet

South outlet

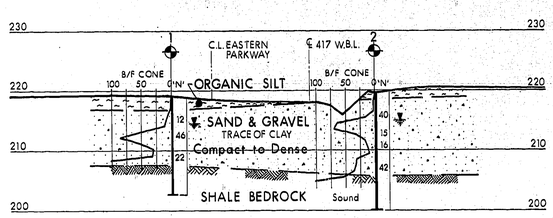


SECTION A-A

SCALE

HORIZ. 40 20 0 40 80 FT.

VERT. 10 5 0 10 20 FT.



SECTION B-B

SCALE

HORIZ. 40 20 0 40 80 FT.

VERT. 10 5 0 10 20 FT.

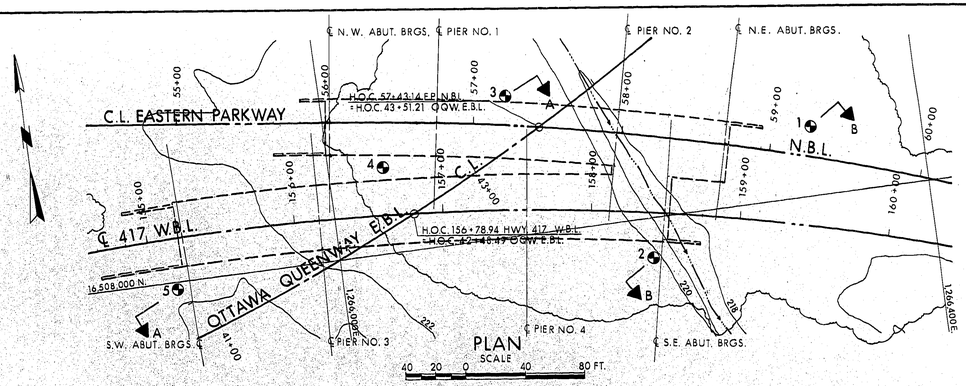
SCALE FOR PROFILES

SCALE

HORIZ. 40 20 0 40 80 FT.

VERT. 10 5 0 10 20 FT.

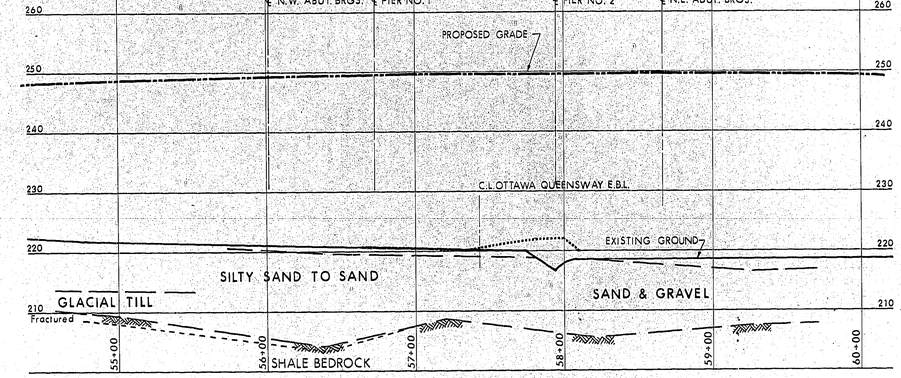
NOTE: The complete soil investigation report for this structure may be examined at the Bridge Office and Foundation Office, Downsview, and at the Ottawa District Office.



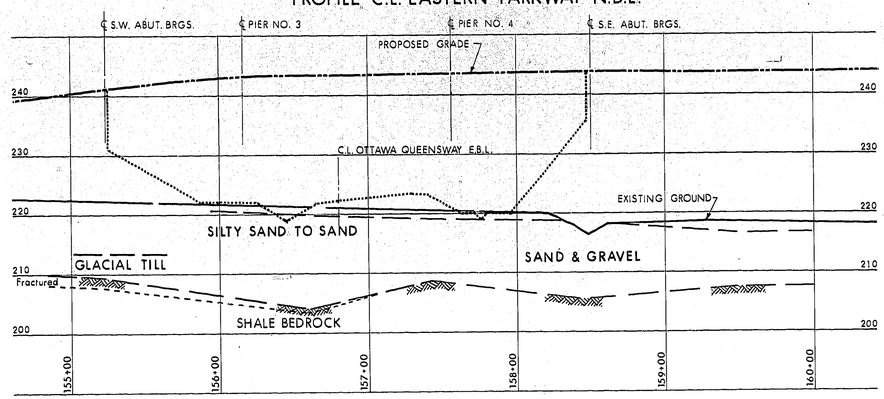
PLAN

SCALE

40 20 0 40 80 FT.

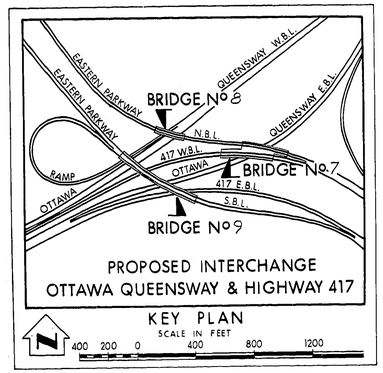


PROFILE C.L. EASTERN PARKWAY N.B.L.



PROFILE ℄ 417 W.B.L.

REF. Nº E-5241-1, E-5437-1, & B-56-28



PROPOSED INTERCHANGE
OTTAWA QUEENSWAY & HIGHWAY 417

KEY PLAN

SCALE IN FEET

N 400 200 0 400 800 1200

LEGEND

- Bore Hole
- Cone Penetration Test
- Bore Hole & Cone Test
- Water Levels established at time of field investigation. July & August 1972.

NO.	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
1	219·1	16,508,046	1,226,328
2	219·7	507,973	226,210
3	220·7	508,094	226,126
4	220·5	508,058	226,037
5	222·6	507,995	225,889

— NOTE —

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

REVISIONS

DATE	BY	DESCRIPTION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
DESIGN SERVICES BRANCH—FOUNDATIONS OFFICE

BRIDGE Nº 7

EASTERN PARKWAY N.B. & HWY. 417 W.B. OVER OTTAWA QW. EB.

HIGHWAY NO. 417 DIST. NO. 9

CO. REGIONAL MUNICIPALITY OF OTTAWA-CARLETON

TWP. GLOUCESTER LOT 24 CON. II

BORE HOLE LOCATIONS & SOIL STRATA

SUBMD. S.A.	CHECKED JC	W.P. NO. 13-68-02	DRAWING NO. 72-11083A
DRAWN J.I.G.	CHECKED GP	W.O. NO. 72-11083	
DATE NOV. 21, 1972	SITE NO. 3-304 A	CONT. NO. 73-192	BRIDGE DRAWING NO. 3-304A-2
APPROVED PRINCIPAL FOUNDATION ENGINEER			

57090

SNO-TRACE 300-8-72

TWP#-56-304A-2-A

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APPENDIX 2

SITE 3-733/C

THURBER

MEMORANDUM

To: Laura Donaldson, P.Eng.
McIntosh Perry Consulting Engineers

Date: July 17, 2015

From: Kenton Power, M.A.Sc., P.Eng.
(Reviewed by Fred Griffiths, P.Eng. and P.K. Chatterji, P.Eng.)

File: 19-3405-3

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 174 WESTBOUND CULVERT STRUCTURE (SITE 3-733/C)
GWP 4074-11-00, GEOCRES 31G5-262

PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This memo presents a brief summary of the factual findings from a foundation review carried out for the culvert structure carrying Highway 174 westbound traffic over the Cyrville Drain in Ottawa, Ontario. It also presents preliminary geotechnical recommendations for potential culvert extensions, replacement or removal. It is noted that the proposed construction options for this site are not yet defined. The preliminary recommendations provided below are for assistance in developing and evaluating the options and will need to be refined during subsequent design stages.

2 SITE DESCRIPTION

The site is located in eastern Ottawa, in the Township of Gloucester approximately 1 km west of the Highway 174 / Blair Road interchange. The culvert carries Cyrville Drain flow below the westbound Highway 174 traffic (three lanes in total plus paved shoulders). Based on the results of the MTO inspection report the culvert is a rigid frame, precast concrete structure with a span of 5.5 m and a height of 4 m at inlet transitioning to a height of 1.8 m at outlet. Creek flow through the culvert is from north to south. The terrain in the vicinity of the inlet and outlet of the culvert is generally flat and is brush and grass covered. Site photos showing the general site conditions are attached.

3 SUBSURFACE CONDITIONS

There were no as-built drawings or GEOGRES reports specific to this structure available at the time of preparing this memo. A review of publically available data was undertaken to develop a generalized soil and bedrock stratigraphy model for this site.

3.1 Background Review – Sources of Information

The following resources were reviewed to provide a general understanding of the subsurface conditions at this site:

- The Physiography of Southern Ontario, by Chapman and Putnam (1984)
- The Geological Survey of Canada, Map 1506A Surficial Geology of Ottawa, by Department of Energy, Mines and Resources (1982)
- The Geological Survey of Canada, Map 1508A Generalized Bedrock Geology of Ottawa-Hull, by Department of Energy, Mines and Resources (1979)
- Ontario Ministry of the Environment (MOE) Water Well Record database
- Ontario Geological Survey (OGS) Borehole Record database
- Information from within Thurber's files for City of Ottawa sites within 200 m of the culvert site

3.2 REGIONAL GEOLOGY

3.2.1 Overburden

The site is situated within the physiographic region identified as the Ottawa Valley Clay Plains, as reported by Chapman and Putnam (1984). This physiographic region generally consists of clay plains interrupted by ridges of rock or sand.

Geological Survey of Canada, Map 1506A Surficial Geology of Ottawa, indicates that the overburden in the region consists predominantly of till plain deposits primarily comprised of silt and sand materials.

A review of the OGS borehole database identified two boreholes within approximately 100 m of the culvert location. The borehole records reported that the overburden materials at the site consist predominantly of a sand and clay till with thickness ranging from approximately 4 m on the north side of the highway to 1 m on the south side underlain by a shale bedrock.

3.2.2 Bedrock

The Generalized Bedrock Geology of Ottawa-Hull, Map 1508A, indicates that the bedrock underlying the site belongs to the Billings Formation of Ordovician age and consists of black shale. It should be noted that Billings Formation shale is susceptible to heaving if allowed to weather in the presence of oxygen.

The MOE water well records indicated that shale bedrock within the vicinity of the site was encountered at depths of less than 2.5 m below grade.

4 SITE OBSERVATIONS

A structure inspection was conducted by MTO in August 2010 for Culvert 3-733/C with the report issued December 2010. Condition data outlined in the report for the culvert structure ranged from poor to good but typically the culvert was rated in good condition.

The site was inspected by Thurber Engineering staff during the week of July 14th, 2014. Several photographs of the site are attached.

At the time of the inspection, the following observations were made:

North Inlet:

- Rip-Rap or rock protection was installed at the site for erosion protection
- Vegetation was noted on the side slopes with no signs of erosion
- No obvious settlement or tilting of the wing walls was noted
- No obvious signs of shallow bedrock were observed
- No obvious settlement of the road surface was observed at the crossing

South Outlet

- Rip-Rap or rock protection was installed at the site for erosion protection
- There were no wing walls present at the outlet of the culvert
- Vegetation was noted on side slopes and over the culvert
- The backslope was measured at approximately 20°
- No obvious signs of shallow bedrock were observed
- A drainage pipe draining directly on top of the culvert was noted to be causing erosion

It should be noted that exposed bedrock was observed along southwest creek bank at Culvert 3-735/C located approximately 140 m southeast of Culvert 3-733/C.

5 GEOTECHNICAL ASSESSMENT

5.1 Frost Considerations

The frost penetration depth at this site is 1.8 m (OPSD 3090.101).

5.2 Seismic Considerations

This site is classified as a Soil Profile Type I in accordance with Section 4.4.6 of the Canadian Highway Bridge Design Code (CHBDC). The zonal acceleration ratio for this site is 0.20 as per Table A3.1.1 of the CHBDC.

Based on the anticipated presence and density of the till as overburden soil, this material is classified as “not susceptible” to liquefaction during the design earthquake event.

5.3 Existing Foundations

The results of the MTO inspection report indicate that Culvert 3-733/C is a rigid frame, concrete culvert that is 51.8 m long, with a span of 5.5 m and a height of 4.0 m.

Based on the frost cover requirement and the anticipated shallow bedrock depth at this site it is likely that the culvert would be founded within the shale bedrock.

PART 2: ENGINEERING DISCUSSION AND PRELIMINARY RECOMMENDATIONS

6 GEOTECHNICAL RECOMMENDATIONS

Based on the available data regarding the ground conditions at this site, the following sections present preliminary geotechnical recommendations for the assessment of the existing culvert and for preliminary design for potential culvert extensions, replacement, and the construction of new wing walls, end sections and/or headwall structures, if required. It is noted that the proposed construction options for this site are not yet defined. The preliminary recommendations provided below are for assistance in developing and evaluating options and will need to be refined during subsequent design stages.

The existing culvert is a concrete rigid-frame open-footing culvert likely founded on bedrock. For culvert extensions, it is preferred that type of foundations and founding elevation match the existing arrangement so as not to undermine the existing foundation. From a foundation perspective for a culvert replacement, a concrete rigid-frame open-footing culvert is preferred, however, a closed box culvert may also be feasible. The geometry of the culvert may not be suitable for a CSP.

6.1 Shallow Foundations

Although spread footings within the overburden are possible, effective dewatering of the native overburden material would be required. Given the relatively shallow depth to bedrock (which must be confirmed by drilling boreholes during the detailed design stage) and the higher geotechnical resistance offered by the bedrock, spread footings within the overburden are not recommended. In addition, footings for potential culvert extensions should match the elevation of the existing foundation element, i.e. be founded on bedrock.

The factored vertical geotechnical resistance of 1500 kPa at ULS may be used for the preliminary design of shallow foundations, founded on or in sound shale bedrock. The SLS condition will not govern for footings in or on the bedrock. The design of any new foundations on bedrock would need to consider interactions with the existing foundations and potential for undermining of the existing structural elements.

Resistance to lateral forces and sliding resistance between concrete and underlying materials should be evaluated using an unfactored coefficient of friction of 0.5 for cast-in-place concrete and 0.45 for pre-cast concrete on sound shale bedrock.

Based on current geological mapping, the shale present at this site may be from the Billings Formation which is susceptible to heaving if allowed to weather in the presence of oxygen. The general mechanism is that oxidation of pyrite within the shale produces sulfuric acid, which in turn reacts with calcite in the shale to form gypsum crystals, which occupy a larger volume than the original materials. A by-product of this chain of reactions also tends to increase sulphate levels which can attack buried concrete structures.

The potentially detrimental effects of shale heaving can be avoided by preventing exposure of the shale to oxygen both during construction and long term. This is typically achieved by limiting exposure of the shale to no more than one day prior to covering with a protective layer such as shotcrete or a concrete mud slab. Sulphate resistant cement should be used in such applications.

6.2 Excavations, Bedding and Backfilling

All excavations must be conducted in accordance with the requirements of the Occupational Health & Safety Act & Regulations (OHSA) for Construction Projects. The anticipated native soils at the site should be classified Type 3 soils above and Type 4 below the groundwater table in accordance with OHSA.

Where excavations will extend below the groundwater level prevailing at the time of construction, the contractor will need to implement groundwater control and ground support systems as are required to carry out the construction in a safe, stable, and unwatered excavation.

Excavations, bedding and backfill for rigid frame structures should be in accordance with OPSS 422 and 902. Backfill for the culvert must consist of free draining granular material conforming to OPSS Granular A or B material specifications. The granular material must be placed to the extent shown on OPSD 803.030 or 803.031.

Subgrade preparation and placement of culvert bedding must be carried out in the dry.

6.3 Static Lateral Earth Pressure Coefficients

Lateral earth pressures acting on structures should be computed in accordance with the CHBDC but generally are given by the expression:

$$P_h = K^*(\gamma h + q)$$

where:

P_h = horizontal pressure on the wall (kPa)
K = earth pressure coefficient
γ = unit weight of retained soil
h = depth below top of fill where pressure is computed (m)
q = value of any surcharge (kPa)

The recommended lateral earth pressure parameters for use in the design for both a horizontal and for 2H:1V (Horizontal:Vertical) back-slope are provided in Table A.

For rigid structures such as Culvert 3-733/C, it is recommended that at-rest horizontal lateral earth pressures be used for design. Active pressures should be used for the design of unrestrained walls.

A lateral pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with the Section 6.9.3 of the CHBDC.

The parameters provided in Table A are based on the assumption that the backfill is fully drained so that there are no unbalanced hydrostatic pressures. If adequate drainage cannot be confirmed, the potential for hydrostatic pressures should be considered.

Table A: Static Lateral Earth Pressure Coefficient

Parameter	OPSS Granular A & OPSS Granular B Type II	Native Sand & Clay Till	OPSS Granular B Type I
Soil Unit Weight, kN/m^3, γ	21	20	20
Angle of Internal Friction, ϕ	35°	32°	30°
Horizontal Back-Slope			
Coefficient of at Rest Earth Pressure, K_o (Restrained Wall)	0.43	0.47	0.50
Coefficient of Active Earth Pressure, K_a (Unrestrained Wall)	0.27	0.31	0.33
2H:1V Back-Slope			
Coefficient of Active Earth Pressure, K_a	0.39	0.47	0.53

6.4 Embankments

It is estimated that there is less than 2 m of fill over the existing culvert and that the roadway embankment is generally less than 1 m above the surrounding terrain. Given the anticipated shallow bedrock and the soil type prevalent in this area settlement would be minimal for minor widening and/or minor grade increases. Embankment side slopes of 2H:1V are appropriate for preliminary design.

6.5 Erosion Control

Active erosion of the embankment was noted below the existing drainage pipe located at the outlet of the culvert. Erosion protection should be provided at this location

Design of the erosion protection measures must consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field. Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact. Treatment at the

outlets should be in accordance with OPSD 810.010. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS 804.

A concrete cut-off wall or clay seal should be installed at the culvert inlet to minimize the potential for seepage through the granular bedding and backfill material and avoid consequent erosion of these materials. The clay seal should have a minimum thickness of 0.5 m, completely surround the culvert, extend laterally the width of the granular backfill material, and extend above the high water level. The material used for the clay seal should conform to the requirements of OPSS 1205.

7 ADDITIONAL INVESTIGATIONS

Further foundation investigations and analysis must be carried out should the culvert structure be replaced or extended or if the height, geometry, or location of the approach fills are to be modified for either short-term construction staging or for vertical or horizontal re-alignments. Should excavations be anticipated within the embankment fills to repair or modify the culvert, consideration should be given to drilling foundation boreholes in the approaches to determine the nature of the fill materials and to allow generation of road way protection design. It is also recommended that monitoring wells be installed to better define the groundwater level as well as the hydraulic conductivity at the site. This information will be required to allow for the design of excavation dewatering systems.

Should the proposed works result in excavations to bedrock, samples of the bedrock should be acquired during the investigation and submitted for chemical testing to determine the pyritic heave potential.

THURBER

8 CLOSURE

We trust this information provided in this technical memorandum meets your present purposes. Please let us know if you have any questions or need additional information.

Thurber Engineering Ltd.

Kenton C. Power, P.Eng.
Geotechnical Engineer

Fred Griffiths, P.Eng.
Associate, Senior Geotechnical Engineer

P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact
Attachments

Preliminary Foundation Design
GWP 4074-11-00
Site Photographs

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 174 WESTBOUND CULVERT STRUCTURE (SITE 3-733/C)

North inlet and embankment

North inlet wingwalls

Preliminary Foundation Design
GWP 4074-11-00
Site Photographs

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 174 WESTBOUND CULVERT STRUCTURE (SITE 3-733/C)

South outlet, note that no wingwalls are present

Drain on east side of outlet

THURBER

APPENDIX 3

SITE 3-735/C

THURBER

MEMORANDUM

To: Laura Donaldson, P.Eng.
McIntosh Perry Consulting Engineers

Date: July 17, 2015

From: Kenton Power, M.A.Sc., P.Eng.
(Reviewed by Fred Griffiths, P.Eng. and P.K. Chatterji, P.Eng.)

File: 19-3405-3

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 174 EASTBOUND CULVERT STRUCTURE (SITE 3-735/C)
GWP 4074-11-00, GEOCRESS 31G5-262

PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This memo presents a brief summary of the factual findings from a foundation review carried out for the culvert structure carrying Highway 174 eastbound traffic over the Cyrville Drain in Ottawa, Ontario. It also presents preliminary geotechnical recommendations for potential culvert extensions or replacement. It is noted that the proposed construction options for this site are not yet defined. The preliminary recommendations provided below are for assistance in developing and evaluating the options and will need to be refined during subsequent design stages.

2 SITE DESCRIPTION

The site is located in eastern Ottawa, in the Township of Gloucester approximately 1 km west of the Highway 174 / Blair Road interchange. The culvert carries the Cyrville Drain flow below the eastbound Highway 174 traffic and the Highway 417 onramp to Highway 174 eastbound traffic (3 lanes in total plus a paved gore area and shoulders). Based on results of the MTO inspection report the culvert is a rigid frame, concrete structure with a span of 5.5 m and a height of 1.8 m. Creek flow through the culvert is from north to south. The terrain in the vicinity of the inlet and outlet of the culvert is generally flat and is brush and grass covered. Exposed bedrock was observed at the site along the banks of the creek. Site photos showing the general site conditions are attached.

3 SUBSURFACE CONDITIONS

There were no as-built drawings or GEOGRES reports specific to this structure available at the time of preparing this memo. A review of publically available data was undertaken to develop a generalized soil and bedrock stratigraphy model for this site. Also the relevant data from the GEOCRES Report No. 31G5-86 for nearby Structure 3-304/1 was reviewed and is presented below.

THURBER

3.1 Background Review – Sources of Information

The following resources were reviewed to provide a general understanding of the subsurface conditions at this site:

- The Physiography of Southern Ontario, by Chapman and Putnam (1984)
- The Geological Survey of Canada, Map 1506A Surficial Geology of Ottawa, by Department of Energy, Mines and Resources (1982)
- The Geological Survey of Canada, Map 1508A Generalized Bedrock Geology of Ottawa-Hull, by Department of Energy, Mines and Resources (1979)
- Ontario Ministry of the Environment (MOE) Water Well Record database
- Ontario Geological Survey (OGS) Borehole Record database
- GEOCRES Report No. 31G5-86

3.2 REGIONAL GEOLOGY

3.2.1 Overburden

The site is situated within the physiographic region identified as the Ottawa Valley Clay Plains, as reported by Chapman and Putnam (1984). This physiographic region generally consists of clay plains interrupted by ridges of rock or sand.

Geological Survey of Canada, Map 1506A Surficial Geology of Ottawa, indicates that the overburden in the region consists predominantly of till plain deposits with drift thickness less than 5 m.

A review of the OGS borehole database identified two boreholes within approximately 300 m of the culvert location. The borehole records reported that the overburden materials at the site consist predominantly of a sand and silt till with thicknesses less than 10 m underlain by a shale bedrock.

3.2.2 Bedrock

The Generalized Bedrock Geology of Ottawa-Hull, Map 1508A, indicates that the bedrock underlying the site belongs to the Billings Formation of Ordovician age and consists of black shale. It should be noted that Billings Formation shale is susceptible to heaving if allowed to weather in the presence of oxygen.

The MOE water well records indicated that shale bedrock within the vicinity of the site was encountered at depths of less than 5 m below grade.

THURBER

3.3 Results from GEOCRES Report No. 31G5-86

A site investigation was carried out by the MTO Foundations Office for the Highway 417 / Highway 174 interchange Structures 3-303, 3-304/1 and 3-304/2; GEOCRES Report No. 31G5-86 dated December 1972. The investigation consisted of sixteen sampled boreholes that were designated 1 to 16.

Based on Thurber's review of the 1972 Foundation Investigation Report, Boreholes 1 and 3, which were advanced as part of the investigation for Bridge 3-304/1, were located approximately 250 from Culvert 3-735/C. Drawing No. 72-11083A (copy attached) illustrates the locations of the investigation boreholes, as well as the soil strata plot for the 1972 investigation. The stratigraphy at this site is generally characterized by a thin layer of organic silt, overlaying a sand and gravel deposit, underlain by shale bedrock.

3.3.1 Organic Silt

An organic silt stratum was reported at the ground surface in Borehole 1. The top of this stratum was at 66.8 m in elevation; and had a thickness 0.8 m. The standard penetration test (SPT) 'N' values were not recorded for this stratum. The estimated undrained shear strength based on in-situ field vane tests ranged from 23 kPa to 33 kPa indicating a soft to firm consistency.

3.3.2 Sand and Gravel

The sand and gravel stratum was reported below the organic silt material in Borehole 1 and below the surface cover at Borehole 3. The top of this stratum ranged from 66.0 m to 66.8 m in elevation and had a thickness from 2.7 m to 3.2 m. The SPT 'N' values range from 11 to 60 blows per 0.3 m of penetration; indicating a compact to very dense condition.

The results of grain size analysis tests completed on two samples of this material indicated a gravel content of 15% and 53%, sand content of 39% and 64%, and a fines content (combined silt and clay size particles) between 8% and 21%.

The moisture content of the samples tested was 5% and 19%.

3.3.3 Bedrock

A grey shale bedrock was encountered beneath the sand and gravel stratum of both boreholes as proven by BX size coring. Both boreholes were terminated in bedrock. The bedrock surface elevation ranged from 63.3 m to 63.6 m. Bedrock core recovery was recorded as 100% in both boreholes. The bedrock was described to be in sound condition. Geological mapping suggests the bedrock at this site is shale of the Billings Formation.

3.4 Groundwater

Groundwater levels were measured in the open boreholes prior to backfilling at elevations of 65.3 m and 66.1 m.

4 SITE OBSERVATIONS

A structure inspection was conducted by MTO in August 2010 for Culvert 3-735/C with the report issued December 2010. Condition data outlined in the report for the culvert structure ranged from poor to good but typically the culvert was rated in good condition.

The site was inspected by Thurber Engineering staff during the week of July 14th, 2014. Several photographs of the site are attached.

At the time of the inspection, the following observations were made:

North Inlet:

- No erosion protection measures were observed at the inlet
- Erosion of the embankment was observed on both sides of the culvert
- Embankment slope above the culvert was measured at 26°; approximately 2H:1V (Horizontal:Vertical)
- Vegetation was noted on the side slopes and over the culvert
- No wing walls were present at the inlet
- No obvious settlement of the road surface was observed at the crossing

South Outlet

- No erosion protection measures were observed at the outlet
- Erosion of the embankment was observed on both sides of the culvert
- Embankment slope above the culvert was measured at 25°; approximately 2H:1V
- Vegetation was noted on the side slopes and over the culvert
- Exposed bedrock was observed along the west bank of the creek
- No wing walls were present at the outlet
- No obvious settlement of the road surface was observed at the crossing

5 GEOTECHNICAL ASSESSMENT

5.1 Frost Considerations

The frost penetration depth at this site is 1.8 m (OPSD 3090.101).

5.2 Seismic Considerations

This site is classified as a Soil Profile Type I in accordance with Section 4.4.6 of the Canadian Highway Bridge Design Code (CHBDC). The zonal acceleration ratio for this site is 0.20 as per Table A3.1.1 of the CHBDC.

Based on the anticipated presence and density of the sand and gravel stratum this material is classified as “not susceptible” to liquefaction during the design earthquake event.

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5.3 Existing Foundations

The results of the MTO inspection report indicate that Culvert 3-735/C is a rigid frame concrete culvert that is 53.3 m long, with a span of 5.5 m and a height of 1.8 m.

Based on the frost cover requirement and the anticipated shallow bedrock depth at this site it is likely that the culvert would be founded within the shale bedrock.

PART 2: ENGINEERING DISCUSSION AND PRELIMINARY RECOMMENDATIONS

6 GEOTECHNICAL RECOMMENDATIONS

Based on the available data regarding the ground conditions at this site, the following sections present preliminary geotechnical recommendations for the assessment of the existing culvert and for preliminary design for potential culvert extensions, replacement, and the construction of new wing walls, end sections and/or headwall structures, if required. It is noted that the proposed construction options for this site are not yet defined. The preliminary recommendations provided below are for assistance in developing and evaluating options and will need to be refined during subsequent design stages.

The existing culvert is a concrete rigid-frame open-footing culvert likely founded on bedrock. For culvert extensions, it is preferred that type of foundations and founding elevation match the existing arrangement so as not to undermine the existing foundation. From a foundation perspective for a culvert replacement, a concrete rigid-frame open-footing culvert is preferred, however, a closed box culvert may also be feasible. The geometry of the culvert may not be suitable for a CSP.

6.1 Shallow Foundations

Although spread footings within the overburden are possible, effective dewatering of the sand and gravel strata would be required. Given the anticipated relatively shallow depth to bedrock (which must be confirmed by drilling boreholes during the detailed design stage) and the higher geotechnical resistance offered by the bedrock, spread footings within the overburden are not recommended. In addition, footings for potential culvert extensions should match the elevation of the existing foundation element, i.e. be founded on bedrock.

For preliminary design, shallow foundations founded on or in sound shale bedrock may be designed with the factored vertical geotechnical resistance of 1500 kPa at ULS. The SLS condition will not govern for footings in or on the bedrock. The design of any new foundations on bedrock would need to consider interactions with the existing foundations and potential for undermining of the existing structural elements.

Resistance to lateral forces and sliding resistance between concrete and underlying materials should be evaluated using an unfactored coefficient of friction of 0.5 for cast-in-place concrete and 0.45 for pre-cast concrete on sound shale bedrock.

Based on current geological mapping, the shale present at this site may be from the Billings Formation which is susceptible to heaving if allowed to weather in the presence of oxygen. The general mechanism is that oxidation of pyrite within the shale produces sulfuric acid, which in turn reacts with calcite in the shale to form gypsum crystals, which occupy a larger volume than the original materials. A by-product of this chain of reactions also tends to increase sulphate levels which can attack buried concrete structures.

The potentially detrimental effects of shale heaving can be avoided by preventing exposure of the shale to oxygen both during construction and long term. This is typically achieved by limiting exposure of the shale to no more than one day prior to covering with a protective layer such as shotcrete or a concrete mud slab. Sulphate resistant cement should be used in such applications.

6.2 Excavations, Bedding and Backfilling

All excavations must be conducted in accordance with the requirements of the Occupational Health & Safety Act & Regulations (OHSA) for Construction Projects. The anticipated native soils at the site should be classified Type 3 soils above and Type 4 below the groundwater table in accordance with OHSA.

Where excavations will extend below the groundwater level prevailing at the time of construction, the contractor will need to implement groundwater control and ground support systems as are required to carry out the construction in a safe, stable, and unwatered excavation.

Excavations, bedding and backfill for rigid frame structures should be in accordance with OPSS 422 and 902. Backfill for the culvert must consist of free draining granular material conforming to OPSS Granular A or B material specifications. The granular material must be placed to the extent shown on OPSD 803.030 or 803.031.

Subgrade preparation and placement of culvert bedding must be carried out in the dry.

6.3 Static Lateral Earth Pressure Coefficients

Lateral earth pressures acting on structures should be computed in accordance with the CHBDC but generally are given by the expression:

$$P_h = K^*(\gamma h + q)$$

where:

P_h = horizontal pressure on the wall (kPa)
K = earth pressure coefficient
γ = unit weight of retained soil
h = depth below top of fill where pressure is computed (m)
q = value of any surcharge (kPa)

The recommended lateral earth pressure parameters for use in the design for both a horizontal and for 2H:1V back-slope are provided in Table A.

For rigid structures such as Culvert 3-735/C, it is recommended that at-rest horizontal lateral earth pressures be used for design. Active pressures should be used for the design of unrestrained walls.

A lateral pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with the Section 6.9.3 of the CHBDC.

The parameters provided in Table A are based on the assumption that the backfill is fully drained so that there are no unbalanced hydrostatic pressures. If adequate drainage cannot be confirmed, the potential for hydrostatic pressures should be considered.

Table A: Static Lateral Earth Pressure Coefficient

Parameter	OPSS Granular A & OPSS Granular B Type II	Native Sand & Gravel	OPSS Granular B Type I
Soil Unit Weight, kN/m^3, γ	21	20	20
Angle of Internal Friction, ϕ	35°	32°	30°
Horizontal Back-Slope			
Coefficient of at Rest Earth Pressure, K_o (Restrained Wall)	0.43	0.47	0.50
Coefficient of Active Earth Pressure, K_a (Unrestrained Wall)	0.27	0.31	0.33
2H:1V Back-Slope			
Coefficient of Active Earth Pressure, K_a	0.39	0.47	0.53

6.4 Embankments

It is estimated that there is less than 2.0 m of fill over the existing culvert and that the roadway embankment is generally less than 1.5 m above the surrounding terrain. Given the anticipated shallow bedrock and the soil type prevalent in this area settlement would be minimal for minor widening and/or minor grade increases. Embankment side slopes of 2H:1V are appropriate for preliminary design.

6.5 Erosion Control

Active erosion of the embankment was noted on both sides of the inlet and outlet and along the creek bank in front of the culvert. Erosion protection should be established at these locations.

Design of the erosion protection measures must consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field.

Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact. Treatment at the outlets should be in accordance with OPSD 810.010. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS 804.

A concrete cut-off wall or clay seal should be installed at the culvert inlet to minimize the potential for seepage through the granular bedding and backfill material and avoid consequent erosion of these materials. The clay seal should have a minimum thickness of 0.5 m, completely surround the culvert, extend laterally the width of the granular backfill material, and extend above the high water level. The material used for the clay seal should conform to the requirements of OPSS 1205.

7 ADDITIONAL INVESTIGATIONS

Further foundation investigations and analysis must be carried out should the culvert structure be replaced or extended or if the height, geometry, or location of the approach fills are to be modified for either short-term construction staging or for vertical or horizontal re-alignments. Should excavations be anticipated within the embankment fills to repair or modify the culvert, consideration should be given to drilling foundation boreholes in the approaches to determine the nature of the fill materials and to allow generation of road way protection design. It is also recommended that monitoring wells be installed to better define the groundwater level as well as the hydraulic conductivity at the site. This information will be required to allow for the design of excavation dewatering systems.

Should the proposed works result in excavations to bedrock, samples of the bedrock should be acquired during the investigation and submitted for chemical testing to determine the pyritic heave potential.

THURBER

8 CLOSURE

We trust this information provided in this technical memorandum meets your present purposes. Please let us know if you have any questions or need additional information.

Thurber Engineering Ltd.

Kenton C. Power, P.Eng.
Geotechnical Engineer

Fred Griffiths, P.Eng.
Associate, Senior Geotechnical Engineer

P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact

Attachments

Preliminary Foundation Design
W.P. 4074-11-00
Site Photographs

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 174 EASTBOUND CULVERT STRUCTURE (SITE 3-735/C)

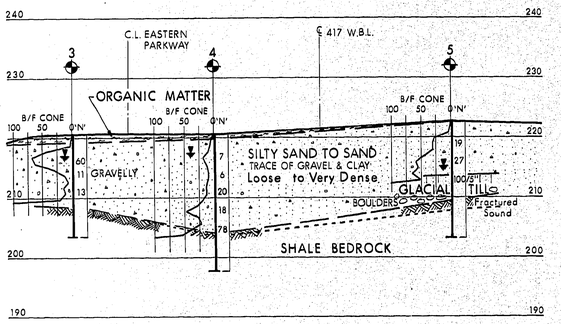
North inlet

South outlet, note the erosion of the bank in front of the culvert

Preliminary Foundation Design
W.P. 4074-11-00
Site Photographs

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 174 EASTBOUND CULVERT STRUCTURE (SITE 3-735/C)

South outlet, note the exposed bedrock along the west bank

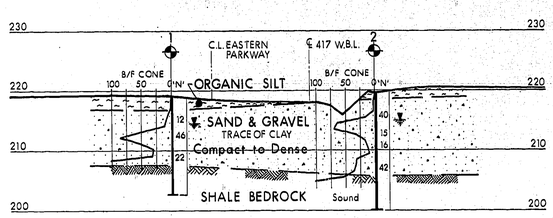


SECTION A-A

SCALE

HORIZ. 40 20 0 40 80 FT.

VERT. 10 5 0 10 20 FT.



SECTION B-B

SCALE

HORIZ. 40 20 0 40 80 FT.

VERT. 10 5 0 10 20 FT.

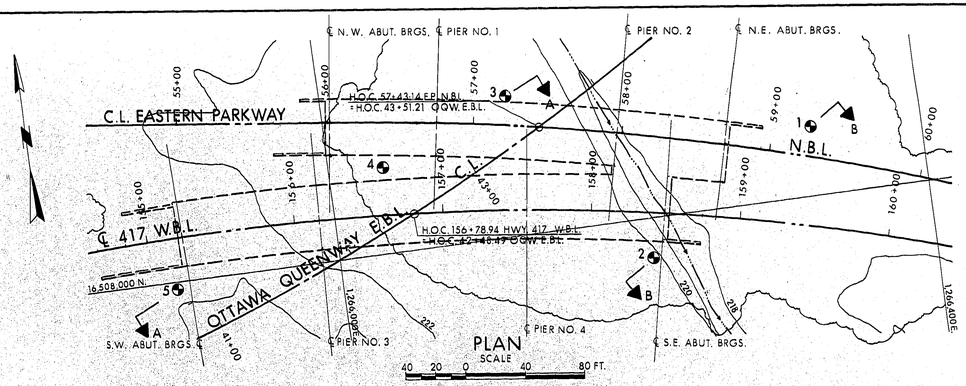
SCALE FOR PROFILES

SCALE

HORIZ. 40 20 0 40 80 FT.

VERT. 10 5 0 10 20 FT.

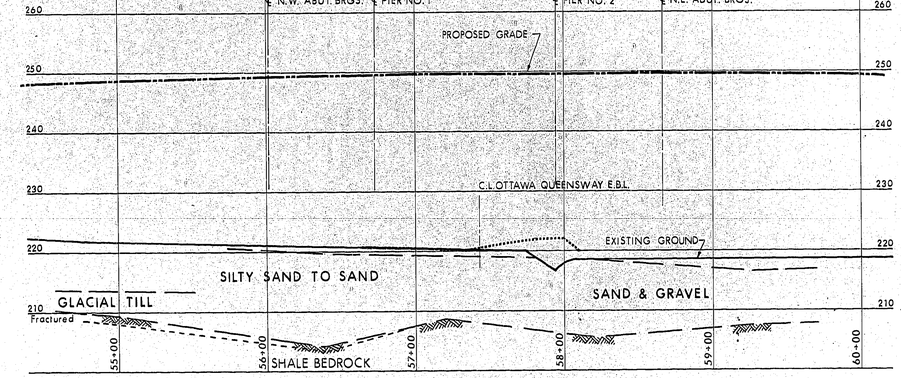
NOTE: The complete soil investigation report for this structure may be examined at the Bridge Office and Foundation Office, Downsview, and at the Ottawa District Office.



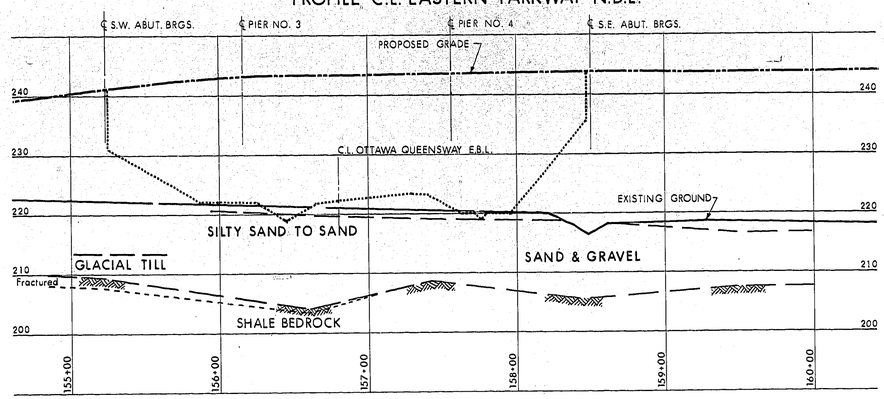
PLAN

SCALE

40 20 0 40 80 FT.

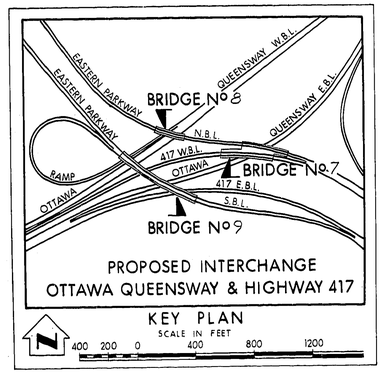


PROFILE C.L. EASTERN PARKWAY N.B.L.



PROFILE ℄ 417 W.B.L.

REF. Nº E-5241-1, E-5437-1, & B-56-28



PROPOSED INTERCHANGE
OTTAWA QUEENSWAY & HIGHWAY 417

KEY PLAN

SCALE IN FEET

N 400 200 0 400 800 1200

LEGEND

- Bore Hole
- Cone Penetration Test
- Bore Hole & Cone Test
- Water Levels established at time of field investigation. July & August 1972.

NO.	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
1	219·1	16,508,046	1,226,328
2	219·7	507,973	226,210
3	220·7	508,094	226,126
4	220·5	508,058	226,037
5	222·6	507,995	225,889

— NOTE —

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

REVISIONS

DATE	BY	DESCRIPTION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
DESIGN SERVICES BRANCH—FOUNDATIONS OFFICE

BRIDGE Nº 7

EASTERN PARKWAY N.B. & HWY. 417 W.B. OVER OTTAWA QW. EB.

HIGHWAY NO. 417 DIST. NO. 9

CO. REGIONAL MUNICIPALITY OF OTTAWA-CARLETON

TWP. GLOUCESTER LOT 24 CON. II

BORE HOLE LOCATIONS & SOIL STRATA

SUBMD. S.A.	CHECKED JC	W.P. NO. 13-68-02	DRAWING NO. 72-11083A
DRAWN J.I.G.	CHECKED GP	W.O. NO. 72-11083	
DATE NOV. 21, 1972	SITE NO. 3-304 A	CONT. NO. 73-192	BRIDGE DRAWING NO. 3-304A-2
APPROVED PRINCIPAL FOUNDATION ENGINEER			

57090

SNO-TRACE 300-8-72

TWP#-56-304A-2-A

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APPENDIX 4

SITE 3-442/C

THURBER

MEMORANDUM

To: Laura Donaldson, P.Eng.
McIntosh Perry Consulting Engineers

Date: July 17, 2015

From: Kenton Power, M.A.Sc., P.Eng.
(Reviewed by Fred Griffiths, P.Eng. and P.K. Chatterji, P.Eng.)

File: 19-3405-3

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 417 EASTBOUND CULVERT STRUCTURE (SITE 3-442/C)
GWP 4074-11-00 GEOCRES 31G5-262

PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This memo presents a brief summary of the factual findings from a foundation review carried out for the culvert structure carrying Highway 417 eastbound traffic over an unnamed creek in Ottawa, Ontario. It also presents preliminary geotechnical recommendations for potential culvert extensions or replacement. It is noted that the proposed construction options for this site are not yet defined. The preliminary recommendations provided below are for assistance in developing and evaluating the options and will need to be refined during subsequent design stages.

2 SITE DESCRIPTION

The site is located in eastern Ottawa, in the Township of Gloucester at the Highway 417 / Highway 174 Interchange. The culvert traverses under the Highway 417 eastbound lanes as they pass beneath the Eastern Parkway southbound bridge, Structure No. 3-303. The culvert carries the flow of an unnamed creek below the eastbound Highway 417 traffic (two lanes in total plus paved shoulders). Based on results of the MTO inspection report the culvert is a rigid frame, concrete, box culvert structure with a span of 3.7 m and a height of 1.5 m. The terrain in the vicinity of the inlet and outlet of the culvert is generally flat and is brush and grass covered with cattail growth at the inlet and outlet. Creek flow through the culvert is from west to east. Site photos showing the general site conditions are attached.

3 SUBSURFACE CONDITIONS

There were no as-built drawings or GEOGRES reports specific to this structure available at the time of preparing this memo. A review of publically available data was undertaken to develop a generalized soil and bedrock stratigraphy model for this site. Also the relevant data from the GEOCRES Report No. 31G5-86 for nearby Structure 3-303 was reviewed and is presented below.

THURBER

3.1 Background Review – Sources of Information

The following resources were reviewed to provide a general understanding of the subsurface conditions at this site:

- The Physiography of Southern Ontario, by Chapman and Putnam (1984)
- The Geological Survey of Canada, Map 1506A Surficial Geology of Ottawa, by Department of Energy, Mines and Resources (1982)
- The Geological Survey of Canada, Map 1508A Generalized Bedrock Geology of Ottawa-Hull, by Department of Energy, Mines and Resources (1979)
- Ontario Ministry of the Environment (MOE) Water Well Record database
- Ontario Geological Survey (OGS) Borehole Record database
- GEOCRES Report No. 31G5-86

3.2 REGIONAL GEOLOGY

3.2.1 Overburden

The site is situated within the physiographic region identified as the Ottawa Valley Clay Plains, as reported by Chapman and Putnam (1984). This physiographic region generally consists of clay plains interrupted by ridges of rock or sand.

Geological Survey of Canada, Map 1506A Surficial Geology of Ottawa, indicates that the overburden in the region consists predominantly of till plain deposits with drift thickness less than 5 m.

A review of the OGS borehole database identified two boreholes within approximately 300 m of the culvert location. The borehole records reported that the overburden materials at the site consist predominantly of a sand and clay till with thicknesses less than 10 m underlain by a shale bedrock.

3.2.2 Bedrock

The Generalized Bedrock Geology of Ottawa-Hull, Map 1508A, indicates that the bedrock underlying the site belongs to the Billings Formation of Ordovician age and consists of black shale. It should be noted that Billings Formation shale is susceptible to heaving if allowed to weather in the presence of oxygen.

The MOE water well records indicated that shale bedrock within the vicinity of the site was encountered at depths of less than 5 m below grade.

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3.3 Results from GEOCRES Report No. 31G5-86

A site investigation was carried out by the MTO Foundations Office for the Highway 417 / Highway 174 Interchange Structures 3-303, 3-304/1 and 3-304/2; GEOCRES Report No. 31G5-86 dated December 1972. The investigation consisted of eight sampled boreholes that were designated 9 to 16.

Based on Thurber's review of the 1972 Foundation Investigation Report, Boreholes 10 and 11 were located approximately 250 m from Culvert 3-442/C. Drawing No. 72-11083C (copy attached) illustrates the locations of the investigation boreholes, as well as the soil strata plot for the 1972 investigation. The stratigraphy at this site is generally characterized by a thin layer of clayey silt, overlaying a sand and gravel deposit, over a glacial till, underlain by shale bedrock.

3.3.1 Clayey Silt

A clayey silt stratum was reported in both Boreholes 10 and 11. The top of this stratum ranged from 68.0 m to 68.1 m in elevation; and the layer has a thickness of 0.9 m to 1.1 m. The standard penetration test (SPT) 'N' values recorded for this stratum were 17 and 18 blows per 0.3 m of penetration indicating a very stiff condition.

Atterberg Limits test results of a sample of the clayey silt indicate low plasticity.

The moisture content of the sample tested was 22%.

3.3.2 Sand and Gravel

The sand and gravel stratum was reported below the clayey silt material in both boreholes. The top of this stratum ranged from 67.0 m to 67.1 m in elevation and the layer has a thickness of 3.0 m to 3.4 m. The SPT 'N' values range from 17 to 31 blows per 0.3 m of penetration; indicating a compact to dense condition.

The results of grain size analysis tests completed on two samples of this material indicated a gravel content of 24% and 32%, sand content of 66% and 68%, and a fines content (combined silt and clay size particles) between 2% and 8%.

The moisture content of the samples tested was 11% and 12%.

3.3.3 Glacial Till

A glacial till stratum was reported beneath the sand and gravel stratum in Borehole 11. The till was described as a heterogeneous mixture of sand, gravel and silt with a trace clay. The top of this stratum was 64.1 m in elevation; and the layer has a thickness of 1.1 m. The SPT 'N' value recorded was greater than 100 blows per 0.3 m penetration, indicating a very dense condition.

The results of a grain size analysis tests including hydrometer analysis completed on a sample of this material indicated a gravel content of 49%, sand content of 31%, a silt content of 16% and clay content of 4%.

The moisture content of the sample tested was 7%.

3.3.4 Bedrock

A shale bedrock was encountered beneath the sand and gravel stratum of Borehole 10 and the glacial till stratum in Borehole 11 as proven by BX size coring. The bedrock surface elevation ranged from 63.0 m to 63.6 m. Bedrock core recovery ranged from 90% to 100%. The bedrock was described to be in sound condition except in Borehole 10 where the upper 0.6 m of bedrock was reported to be weathered. Geological mapping suggests the bedrock at this site is shale of the Billings Formation.

3.4 Groundwater

Groundwater levels were measured in the open boreholes prior to backfilling at an elevation of 65.9 m.

4 SITE OBSERVATIONS

A structure inspection was conducted by MTO in August 2010 for Culvert 3-442/C with the report issued December 2010. Condition data outlined in the report for the culvert structure ranged from poor to good but typically the culvert was rated in good condition.

The site was inspected by Thurber Engineering staff during the week of July 14th, 2014. Several photographs of the site are attached.

At the time of the inspection, the following observations were made:

West Inlet:

- Rip-Rap or rock protection was installed at the site for erosion protection
- Vegetation was noted on the side slopes and over the culvert
- No signs of erosion were observed
- No wing walls were present at the inlet
- No obvious settlement of the road surface was observed at the crossing

East Outlet:

- Rip-Rap or rock protection was installed at the site for erosion protection
- Vegetation was noted on the side slopes and over the culvert
- Erosion of the embankment was observed on both sides of the culvert
- No wing walls were present at the outlet
- No obvious settlement of the road surface was observed at the crossing

THURBER

5 GEOTECHNICAL ASSESSMENT

5.1 Frost Considerations

The frost penetration depth at this site is 1.8 m (OPSD 3090.101).

5.2 Seismic Considerations

This site is classified as a Soil Profile Type I in accordance with Section 4.4.6 of the Canadian Highway Bridge Design Code (CHBDC). The zonal acceleration ratio for this site is 0.20 as per Table A3.1.1 of the CHBDC.

Based on the anticipated presence and density of the sand and gravel stratum and the plasticity of the clayey silt, these materials are classified as “not susceptible” to liquefaction during the design earthquake event.

5.3 Existing Foundations

The results of the MTO inspection report indicate that the Culvert 3-442/C is a box culvert that is 120 m long, with a span of 5.5 m and a height of 1.5 m.

Based on the anticipated site stratigraphy the existing culvert is likely founded in the compact to dense sand and gravel, the underlying very dense till strata or on / in the sound shale bedrock.

PART 2: ENGINEERING DISCUSSION AND PRELIMINARY RECOMMENDATIONS

6 GEOTECHNICAL RECOMMENDATIONS

Based on the available data regarding the ground conditions at this site, the following sections present preliminary geotechnical recommendations for the assessment of the existing culvert and for preliminary design for potential culvert extensions, replacement, and the construction of new wing walls, end sections and/or headwall structures, if required. It is noted that the proposed construction options for this site are not yet defined. The preliminary recommendations provided below are for assistance in developing and evaluating options and will need to be refined during subsequent design stages.

The existing culvert is a concrete rigid-frame open-footing culvert likely founded on bedrock. For culvert extensions, it is preferred that type of foundations and founding elevation match the existing arrangement so as not to undermine the existing foundation. From a foundation perspective for a culvert replacement, a concrete rigid-frame open-footing culvert is preferred, however, a closed box culvert may also be feasible. The geometry of the culvert may not be suitable for a CSP.

6.1 Shallow Foundations

Given the anticipated site stratigraphy the design of shallow foundations placed on either the native overburden materials or on the shale bedrock may be considered.

For preliminary design, shallow foundations founded in the native undistributed compact to very dense soils with a minimum embedment depth of 1.8 m, may be designed with the factored vertical geotechnical resistance at ULS of 350 kPa. The vertical geotechnical reaction at SLS is 225 kPa; based on a total footing settlement of 25 mm.

The factored vertical geotechnical resistance of 1500 kPa at ULS may be used for the preliminary design of shallow foundations, founded on or in sound shale bedrock. The SLS condition will not govern for footings in or on the bedrock. The design of any new foundations on bedrock would need to consider interactions with the existing foundations and potential for undermining of the existing structural elements.

Resistance to lateral forces and sliding resistance between concrete and underlying materials should be evaluated using an unfactored coefficients of friction provided in Table A.

Table A: Unfactored Coefficients of Friction between Concrete and Founding Material

	Founding Material	
Concrete Type	**Sand & Gravel or Glacial Till**	**Sound Shale Bedrock**
Cast-in-place concrete	0.45	0.50
Precast concrete	0.40	0.45

Based on current geological mapping, the shale present at this site may be from the Billings Formation which is susceptible to heaving if allowed to weather in the presence of oxygen. The general mechanism is that oxidation of pyrite within the shale produces sulfuric acid, which in turn reacts with calcite in the shale to form gypsum crystals, which occupy a larger volume than the original materials. A by-product of this chain of reactions also tends to increase sulphate levels which can attack buried concrete structures.

The potentially detrimental effects of shale heaving can be avoided by preventing exposure of the shale to oxygen both during construction and long term. This is typically achieved by limiting exposure of the shale to no more than one day prior to covering with a protective layer such as shotcrete or a concrete mud slab. Sulphate resistant cement should be used in such applications.

6.2 Excavations, Bedding and Backfilling

All excavations must be conducted in accordance with the requirements of the Occupational Health & Safety Act & Regulations (OHSA) for Construction Projects. The anticipated native

soils at the site should be classified as Type 3 above and Type 4 below the groundwater table in accordance with OHSA.

Where excavations will extend below the groundwater level prevailing at the time of construction, the contractor will need to implement groundwater control and ground support systems as are required to carry out the construction in a safe, stable, and unwatered excavation.

Excavations, bedding and backfill for rigid structures should be in accordance with OPSS 422 and 902. Backfill for the culvert must consist of free draining granular material conforming to OPSS Granular A or B material specifications. The granular material must be placed to the extent shown on OPSD 803.030 or 803.031.

Subgrade preparation and placement of culvert bedding must be carried out in the dry.

6.3 Static Lateral Earth Pressure Coefficients

Lateral earth pressures acting on structures should be computed in accordance with the CHBDC but generally are given by the expression:

$$P_h = K^*(\gamma h + q)$$

where:

P_h = horizontal pressure on the wall (kPa)
K = earth pressure coefficient
γ = unit weight of retained soil
h = depth below top of fill where pressure is computed (m)
q = value of any surcharge (kPa)

The recommended lateral earth pressure parameters for use in the design for both a horizontal and for 2H:1V (Horizontal:Vertical) back-slope are provided in Table B.

For rigid structures such as Culvert 3-442/C, it is recommended that at-rest horizontal lateral earth pressures be used for design. Active pressures should be used for the design of unrestrained walls.

A lateral pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with the Section 6.9.3 of the CHBDC.

The parameters provided in Table B are based on the assumption that the backfill is fully drained so that there are no unbalanced hydrostatic pressures. If adequate drainage cannot be confirmed, the potential for hydrostatic pressures should be considered.

Table B: Static Lateral Earth Pressure Coefficients

Parameter	OPSS Granular A & OPSS Granular B Type II	Native Glacial Till	OPSS Granular B Type I / Native Sand & Gravel	Clayey Silt
Soil Unit Weight, kN/m^3, γ	21	20	20 / 19	19
Angle of Internal Friction, ϕ	35°	32°	30°	29°
Horizontal Back-Slope				
Coefficient of at Rest Earth Pressure, K_o (Restrained Wall)	0.43	0.47	0.50	0.52
Coefficient of Active Earth Pressure, K_a (Unrestrained Wall)	0.27	0.31	0.33	0.35
2H:1V Back-Slope				
Coefficient of Active Earth Pressure, K_a	0.39	0.47	0.53	0.57

6.4 Embankments

It is estimated that there is less than 1.5 m of fill over the existing culvert and that the roadway embankment is generally less than 1 m above the surrounding terrain. Given the anticipated shallow bedrock and the soil type prevalent in this area settlement would be minimal for minor widening and/or minor grade increases. Embankment side slopes of 2H:1V are appropriate for preliminary design.

6.5 Erosion Control

Active erosion of the embankment was noted on both sides of the outlet of Culvert 3-442/C. Erosion protection should be re-established at those locations.

Design of the erosion protection measures must consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field. Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact. Treatment at the outlets should be in accordance with OPSD 810.010. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS 804.

A concrete cut-off wall or clay seal should be installed at the culvert inlet to minimize the potential for seepage through the granular bedding and backfill material and avoid consequent erosion of these materials. The clay seal should have a minimum thickness of 0.5 m, completely surround the culvert, extend laterally the width of the granular backfill material, and extend above the high water level. The material used for the clay seal should conform to the requirements of OPSS 1205.

7 ADDITIONAL INVESTIGATIONS

Further foundation investigations and analysis must be carried out should the culvert structure be replaced or extended or if the height, geometry, or location of the approach fills are to be modified for either short-term construction staging or for vertical or horizontal re-alignments. Should excavations be anticipated within the embankment fills to repair or modify the culvert, consideration should be given to drilling foundation boreholes in the approaches to determine the nature of the fill materials and to allow generation of road way protection design. It is also recommended that monitoring wells be installed to better define the groundwater level as well as the hydraulic conductivity at the site. This information will be required to allow for the design of excavation dewatering systems.

Should the proposed works result in excavations to bedrock, samples of the bedrock should be acquired during the investigation and submitted for chemical testing to determine the pyritic heave potential.

THURBER

8 CLOSURE

We trust this information provided in this technical memorandum meets your present purposes. Please let us know if you have any questions or need additional information.

Thurber Engineering Ltd.

Kenton C. Power, P.Eng.
Geotechnical Engineer

Fred Griffiths, P.Eng.
Associate, Senior Geotechnical Engineer

P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact

Attachments

Preliminary Foundation Design
W.P. 4311-11-01
Site Photographs

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 417 EASTBOUND CULVERT STRUCTURE (SITE 3-442/C)

Inlet

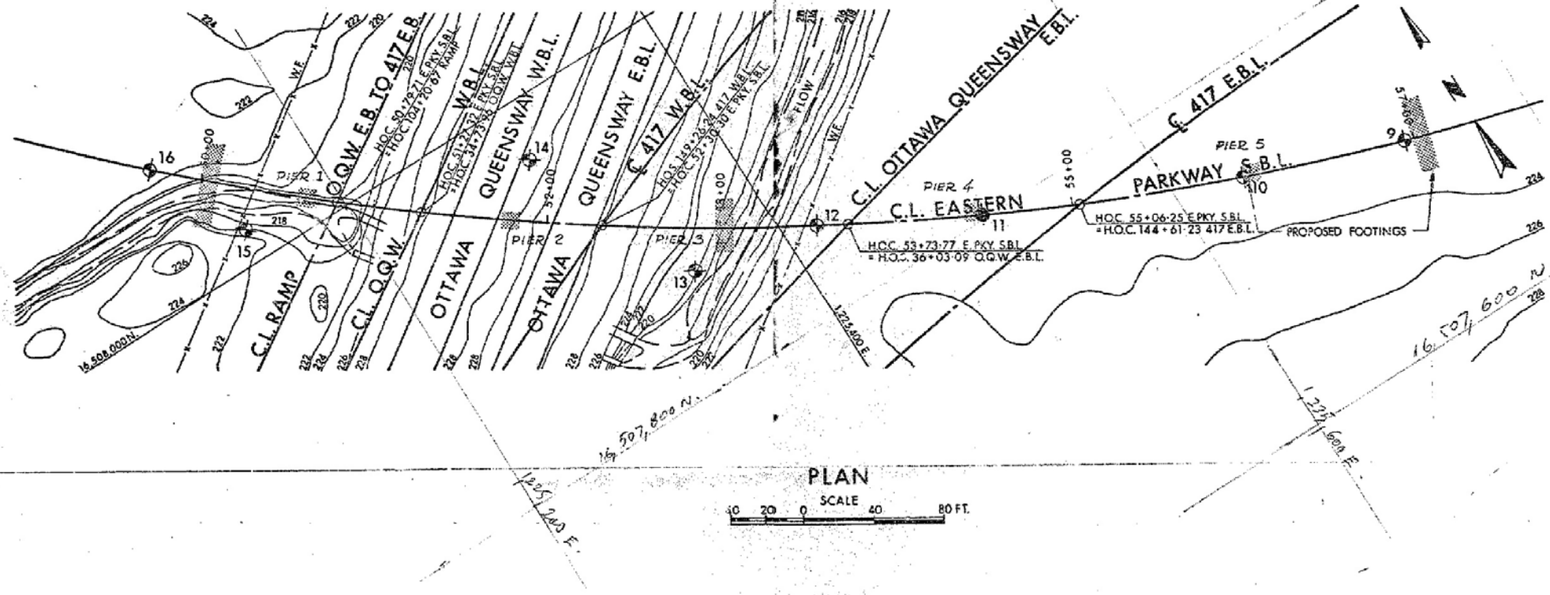
Inlet looking upstream

Preliminary Foundation Design
W.P. 4311-11-01
Site Photographs

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 417 EASTBOUND CULVERT STRUCTURE (SITE 3-442/C)

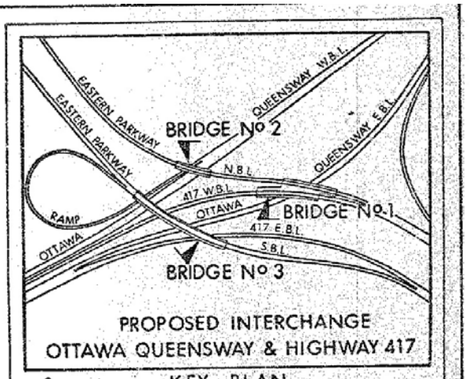
Outlet

Outlet looking downstream



PLAN

SCALE 40 20 0 40 80 FT.



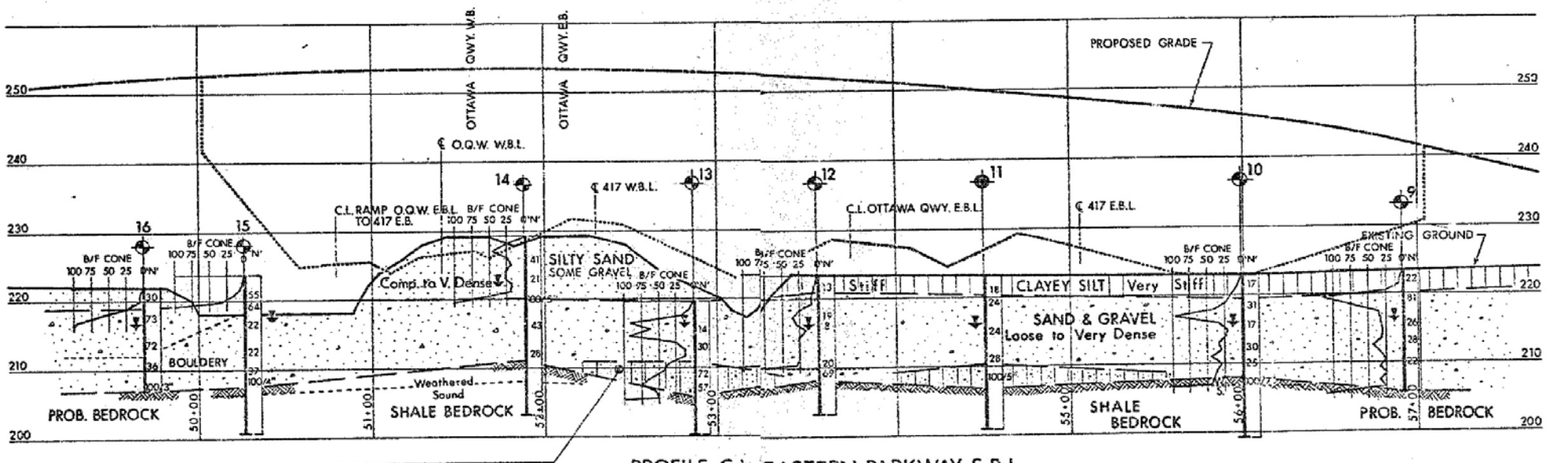
PROPOSED INTERCHANGE
OTTAWA QUEENSWAY & HIGHWAY 417

KEY PLAN
SCALE IN FEET
400 200 0 400 800 1200

LEGEND

- Bore Hole
- Cone Penetration Test
- Bore Hole & Cone Test
- Water Levels established at time of Field investigation Aug. & Oct. 1972.

NO.	ELEVATION	CO-ORDINATES NORTH	EAST
9	223·6	16,507,706	1,225,729
10	223·2	507,739	225,639
11	223·3	507,799	225,509
12	223·5	507,844	225,420
13	219·8	507,862	225,347
14	229·3	507,967	225,300
15	223·7	508,018	225,141
16	222·1	508,078	225,112



PROFILE C.L. EASTERN PARKWAY S.B.L.

SCALE
HORIZ. 40 20 0 40 80 FT.
VERT. 10 5 0 10 20 FT.

GLACIAL TILL
HET. MIXTURE SILT, SAND & GRAVEL
Very Dense

REF. N° 8-56-26 & E-5239-1

— NOTE —

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

REVISIONS		
DATE	BY	DESCRIPTION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
DESIGN SERVICES BRANCH—FOUNDATIONS OFFICE

BRIDGE No 3

EASTERN PARKWAY S.B. OVER OTTAWA QUEENSWAY & HWY. 417

HIGHWAY NO. 417 DIST. NO. 9
CO. REGIONAL MUNICIPALITY OF OTTAWA-CARLETON
TWP. GLOUCESTER LOT 25 CON. II

BORE HOLE LOCATIONS & SOIL STRATA

SUBMT. S.A.	CHECKED	W.P. NO. 13-68-08	DRAWING NO. 72-11083 C
DRAWN J.I.G.	CHECKED	W.O. NO. 72-11083	
DATE NOV. 22, 1972		SITE NO.	BRIDGE DRAWING NO.
APPROVED PRINCIPAL FOUNDATION ENGINEER		CONT. NO.	

THURBER

APPENDIX 5

SITE 3-732/C

THURBER

MEMORANDUM

To: Laura Donaldson, P.Eng.
McIntosh Perry Consulting Engineers

Date: July 17, 2015

From: Kenton Power, P.Eng.
(Reviewed by Fred Griffiths, P.Eng. and P.K. Chatterji, P.Eng.)

File: 19-3405-3

PRELIMINARY FOUNDATION DESIGN
CYRVILLE ROAD STRUCTURAL CULVERT CYRVILLE COLLECTOR DRAIN (SITE 3-732/C)
GWP 4074-11-00 GEOCRES 31G5-262

PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This memo presents a brief summary of the factual findings from a foundation review carried out for the culvert structure carrying traffic on Cyrville Road over the Cyrville Collector Drain in Ottawa, Ontario. It also presents preliminary geotechnical recommendations for potential culvert extensions or replacement. It is noted that the proposed construction options for this site are not yet defined. The preliminary recommendations provided below are for assistance in developing and evaluating the options and will need to be refined during subsequent design stages.

The following reference numbers apply to this site:

- Current W.P. -
- Site No. 3-732/C
- GEOCRES No. 31G5-114
- Construction Contract 73-192
- Historic W.P. 13-68-04

2 SITE DESCRIPTION

The site is located in eastern Ottawa, in the Township of Gloucester approximately 600 m north of the Highway 417 / Innes Road Interchange and 50 m east of the Highway 417 / Cyrville Road underpass. The culvert carries the Cyrville Collector Drain flow below the Cyrville Road east and westbound lanes (two lanes in total plus paved and grassed walkways). Based on results of the MTO inspection report the culvert is a rigid frame, concrete structure with a span of 5.5 m and a height of 2.1 m. Creek flow through the culvert is from north to south. The terrain in the vicinity of the inlet and outlet of the culvert is generally flat and is brush and grass covered. Site photos showing the general site conditions are attached.

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3 SUBSURFACE CONDITIONS

A site investigation was carried out by the MTO Foundations Office as addendum to GEOCRES Report No. 31G5-114 dated January 1973. The investigation was conducted between September and November of 1972 and consisted of four sampled boreholes designated Borehole 9 through 12; two of which were accompanied by dynamic cone penetration tests. Drawing No. 72-11109B (copy attached) illustrates the locations of the culvert and the investigation boreholes, as well as the soil strata plot for the investigation.

Based on the review of historic air-photos it appears that the Alternative 2 alignment indicated on Drawing No. 72-11190B was selected for the culvert and as such Boreholes 9 and 11 are most representative. The stratigraphy in the area of the culvert is generally characterized by a silty sand to sand, overlaying glacial till, underlain by a shale bedrock.

3.1 Silty Sand to Sand

The top of the silty sand to sand stratum ranges from 67.4 to 67.5 m in elevation and the layer extends to 1.5 m to 2.4 m below ground. The standard penetration test (SPT) 'N' values ranged from 5 to 40 blows per 0.3 m of penetration; indicating a loose to dense condition.

3.2 Glacial Till

Underlying the silty sand to sand stratum is a glacial till deposit. The surface of this deposit ranges in elevation from 65.0 to 66.0 m and the layer had a thickness of 0.2 to 2.3 m. This layer is described as cohesive and consists of a matrix of clayey silt which binds the sand and gravel particles. The SPT 'N' values were greater than 100 blows per 0.3 m of penetration; indicating very dense condition.

3.3 Bedrock

Beneath the glacial till layer, grey shale bedrock was encountered with surface elevations ranging from 63.7 m to 64.8 m. The upper 3.2 m of the shale was reported as fractured and weathered. At greater depth the shale was described as sound. Geological mapping suggests the bedrock at this site is shale of the Billings Formation.

3.4 Groundwater

Groundwater levels were measured in the open boreholes prior to backfilling at elevations of 65.8 m and 66.4 m.

4 SITE OBSERVATIONS

A structure inspection was conducted by MTO in August 2010 for Culvert 3-732/C with the report issued December 2010. Condition data outlined in the report for the culvert structure ranged from poor to good but typically the culvert was rated in good condition.

The site was inspected by Thurber Engineering staff during the week of July 14th, 2014. Several photographs of the site are attached.

At the time of the inspection, the following observations were made:

North Inlet:

- No erosion protection measures were observed at the inlet
- Metal fencing was anchored into the top of the culvert and ran perpendicular to the culvert
- Erosion of the embankment was observed on both sides of the culvert
- Vegetation was noted on the side slopes and over the culvert
- No wing walls were present at the inlet
- No obvious settlement of the road surface was observed at the crossing

South Outlet:

- No erosion protection measures were observed at the outlet
- Metal fencing was anchored into top of the culvert and ran perpendicular to the culvert
- Erosion of the embankment was observed on both sides of the culvert
- Vegetation was noted on the side slopes and over the culvert
- No wing walls were present at the outlet
- No obvious settlement of the road surface was observed at the crossing

5 GEOTECHNICAL ASSESSMENT

5.1 Frost Considerations

The frost penetration depth at this site is 1.8 m (OPSD 3090.101).

5.2 Seismic Considerations

This site is classified as a Soil Profile Type I in accordance with Section 4.4.6 of the Canadian Highway Bridge Design Code (CHBDC). The zonal acceleration ratio for this site is 0.20 as per Table A3.1.1 of the CHBDC.

Based on the density of the silty sand/sandy silt and the till at this site, these materials are classified as “not susceptible” to liquefaction during an earthquake event.

5.3 Existing Foundations

The results of the MTO inspection report indicate that the Culvert 3-732/C is a rigid frame concrete culvert that is 49.5 m long, with a span of 5.5 m and a height of 2.1 m. The Foundation Design Report indicated that the finished grade of Cyrville Road was to be at approximate elevation 71.6 m and that the invert of the culvert is at approximate elevation 63.4 m.

Based on the frost cover requirement and the anticipated shallow bedrock depth at this site it is likely that the culvert is founded within the weathered shale bedrock.

The Foundation Design Report also indicates that the culvert was to be founded on the weathered to sound bedrock. The design allowable bearing value of 10 tsf or approximately 950 kPa was recommended for the culvert.

PART 2: ENGINEERING DISCUSSION AND PRELIMINARY RECOMMENDATIONS

6 GEOTECHNICAL RECOMMENDATIONS

Based on the available data regarding the ground conditions at this site, the following sections present preliminary geotechnical recommendations for the assessment of the existing culvert and for preliminary design for potential culvert extensions or replacement and new wing walls, end sections and/or headwall structures, if required. It is noted that the proposed construction options for this site are not yet defined. The preliminary recommendations provided below are for assistance in developing and evaluating options and will need to be refined during subsequent design stages.

The existing culvert is a concrete rigid-frame open-footing culvert likely founded on bedrock. For culvert extensions, it is preferred that type of foundations and founding elevation match the existing arrangement so as not to undermine the existing foundation. From a foundation perspective for a culvert replacement, a concrete rigid-frame open-footing culvert is preferred, however, a closed box culvert may also be feasible. The geometry of the culvert may not be suitable for a CSP.

6.1 Spread Footings

Although spread footings within the overburden are possible, effective dewatering of the sand and gravel strata would be required. Given the anticipated relatively shallow depth to the shale bedrock, and the higher geotechnical resistance offered by the bedrock, spread footings within the overburden are not recommended. In addition, footings for potential culvert extensions should match the elevation of the existing foundation element, i.e. be founded on bedrock.

The factored vertical geotechnical resistance of 1000 kPa at ULS may be used for the preliminary design of shallow foundations, founded on or in weathered shale bedrock. The SLS condition will not govern for footings in or on the bedrock. The design of any new foundations on bedrock would need to consider interactions with the existing foundations and potential for undermining of the existing structural elements.

Resistance to lateral forces and sliding resistance between concrete and underlying materials should be evaluated using an unfactored coefficient of friction of 0.45 for cast-in-place concrete and 0.4 for pre-cast concrete on weathered shale bedrock.

Based on current geological mapping, the shale present at this site may be from the Billings Formation which is susceptible to heaving if allowed to weather in the presence of oxygen. The general mechanism is that oxidation of pyrite within the shale produces sulfuric acid, which in turn reacts with calcite in the shale to form gypsum crystals, which occupy a larger volume than the original materials. A by-product of this chain of reactions also tends to increase sulphate levels which can attack buried concrete structures.

The potentially detrimental effects of shale heaving can be avoided by preventing exposure of the shale to oxygen both during construction and long term. This is typically achieved by limiting exposure of the shale to no more than one day prior to covering with a protective layer such as shotcrete or a concrete mud slab. Sulphate resistant cement should be used in such applications.

6.2 Excavations, Bedding and Backfilling

All excavations must be conducted in accordance with the requirements of the Occupational Health & Safety Act & Regulations (OHSA) for Construction Projects. The anticipated native soils at the site should be classified as Type 3 above and Type 4 below the groundwater table in accordance with OHSA.

Where excavations will extend below the groundwater level prevailing at the time of construction, the contractor will need to implement groundwater control and ground support systems as are required to carry out the construction in a safe, stable, and unwatered excavation.

Excavations, bedding and backfill for rigid structures should be in accordance with OPSS 422 and 902. Backfill for the culvert must consist of free draining granular material conforming to OPSS Granular A or B material specifications. The granular material must be placed to the extent shown on OPSD 803.030 or 803.031.

Subgrade preparation and placement of culvert bedding must be carried out in the dry.

6.3 Static Lateral Earth Pressure Coefficients

Lateral earth pressures acting on structures should be computed in accordance with the CHBDC but generally are given by the expression:

$$P_h = K^*(\gamma h + q)$$

where:

P_h = horizontal pressure on the wall (kPa)
K = earth pressure coefficient
γ = unit weight of retained soil
h = depth below top of fill where pressure is computed (m)
q = value of any surcharge (kPa)

The recommended lateral earth pressure parameters for use in the design for both a horizontal and for 2H:1V (Horizontal:Vertical) back-slope are provided in Table A.

For rigid structures such as Culvert 3-732/C, it is recommended that at-rest horizontal lateral earth pressures be used for design. Active pressures should be used for the design of unrestrained walls.

A lateral pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with the Section 6.9.3 of the CHBDC.

The parameters provided in Table A are based on the assumption that the backfill is fully drained so that there are no unbalanced hydrostatic pressures. If adequate drainage cannot be confirmed, the potential for hydrostatic pressures should be considered.

Table A: Static Lateral Earth Pressure Coefficients

Parameter	OPSS Granular A & OPSS Granular B Type II	Native Glacial Till	OPSS Granular B Type I / Native Silty Sand
Soil Unit Weight, kN/m^3, γ	21	20	20 / 19
Angle of Internal Friction, ϕ	35°	32°	30°
Horizontal Back-Slope			
Coefficient of at Rest Earth Pressure, K_o (Restrained Wall)	0.43	0.47	0.50
Coefficient of Active Earth Pressure, K_a (Unrestrained Wall)	0.27	0.31	0.33
2H:1V Back-Slope			
Coefficient of Active Earth Pressure, K_a	0.39	0.47	0.53

6.4 Embankments

Based on the original Foundation Design Report, the embankment soils consist of compact fill to a height of approximately 4.2 m above the original ground surface. Given the anticipated shallow bedrock and the soil type prevalent in this area settlement would be minimal for minor widening and/or minor grade increases. Embankment side slopes of 2H:1V are appropriate for preliminary design.

6.5 Erosion Control

Active erosion of the embankment was noted on both sides of the inlet and outlet of Culvert 3-732/C. Erosion protection should be established at these locations.

Design of the erosion protection measures must consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field. Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact. Treatment at the outlets should be in accordance with OPSD 810.010. A vegetation cover should be established on all

other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS 804.

A concrete cut-off wall or clay seal should be installed at the culvert inlet to minimize the potential for seepage through the granular bedding and backfill material and avoid consequent erosion of these materials. The clay seal should have a minimum thickness of 0.5 m, completely surround the culvert, extend laterally the width of the granular backfill material, and extend above the high water level. The material used for the clay seal should conform to the requirements of OPSS 1205.

7 ADDITIONAL INVESTIGATIONS

Further foundation investigations and analysis will be warranted should the culvert structure be replaced or extended or if the height, geometry, or location of the approach fills are to be modified for either short-term construction staging or for vertical or horizontal re-alignments. Should excavations be anticipated within the embankment fills to repair or modify the culvert, consideration should be given to drilling foundation boreholes in the approaches to determine the nature of the fill materials and to allow generation of road way protection design. It is also recommended that monitoring wells be installed to better define the groundwater level as well as the hydraulic conductivity at the site. This information will be required to allow for the design of excavation dewatering systems.

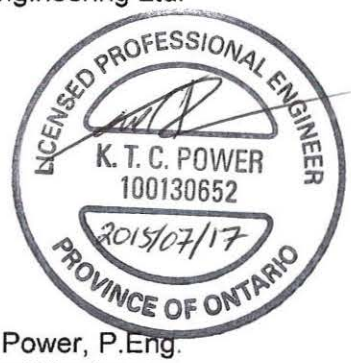
Should the proposed works result in excavations to bedrock, samples of the bedrock should be acquired during the investigation and submitted for chemical testing to determine the pyritic heave potential.

THURBER

8 CLOSURE

We trust this information provided in this technical memorandum meets your present purposes. Please let us know if you have any questions or need additional information.

Thurber Engineering Ltd.



Kenton C. Power, P.Eng.
Geotechnical Engineer

Fred Griffiths, P.Eng.
Associate, Senior Geotechnical Engineer

P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact

Attachments

Preliminary Foundation Design
W.P. 4043-11-01
Site Photographs

PRELIMINARY FOUNDATION DESIGN
CYRVILLE ROAD STRUCTURAL CULVERT CYRVILLE COLLECTOR DRAIN
(SITE 3-732/C)

North inlet, note erosion of slope

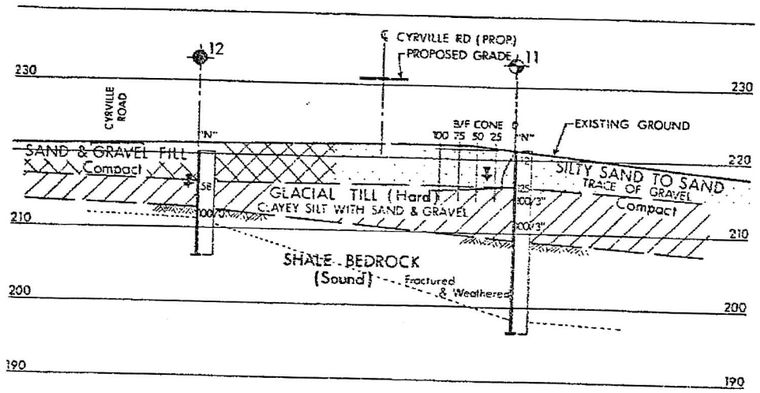
Slope behind north inlet

Preliminary Foundation Design
W.P. 4043-11-01
Site Photographs

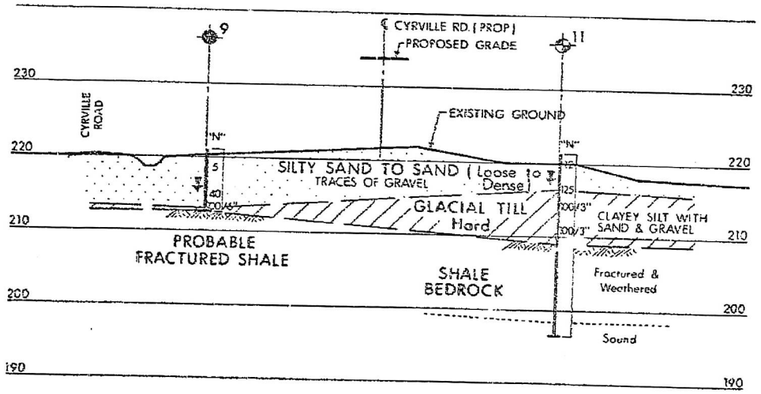
PRELIMINARY FOUNDATION DESIGN
CYRVILLE ROAD STRUCTURAL CULVERT CYRVILLE COLLECTOR DRAIN
(SITE 3-732/C)

Tree at front face of north inlet

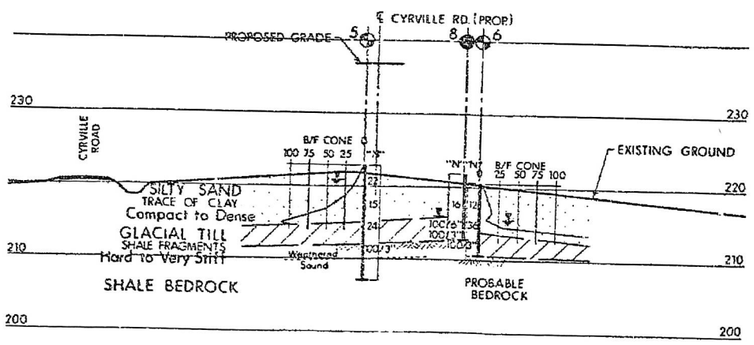
South outlet, note erosion of slope



PROFILE ALTERNATE 3



PROFILE ALTERNATE 2

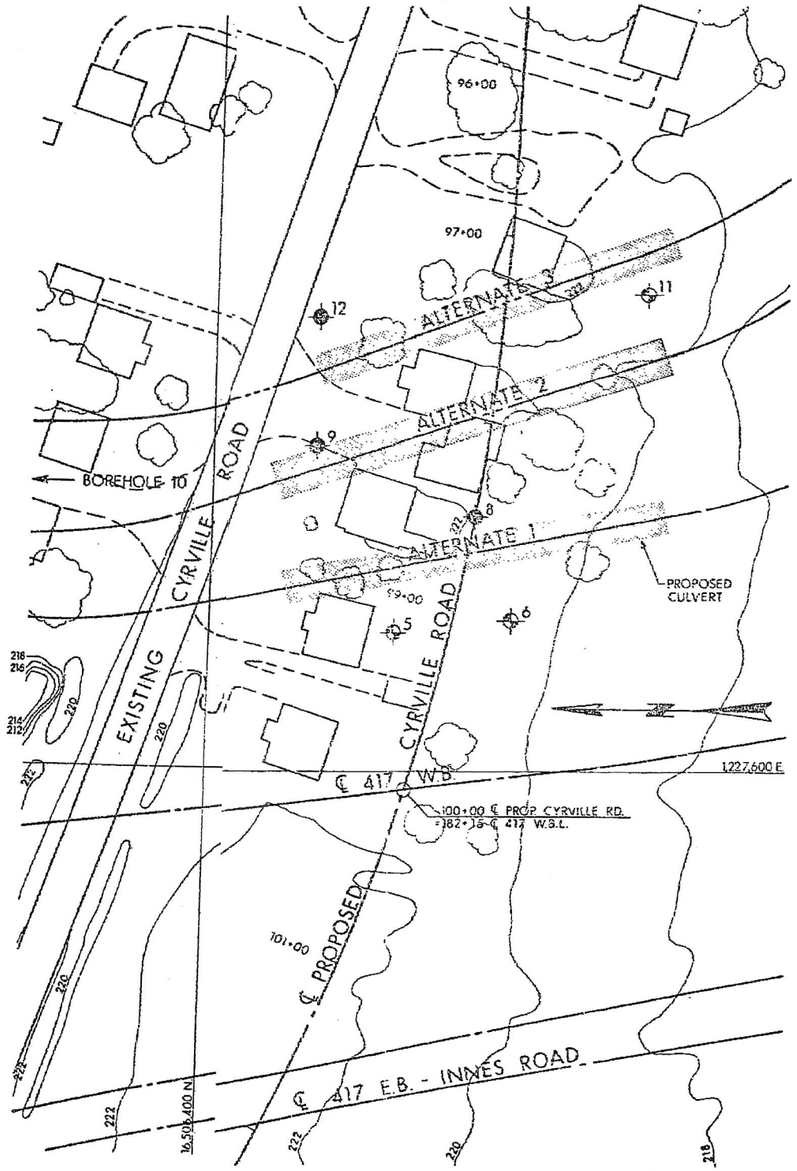


PROFILE ALTERNATE 1

SCALE

HORIZ. 40 20 0 40 80 FT.

VERT. 10 5 0 10 20 FT.



PLAN

SCALE

40 20 0 40 80 FT

SEE DWG. 72 - 11109A

KEY PLAN

SCALE IN MILES

LEGEND

- Bore Hole
- Cone Penetration Test
- Bore Hole & Cone Test
- Water Levels established at time of Field investigation. Sept. & Oct. 1972.

NO.	ELEVATION	CO-ORDINATES NORTH.	EAS.
5	222·9	16,506,303	1,227,670
6	220·6	506,241	227,676
8	221·9	506,261	227,731
9	221·1	506,346	227,774
10	222·0	506,686	227,754
11	221·4	506,172	227,855
12	220·2	506,345	227,842

— NOTE —

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

REVISIONS			
	DATE	BY	DESCRIPTION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

CYRVILLE ROAD PROPOSED CULVERT

(ALTERNATES I, II & III)

HIGHWAY NO. 417 (SCHEME D) DIST. NO. 9

CO. REG. MUNICIPALITY OF OTTAWA - CARLETON

TWP. GLOUCESTER LOT CON.

BORE HOLE LOCATIONS & SOIL STRATA

SUBM'D J.C.	CHECKED	W.P. NO. 13-68-04	DRAWING NO. 72-11109B
DRAWN J.L.G.	CHECKED	W.O. NO. 72-11109	
DATE DEC. 28, 1972		SITE NO.	BRIDGE DRAWING NO.
APPROVED PRINCIPAL FOUNDATION ENGINEER		CONT. NO.	

REF DELEUW CATHER 284-134 22-4

THURBER

APPENDIX 6

3-443/C

THURBER

MEMORANDUM

To: Laura Donaldson, P.Eng.
McIntosh Perry Consulting Engineers

Date: July 17, 2015

From: Kenton Power, M.A.Sc., P.Eng.
(Reviewed by Fred Griffiths, P.Eng. and P.K. Chatterji, P.Eng.)

File: 19-3405-3

PRELIMINARY FOUNDATION DESIGN
SOUTH CYRVILLE DRAIN CULVERT (SITE 3-443/C)
GWP 4074-11-00 GEOCRES 31G5-262

PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This memo presents a brief summary of the factual findings from a foundation review carried out for the culvert structure carrying the South Cyrville Collector Drain under Highway 417 in Ottawa, Ontario. It also presents preliminary geotechnical recommendations for potential culvert extensions or replacement. It is noted that the proposed construction options for this site are not yet defined though concrete rehabilitation work is proposed for this structure. The preliminary recommendations provided below are for assistance in developing and evaluating the options and will need to be refined during subsequent design stages.

The following reference numbers apply to this site:

- Current W.P. 4074-11-00
- Site No. 3-443/C
- GEOCRES No. 31G5-266
- Construction Contract 73-191
- Historic W.P. 13-68-12

2 SITE DESCRIPTION

The site is located in eastern Ottawa, in the Township of Gloucester approximately 320 m northwest of the Highway 417 / Innes Road Interchange. The concrete culvert carries the South Cyrville Collector Drain flow below both the Highway 417 east and westbound lanes (four lanes in total plus paved shoulders and gore areas) and the on and off ramps for the Innes Road Interchange. Based on the historic construction drawing entitled Open Box Culvert South Cyrville Drain Under Hwy 417 (copy attached), the culvert was constructed in ten, open bottom, concrete sections plus three additional concrete panel sections, two at the inlet and one at the outlet. The additional panels at the inlet include a curve to the culvert alignment and a skewed end. The additional outlet panel includes a skewed end. The total length of structure is reported to be 114.6 m, with a span of 4.9 m and a height of 1.8 m.

The terrain in the vicinity of the outlet of the culvert (east end) is generally flat and is brush, grass and tree covered. The land north and south of the inlet (west end) is also brush covered though directly west of the inlet is another culvert that services the adjacent industrial/commercial development. Flow through the culvert is from west to east. Site photos showing the general site conditions are attached.

3 SUBSURFACE CONDITIONS

There are no GEOGRES reports specific to this structure available at the time of preparing this memo. A review of publically available data was undertaken to develop a generalized soil and bedrock stratigraphy model for this site. Relevant data from the construction drawings from Contract No. 73-191 were reviewed and are presented below. As part of the scope of work for the current detail design investigation for this site, three boreholes were advanced in the vicinity of Culvert 3-443/C. The results of the current investigation have also been incorporated into this Preliminary Foundation Design Memo for completeness.

3.1 Background Review – Sources of Information

The following resources were reviewed to provide a general understanding of the subsurface conditions at this site:

- The Physiography of Southern Ontario, by Chapman and Putnam (1984);
- The Geological Survey of Canada, Map 1506A Surficial Geology of Ottawa, by Department of Energy, Mines and Resources (1982);
- The Geological Survey of Canada, Map 1508A Generalized Bedrock Geology of Ottawa-Hull, by Department of Energy, Mines and Resources (1979);
- Ontario Ministry of the Environment (MOE) Water Well Record database;
- Ontario Geological Survey (OGS) Borehole Record database;
- Construction drawings from MTO Contract No. 73-191; and
- Results from Thurber's 2014 Detailed Design Investigation GEOCRES No. 31G5-266.

3.2 REGIONAL GEOLOGY

3.2.1 Overburden

The site is situated within the physiographic region identified as the Ottawa Valley Clay Plains, as reported by Chapman and Putnam (1984). This physiographic region generally consists of clay plains interrupted by ridges of rock or sand.

Geological Survey of Canada, Map 1506A Surficial Geology of Ottawa, indicates that the overburden in the region consists predominantly of till plain deposits with drift thickness less than 5 m.

A review of the OGS borehole database identified two boreholes within approximately 300 m of the culvert location. The borehole records reported that the overburden materials at the site

consist predominantly of a silt and sand till with thicknesses less than 3 m underlain by a shale bedrock.

3.2.2 Bedrock

The Generalized Bedrock Geology of Ottawa-Hull, Map 1508A, indicates that the bedrock underlying the site belongs to the Billings Formation of Ordovician age and consists of black shale. It should be noted that Billings Formation shale is susceptible to heaving if allowed to weather in the presence of oxygen.

The MOE water well records indicated that shale bedrock within the vicinity of the site was encountered at depths of less than 3 m below grade.

3.3 MTO Contract No. 73-191

The results of a site investigation for the Highway 417 / Innes Road Interchange were included in the Construction Drawings for Contract No. 73-191.

Based on Thurber's review of these contract drawings, Boreholes 6 and 7 were located approximately 55.5 m north and 110.8 m south of Culvert 3-443/C respectively. Drawing No. 73-11096B (copy attached) illustrates the locations of the investigation boreholes, as well as the soil strata plot for the investigation. The stratigraphy at this site is generally characterized by a thin deposit of stiff to very stiff glacial till, underlain by bedrock.

3.4 2014 Detailed Design Investigation for Culvert 3-443/C

A site investigation was carried out by Thurber for the rehabilitation of Culvert 3-443/C. The investigation consisted of three sampled boreholes that were designated 14-1, 14-2 and 14-3. Drawing No. 1 (copy attached) illustrates the approximate location of Culvert 3-443/C and the investigation boreholes. A detailed description of the investigation methodology can be found in Thurber's Foundation Investigation Report for this site, GEOCRES No. 31G5-266.

The stratigraphy at this site is generally characterized by an embankment fill layer consisting predominantly of sand and gravel overlying a thin stratum of silty sand with gravel underlain by shale bedrock. Further details are provided in the following sub-sections.

3.4.1 Rootmat

A 150 mm thick rootmat layer was encountered at the ground surface of Borehole 14-3.

3.4.2 Fill – Sand and Gravel

A fill layer was encountered at the ground surface of Borehole 14-1 and below the ground surface cover of Borehole 14-3. The fill layer consisted predominately of sand and gravel with varying amounts of silt and trace amounts of clay size particles. Occasional roots and wood fragments were noted in the fill layer of Borehole 14-3. The top of this stratum ranged from 63.9 m to 64.8 m in elevation and the layer has a thickness of 1.8 m to 2.2 m. The standard

penetration test ‘N’ values ranged from 13 to 36 blows per 0.3 m of penetration; indicating a compact to dense condition.

The results of grain size analysis tests completed on three samples of this material indicated a gravel content ranging from 36% to 45%, sand content from 40% to 43%, and a fines content (combined silt and clay size particles) between 12% and 24%.

The moisture content of the samples tested ranged from 2% to 19%.

3.4.3 Silty Sand with Gravel

A silty sand with gravel stratum was encountered at the ground surface of Borehole 14-2. The top of this stratum was at elevation 61.4 m and the layer has a thickness of 0.1 m.

Due to the low quantity of sample recovered from this stratum, no moisture content or gradation testing could be performed.

3.4.4 Bedrock

A shale bedrock was encountered beneath the fill layers in Boreholes 14-1 and 14-3 and beneath the silty sand with gravel stratum in Borehole 14-2. All three boreholes were terminated in bedrock. The bedrock / soil interface was proven by NQ size coring in both Boreholes 14-2 and 14-3. A weathered layer of bedrock was encountered in Borehole 14-1 as proven by split spoon sampling. The bedrock surface ranged in elevation from 61.3 m to 62.6 m. Bedrock solid core recovery ranged from 79% to 100%; total core recovery ranged from 75% to 100%; and the measured RQD values ranged from 16% to 53%. Based on the RQD values the rock mass quality is classified as ranging from very poor to poor. The bedrock fractures had a flat orientation with a fracture index of 2 to 7 fractures per 0.3 m.

Geological mapping suggests the bedrock at this site is shale of the Billings Formation.

3.5 Groundwater

A 19 mm inside diameter PVC monitoring well was installed in each of Boreholes 14-2 and 14-3. Groundwater levels in the monitoring wells were recorded on September 5, 2014 at depths of 0.0 m and 1.7 m corresponding to elevations of 61.4 m and 62.4 m. The water level observed in the monitoring well install in bedrock in Borehole 14-2 was at ground surface. The water level observed in the monitoring well straddling the overburden–bedrock interface in Borehole 14-3 was within the overburden.

The water level in the South Cyrville Collector Drain was measured at the time of Thurber’s field investigation at a depth of 2.2 m below the top of the culvert; corresponding to an elevation of 61.6 m. A water level elevation for the drain was also indicated on existing historical construction drawings as 62.4 m on November 13, 1971.

4 SITE OBSERVATIONS

A structure inspection was conducted by MTO in August 2010, for Culvert 3-443/C with the report issued December 2010. Condition data outlined in the report for the culvert structure ranged from poor to good but typically the culvert was rated in good condition. The report recommended concrete rehabilitation work to be completed for the culvert within 1 to 5 years of the inspection.

The site was inspected by Thurber Engineering staff during the week of July 14th, 2014. Several photographs of the site are attached.

At the time of the inspection, the following observations were made:

West Inlet:

- No erosion protection measures were observed at the inlet
- Metal fencing was anchored into the top of the culvert and ran perpendicular to the culvert
- Vegetation was noted on the side slopes, and on top of the culvert
- Erosion of the embankment was observed on both sides of the culvert
- No obvious settlement of the road surface was observed at the crossing
- Tilting of and erosion behind the concrete block headwall / retaining wall of the culvert just upstream of Culvert 3-443/C was observed

East Outlet:

- No erosion protection measures were observed at the outlet
- Erosion of the embankment was observed on both sides of the culvert
- Vegetation was noted on the side slopes and over the culvert
- No obvious settlement of the road surface was observed at the crossing

5 GEOTECHNICAL ASSESSMENT

5.1 Frost Considerations

The frost penetration depth at this site is 1.8 m (OPSD 3090.101). Foundations for open footing culverts on soil must be provided with protection equivalent to 1.8 m of cover. Closed box culverts do not typically require frost protection in addition to standard bedding and backfill.

5.2 Seismic Considerations

This site is classified as a Soil Profile Type I in accordance with Section 4.4.6 of the Canadian Highway Bridge Design Code (CHBDC). The zonal acceleration ratio for this site is 0.20 as per Table A3.1.1 of the CHBDC.

Based on the relatively thin stratum of overburden at this site this material is classified as “not susceptible” to liquefaction during the design earthquake event.

5.3 Existing Foundations

As indicated on the historical contract drawings, the culvert invert has a design elevation ranging from 61.4 m to 61.3 m; and a top of culvert elevation ranging from 63.9 m to 63.8 m at the inlet and outlet respectively.

The construction drawings also indicate that the culvert is founded on 0.96 m wide concrete footings, founded in the shale bedrock. The base of the concrete footings are at an elevation ranging from 59.9 m to 59.7 m at the inlet and outlet respectively.

PART 2: ENGINEERING DISCUSSION AND PRELIMINARY RECOMMENDATIONS

6 GEOTECHNICAL RECOMMENDATIONS

Based on the available data regarding the ground conditions at this site, the following sections present preliminary geotechnical recommendations for the assessment of the existing culvert and for preliminary design for potential culvert extensions, replacement, and the construction of new wing walls, end sections and/or headwall structures, if required. It is noted that the proposed construction options for this site are not yet defined though presently concrete rehabilitation work is proposed for this structure. The preliminary recommendations provided below are for assistance in developing and evaluating options and will need to be refined during subsequent design stages.

The existing culvert is a concrete rigid-frame open-footing culvert likely founded on bedrock. For culvert extensions, it is preferred that type of foundations and founding elevation match the existing arrangement so as not to undermine the existing foundation. From a foundation perspective for a culvert replacement, a concrete rigid-frame open-footing culvert is preferred, however, a closed box culvert may also be feasible. The geometry of the culvert may not be suitable for a CSP.

6.1 Shallow Foundations

Although spread footings within the overburden are possible, effective dewatering of the sand and gravel strata would be required. Given the anticipated relatively shallow depth to bedrock and the higher geotechnical resistance offered by the bedrock, spread footings within the overburden are not recommended. In addition, footings for potential culvert extensions should match the elevation of the existing foundation element, i.e. be founded on bedrock.

The factored vertical geotechnical resistance of 1000 kPa at ULS may be used for the preliminary design of shallow foundations for both open footing and box culverts, founded on or in weathered shale bedrock. The SLS condition will not govern for footings in or on the bedrock. The design of any new foundations on bedrock would need to consider interactions with the existing foundations and potential for undermining of the existing structural elements.

Resistance to lateral forces and sliding resistance between concrete and underlying materials should be evaluated using an unfactored coefficient of friction of 0.45 for cast-in-place concrete and 0.4 for pre-cast concrete on weathered shale bedrock.

Based on current geological mapping, the shale present at this site may be from the Billings Formation which is susceptible to heaving if allowed to weather in the presence of oxygen. The general mechanism is that oxidation of pyrite within the shale produces sulfuric acid, which in turn reacts with calcite in the shale to form gypsum crystals, which occupy a larger volume than the original materials. A by-product of this chain of reactions also tends to increase sulphate levels which can attack buried concrete structures.

The potentially detrimental effects of shale heaving can be avoided by preventing exposure of the shale to oxygen both during construction and long term. This is typically achieved by limiting exposure of the shale to no more than one day prior to covering with a protective layer such as shotcrete or a concrete mud slab. Sulphate resistant cement should be used in such applications.

6.2 Excavations, Bedding and Backfilling

All excavations must be conducted in accordance with the requirements of the Occupational Health & Safety Act & Regulations (OHSA) for Construction Projects. The anticipated native soils at the site should be classified as Type 3 above and Type 4 below the groundwater table in accordance with OHSA. Excavation into the shale bedrock should be designed as Type 3 soil. The embankment fill material should be classified as Type 3.

Where excavations will extend below the groundwater level prevailing at the time of construction, the contractor will need to implement groundwater control and ground support systems as are required to carry out the construction in a safe, stable, and unwatered excavation.

Excavations, bedding and backfill for rigid structures should be in accordance with OPSS 422 and 902. Backfill for the culvert must consist of free draining granular material conforming to OPSS Granular A or B material specifications. The granular material must be placed to the extent shown on OPSD 803.030 or 803.031. For preliminary purposes, the bedding layer should be 300 mm in thickness.

Subgrade preparation and placement of culvert bedding must be carried out in the dry.

6.3 Static Lateral Earth Pressure Coefficients

Lateral earth pressures acting on structures should be computed in accordance with the CHBDC but generally are given by the expression:

$$P_h = K^*(\gamma h + q)$$

where:

P_h = horizontal pressure on the wall (kPa)
K = earth pressure coefficient
γ = unit weight of retained soil
h = depth below top of fill where pressure is computed (m)
q = value of any surcharge (kPa)

The recommended lateral earth pressure parameters for use in the design for both a horizontal and for 2H:1V (Horizontal:Vertical) back-slope are provided in Table A.

For rigid structures such as Culvert 3-443/C, it is recommended that at-rest horizontal lateral earth pressures be used for design. Active pressures should be used for the design of unrestrained walls.

A lateral pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with the Section 6.9.3 of the CHBDC.

The parameters provided in Table A are based on the assumption that the backfill is fully drained so that there are no unbalanced hydrostatic pressures. If adequate drainage cannot be confirmed, the potential for hydrostatic pressures should be considered.

Table A: Static Lateral Earth Pressure Coefficients

Parameter	OPSS Granular A & OPSS Granular B Type II	OPSS Granular B Type I & Existing Fill / Native Silty Sand
Soil Unit Weight, kN/m^3, γ	21	20 / 19
Angle of Internal Friction, ϕ	35°	30°
Horizontal Back-Slope		
Coefficient of at Rest Earth Pressure, K_o (Restrained Wall)	0.43	0.50
Coefficient of Active Earth Pressure, K_a (Unrestrained Wall)	0.27	0.33
2H:1V Back-Slope		
Coefficient of Active Earth Pressure, K_a	0.39	0.53

6.4 Embankments

Based on the available construction drawings the embankment height for the east and westbound lanes of Highway 417 at the culvert crossing ranges from approximately 3 m to 2.5 m over the inlet and outlet respectively and approximately 0.3 m within the highway median. The embankments were constructed with side slopes at the inlet and outlet of the culvert of approximately 4H:1V. The median embankment was constructed side slopes of approximately 10H:1V.

Given the shallow bedrock and the soil type prevalent in this area settlement would be minimal for minor widening and/or minor grade increases. Embankment side slopes of no steeper than 2H:1V are appropriate for preliminary design.

6.5 Erosion Control

Active erosion of the embankment was noted on both sides of the inlet and outlet of Culvert 3-443/C. Erosion protection should be established at these locations. Design of the erosion protection measures must consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field.

Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact. Treatment at the outlets should be in accordance with OPSD 810.010. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS 804.

A concrete cut-off wall or clay seal should be installed at the culvert inlet to minimize the potential for seepage through the granular bedding and backfill material and avoid consequent erosion of these materials. The clay seal should have a minimum thickness of 0.5 m, completely surround the culvert, extend laterally the width of the granular backfill material, and extend above the high water level. The material used for the clay seal should conform to the requirements of OPSS 1205.

7 ADDITIONAL INVESTIGATIONS

Should the proposed works result in excavations to bedrock, samples of the bedrock should be acquired during the investigation and submitted for chemical testing to determine the pyritic heave potential.

THURBER

8 CLOSURE

We trust this information provided in this technical memorandum meets your present purposes. Please let us know if you have any questions or need additional information.

Thurber Engineering Ltd.

Kenton C. Power, P.Eng.
Geotechnical Engineer

Fred Griffiths, P.Eng.
Associate, Senior Geotechnical Engineer

P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact

Attachments

W.P. 4074-11-00
Site Photographs

PRELIMINARY FOUNDATION DESIGN
SOUTH CYRVILLE DRAIN CULVERT STRUCTURE (SITE 3-443/C)

West inlet looking upstream.
Note condition of headwall and retaining wall structure of adjacent upstream CSP Arch culvert

West inlet looking upstream.

W.P. 4074-11-00
Site Photographs

PRELIMINARY FOUNDATION DESIGN
SOUTH CYRVILLE DRAIN CULVERT STRUCTURE (SITE 3-443/C)

East outlet looking downstream

East outlet

CONT. No. 73-191
W. P. No. 13-68-12

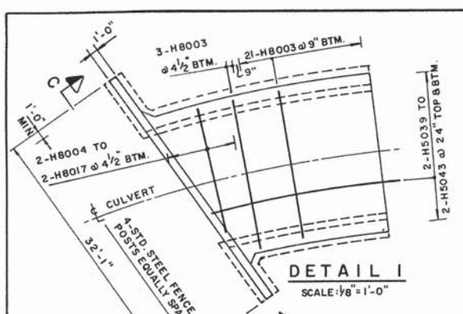
NORTH

OPEN BOX CULVERT
SOUTH CYRVILLE DRAIN
UNDER HWY. 417

SHEET 89

De Leuw, Cather consulting engineers

LOCATION OF WORKING POINTS			
POINT	STATION	CO-ORDINATES NORTH	EAST
W.P. 1	73+03	505,477.187	227,574.632
W.P.2	73+46.577	505,471.347	227,617.729
W.P.3	76+79	505,391.159	227,940.346



DETAIL 1
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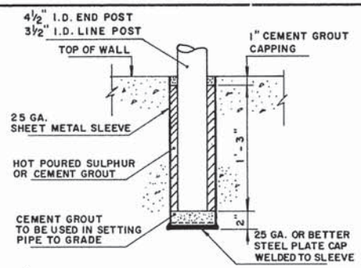

POST SETTING DETAIL
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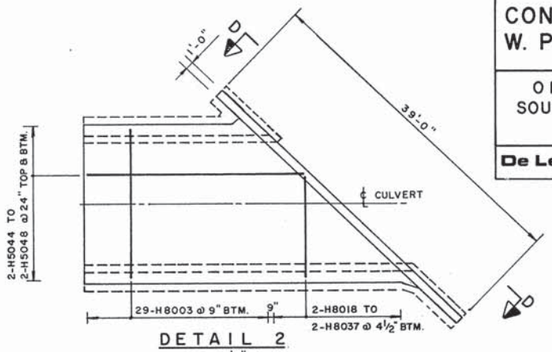
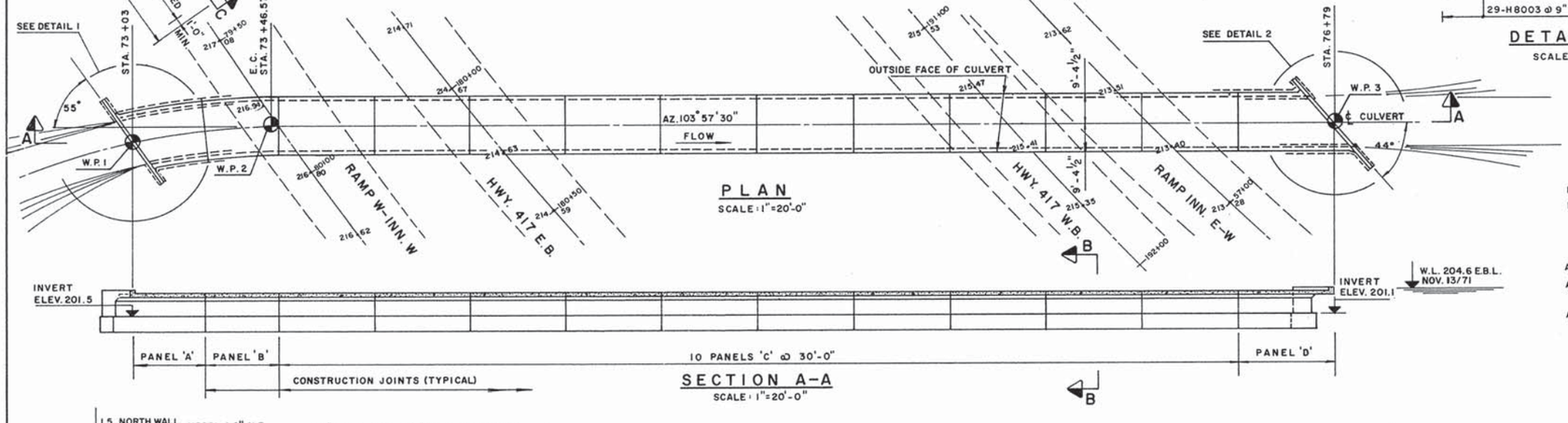


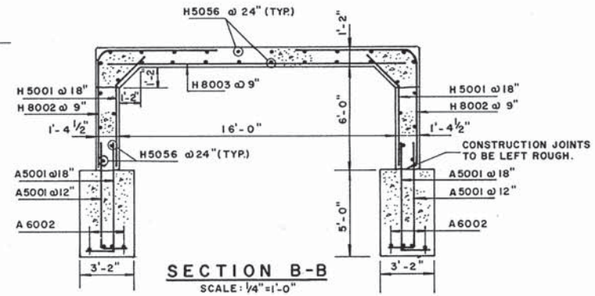
DETAIL 2
SCALE: ⅛"=1'-0"

GENERAL NOTES:
CONCRETE STRENGTH AT 28 DAYS 3000 P.S.I.
CLEAR COVER TO REINFORCING STEEL -
SLAB TOP 1½"
BOT. 1"
WALLS 2"
FOOTINGS 3"



PLAN
SCALE: 1"=20'-0"

SECTION A-A
SCALE: 1"=20'-0"



SECTION B-B
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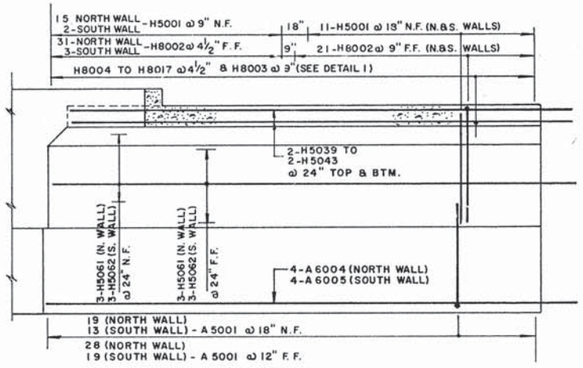
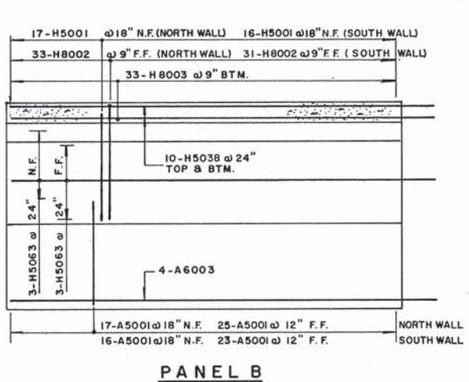
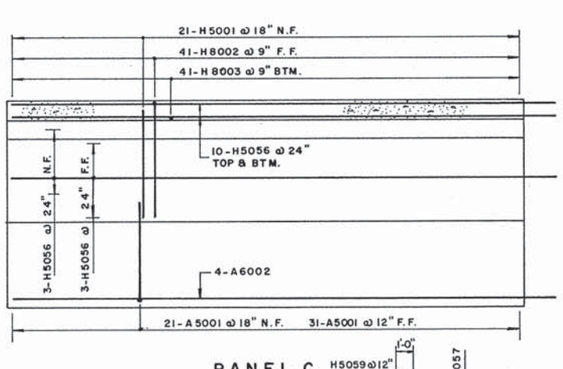


PANEL A



PANEL B



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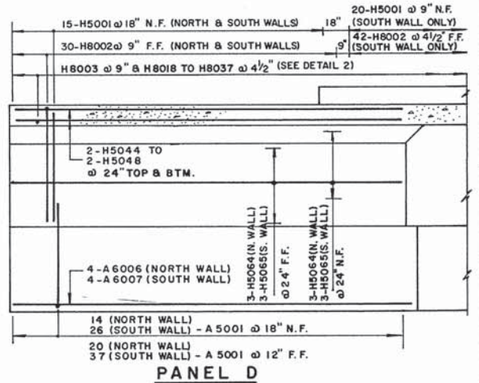
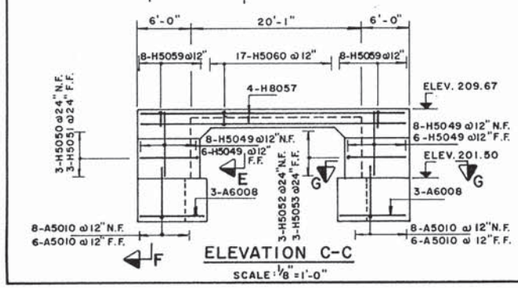
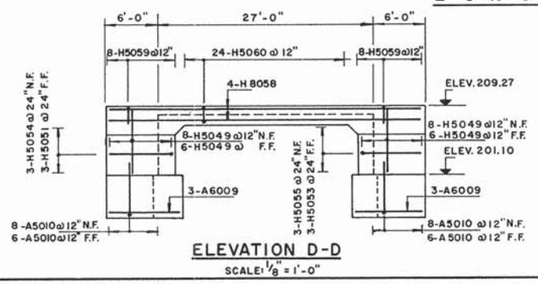


PANEL D

LONGITUDINAL SECTIONS
SCALE: ¼"=1'-0"



ELEVATION C-C
SCALE: ⅛"=1'-0"



ELEVATION D-D
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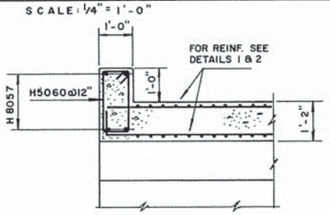

SECTION E-E
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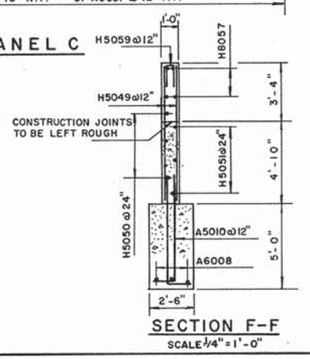

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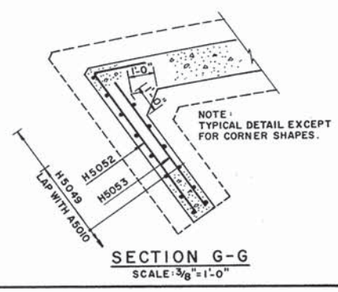
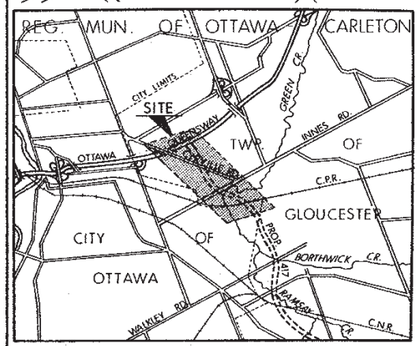


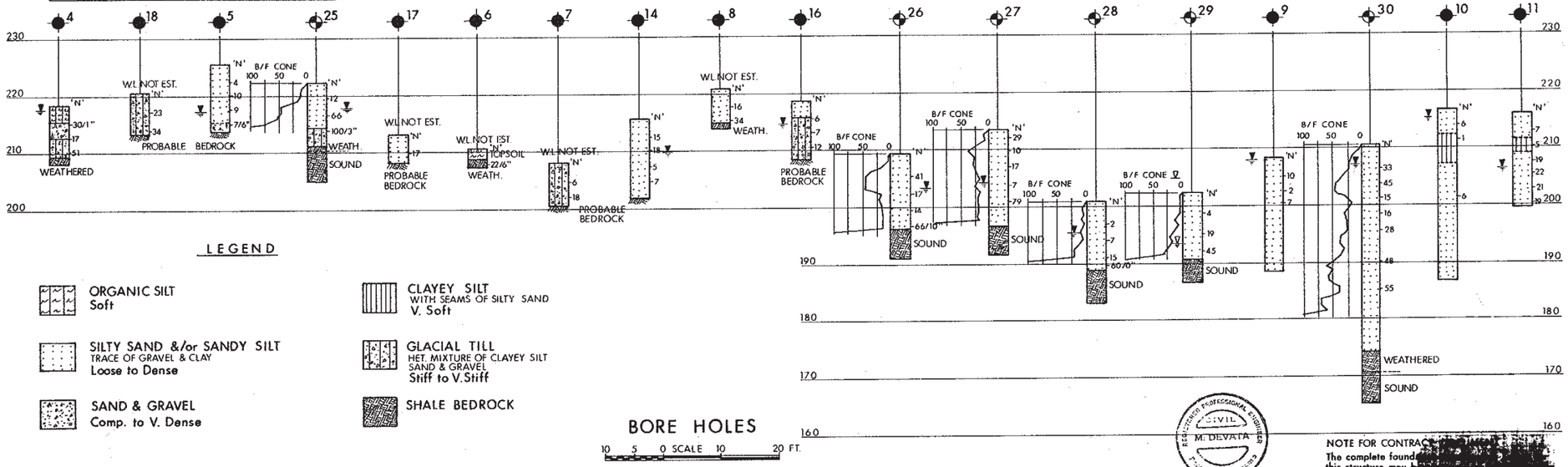
SECTION G-G
SCALE: ⅜"=1'-0"

FOR REDUCED PLAN
USE SCALE BELOW
0 1 2 3
3 INCHES ON ORIGINAL PLAN

105



KEY PLAN
SCALE IN MILES
1 0.5 0 1 2 3 4



PLAN
200 100 0 SCALE 200 400 FT

BORE HOLES
10 5 0 SCALE 10 20 FT.

LEGEND

- ORGANIC SILT — Soft
- SILTY SAND &/or SANDY SILT — TRACE OF GRAVEL & CLAY — Loose to Dense
- SAND & GRAVEL — Comp. to V. Dense
- CLAYEY SILT — WITH SEAMS OF SILTY SAND — V. Soft
- GLACIAL TILL — HET. MIXTURE OF CLAYEY SILT SAND & GRAVEL — Stiff to V. Stiff
- SHALE BEDROCK

LEGEND

- Bore Hole
- Cone Penetration Test
- Bore Hole & Cone Test
- Water Levels established at time of field investigation. NOV. 71 & DEC. 73
- (50) High Mast Lighting Pole & Pole Nº
- Head / Encountered — ARTESIAN WATER

NO.	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
4	218·6	16,507,577	1,226,852
5	225·8	16,506,950	1,227,370
6	210·7	16,505,590	1,227,695
7	208·2	16,505,147	1,227,948
8	220·9	16,504,212	1,227,889
9	208·5	16,504,211	1,229,761
10	216·8	16,503,222	1,231,240
11	216·0	16,502,780	1,231,412
14	215·9	16,504,763	1,228,296
16	218·9	16,504,370	1,228,239
17	213·2	16,506,072	1,227,564
18	220·7	16,507,314	1,227,150
25	222·4	16,506,291	1,227,514
26	209·6	16,504,750	1,228,523
27	213·7	16,504,625	1,228,484
28	201·0	16,504,781	1,229,223
29	202·4	16,504,331	1,229,225
30	210·3	16,503,878	1,230,571

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

REVISIONS

DATE	BY	DESCRIPTION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
ENGINEERING SERVICES BRANCH — GEOTECHNICAL OFFICE

HIGH MAST ILLUMINATION

HIGHWAY NO. 417 & OTTAWA QUEENSWAY DIST. NO. 9
REG. MUN. OF OTTAWA-CARLETON
TWP. GLOUCESTER LOT CON.

BORE HOLE LOCATIONS & SOIL STRATA

SUBMD. J. B.	CHECKED	W.P. NO. 13-68-01	DRAWING NO. 73-11096 B
DRAWN S.O.	CHECKED	W.O. NO. 73-11096	
DATE 17 JAN. 1974		SITE NO.	BRIDGE DRAWING NO.
APPROVED		CONT. NO.	

REGISTERED PROFESSIONAL ENGINEER — CIVIL — M. DEVATA — PROVINCE OF ONTARIO

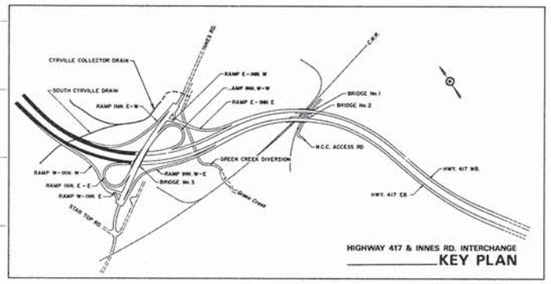
NOTE FOR CONTRACTORS
The complete foundation report for this structure may be examined at the Office and Foundations Section, Downsview and at the OTTAWA

CONT. No. 73-191
W. P. No. 13-68-12

PROFILES
HIGHWAY 417

SHEET
36

De Leuw, Cather consulting engineers



HIGHWAY 417 & INNES RD. INTERCHANGE
KEY PLAN

LIMIT OF CONT.
STA. 184 + 75

LIMIT OF PAV.
STA. 185 + 00

CYRVILLE RD
(REG RD 30)

DIRECTION

℄ SOUTH CYRVILLE DRAIN

TOP OF PAVEMENT ALIGNMENT CONTROL

-0·236 %

SUB-GRADE

WL 204.8
NOV 20/71

EXISTING GROUND LINE

16'x6' CONCRETE CULVERT (OPEN TYPE)
INV. LT. (STA. 76 + 79) 201·18

HIGHWAY 417 WESTBOUND

D-3° 30' Ls-450.00 Ls-450.00 D-2° 45'

CS ST TS SC

240 230 210 200

170 5 180 5 190 5 200

DIRECTION INDICATES TRAFFIC FLOW

LIMIT OF CONT.
STA. 174 + 25

LIMIT OF PAV.
STA. 175 + 00

CYRVILLE RD
(REG RD 30)

℄ SOUTH CYRVILLE DRAIN

TOP OF PAVEMENT ALIGNMENT CONTROL

DIRECTION

-0·16 %

DD 411-A

SUB-GRADE

WL 204.6
NOV 13/71

16'x6' CONCRETE CULVERT (OPEN TYPE)
INV. RT. (STA. 73 + 03) 201·50

EXISTING GROUND LINE

HIGHWAY 417 EASTBOUND

D-3° 30' Ls-450.00 Ls-450.00 D-2° 35' 43.89"

CS ST TS SC

240 230 220 210 200 190

160 5 170 5 180 5 190

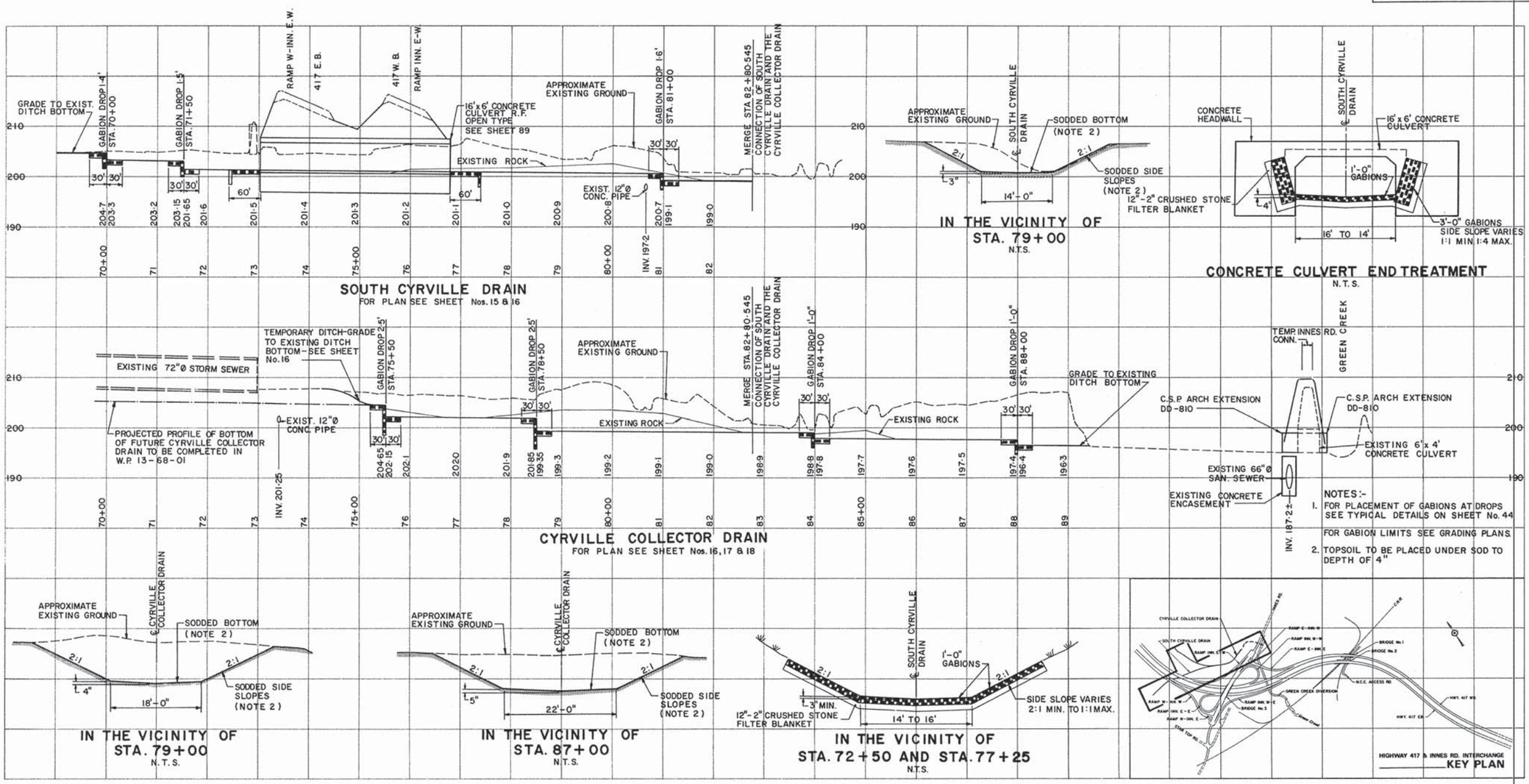
SCALES
50 0 100
Horizontal
5 0 10
Vertical

CONT. No. 73-191
W. P. No. 13-68-12

DRAINAGE PROFILES
STORM DRAIN AND CROSS-SECTIONS

SHEET 43

De Leuw, Cather consulting engineers



QUANTITIES

Sta.	– Sta.	
E.C.		C.Y.
St.		C.Y.
E.D.		C.Y.
M.E.		C.Y.
M.B.E.		C.Y.
E.F.		C.Y.
R.C.		C.Y.
Sh.		C.Y.
R.D.		C.Y.
M.B.R.		C.Y.
R.F.		C.Y.

Sta.	– Sta.	
E.C.		C.Y.
St.		C.Y.
E.D.		C.Y.
M.E.		C.Y.
M.B.E.		C.Y.
E.F.		C.Y.
R.C.		C.Y.
Sh.		C.Y.
R.D.		C.Y.
M.B.R.		C.Y.
R.F.		C.Y.

NOTES:-
1. FOR PLACEMENT OF GABIONS AT DROPS SEE TYPICAL DETAILS ON SHEET No. 44
FOR GABION LIMITS SEE GRADING PLANS.
2. TOPSOIL TO BE PLACED UNDER SOD TO DEPTH OF 4"

SCALES
50' 0' 100' Horizontal
5' 0' 10' Vertical

NOTE: GABIONS ARE NOT TO BE USED WHERE CHANNEL IS IN ROCK CUT OR AS DIRECTED BY THE ENGINEER.

CONT. No. 73-191
W. P. No. 13-68-12

NORTH

GRADING, PAVING & DRAINAGE
HWY.417 WB. - LIMIT OF CONTRACT TO STA.196+00
HWY.417 EB. - LIMIT OF CONTRACT TO STA.186+00

SHEET 15

De Leuw, Cather consulting engineers

CON 2 (OTTAWA FRONT)
LOT 24

SOUTH CYRVILLE DRAIN

LIMIT OF CONT.
STA. 184 + 75

LIMIT OF PAV.
STA. 185 + 00

H-927-71

STA 77+50

STA 53+00

STA 196+00

STA 186+00

STA 72+50

H W Y. 4 1 7 W B.

R A M P I N N. E - W

H W Y. 4 1 7 E B.

R A M P W - I N N. W.

127

O.S.F. No. 3L

O.S.F. No. 3R

16' x 6' CONC. CULV.

4'x 10' INV. 210-4

4'x 10' INV. 210-2

DD-905-A CASE d

DD-905-A EXISTING N.C.C. PROPERTY LINE

DD-905-A EXISTING N.C.C. PROPERTY LINE

P-6067-42

END FENCE

LIMIT OF PAV.
STA. 175 + 00

LIMIT OF CONT.
STA. 174 + 25

N 15,506,000
E 1,227,200

N 15,505,600
E 1,228,000

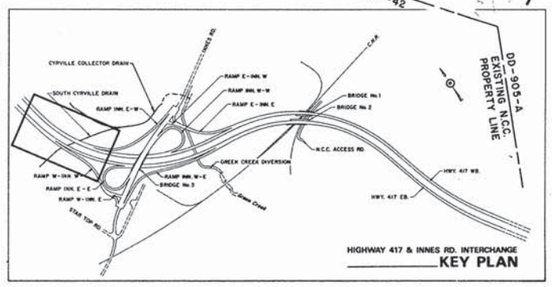
E 1,227,400

N 15,505,200
E 1,227,600

417 W.B.L.
D - 2°45'
Ls - 450'.00

417 E.B.L.
D - 2°35' 43.89"
Ls - 450'.00

NOTE:
GUIDE RAIL PROTECTION AT SIGN FOOTINGS TO BE PLACED IN FUTURE CONTRACT.



HIGHWAY 417 & INNES RD. INTERCHANGE
KEY PLAN

SCALE
20' 0' 40'

CONT. No. 73-191
W. P. No. 13-68-12

NORTH

GRADING, PAVING & DRAINAGE
CYRV. COLL. DRAIN-LIMIT OF CONSTR TO STA 81+00
SOUTH CYRV. DRAIN-LIMIT OF CONSTR TO STA 72+50
SOUTH CYRV. DRAIN-STA. 77 + 50 TO STA. 81 + 00

SHEET 16

De Leuw, Cather consulting engineers

CON 2 (OTTAWA FRONT)
LOT 24

LIMIT OF CONSTR.
STA. 74 + 15

LIMIT OF CONSTR.
STA. 69 + 15

STA. 72+50

STA. 77+50

STA. 81 + 00

417 E.B.L.

417 W.B.L.

N 16,505,600

E 1,227,400

N 16,505,200

E 1,227,800

E 1,228,400

SOUTH CYRVILLE DRAIN

CYRVILLE COLL. DRAIN

72"x16' CSP

R.B.W.E.

B.W.E.

Bush

SA

MH

BM

H-927-71

12" SANITARY SEWER

27" SANITARY SEWER

END FENCE OPP. STA. 75 + 20

DD-905-A

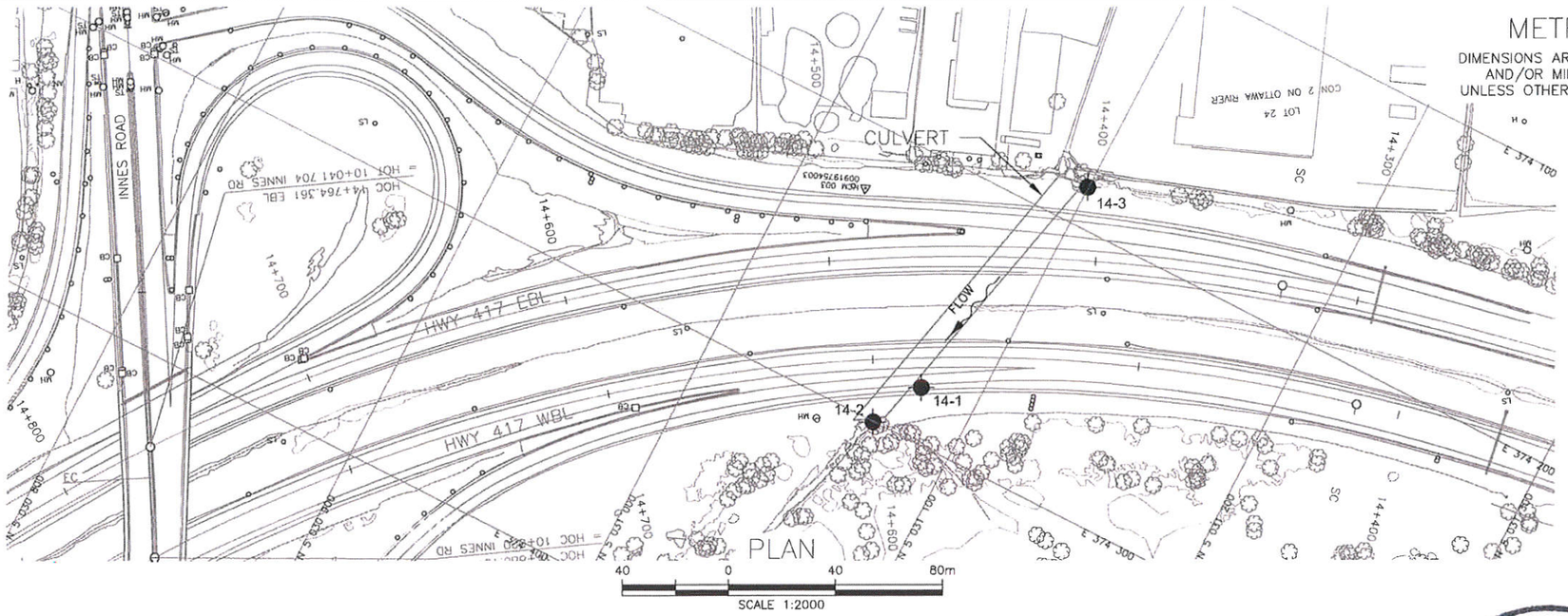
EXISTING N.C.C. PROPERTY LINE

APPROX LOT LINE

WATER

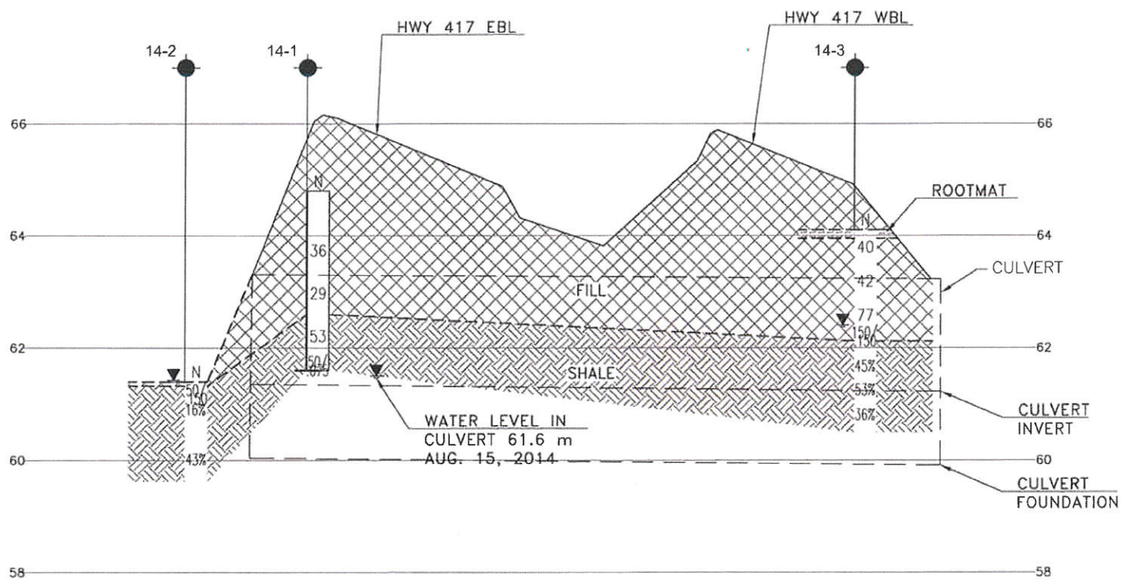
SCALE
20' 0' 40'

HIGHWAY 417 & INNES RD. INTERCHANGE
KEY PLAN



METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN



PROFILE ALONG HWY. 417 CULVERT

20 0 20 40m H 1:1000

2 0 2 4m V 1:100

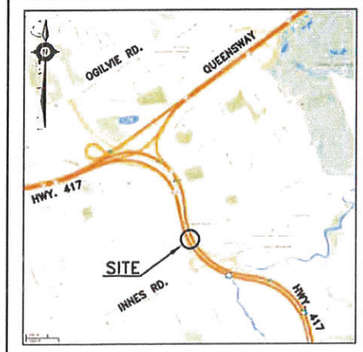
CONT No
WP No 4074-11-00

SOUTH CYRVILLE DRAIN
CULVERT 3-443/C

BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

●	Borehole
⊕	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
▼	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
14-1	64.8	5 031 078.6	374 280.5
14-2	61.4	5 031 068.5	374 300.2
14-3	64.1	5 031 099.7	374 185.2

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 31G5-266

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
July 3/15
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
F. J. GRIFFITHS
July 3/15
PROVINCE OF ONTARIO

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	CM	CHK	PC	CODE	LOAD
DRAWN	MFA	CHK	CM	SITE	STRUCT

DATE DEC. 2014
DWG 1

MINISTRY OF TRANSPORTATION, ONTARIO

FILENAME: H:\Projects\19\3405\3 - Hwy 417 Aviation to Ramsayville\Culverts\Culvert 6 - Site 3-443_C\CAD files\Ogilvie\Ltr4053-HWY417-OgilvieCulvert.dwg
PLOTDATE: 7/2/2015 11:04 AM

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 14-1 1 OF 1 METRIC

W.P. 4074-11-00 LOCATION Highway 417 E-W Ramp Shoulder N 5 031 078.6 E 374 280.5 ORIGINATED BY KMY

HWY 417 BOREHOLE TYPE Hollow Stem Auger COMPILED BY KMY

DATUM Geodetic DATE 2014.08.15 - 2014.08.15 CHECKED BY FJG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
64.8											
0.0	SAND and GRAVEL, some silt, trace clay Grey **FILL**		1	GS					○		36 40 24 (SI+CL)
	- Gravel layer from 0.7 m to 0.8 m		2	SS	36		64		○		
			3	SS	29		63		○		41 43 16 (SI+CL)
62.6											
2.2	**SHALE**, highly weathered, extremely weak, thinly laminated, grey, very fine grained		4	SS	53		62		○		
61.6			5	SS	50/				○		
3.2	End of Borehole at 3.2 m Borehole open and dry on completion				75mm						

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

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

ONTMT4S 19-3405-3-CULVERT 6.GPJ 2012TEMPLATE(MTO).GDT 2/7/15

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 14-2 1 OF 1 METRIC

W.P. 4074-11-00 LOCATION South Cyrville Drain Outlet N 5 031 068.5 E 374 300.2 ORIGINATED BY KMY

HWY 417 BOREHOLE TYPE Portable COMPILED BY KMY

DATUM Geodetic DATE 2014.08.20 - 2014.08.20 CHECKED BY FJG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
61.4											
0.0			1	SS	50/ 150mm	▽				FI	
0.1	**Silty SAND** with gravel Grey Wet									7	
			1	RUN			61				RUN #1 TCR=75% SCR=100% RQD=16%
	SHALE, slightly weathered, weak, thinly laminated, very closely jointed, very fine-grained, grey									4	
	- Fracture zone from 1.21 m to 1.23 m		2	RUN						5	RUN #2 TCR=84% SCR=92% RQD=43%
	- Fracture zone 1.43 m to 1.47 m						60			5	
59.7											
1.8	End of Borehole at 1.8 m 3/4" PVC monitoring well with 5' slotted screen installed Water level at ground surface on Sept. 5, 2014										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

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

ONTMT4S 19-3405-3-CULVERT 6.GPJ 2012TEMPLATE(MTO).GDT 2/7/15

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 14-3 1 OF 1 METRIC

W.P. 4074-11-00 LOCATION South Cyrville Drain Inlet N 5 031 099.7 E 374 185.2 ORIGINATED BY KMY

HWY 417 BOREHOLE TYPE Portable COMPILED BY KMY

DATUM Geodetic DATE 2014.08.22 - 2014.08.22 CHECKED BY FJG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
64.1											
0.0	**Rootmat (150 mm)**						64				
0.2	GRAVEL and SAND, some silt, trace clay, occasional roots and wood fragments Grey **FILL**		1	SS	13						
			2	SS	14				○		45 43 12 (SI+CL)
62.9							63				
1.2	Clayey SAND with gravel Grey **FILL**		3	SS	25				○		
62.1			4	SS	50/						
2.0	**SHALE**, slightly weathered, very thinly bedded, very fine-grained, grey, weak, very closely jointed		1	RUN	150mm		62			FI	RUN #2 TCR=97% SCR=89% RQD=45%
			2	RUN						2	
			3	RUN						3	RUN #3 TCR=100% SCR=92% RQD=53%
	- Silty clay seam at 3 m		4	RUN			61			3	RUN #4 TCR=100% SCR=79% RQD=36%
60.5										5	
3.6	- Silty clay seam at 3.5 m End of Borehole at 3.6 m 3/4" PVC monitoring well with 5' slotted screen installed Water level at 1.7 m on Sept. 5, 2014										

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

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

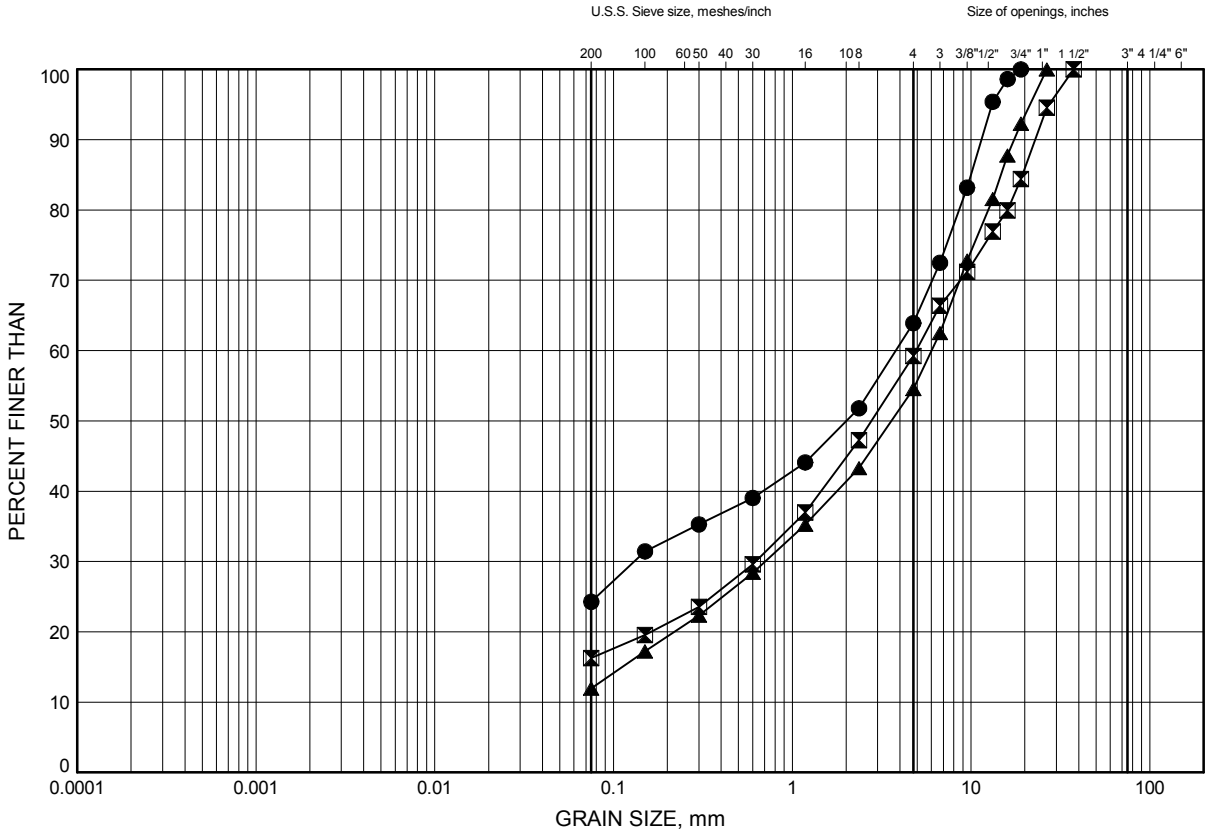
ONTMT4S 19-3405-3-CULVERT 6.GPJ 2012TEMPLATE(MTO).GDT 2/7/15

South Cyrville Drain Inlet

GRAIN SIZE DISTRIBUTION

FIGURE C1

Fill



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-1	0.15	64.67
⊠	14-1	1.83	62.99
▲	14-3	0.91	63.20

Date November 2014

W.P. 4074-11-00

THURBER

Prep'd CM

Chkd. FJG

GRAIN SIZE DISTRIBUTION - THURBER 19-3405-3-CULVERT 6.GPJ 14/11/14

THURBER

APPENDIX 7

SITE 3-762/C

THURBER

MEMORANDUM

To: Laura Donaldson, P.Eng.
McIntosh Perry Consulting Engineers

Date: July 17, 2015

From: Kenton Power, M.A.Sc., P.Eng.
(Reviewed by Fred Griffiths, P.Eng. and P.K. Chatterji, P.Eng.)

File: 19-3405-3

PRELIMINARY FOUNDATION DESIGN
INNES ROAD CULVERT STRUCTURE (SITE 3-762/C)
GWP 4074-11-00 GEOCRES 31G5-262

PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This memo presents a brief summary of the factual findings from a foundation review carried out for the culvert structure carrying an unnamed creek under Innes Road in Ottawa, Ontario. It also presents preliminary geotechnical recommendations for potential culvert extensions or replacement. It is noted that the proposed construction options for this site are not yet defined. The preliminary recommendations provided below are for assistance in developing and evaluating the options and will need to be refined during subsequent design stages.

2 SITE DESCRIPTION

The site is located in eastern Ottawa, in the Township of Gloucester approximately 225 m northeast of the Highway 417 / Innes Road Interchange. The culvert carries the flow of an unnamed creek below the east and westbound lanes of Innes Road, and the Highway 417 westbound on and off ramps of the Innes Road Interchange (6 lanes in total plus paved gore areas, concrete sidewalks and median). Based on results of the MTO inspection report the culvert is a concrete, box structure with a span of 6 m and a height of 2.4 m. The terrain in the vicinity of the inlet and outlet of the culvert is generally flat and is brush, tree and grass covered. Creek flow through the culvert is from north to south. Site photos showing the general site conditions are attached.

3 SUBSURFACE CONDITIONS

There were no as-built drawings or GEOGRES reports specific to this structure available at the time of preparing this memo. As such a review of publically available data was undertaken to develop a generalized soil and bedrock stratigraphy model for this site. Also the relevant data from the GEOCRES Report No. 31G5-85 for Structure 3-310 was reviewed and is presented below.

3.1 Background Review – Sources of Information

The following resources were reviewed to provide a general understanding of the subsurface conditions at this site:

- The Physiography of Southern Ontario, by Chapman and Putnam (1984)
- The Geological Survey of Canada, Map 1506A Surficial Geology of Ottawa, by Department of Energy, Mines and Resources (1982)
- The Geological Survey of Canada, Map 1508A Generalized Bedrock Geology of Ottawa-Hull, by Department of Energy, Mines and Resources (1979)
- Ontario Ministry of the Environment (MOE) Water Well Record database
- Ontario Geological Survey (OGS) Borehole Record database
- GEOCRES Report No. 31G5-85

3.2 REGIONAL GEOLOGY

3.2.1 Overburden

The site is situated within the physiographic region identified as the Ottawa Valley Clay Plains, as reported by Chapman and Putnam (1984). This physiographic region generally consists of clay plains interrupted by ridges of rock or sand.

Geological Survey of Canada, Map 1506A Surficial Geology of Ottawa, indicates that the site is located near the boundary of two geological deposits with Innes Road being the general dividing line. The two overburden deposits in the region are described as granular till plain deposits with drift thickness generally less than 5 m north of Innes Road and a clay and silt deposit south of Innes Road.

A review of the OGS borehole database identified three boreholes within approximately 25 m of the culvert location. The borehole records reported that the overburden materials at the site consist predominantly of a sand and silt with thicknesses less than 5 m underlain by a shale bedrock.

3.2.2 Bedrock

The Generalized Bedrock Geology of Ottawa-Hull, Map 1508A, indicates that the site lies near the boundary of the Billings and Carlsbad Formation; both of which are shale bedrock from the Ordovician age. It should be noted that Billings Formation shale is susceptible to heaving if allowed to weather in the presence of oxygen.

The MOE water well records indicated that shale bedrock within the vicinity of the site was encountered at depths of less than 5 m below grade.

THURBER

3.3 Results from GEOCRES Report No. 31G5-5

A site investigation was carried out by the MTO Foundations Office for the Highway 417 S-EW Off-Ramp Bridge over Green Creek Structure 3-310; GEOCRES Report No. 31G5-85 dated August 1972. The investigation consisted of six sampled boreholes and four additional dynamic cone penetration tests that were designated 1 to 10. The Key Plan insert of the historical General Plan Drawing (copy attached) illustrates the approximate location of Culvert 3-762/C.

Based on Thurber's review of the 1972 Foundation Design Report, Borehole 1 was located approximately 30 m from Culvert 3-762/C. Drawing No. 72-11067A (copy attached) illustrates the locations of the investigation boreholes, as well as the soil strata plot for the 1972 investigation. The stratigraphy at this site is generally characterized by a silty sand with some gravel deposit and occasional clayey silt seams, underlain by shale bedrock.

3.3.1 Silty Sand

The silty sand stratum with varying amounts of gravel was reported at the ground surface of Borehole 1. Occasional clay silt seams were encountered in Borehole 1 but no seam thicknesses were recorded. The top of this stratum was at elevation 61.2 m and the layer had a thickness of 3.7 m. The standard penetration test (SPT) 'N' values range from 2 to 15 blows per 0.3 m of penetration; indicating a very loose to compact condition.

The results of grain size analysis test including hydrometer analysis completed on a sample of this material indicated a gravel content of 24%, sand content of 53%, silt content of 18%, and clay content of 5%.

The moisture content of the sample tested was 10%.

3.3.2 Bedrock

A shale bedrock was encountered beneath the silty sand stratum; as proven by BX size coring. Borehole 1 was terminated in bedrock. The bedrock surface elevation was at 57.6 m. Bedrock core recovery ranged from 90% to 100%. The bedrock was described to be in sound condition Geological mapping suggests that this site is near the boundary between the Billings and Carlsbad Formations.

3.4 Groundwater

Groundwater levels were measured in the open boreholes prior to backfilling at an elevation of 59.6 m.

THURBER

4 SITE OBSERVATIONS

A structure inspection was conducted by MTO in August 2013 for Culvert 3-762/C with the report issued September 2013. Condition data outlined in the report for the culvert structure ranged from poor to good but typically the culvert was rated in good condition.

The site was inspected by Thurber Engineering staff during the week of July 14th, 2014. Several photographs of the site are attached.

At the time of the inspection, the following observations were made:

North Inlet:

- No erosion protection measures were observed at the inlet
- Vegetation was noted on the side slopes, on top of the culvert and behind the wing walls
- No signs of erosion were observed at the inlet
- A concrete lining of the north creek bank was observed at the creek bend just north of the inlet. It is likely associated with a stormwater inlet to the creek located just upstream.
- Some signs of erosion were observed of the toe of the concrete lining
- No obvious settlement of the road surface was observed at the crossing

South Outlet:

- No erosion protection measures were observed at the outlet
- Vegetation was noted on the side slopes, on top of the culvert and behind the wing walls
- Some signs of settlement and tilting of the wing walls were observed at the outlet
- No obvious settlement of the road surface was observed at the crossing

5 GEOTECHNICAL ASSESSMENT

5.1 Frost Considerations

The frost penetration depth at this site is 1.8 m (OPSD 3090.101).

5.2 Seismic Considerations

This site is classified as a Soil Profile Type I in accordance with Section 4.4.6 of the Canadian Highway Bridge Design Code (CHBDC). The zonal acceleration ratio for this site is 0.20 as per Table A3.1.1 of the CHBDC.

Based on the anticipated presence and density of the silty sand this material is classified as “not susceptible” to liquefaction during the design earthquake event.

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5.3 Existing Foundations

The results of the MTO inspection report indicate that Culvert 3-762/C is a box culvert 80 m long, with a span of 6.0 m and a height of 2.4 m.

Based on the anticipated site stratigraphy Culvert 3-762/C is likely founded in the compact silty sand stratum.

PART 2: ENGINEERING DISCUSSION AND PRELIMINARY RECOMMENDATIONS

6 GEOTECHNICAL RECOMMENDATIONS

Based on the available data regarding the ground conditions at this site, the following sections present preliminary geotechnical recommendations for the assessment of the existing culvert and for preliminary design for potential culvert extensions, replacement, and the construction of new wing walls, end sections and/or headwall structures, if required. It is noted that the proposed construction options for this site are not yet defined. The preliminary recommendations provided below are for assistance in developing and evaluating options and will need to be refined during subsequent design stages.

The existing culvert is a concrete box culvert likely founded on compact sand. For culvert extensions, it is preferred that type of foundations and founding elevation match the existing arrangement so as not to undermine the existing foundation. From a foundation perspective for foundation perspective for a culvert replacement, a concrete rigid-frame open-footing culvert could have bearing resistance limitations as well as groundwater concerns during construction. Both concrete closed boxes and CSP arches would be preferred.

6.1 Shallow Foundations

Given the anticipated site stratigraphy (which must be confirmed by drilling boreholes during the detailed design stage) the design of shallow foundations founded on the native overburden materials may be considered. In addition, footings for potential culvert extensions or new wing walls should match the elevation of the existing foundation element to avoid undermining or other damage to the existing infrastructure.

The factored vertical geotechnical resistance at ULS of 150 kPa may be used for the preliminary design of shallow foundations, founded on compact native silty sand having a minimum embedment depth of 1.8 m and a width of between 1 m and 2 m. The vertical geotechnical reaction at SLS is 100 kPa based on a total footing settlement of 25 mm.

A replacement culvert would likely require a span and an invert elevation similar to the existing. For the preliminary design of a box culvert founded at the same elevation as the existing culvert on native compact silty sand and a base width of 6.0 m, the factored vertical geotechnical resistance at ULS is 150 kPa. The vertical geotechnical reaction at SLS is 85 kPa based on a total footing settlement of 25 mm.

Resistance to lateral forces and sliding resistance between concrete and underlying materials should be evaluated using an unfactored coefficient of friction of 0.40 for cast-in-place concrete and 0.35 for pre-cast concrete on native compact silty sand.

6.2 Excavations, Bedding and Backfilling

All excavations must be conducted in accordance with the requirements of the Occupational Health & Safety Act & Regulations (OHSA) for Construction Projects. The anticipated native silty sand at the site should be classified be classified as Type 3 above and Type 4 below the groundwater table in accordance with OHSA.

Where excavations will extend below the groundwater level prevailing at the time of construction, the contractor will need to implement groundwater control and ground support systems as are required to carry out the construction in a safe, stable, and unwatered excavation.

Excavations, bedding and backfill for rigid structures should be in accordance with OPSS 422 and 902. Backfill for the culvert must consist of free draining granular material conforming to OPSS Granular A or B material specifications. The granular material must be placed to the extent shown on OPSD 803.030 or 803.031.

Subgrade preparation and placement of culvert bedding must be carried out in the dry.

6.3 Static Lateral Earth Pressure Coefficients

Lateral earth pressures acting on structures should be computed in accordance with the CHBDC but generally are given by the expression:

$$P_h = K^*(\gamma h + q)$$

where:

P_h = horizontal pressure on the wall (kPa)
K = earth pressure coefficient
γ = unit weight of retained soil
h = depth below top of fill where pressure is computed (m)
q = value of any surcharge (kPa)

For rigid structures such as Culvert 3-762/C, it is recommended that at-rest horizontal lateral earth pressures be used for design. Active pressures should be used for the design of unrestrained walls.

A lateral pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with the Section 6.9.3 of the CHBDC.

The parameters provided in Table A are based on the assumption that the backfill is fully drained so that there are no unbalanced hydrostatic pressures. If adequate drainage cannot be confirmed, the potential for hydrostatic pressures should be considered.

Table A: Static Lateral Earth Pressure Coefficient

Parameter	OPSS Granular A & OPSS Granular B Type II	OPSS Granular B Type I / Native Silty Sand
Soil Unit Weight, kN/m^3, γ	21	20 / 19
Angle of Internal Friction, ϕ	35°	30°
Horizontal Back-Slope		
Coefficient of at Rest Earth Pressure, K_o (Restrained Wall)	0.43	0.50
Coefficient of Active Earth Pressure, K_a (Unrestrained Wall)	0.27	0.33
2H:1V Back-Slope		
Coefficient of Active Earth Pressure, K_a	0.39	0.53

6.4 Embankments

It is estimated that there is approximately 2 m of fill over the existing culvert and that the roadway embankment is generally less than 1.5 m above the surrounding terrain. Given the anticipated shallow bedrock and the soil type prevalent in this area settlement would be minimal for minor widening and/or minor grade increases. Embankment side slopes of 2H:1V are appropriate for preliminary design.

6.5 Erosion Control

During Thurber's site inspection no erosion protection measures were observed at the site.

Erosion protection should be provided at the culvert inlet and outlet areas. Design of the erosion protection measures must consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field.

Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact. Treatment at the outlets should be in accordance with OPSD 810.010. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS 804.

A concrete cut-off wall or clay seal should be installed at the culvert inlet to minimize the potential for seepage through the granular bedding and backfill material and avoid consequent erosion of these materials. The clay seal should have a minimum thickness of 0.5 m, completely surround the culvert, extend laterally the width of the granular backfill material, and extend above the high water level. The material used for the clay seal should conform to the requirements of OPSS 1205.

7 ADDITIONAL INVESTIGATIONS

Further foundation investigations and analysis must be carried out should the culvert structure be replaced or extended or if the height, geometry, or location of the approach fills are to be modified for either short-term construction staging or for vertical or horizontal re-alignments. Should excavations be anticipated within the embankment fills to repair or modify the culvert, consideration should be given to drilling foundation boreholes in the approaches to determine the nature of the fill materials and to allow generation of road way protection design. It is also recommended that monitoring wells be installed to better define the groundwater level as well as the hydraulic conductivity at the site. This information will be required to allow for the design of excavation dewatering systems.

The configuration of the Culvert 3-762/C and its founding elevation must be confirmed during the detailed design stage in order to determine if refinement to the recommendations provided is required.

Should the proposed works result in excavations to bedrock, samples of the bedrock should be acquired during the investigation and submitted for chemical testing to determine the pyritic heave potential.

THURBER

8 CLOSURE

We trust this information provided in this technical memorandum meets your present purposes. Please let us know if you have any questions or need additional information.

Thurber Engineering Ltd.

Kenton C. Power, P.Eng.
Geotechnical Engineer

Fred Griffiths, P.Eng.
Associate, Senior Geotechnical Engineer

P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact

Attachments

Preliminary Foundation Design
Site Photographs

PRELIMINARY FOUNDATION DESIGN
INNES ROAD CULVERT STRUCTURE (SITE 3-762/C)

North inlet

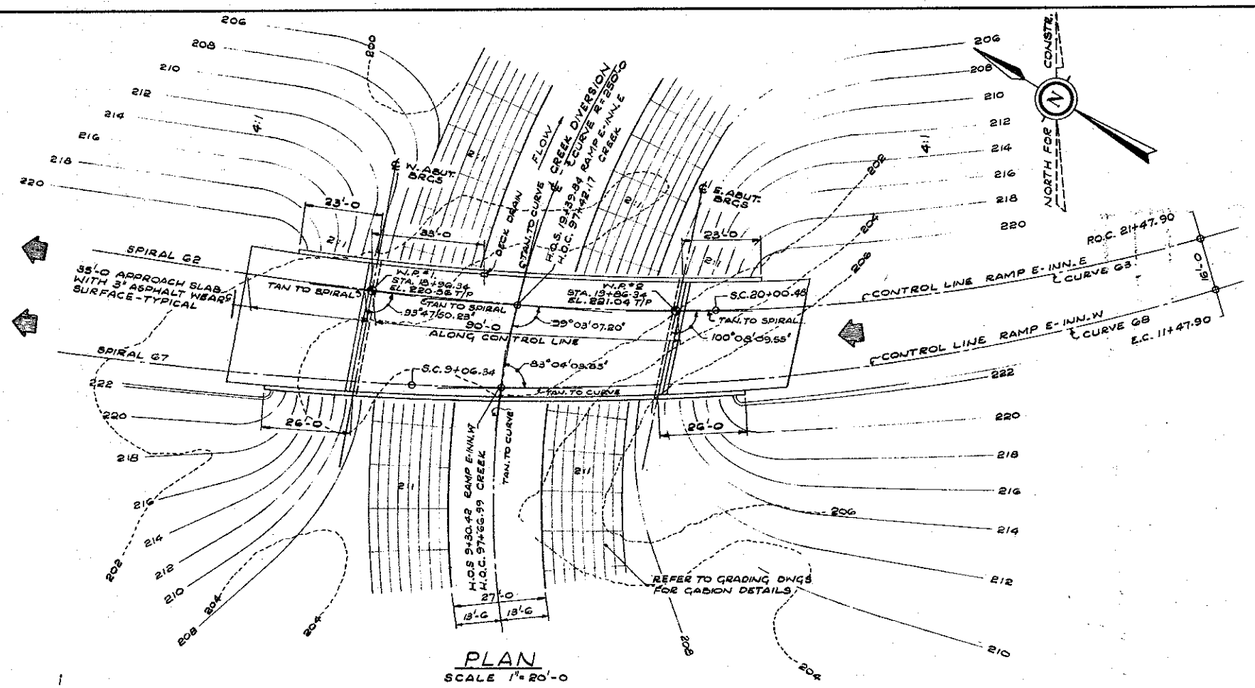
Concrete lining of creek bank, located along the north creek bank north of inlet

Preliminary Foundation Design
Site Photographs

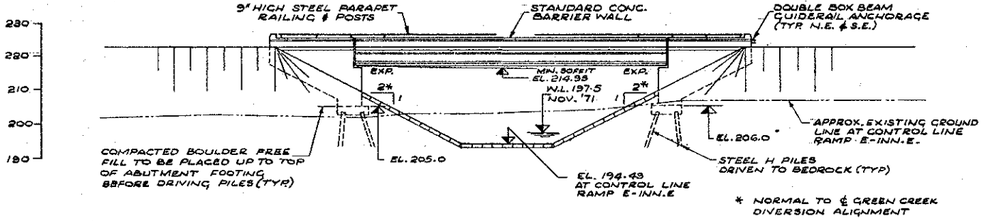
PRELIMINARY FOUNDATION DESIGN
INNES ROAD CULVERT STRUCTURE (SITE 3-762/C)

South outlet

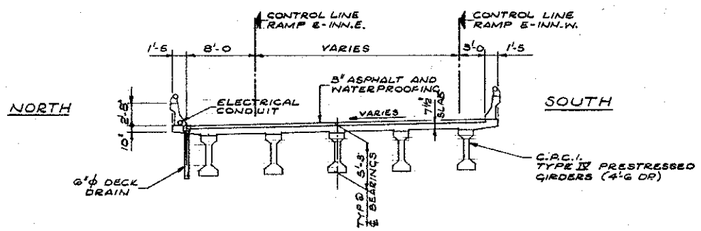
Tilt of outlet wing wall



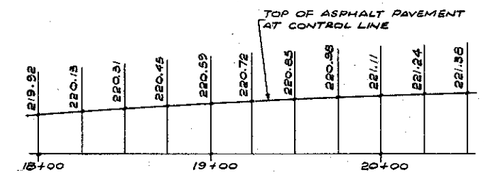
PLAN
SCALE 1"=20'-0



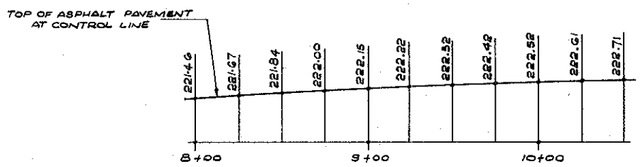
ELEVATION
SCALE 1"=20'-0



TYPICAL DECK SECTION
SCALE 1/8"=1'-0



PROFILE RAMP E-INN.E.
(SPLINED) N.T.S.



PROFILE RAMP E-INN.W.
(SPLINED) N.T.S.

REFERENCE BENCH MARK
BENCH MARK 218.76
GEODETIC DATUM
CUT CROSS ON N.E. CORNER OF RWY BRIDGE
540.0' RT OF 202+15 E.B.L.

CURVE DATA

RAMP E-INN.E

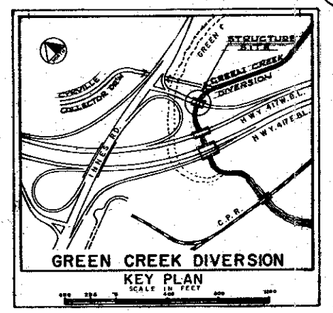
CIRCULAR CURVE G8		SPIRAL G2	
△	= 39°00'00.00"	θ_s	= 10°00'00.00"
D	= 10°00'00.00"	L_s	= 200.00'
R	= 572.958'	L_T	= 133.547'
T	= 182.278'	S_T	= 66.861'
L	= 260.00'		
E	= 15.071'		

RAMP E-INN.W

CIRCULAR CURVE G8		SPIRAL G7	
△	= 18°07'05.25"	θ_s	= 5°37'30.00"
D	= 7°30'00.00"	L_s	= 150.00'
R	= 763.944'	L_T	= 100.051'
T	= 121.800'	S_T	= 50.040'
L	= 241.566'		
E	= 9.649'		

NOTES:
- W.R. DENOTES WORKING POINT.
- T/P DENOTES TOP OF ASPH. PAV'T.

LIST OF DRAWINGS
1. GENERAL PLAN
2. BOREHOLE LOCATIONS & SOIL STRATA
3. FOUNDATION LAYOUT & DETAILS
4. WEST ABUTMENT
5. EAST ABUTMENT
6. PRESTRESSED GIRDERS & BEARINGS
7. DECK DETAILS
8. CONCRETE BARRIER WALL (2'-8 HIGH)
9. STEEL PARAPET RAILING (SINGLE TUBE)
10. APPROACH SLABS
11. STANDARD DETAILS I
12. STANDARD DETAILS II
13. PLAN - EMBEDDED DETAILS
14. EMBEDDED DETAILS



GENERAL NOTES

CLASS OF CONCRETE

PRESTRESSED CONCRETE GIRDERS	-5000 P.S.I.
APPROACH SLABS	-4000 P.S.I.
DECK, DIAPHRAGMS, & BARRIER WALLS	-4000 P.S.I.
REMAINDER	-3000 P.S.I.

CLEAR COVER ON REINFORCING STEEL
FOOTINGS & ABUTMENTS -3"
DECK: TOP - 1½", BOTTOM - 1", DIAPHRAGMS - 1½"
BARRIER WALLS - 1½".
APPROACH SLABS - 2".

CONSTRUCTION NOTES
THE CONTRACTOR IS RESPONSIBLE FOR FINISHING THE BEARING SEATS DEAD LEVEL TO THE SPECIFIED ELEVATIONS WITH A TOLERANCE OF ±1/8". NO CONCRETE SHALL BE PLACED ABOVE THE ABUTMENT BEARING SEATS UNTIL THE CONCRETE IN THE DECK HAS BEEN PLACED.

REVISIONS	DATE	BY	DESCRIPTION
	MAY'74	A.B.	THIS PLAN SUPERCEDES PREVIOUS GENERAL PLAN 3-310-1 ISSUED APRIL '73 DUE TO CHANGE IN GREEN CREEK DIVERSION ALIGNMENT.

REGISTERED PROFESSIONAL ENGINEER — CIVIL — G.S. SAUNDERS — PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER — L.D. HIMEBAUGH — PROVINCE OF ONTARIO

FOR REDUCED PLAN
USE SCALE BELOW
0 1 2 3
3 INCHES ON ORIGINAL PLAN

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS
ONTARIO
DeLeuw, Cather
ENGINEERS & PLANNERS - OTTAWA

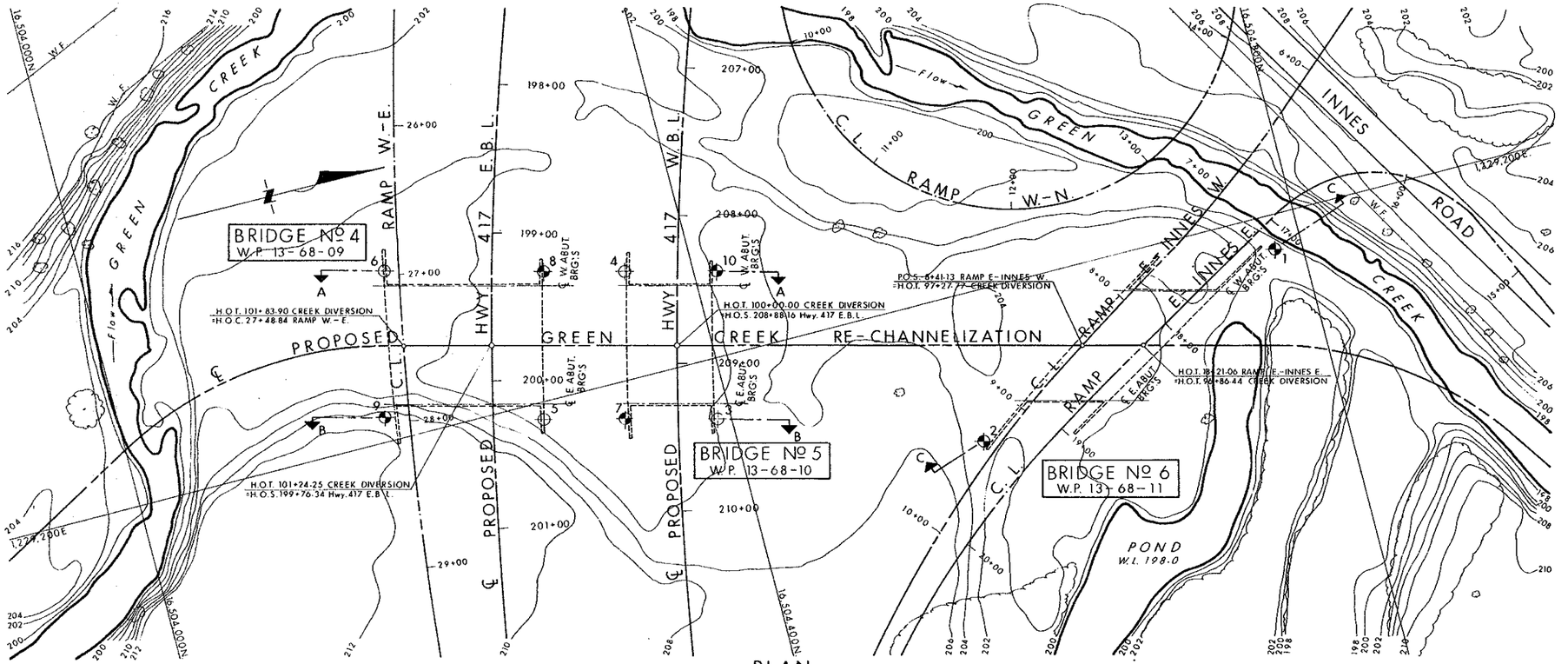
GREEN CREEK UNDER N.B. RAMP TO INNES ROAD BRIDGE No. 6 RELOCATION

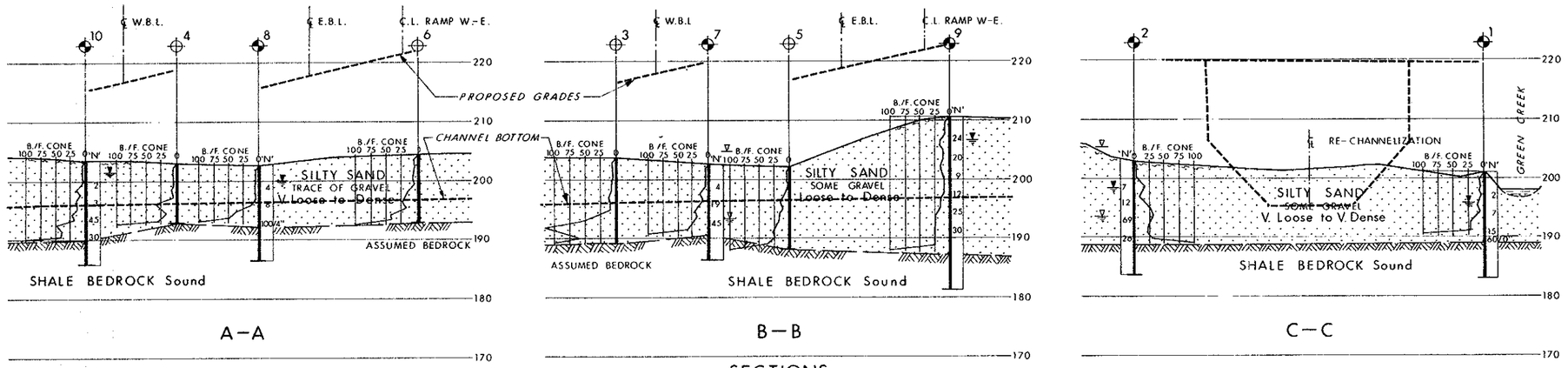
KING'S HIGHWAY No. 417 — DIST. No. 9
CO. REG. MUNICIPALITY OF OTTAWA-CARLETON
TWP. GLOUCESTER — LOT 23 — CON. III

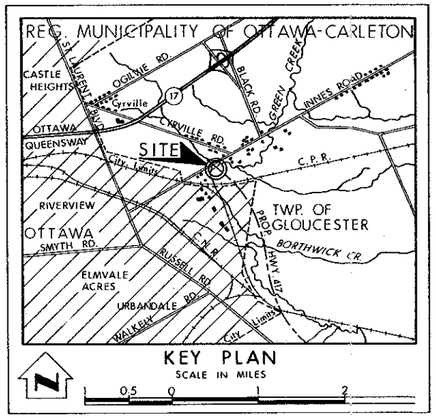
GENERAL PLAN

APPROVED _____ STRUCTURAL ENGINEER — CONTRACT No. 73-191

DESIGN	G.S.S.	CHECK	L.D.H.	W.P. No. 13-68-11
DRAWING	A.B.	CHECK	R.A.P.	
DATE	MAY, '74	LOADING	MS 20-44	SITE No. 3-310 SHEET 1.







LEGEND

- Bore Hole
- Cone Penetration Test
- Bore Hole & Cone Test
- Water Levels established at time of field investigation. June 1972
- Head Artesian Water Levels Encountered

NO.	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
1	201.0	16,504,781	1,229,223
2	202.7	16,504,561	1,229,300
3	203.7	16,504,391	1,229,240
4	203.0	16,504,355	1,229,128
5	202.1	16,504,277	1,229,212
6	204.5	16,504,200	1,229,087
7	202.4	16,504,331	1,229,225
8	202.5	16,504,302	1,229,114
9	210.3	16,504,175	1,229,183
10	203.4	16,504,415	1,229,143

— NOTE —

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

REVISIONS		
DATE	BY	DESCRIPTION

NOTE: The complete soil investigation report for this structure may be examined at the Bridge Office and Foundation Office, Downsview, and at the OTTAWA District Office.

REF. NO. B56-34

MINISTRY OF TRANSPORTATION & COMMUNICATIONS
DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

BRIDGE No. 4
GREEN CREEK

HIGHWAY NO. Prop. 417 E.B.L. DIST. NO. 9
REG. MUNICIPALITY OF OTTAWA-CARLETON
TWP. GLOUCESTER LOT. CON.

BORE HOLE LOCATIONS & SOIL STRATA

SUBMD. S.A.	CHECKED	W.P. NO. 13-68-09	DRAWING NO. 72-11067A
DRAWN	CHECKED	JOB NO. 72-11067	
DATE July 27, 1972		SITE NO. 3-311B	BRIDGE DRAWING NO. 3-311B-2
APPROVED PRINCIPAL FOUNDATION ENGINEER		CONT. NO. 73-191	

THURBER

APPENDIX 8

SITE 3-730/C

THURBER

MEMORANDUM

To: Laura Donaldson, P.Eng.
McIntosh Perry Consulting Engineers

Date: July 17, 2015

From: Kenton Power, P.Eng.
(Reviewed by Fred Griffiths, P.Eng. and P.K. Chatterji, P.Eng.)

File: 19-3405-3

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 417 STRUCTURAL CULVERT (SITE 3-730/C)
GWP 4074-11-00, GEOCRES 31G5-262

PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This memo presents a brief summary of the factual findings from a foundation review carried out for the culvert structure carrying traffic on Highway 417 over Borthwick Creek in Ottawa, Ontario. It also presents preliminary geotechnical recommendations for potential culvert extensions or replacement. It is noted that the proposed construction options for this site are not yet defined. The preliminary recommendations provided below are for assistance in developing and evaluating the options and will need to be refined during subsequent design stages.

The following reference numbers apply to this site:

- Current W.P. -
- Site No. 3-730/C
- GEOCRES No. 31G5-91
- Construction Contract 73-190
- Historic W.P. 10-69-22

2 SITE DESCRIPTION

The site is located in eastern Ottawa, in the Township of Gloucester approximately 340 m north of the Highway 417 / Walkley Road Interchange. The culvert carries the Borthwick Creek flow below both the east and westbound lanes of Highway 417 (four lanes in total plus granular shoulders) and the on and off ramps for the Walkley Road Interchange. Based on the historic General Layout Drawing (copy attached), the culvert was constructed in ten, closed bottom, concrete sections with concrete tapered portal sections at the inlet and outlet. The total length of structure is reported to be 115.8 m, with a span of 3.0 m and a height of 2.4 m. The terrain in the vicinity of the inlet and outlet of the culvert is generally flat and is brush and grass covered. Site photos showing the general site conditions are attached.

THURBER

3 SUBSURFACE CONDITIONS

A site investigation was carried out by the MTO Foundations Office; GEOCRES Report No. 31G5-91 dated March 1973. The investigation consisted of three sampled boreholes designated 3 to 5 which were located in the vicinity of the proposed culvert. Drawing No. 72-11146A (copy attached) illustrates the locations of the culvert structure, the investigation boreholes, as well as the soil strata plot for the investigation. The stratigraphy in the area of the culvert structure is generally characterized by a silty clay stratum, overlaying a glacial till material consisting mainly of silt and sand, underlain by shale bedrock.

3.1 Silty Clay

A clay stratum with interspersed seams of clayey silt to silt was encountered in all three boreholes. The thickness of the individual seams was noted to range from 13 mm to 25 mm. The top of this stratum ranged from 62.9 m to 64.6 m in elevation and the layer had a thickness of 4.4 m to 5.2 m. The standard penetration test (SPT) 'N' values ranged from 8 to 12 blows per 0.3 m of penetration. The estimated undrained shear strength based on in-situ field vane tests ranged from 23 kPa to 95 kPa while laboratory shear strength tests results ranged from 40 kPa to 93 kPa. Based on these values, it is estimated that the consistency of the stratum varies from very stiff in the upper portion decreasing to firm with depth.

The results of a grain size analysis test including hydrometer testing completed on a sample of this material indicated a gravel content of 0%, sand content of 2%, silt content of 38%, and clay content of 60%. Atterberg Limits test results of five samples of the silty clay material indicate a clay of intermediate to high plasticity.

Consolidation characteristics determined for the silty clay from two oedometer tests indicate an initial void ratio of 1.42 and 1.13 and compression index of 0.67 and 0.76. The pre-consolidation pressure was found to be in excess of 180 kPa; higher than the effective in-situ vertical stress. A third oedometer tests was conducted on the varved material (clayey silt to silt) which indicated an initial void ratio of 0.652 and compression index of 0.06.

The moisture content of the samples tested ranged from 22% to 48%.

3.2 Silt

A silt with gravel stratum was encountered underlying the clay stratum in Borehole 4. The surface of this deposit was at elevation 59.0 m and the layer had a thickness of 0.9 m. The SPT 'N' value was 25 blows per 0.3 m of penetration; indicating a compact condition.

3.3 Glacial Till

A glacial till stratum was encountered beneath the silty clay stratum in Boreholes 3 and 5 and beneath the silt stratum in Borehole 4. The till was described as a heterogeneous mixture of silt and sand with some clay and gravel. A boulder zone was encountered in the lower part of the till in Borehole 3. Coring was required to penetrate this layer. The top of the glacial till stratum ranged from 58.3 m to 59.4 m in elevation and the layer had a thickness of 2.1 m to 2.7 m. The SPT 'N'

values ranged from 44 to 62 blows per 0.3 m of penetration; indicating a dense to very dense condition.

The results of a grain size analysis test including hydrometer testing completed on samples of this material indicated a gravel content between 8% and 36%, sand content between 22% and 53%, silt content between 23% and 50%, and clay content of 10% and 15%.

The moisture content of the glacial till samples tested ranged from 12% to 15%.

3.4 Bedrock

A shale to sandy limestone bedrock was encountered beneath the glacial till in all three boreholes as proven by BX size coring. All boreholes were terminated in bedrock. The bedrock surface elevation ranged from 55.6 m in Borehole 3 to 56.8 m in Borehole 5. Bedrock core recovery ranged from 97% to 100%. The bedrock was described to be in sound condition. Geological mapping suggests the bedrock at this site is shale of the Carlsbad Formation.

3.5 Groundwater

Groundwater levels were measured in the open boreholes prior to backfilling at elevations ranging from 62.5 m to 64.0 m.

4 SITE OBSERVATIONS

A structure inspection was conducted by MTO in August 2010 for Culvert 3-730/C with the report issued December 2010. Condition data outlined in the report for the culvert structure ranged from poor to good but typically the culvert was rated in good condition. The report recommends repairs to the inlet connections within two years of the report date and soffit and fascia repairs within 6 to 10 years.

The site was inspected by Thurber Engineering Ltd. staff during the week of July 14, 2014. Several photographs of the site are attached.

At the time of the inspection, the following observations were made:

Eastern Inlet:

- Gabions were installed at the site for erosion protection
- Erosion over the culvert and tapered portal sections was noted
- Vegetation on side slopes was noted
- No obvious tilt of tapered portal sections
- No obvious settlement of road or ramp surface was observed at the culvert crossing

Western Outlet:

- Gabions were installed at the site for erosion protection
- Vegetation on side slopes was noted

- No obvious tilt of portal sections
- Some erosion of side slopes of creek was noted
- No obvious settlement of road or ramp surface was observed at the culvert crossing

5 GEOTECHNICAL ASSESSMENT

5.1 Frost Considerations

The frost penetration depth at this site is 1.8 m (OPSD 3090.101).

5.2 Seismic Considerations

This site is best classified as a Soil Profile Type III in accordance with Section 4.4.6 of the Canadian Highway Bridge Design Code (CHBDC). The zonal acceleration ratio for this site is 0.20 as per Table A3.1.1 of the CHBDC.

Based on the density of the till and the plasticity of the clay, these materials are classified as “not susceptible” to liquefaction during the design earthquake event.

5.3 Existing Foundations

As indicated on the General Layout Drawing, the design invert elevation of the box culvert ranged from 60.7 m to 60.5 m. The thickness of the concrete base is dimensioned to be 0.3 m. No bedding material is indicated on the available drawings. Therefore, the culvert is founded at approximate elevations ranging from 60.4 m to 60.2 m which is within the silty clay layer. The recommended design allowable bearing value as reported in the 1973 Foundation Design Report was 86 kPa.

The Foundation Design Report also indicates that approximately 2.7 m of fill will be placed above the culvert. This corresponds to an approximate finished grade elevation for the highway of 66.4 m.

PART 2: ENGINEERING DISCUSSION AND PRELIMINARY RECOMMENDATIONS

6 GEOTECHNICAL RECOMMENDATIONS

Based on the available data regarding the ground conditions at this site, the following sections present preliminary geotechnical recommendations for the assessment of the existing culvert and for preliminary design for potential culvert extensions, replacement, and the construction of new wing walls, end sections and/or headwall structures, if required. It is noted that the proposed construction options for this site are not yet defined. The preliminary recommendations provided below are for assistance in developing and evaluating options and will need to be refined during subsequent design stages.

The existing culvert is a concrete box culvert likely founded on very stiff to firm clay. For culvert extensions, it is preferred that type of foundations and founding elevation match the existing

arrangement so as not to undermine the existing foundation. From a foundation perspective for a culvert replacement, a concrete rigid-frame open-footing culvert could have bearing resistance limitations as well as groundwater concerns during construction. Both concrete closed boxes and CSP arches would be preferred.

6.1 Foundations

For strip footings founded on native very stiff to firm silty clay having a minimum embedment depth of 1.8 m and a width of between 1 m and 2 m, the factored vertical geotechnical resistance at ULS is 120 kPa. The vertical geotechnical reaction at SLS is 100 kPa based on a total footing settlement of 25 mm.

For strip footings founded on native glacial till having a minimum embedment depth of 1.8 m and a width of between 1 m and 2 m, the factored vertical geotechnical resistance at ULS is 375 kPa. The vertical geotechnical reaction at SLS is 250 kPa based on a total footing settlement of 25 mm.

A replacement closed box culvert would likely require a span and an invert elevation similar to the existing. For a culvert base founded on native very stiff to firm clay, a minimum embedment of 1.8 m and a base width of 4 m, the factored vertical geotechnical resistance at ULS is 150 kPa. The vertical geotechnical reaction at SLS is 85 kPa based on a total footing settlement of 25 mm.

Resistance to lateral forces and sliding resistance between concrete and underlying materials should be evaluated using an unfactored coefficients of friction provided in Table A.

Table A: Unfactored Coefficients of Friction between Concrete and Founding Material

	Founding Material	
Concrete Type	**Glacial Till**	**Silty Clay**
Cast-in-place concrete	0.45	0.35
Precast concrete	0.40	0.30

6.2 Excavations, Bedding and Backfilling

All excavations must be conducted in accordance with the requirements of the Occupational Health & Safety Act & Regulations (OHSA) for Construction Projects. The native very stiff to firm silty clay soil reported at this site should be classified as Type 3 in accordance with OHSA.

Where excavations will extend below the groundwater level prevailing at the time of construction, the contractor will need to implement groundwater control and ground support systems as are required to carry out the construction in a safe, stable, and unwatered excavation.

It is noted that excavation base instability is possible at this site for some excavation depths due to unbalanced hydrostatic forces in the glacial till layer. Well point and or water tight shoring systems may be needed.

Excavations, bedding and backfill for rigid structures should be in accordance with OPSS 422 and 902. Backfill for the culvert must consist of free draining granular material conforming to OPSS Granular A or B material specifications. The granular material must be placed to the extent shown on OPSD 803.030 or 803.031.

Subgrade preparation and placement of culvert bedding must be carried out in the dry.

6.3 Static Lateral Earth Pressure Coefficients

Lateral earth pressures acting on structures should be computed in accordance with the CHBDC but generally are given by the expression:

$$P_h = K^*(\gamma h + q)$$

where:

P_h = horizontal pressure on the wall (kPa)
K = earth pressure coefficient
γ = unit weight of retained soil
h = depth below top of fill where pressure is computed (m)
q = value of any surcharge (kPa)

The recommended lateral earth pressure parameters for use in the design for both a horizontal and for 2H:1V (Horizontal:Vertical) back-slope are provided in Table B.

For rigid structures such as Culvert 3-730/C, it is recommended that at-rest horizontal lateral earth pressures be used for design. Active pressures should be used for the design of unrestrained walls.

A lateral pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with the Section 6.9.3 of the CHBDC.

The parameters provided in Table B are based on the assumption that the backfill is fully drained so that there are no unbalanced hydrostatic pressures. If adequate drainage cannot be confirmed, the potential for hydrostatic pressures should be considered.

Table B: Static Lateral Earth Pressure Coefficients

Parameter	OPSS Granular A & OPSS Granular B Type II	OPSS Granular B Type I	Native Silty Clay
Soil Unit Weight, kN/m^3, γ	21	20	17
Angle of Internal Friction, ϕ	35°	30°	27°
Horizontal Back-Slope			
Coefficient of at Rest Earth Pressure, K_o (Restrained Wall)	0.43	0.5	0.55
Coefficient of Active Earth Pressure, K_a (Unrestrained Wall)	0.27	0.33	0.38
2H:1V Back-Slope			
Coefficient of Active Earth Pressure, K_a	0.39	0.53	0.70

6.4 Erosion Control

Erosion protection should be provided at the culvert inlet and outlet areas. Design of the erosion protection measures must consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field.

Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact. Treatment at the outlets should be in accordance with OPSD 810.010. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS 804.

A concrete cut-off wall or clay seal should be installed at the culvert inlet to minimize the potential for seepage through the granular bedding and backfill material and avoid consequent erosion of these materials. The clay seal should have a minimum thickness of 0.5 m, completely surround the culvert (excluding beneath an open footing culvert), extend laterally the width of the granular backfill material, and extend above the high water level. The material used for the clay seal should conform to the requirements of OPSS 1205. It is noted that a concrete cut off wall was included in the design for this site.

6.5 Embankments

Based on the original MTO Foundation Design Report, the embankments would extend approximately 2.7 m above the grades existing at the time of the investigation. Side slopes of 2H:1V were considered to be stable and settlement of less than 25 mm was predicted. It is anticipated that minor grade raises or embankment widening would therefore not induce significant additional settlement or generate stability concerns.

7 ADDITIONAL INVESTIGATIONS

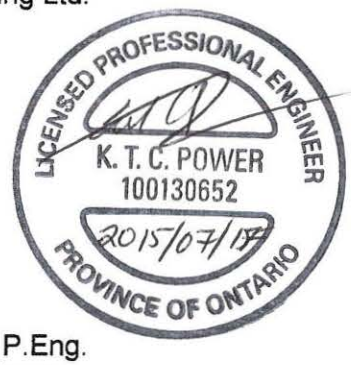
Further foundation investigations and analysis must be carried out should the culvert structure be replaced or extended or if the height, geometry, or location of the approach fills are to be modified for either short-term construction staging or for vertical or horizontal re-alignments. Should excavations be anticipated within the embankment fills to repair or modify the culvert, consideration should be given to drilling foundation boreholes in the approaches to determine the nature of the fill materials and to allow generation of road way protection design. It is also recommended that piezometers be installed to better define the groundwater level in both the silty clay and glacial till strata as well as the insitu hydraulic conductivity. This information will be required to allow for the design of excavation dewatering systems.

THURBER

8 CLOSURE

We trust this information provided in this technical memorandum meets your present purposes. Please let us know if you have any questions or need additional information.

Thurber Engineering Ltd.



Kenton C. Power, P.Eng.
Geotechnical Engineer

Fred Griffiths, P.Eng.
Associate, Senior Geotechnical Engineer

P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact

Attachments

GWP 4074-11-00
Site Photographs

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 417 STRUCTURAL CULVERT (SITE 3-730/C)

On-ramp surface at 3-730/C crossing

Condition of north tapered portal wall at inlet

GWP 4074-11-00
Site Photographs

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 417 STRUCTURAL CULVERT (SITE 3-730/C)

Condition of south tapered portal wall at inlet

Erosion over culvert and tapered portal at inlet

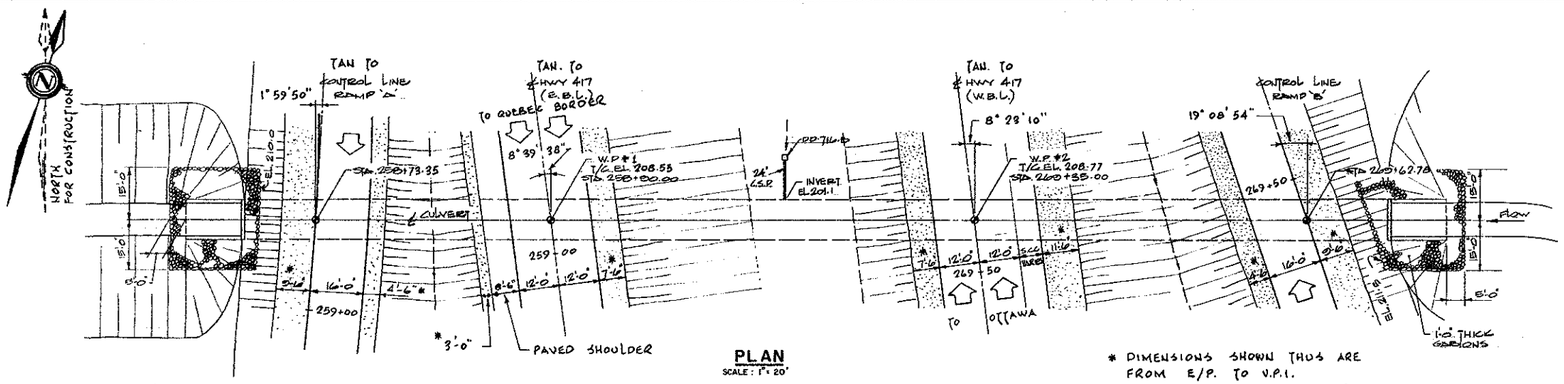
GWP 4074-11-00
Site Photographs

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 417 STRUCTURAL CULVERT (SITE 3-730/C)

Overall condition at outlet

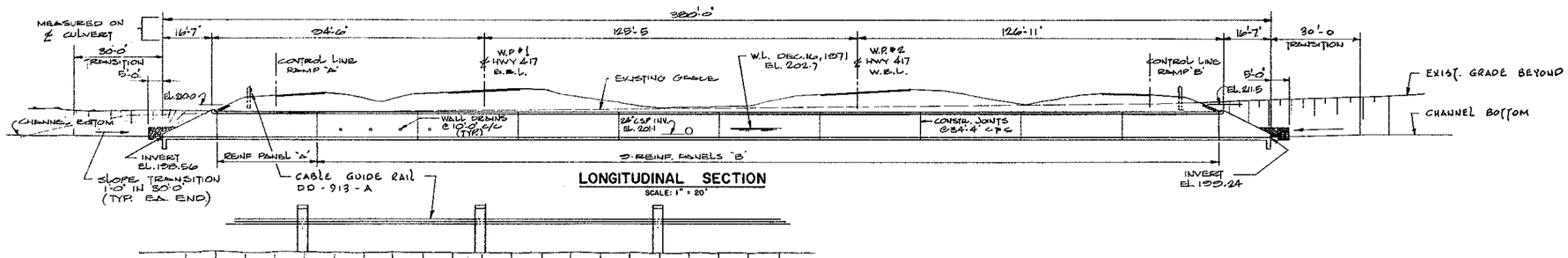
Rip rap on top of tapered portal and culvert at outlet

Looking upstream from outlet

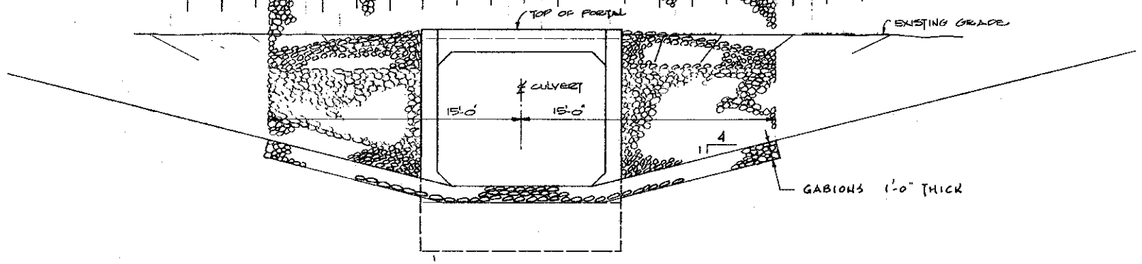


PLAN
SCALE: 1" = 20'

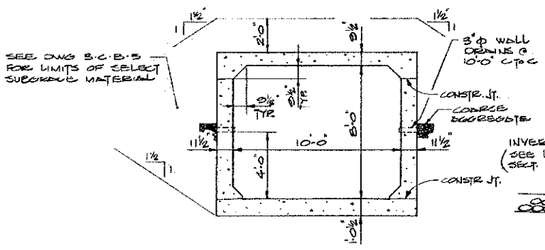
* DIMENSIONS SHOWN THUS ARE FROM E/P. TO V.P.I.



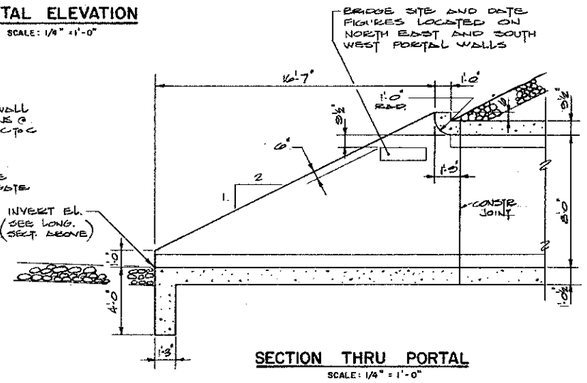
LONGITUDINAL SECTION
SCALE: 1" = 20'



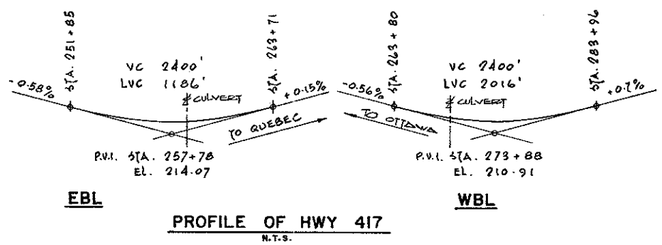
PORTAL ELEVATION
SCALE: 1/4" = 1'-0"



TYPICAL SECTION
SCALE: 1/4" = 1'-0"



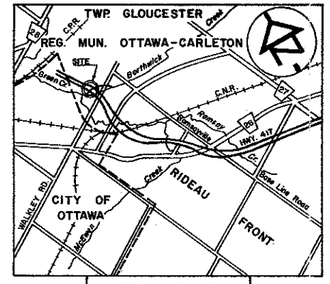
SECTION THRU PORTAL
SCALE: 1/4" = 1'-0"



PROFILE OF HWY 417
N.T.S.

LIST OF DRAWINGS

3-C-B-1 GENERAL LAYOUT
3-C-B-2 BOREHOLE LOCATION AND SOIL STRATA
3-C-B-3 CULVERT DETAILS



KEY PLAN
SCALE - 1 IN. = 1 MI.

96

BENCH MARK

BM 213.12
GEODETIC DATUM TOP OF H.B.P.C. CONCRETE MONUMENT 325.0 FT. R/W. OF STA. 256+87. E.B.L. HWY #417

GENERAL NOTES

- CLASS OF CONCRETE 3000 P.S.I.
- CLEAR COVER TO REINFORCING STEEL 3" EXCEPT AS NOTED.
- ALL EXPOSED CORNERS TO BE CHAMFERED ¾"
- FILL SHALL BE PLACED AT BOTH SIDES OF CULVERT SIMULTANEOUSLY.
- WALL DRAINS SHALL BE BITUMINIZED FIBRE PIPE. PLACE 1 CU. FT OF COARSE AGGREGATE AT EACH DRAIN.
- W/P DENOTES WORKING POINT
  E/P DENOTES EDGE OF PAVEMENT
  T/C DENOTES TOP OF CONCRETE CULVERT
  V.P.I. DENOTES VERTICAL POINT OF INTERSECTION OF SHOULDER AND FILL SLOPE.
- CONSTRUCTION STAGING
  THE EASTERLY 150 FEET OF CULVERT SHALL BE CONSTRUCTED IN SECTIONS OF 64'-4 MAXIMUM LENGTH TO PREVENT INSTABILITY OF SOIL STRATA BENEATH THE CULVERT. EACH SECTION SHALL BE EXCAVATED AND THE CULVERT CONSTRUCTED AND BACKFILLED PRIOR TO EXCAVATING FOR THE NEXT SECTION.

REVISIONS			
	DATE	BY	DESCRIPTION

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS
ONTARIO

Consulting Engineers & Planners

BORTHWICK CREEK UNDER HWY. 417

KING'S HIGHWAY No. 417 — DIST. No. 9
CO. REG. MUN. OTTAWA - CARLETON
TWP. GLOUCESTER — LOT A — CON. VI

GENERAL LAYOUT

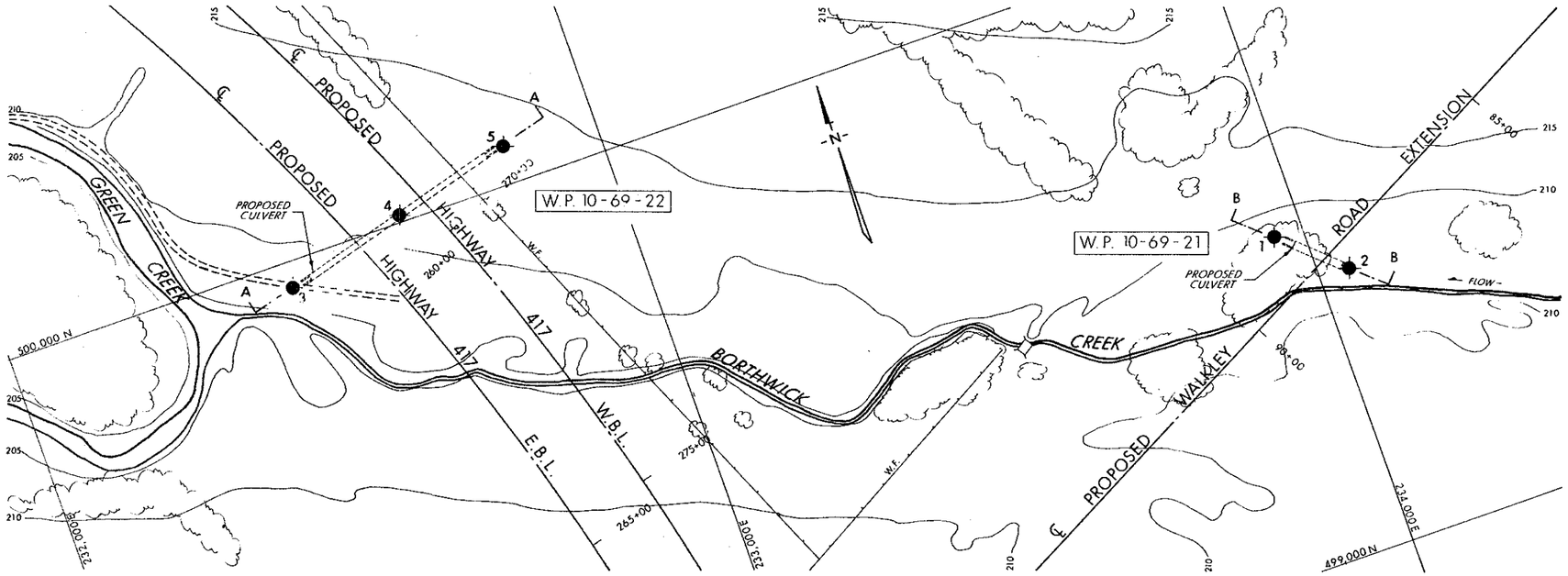
APPROVED (STRUCTURAL ENGINEER)

SITE No.	3-C-B	W.P. No.	10-69-22
CONTRACT Nos.			72-19A
DRAWING No.	3-C-B-1		

DESIGN	STD.	CHECK	G.K.
DRAWING	C.S.	CHECK	G.K.
DATE	MAR. 73	LOADING	HS20-44

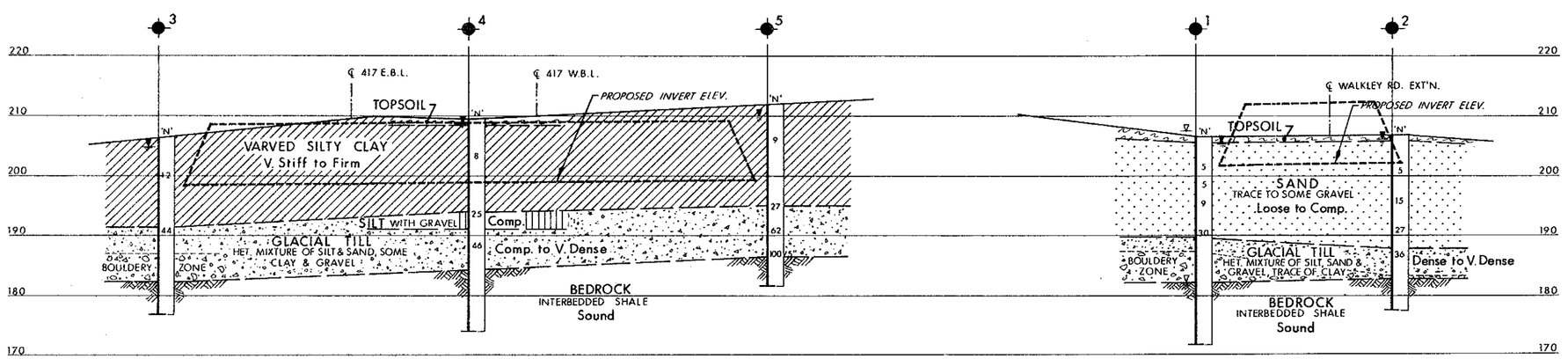
REGISTERED PROFESSIONAL ENGINEER — G. KNIGHTS — PROVINCE OF ONTARIO

FOR REDUCED PLAN
USE SCALE BELOW
0 1 2 3
3 INCHES ON ORIGINAL PLAN



PLAN

100 50 0 SCALE 100 200 FT.



A - A

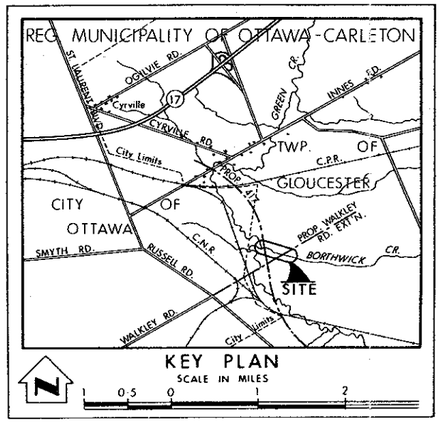
SECTIONS

VERT. 10 5 0 SCALE 10 20 FT.

HORIZ. 40 20 0 40 80

B - B

NOTE: The complete soil investigation report for this structure may be examined at the Bridge Office and Foundation Office, Downsview, and at the OTTAWA District Office.



LEGEND

- Bore Hole
- Cone Penetration Test
- Bore Hole & Cone Test
- Water Levels established at time of field investigation. JAN. 1973

▽ Head
▽ Encountered
ARTESIAN WATER

NO.	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	206·4	499,529	233,953
2	206·9	499,443	234,049
3	206·4	499,960	232,463
4	209·5	500,012	232,660
5	212·0	500,060	232,852

— NOTE —

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

REVISIONS			
	DATE	BY	DESCRIPTION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
DESIGN SERVICES BRANCH—FOUNDATIONS OFFICE

BORTHWICK CREEK CULVERTS

HIGHWAY NO. ~~417 & WALKLEY RD. EXT'N.~~ DIST. NO. 9
REG. MUNICIPALITY OF OTTAWA - CARLETON
TWP. GLOUCESTER LOT ____ CON. ____

BORE HOLE LOCATIONS & SOIL STRATA

SUBMD. D.B.	CHECKED	W.P. NO. 10-69-22	DRAWING NO. 72-11146A
DRAWN S.O.	CHECKED	W.O. NO. 72-11146	
DATE 23 FEB. 1973		SITE NO. 3-C-B	BRIDGE DRAWING NO 3-C-B-2
APPROVED PRINCIPAL FOUNDATION ENGINEER		CONT. NO. 73-80	

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APPENDIX 9

SITE 3-736/C

THURBER

MEMORANDUM

To: Laura Donaldson, P.Eng.
McIntosh Perry Consulting Engineers

Date: July 17, 2015

From: Kenton Power, M.A.Sc., P.Eng.
(Reviewed by Fred Griffiths, P.Eng. and P.K. Chatterji, P.Eng.)

File: 19-3405-3

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 417 STRUCTURAL CULVERT (SITE 3-736/C)
GWP 4074-11-00, GEOCRES 31G5-262

PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This memo presents a brief summary of the factual findings from a foundation review carried out for the culvert structure carrying traffic on Walkley Road over Borthwick Creek in Ottawa, Ontario. It also presents preliminary geotechnical recommendations for potential culvert extensions or replacement. It is noted that the proposed construction options for this site are not yet defined. The preliminary recommendations provided below are for assistance in developing and evaluating the options and will need to be refined during subsequent design stages.

The following reference numbers apply to this site:

- Current W.P. -
- Site No. 3-736/C
- GEOCRES No. 31G5-91
- Construction Contract 73-190
- Historic W.P. 10-69-21

2 SITE DESCRIPTION

The site is located in eastern Ottawa, in the Township of Gloucester approximately 360 m northeast of the Highway 417 / Walkley Road Interchange. The culvert carries the Borthwick Creek flow below both the Walkley Road east and westbound lanes (two lanes in total plus granular shoulders) and the on ramp for the Walkley Road Interchange. Based on the historic General Layout Drawing (copy attached), the culvert was constructed in three, closed bottom, concrete sections with concrete tapered portal sections at the inlet and outlet. The total length of structure is reported to be 36.6 m, with a span of 3.0 m and a height of 2.4 m. The terrain in the vicinity of the inlet and outlets of the culvert is generally flat and is brush and grass covered. Site photos showing the general site conditions are attached.

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3 SUBSURFACE CONDITIONS

A site investigation was carried out by the MTO Foundations Office; GEOCRES Report No. 31G5-91 dated March 1973. The investigation consisted of two sampled boreholes designated 1 and 2 which were located in the vicinity of the proposed culvert. Drawing No. 72-11146A (copy attached) illustrates the locations of the culvert structure, the investigation boreholes, and as well as the soil strata plot for the investigation. The stratigraphy in the area of the culvert structure is generally characterized by a sand stratum, overlaying a glacial till material consisting mainly of silt and sand, underlain by shale bedrock. Cobbles and boulders were noted in the glacial till deposit.

3.1 Topsoil

Grass and topsoil were present at the ground surface with a thickness of 300 mm in each borehole.

3.2 Sand

The sand stratum was encountered in both boreholes. The top of the sand stratum ranged from 62.6 m to 62.8 m in elevation and the layer had a thickness of 4.8 m to 5.5 m. The standard penetration test (SPT) 'N' values ranged from 5 to 30 blows per 0.3 m indicating a loose to dense condition that typically increased with depth.

The results of grain size analysis tests completed on five samples of this material indicated a gravel content ranging from 0% to 34%, sand content ranging from 50% to 99%, fines content (combined silt and clay size particles) between 1% and 16%.

The moisture content of the samples tested ranged from 14% to 34%.

3.3 Till

A glacial till stratum was encountered beneath the sand stratum in both boreholes. The till was described as a heterogeneous mixture of silt and sand with gravel and trace clay. A bouldery zone was encountered in the lower part of the till in Borehole 3. Coring was required to penetrate this layer. The top of the glacial till stratum ranges from 57.3 m to 57.9 m in elevation while the layer thickness ranged from 1.5 m to 2.3 m. The SPT 'N' value was 36 blows per 0.3 m penetration, indicating a dense condition.

The moisture content of the sample tested 7%.

3.4 Bedrock

A shale to silty limestone bedrock was encountered beneath the glacial till in both boreholes as proven by BX size coring. Both boreholes were terminated in bedrock. The bedrock surface elevation ranged from 55.5 m to 55.7 m Bedrock core recovery ranged from 97% to 100%. The bedrock was described to be in sound condition. Geological mapping suggests the bedrock at this site is shale of the Carlsbad Formation.

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3.5 Groundwater

Groundwater levels were measured in the open boreholes prior to backfilling at elevations ranging from 62.6 m to 62.8 m. An artesian groundwater condition with a head of 0.3 m was encountered in Borehole 1 once the borehole penetrated the bedrock surface at elevation 55.5 m. Excavations to the bedrock surface are not anticipated for construction project at this site as such it is not likely that the artesian conditions will be encountered.

4 SITE OBSERVATIONS

A structure inspection was conducted by MTO in August 2010 for Culvert 3-736/C with the report issued December 2010. Condition data outlined in the report for the culvert structure ranged from poor to good but typically the culvert was rated in good condition with no proposed recommended work on the structure at the time of the inspection.

The site was inspected by Thurber Engineering Ltd. staff during the week of July 14, 2014. Several photographs of the site are attached.

At the time of the inspection, the following observations were made:

South Inlet:

- Gabions were installed at the site for erosion protection
- Vegetation on side slopes was noted
- Backslope behind tapered portal sections was measured at approximately 2H:1V (Horizontal:Vertical)
- No obvious settlement of road or ramp surface was observed at the culvert crossing

North Outlet:

- Gabions were installed at the site for erosion protection
- Vegetation on side slopes was noted
- Backslope behind tapered portal sections was measured at approximately 2H:1V
- No obvious settlement of road or ramp surface was observed at the culvert crossing

5 GEOTECHNICAL ASSESSMENT

5.1 Frost Considerations

The frost penetration depth at this site is 1.8 m (OPSD 3090.101).

Based on the General Layout Drawing, the design culvert invert elevation ranged from 61.5 m and 61.6 m and appears to satisfy the frost cover requirement.

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5.2 Seismic Considerations

This site is best classified as a Soil Profile Type III in accordance with Section 4.4.6 of the Canadian Highway Bridge Design Code (CHBDC). The zonal acceleration ratio for this site is 0.20 as per Table A3.1.1 of the CHBDC.

The upper portion of the sand stratum maybe susceptible to liquefaction during the design earthquake event at elevations greater than 59.5 m due to the loose condition of the sand and the high groundwater table. Based on the density of the till at this site, this material is classified as “not susceptible” to liquefaction during the design earthquake event.

5.3 Existing Foundations

As indicated on the General Layout Drawing, the design invert elevation of the box culvert was to range from 61.5 m to 61.6 m. The thickness of the concrete base is dimensioned to be 0.3 m. No bedding material is indicated on the available drawings. Therefore, the culvert is founded at approximate elevations ranging from 61.2 m to 61.3 m which is within the sand stratum. The recommended design allowable bearing value as reported in the 1973 Foundation Design Report was 57 kPa.

The Foundation Design Report also indicates that approximately 2.1 m of fill will be placed above the culvert. This corresponds to an approximate finished grade elevation for the highway of 66.7 m.

PART 2: ENGINEERING DISCUSSION AND PRELIMINARY RECOMMENDATIONS

6 GEOTECHNICAL RECOMMENDATIONS

Based on the available data regarding the ground conditions at this site, the following sections present preliminary geotechnical recommendations for the assessment of the existing culvert and for preliminary design for potential culvert extensions, replacement, and the construction of new wing walls, end sections and/or headwall structures, if required. It is noted that the proposed construction options for this site are not yet defined. The preliminary recommendations provided below are for assistance in developing and evaluating options and will need to be refined during subsequent design stages.

The existing culvert is a concrete box culvert likely founded on compact sand. For culvert extensions, it is preferred that type of foundations and founding elevation match the existing arrangement so as not to undermine the existing foundation. From a foundation perspective for foundation perspective for a culvert replacement, a concrete rigid-frame open-footing culvert could have bearing resistance limitations as well as groundwater concerns during construction. Both concrete closed boxes and CSP arches would be preferred.

6.1 Foundations

For strip footings founded on native loose to compact sand layer having a minimum embedment depth of 1.8 m and a width of between 1 m and 2 m, the factored vertical geotechnical resistance at ULS is 200 kPa. The vertical geotechnical reaction at SLS is 100 kPa based on a total footing settlement of 25 mm.

For strip footings founded on native dense glacial till having a minimum embedment depth of 1.8 m and a width of between 1 m and 2 m, the factored vertical geotechnical resistance at ULS is 375 kPa. The vertical geotechnical reaction at SLS is 250 kPa based on a total footing settlement of 25 mm.

A replacement closed box culvert would likely require a span and an invert elevation similar to the existing. For a culvert base founded on native loose to compact sand with a minimum embedment of 1.8 m and base width of 3.6 m, the factored vertical geotechnical resistance at ULS is 200 kPa. The vertical geotechnical reaction at SLS is 90 kPa based on a total footing settlement of 25 mm.

Resistance to lateral forces and sliding resistance between concrete and underlying materials should be evaluated using an unfactored coefficients of friction provided in Table A.

Table A: Unfactored Coefficients of Friction between Concrete and Founding Material

	Founding Material	
Concrete Type	**Glacial Till**	**Silty Sand**
Cast-in-place concrete	0.45	0.40
Precast concrete	0.40	0.35

6.2 Excavations, Bedding and Backfilling

All excavations must be conducted in accordance with the requirements of the Occupational Health & Safety Act & Regulations (OHSA) for Construction Projects. The anticipated native materials at the site should be classified be classified as Type 3 above and Type 4 below the groundwater table in accordance with OHSA.

Where excavations will extend below the groundwater level prevailing at the time of construction, the contractor will need to implement groundwater control and ground support systems as are required to carry out the construction in a safe, stable, and unwatered excavation.

Excavations, bedding and backfill for rigid structures should be in accordance with OPSS 422 and 902. Backfill for the culvert must consist of free draining granular material conforming to OPSS Granular A or B material specifications. The granular material must be placed to the extent shown on OPSD 803.030 or 803.031.

Subgrade preparation and placement of culvert bedding must be carried out in the dry.

6.3 Static Lateral Earth Pressure Coefficients

Lateral earth pressures acting on the structure should be computed in accordance with the CHBDC but generally are given by the expression:

$$P_h = K^*(\gamma h + q)$$

where:

P_h = horizontal pressure on the wall (kPa)
K = earth pressure coefficient
γ = unit weight of retained soil
h = depth below top of fill where pressure is computed (m)
q = value of any surcharge (kPa)

The recommended lateral earth pressure parameters for use in the design for both a horizontal and for 2H:1V (Horizontal:Vertical) back-slope are provided in Table B.

For rigid structures such as Culvert 3-736/C, it is recommended that at-rest horizontal lateral earth pressures be used for design. Active pressures should be used for the design of unrestrained walls.

A lateral pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with the Section 6.9.3 of the CHBDC.

The parameters provided in Table B are based on the assumption that the backfill is fully drained so that there are no unbalanced hydrostatic pressures. If adequate drainage cannot be confirmed, the potential for hydrostatic pressures should be considered.

Table B: Static Lateral Earth Pressure Coefficients

Parameter	OPSS Granular A & OPSS Granular B Type II	OPSS Granular B Type I / Native Sand
Soil Unit Weight, kN/m^3, γ	21	20 / 19
Angle of Internal Friction, ϕ	35°	30°
Horizontal Back-Slope		
Coefficient of at Rest Earth Pressure, K_o (Restrained Wall)	0.43	0.5
Coefficient of Active Earth Pressure, K_a (Unrestrained Wall)	0.27	0.33
2H:1V Back-Slope		
Coefficient of Active Earth Pressure, K_a	0.39	0.53

6.4 Erosion Control

Erosion protection should be provided at the culvert inlet and outlet areas. Design of the erosion protection measures must consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field.

Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact. Treatment at the outlets should be in accordance with OPSD 810.010. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS 804.

A concrete cut-off wall or clay seal should be installed at the culvert inlet to minimize the potential for seepage through the granular bedding and backfill material and avoid consequent erosion of these materials. The clay seal should have a minimum thickness of 0.5 m, completely surround the culvert (excluding beneath an open footing culvert), extend laterally the width of the granular backfill material, and extend above the high water level. The material used for the clay seal should conform to the requirements of OPSS 1205. It is noted that a concrete cut off wall was included in the design for this site.

6.5 Embankments

Based on the original MTO Foundation Investigation Report, the embankments would extend 2.7 m to 3 m above the grades existing at the time of the investigation. Side slopes of 2H:1V were considered to be stable and settlement of less than 25 mm was predicted. The side slopes where measured during Thurber's site inspection coincide the design side slope values. It is anticipated that minor grade raises or embankment widening would therefore not induce significant additional settlement or generate stability concerns.

7 ADDITIONAL INVESTIGATIONS

Further foundation investigations and analysis must be carried out should the culvert structure be replaced or extended or if the height, geometry, or location of the approach fills are to be modified for either short-term construction staging or for vertical or horizontal re-alignments. Should excavations be anticipated within the embankment fills to repair or modify the culvert, consideration should be given to drilling foundation boreholes in the approaches to determine the nature of the fill materials and to allow generation of road way protection design. It is also recommended that monitoring wells be installed to better define the groundwater level as well as the hydraulic conductivity at the site. This information will be required to allow for the design of excavation dewatering systems.

THURBER

8 CLOSURE

We trust this information provided in this technical memorandum meets your present purposes. Please let us know if you have any questions or need additional information.

Thurber Engineering Ltd.

Kenton C. Power, P.Eng.
Geotechnical Engineer

Fred Griffiths, P.Eng.
Associate, Senior Geotechnical Engineer

P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact

Attachments

GWP 4074-11-00
Site Photographs

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 417 STRUCTURAL CULVERT (SITE 3-736/C)

Condition of road surface looking north to south

Condition of outlet

GWP 4074-11-00
Site Photographs

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 417 STRUCTURAL CULVERT (SITE 3-736/C)

Overtop looking down on outlet showing condition of gabions

Looking downstream from outlet

GWP 4074-11-00
Site Photographs

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 417 STRUCTURAL CULVERT (SITE 3-736/C)

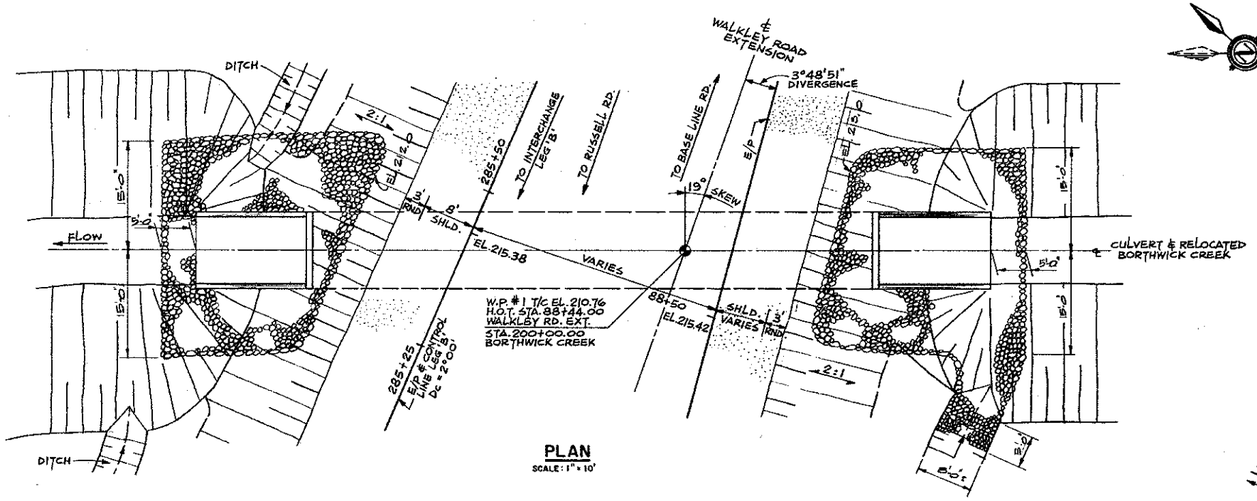
Overall condition of inlet

Overtop looking down on inlet showing condition of gabions

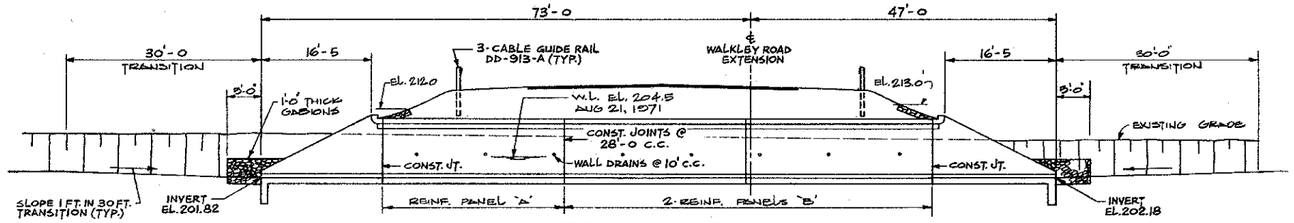
GWP 4074-11-00
Site Photographs

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 417 STRUCTURAL CULVERT (SITE 3-736/C)

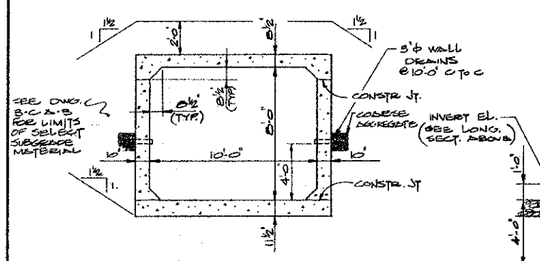
Looking upstream from inlet



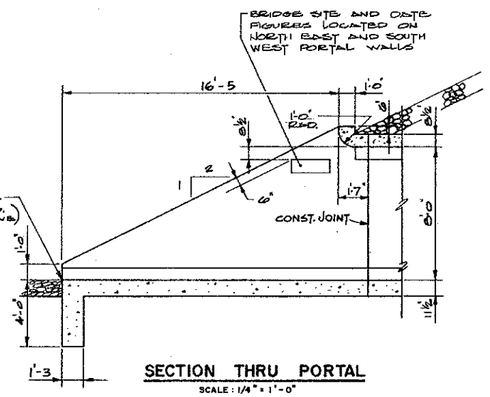
PLAN
SCALE : 1" = 10'



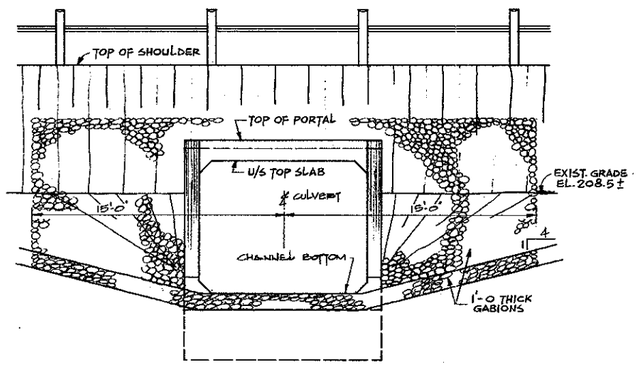
LONGITUDINAL SECTION
SCALE : 1" = 10'



TYPICAL SECTION
SCALE : 1/4" = 1'-0"



SECTION THRU PORTAL
SCALE : 1/4" = 1'-0"



PORTAL ELEVATION
SCALE: 1/4" = 1'-0"

NORTH FOR CONST.

LIST OF DRAWINGS

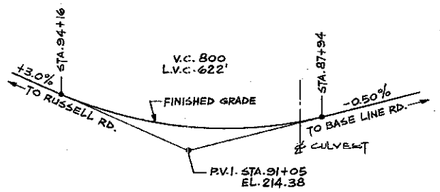
3-C-A-1 - GENERAL LAYOUT
3-C-A-2 - BOREHOLE LOCATION AND SOIL STRATA
3-C-A-3 - CULVERT DETAILS

CURVE DATA - LEG 'B'

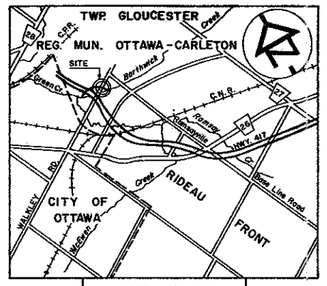
Δ = 4°47'45"
D = 2°
T = 119.97'
L = 239.80'
P.I. STA. 285+79.13 - LEG 'B'
= STA. 88+16.86 - ℄ WALKLEY ROAD

SKEW DATA - 19°

SIN = 0.3255682
COS = 0.9455186
TAN = 0.3443276
SEC = 1.0576207



PROFILE OF WALKLEY ROAD
N.T.S.



KEY PLAN
SCALE - 1 IN. = 1 MI.

93

BENCH MARK

B.M. 215.12 (GEODETIC DATUM)
TOP OF H.E.P.C. CONCRETE MONUMENT 323.0 FT. RT. OF STA. 269+57 E.B.L. HWY. NO. 417

GENERAL NOTES

- CLASS OF CONCRETE 3000 P.S.I.
- CLEAR COVER TO REINFORCING STEEL 2" EXCEPT AS NOTED.
- ALL EXPOSED CORNERS TO BE CHAMFERED ¾".
- FILL SHALL BE PLACED AT BOTH SIDES OF CULVERT SIMULTANEOUSLY.
- WALL DRAINS SHALL BE BITUMINIZED FIBRE PIPE. PLACE 1 CU. FT OF COARSE AGGREGATE AT EACH DRAIN.
- W.P. DENOTES WORKING POINT
  T/C DENOTES TOP OF CONCRETE CULVERT
  E/P DENOTES EDGE OF PAVEMENT

REVISIONS			
	DATE	BY	DESCRIPTION

G. KNIGHTS
REGISTERED PROFESSIONAL ENGINEER
PROVINCE OF ONTARIO

FOR REDUCED PLAN
USE SCALE BELOW
0 1 2 3
3 INCHES ON ORIGINAL PLAN

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS
ONTARIO
Consulting Engineers & Planners

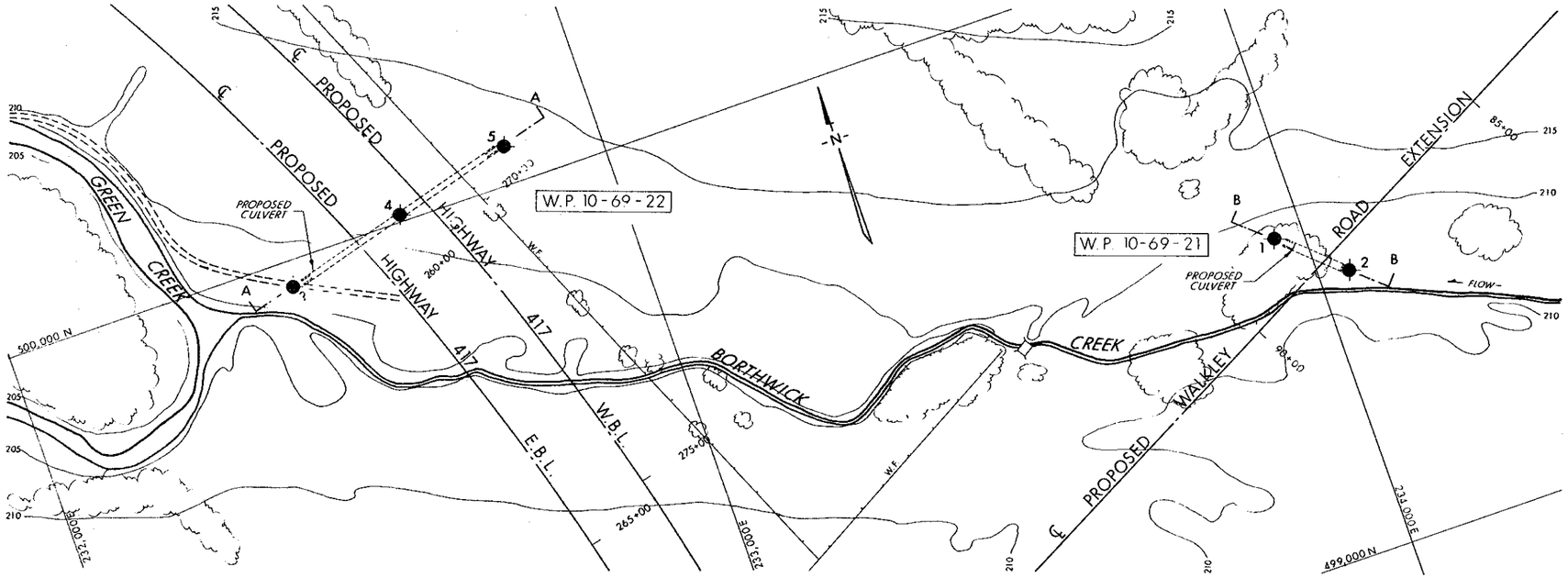
BORTHWICK CREEK UNDER WALKLEY ROAD

KING'S HIGHWAY No. 417 — DIST. No. 9
CO. REG. MUN. OTTAWA - CARLETON
TWP. GLOUCESTER — LOT A — CON. VI

GENERAL LAYOUT

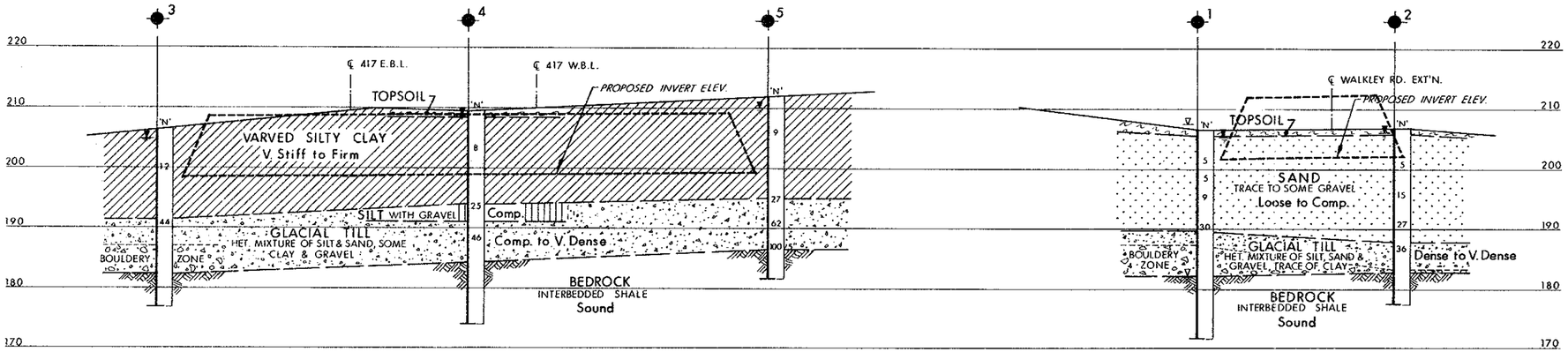
APPROVED (STRUCTURAL ENGINEER)

				SITE No. 3-C-A	W.P. No. 10-69-21
				CONTRACT Nos.	73-R10
DESIGN	STD.	CHECK	G.K.		
DRAWING	C.S.	CHECK	G.K.	DRAWING No.	3-C-A-1
DATE	MAR. 73	LOADING	HS20-44		



PLAN

100 50 0 SCALE 100 200 FT.



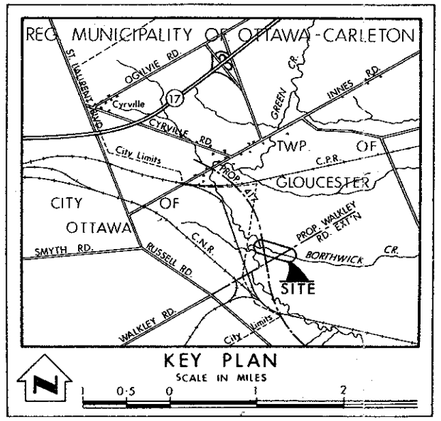
A - A

SECTIONS

VERT. 10 5 0 SCALE 10 20 FT.
HORIZ. 40 20 0 40 80

B - B

NOTE: The complete soil investigation report for this structure may be examined at the Bridge Office and Foundation Office, Downsview, and at the OTTAWA District Office.



LEGEND

- Bore Hole
- Cone Penetration Test
- Bore Hole & Cone Test
- Water Levels established at time of field investigation, JAN. 1973

▽ Head
▽ Encountered
ARTESIAN WATER

NO.	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	206.4	499,529	233,953
2	206.9	499,443	234,049
3	206.4	499,960	232,463
4	209.5	500,012	232,660
5	212.0	500,060	232,852

— NOTE —

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

REVISIONS

DATE	BY	DESCRIPTION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

BORTHWICK CREEK CULVERTS

HIGHWAY NO. ~~417~~ & WALKLEY RD. EXT'N. DIST. NO. 9
REG. MUNICIPALITY OF OTTAWA - CARLETON
TWP. GLOUCESTER LOT ____ CON. ____

BORE HOLE LOCATIONS & SOIL STRATA

SUBMD. D.B.	CHECKED W.P.	W.P. NO. 10-69-21	DRAWING NO. 72-11146A
DRAWN S.O.	CHECKED	W.O. NO. 72-11146	
DATE 23 FEB. 1973		SITE NO. 3-C-A	BRIDGE DRAWING NO 3-C-A-2
APPROVED PRINCIPAL FOUNDATION ENGINEER		CONT. NO. 73-6D	

THURBER

APPENDIX 10

SITE 3-312/C

THURBER

MEMORANDUM

To: Laura Donaldson, P.Eng.
McIntosh Perry Consulting Engineers

Date: July 17, 2015

From: Kenton Power, M.A.Sc., P.Eng.
(Reviewed by Fred Griffiths, P.Eng. and P.K. Chatterji, P.Eng.)

File: 19-3405-3

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 417 STRUCTURAL CULVERT (SITE 3-312/C)
GWP 4074-11-00, GEOCRES 31G5-262

PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This memo presents a brief summary of the factual findings from a foundation review carried out for the twin culvert structure carrying traffic on Walkley Road over Green Creek in Ottawa, Ontario. It also presents preliminary geotechnical recommendations for potential culvert extensions or replacement. It is noted that the proposed construction options for this site are not yet defined. The preliminary recommendations provided below are for assistance in developing and evaluating the options and will need to be refined during subsequent design stages.

The following reference numbers apply to this site:

- Current W.P. -
- Site No. 3-312/C
- GEOCRES No. 31G5-87
- Construction Contract 73-190
- Historic W.P. 10-69-13

2 SITE DESCRIPTION

The site is located in eastern Ottawa, in the Township of Gloucester approximately 350 m southwest of the Highway 417 / Walkley Road Interchange. The twin culverts carry the Green Creek flow below Walkley Road (four lanes in total plus paved sidewalks and a concrete median) and the on and off ramps for the Walkley Road Interchange. Based on the historic General Layout Drawing (copy attached), the twin circular steel pipe culverts were constructed with beveled inlet and outlet sections. The total length of structure is reported to be 66.5 m. The internal diameter of each pipe culvert was noted as 5.5 m. Prior to construction of the culvert Green Creek flowed from south to north at a location further to the west. The creek was diverted to an area of relatively flat ground at an approximate elevation of 66.5 m. Mature trees are located on the north side of Walkley Road while the south side is brush and grass covered. Site photos showing the general site conditions are attached.

THURBER

3 SUBSURFACE CONDITIONS

A site investigation was carried out by the MTO Foundations Office; GEOCRES Report No. 31G5-87 dated December 1972. The original investigation was conducted in October 1972 and consisted of two sampled boreholes designated 1 and 2 and one dynamic cone penetration test designated 1A. Additional fieldwork was undertaken at the site in February 1973 to better understand the groundwater regime at the site. The additional field work consisted of two sampled boreholes designated 3 and 4 and the excavation of a single test pit (designated TP1). An addendum to the original report was issued February 1973 to incorporate findings of the second investigation. Drawing No. 72-11088A (copy attached) illustrates the locations of the culvert structures, the investigation boreholes, test pits, and the soil strata plot for the investigation. The stratigraphy in the area of the culvert structure is generally characterized by a silty clay, silt and sand overlying a dense glacial till material consisting mainly of silt and sand, underlain by shale bedrock.

3.1 Silty Clay

A clay stratum with interspersed seams of clayey silt to silt was encountered in all four boreholes. The thickness of the individual seams was noted to range from 13 mm to 50 mm. The top of the clay strata ranged from 66.8 m to 66.1 m in elevation and the layer had a thickness of 6.4 m to 7.6 m. The standard penetration test (SPT) 'N' values ranged from 4 to 15 blows per 0.3 m. The estimated undrained shear strength based on in-situ field vane tests ranged from 28 kPa to 95 kPa while laboratory vane tests results ranged from 29 kPa to 57 kPa. The unconfined shear strength and quick triaxial testing carried out on four samples yielded results of 142 kPa to 29 kPa. Based on these values, it is estimated that the consistency of the stratum varies from very stiff in the upper portion decreasing to firm with depth.

Atterberg Limits test results of four samples of the silty clay material indicate a clay of intermediate plasticity to a clay of high plasticity.

Consolidation characteristics determined for the silty clay from two oedometer tests indicate an initial void ratio of 0.838 and 1.388 and compression index of 0.048 and 0.724. The pre-consolidation pressure was found to be in excess of 200 kPa higher than the effective in-situ vertical stress.

The moisture content of the samples tested ranged from 30% to 50%.

3.2 Silt

The silt stratum was encountered in all four boreholes. The top of the silt stratum ranged from 58.4 m to 59.7 m in elevation and the layer had a thickness of 3.0 m to 3.4 m in Boreholes 1 and 2. Both Boreholes 3 and 4 were terminated in this soil without penetrating the full thickness of this stratum. The SPT 'N' values ranged from 1 to 12 blows per 0.3 m indicating a very loose to compact condition but typically loose.

The results of a grain size analysis test including hydrometer testing completed on three samples of this material indicated a gravel content ranging from 0% to 28%, sand content

ranging from 33% to 53%, silt content ranging from 28% to 52%, and clay content ranging from 7% to 15%.

The moisture content of the samples tested ranged from 7% to 22%.

3.3 Till

A glacial till stratum was encountered beneath the silt stratum in Boreholes 1 and 2. The till was described as a heterogeneous mixture of silt, sand and clay. The top of the glacial till stratum ranges from 56.3 m to 56.4 m in elevation and the layer had a thickness of 4.3 m to 4.6 m. The SPT 'N' valued ranged from 10 to 135 blows per 0.3 m indicating a compact to very dense condition.

The moisture content of the samples tested was 7% to 8%.

3.4 Bedrock

A shale bedrock was encountered beneath the glacial till in Boreholes 2 as proven by BX size coring. Auger refusal on inferred bedrock was noted in Borehole 1. The bedrock surface elevation ranged from 51.9 m to 52.1 m. Bedrock core recovery ranged from 91% to 100%. The bedrock was described to be in sound condition. Geological mapping suggests the bedrock at this site is shale of the Carlsbad Formation.

3.5 Groundwater

Groundwater levels were measured in the open boreholes prior to backfilling at elevations ranging from 61.6 m to 64.6 m.

4 SITE OBSERVATIONS

A structure inspection was conducted by MTO in July 2012 for Culverts 3-312/C with the report issued November 2012. Condition data outlined in the report for the for culvert structure ranged from poor to good but typically the culvert was rated in good condition with no proposed recommended work on the structure at the time of the inspection. It was noted that there was a 1.0 m thick deposit of sediment inside the culvert and the stream was stagnant in the south culvert with the majority of the stream flow through the north culvert.

The site was inspected by Thurber Engineering Ltd. staff during the week of July 14, 2014. Several photographs of the site are attached. At the time of the inspection, the following observations were made:

South Inlet:

- Gabions were installed at the site for erosion protection
- Vegetation on side slopes was noted
- No obvious settlement of road or ramp surface was observed at the crossing

North Outlet:

- Gabions were installed at the site for erosion protection
- Vegetation on side slopes was noted
- No obvious settlement of road or ramp surface was observed at the crossing

5 GEOTECHNICAL ASSESSMENT

5.1 Frost Considerations

The frost penetration depth at this site is 1.8 m (OPSD 3090.101).

5.2 Seismic Considerations

This site is classified as a Soil Profile Type III in accordance with Section 4.4.6 of the Canadian Highway Bridge Design Code (CHBDC). The zonal acceleration ratio for this site is 0.20 as per Table A3.1.1 of the CHBDC.

The silt stratum maybe susceptible to liquefaction during the design earthquake event at approximate elevations between 55 m and 60 m due to the loose condition of the silt and the high groundwater table. Based on the density of the till and the plasticity of the clay, these materials are classified as “not susceptible” to liquefaction during the design earthquake event.

5.3 Existing Foundations

As indicated on the General Layout Drawing the design invert elevation of the twin culverts was noted as 60.0 m. A 300 mm thick layer of select subgrade material was noted as bedding material for the culverts. Therefore, the culvert is founded at an approximate elevation 59.7 m which is near the base of the silty clay stratum. The recommended design allowable bearing value as reported in the Foundation Design Report was 48 kPa.

The Foundation Design Report also indicates that design elevation for Walkley Road at the culvert crossing was to be approximately 69.2 m. Therefore approximately 2.7 m of fill would have been required to construct the Walkley Road extension in the vicinity of the culverts.

PART 2: ENGINEERING DISCUSSION AND PRELIMINARY RECOMMENDATIONS

6 GEOTECHNICAL RECOMMENDATIONS

Based on the available data regarding the ground conditions at this site, the following sections present preliminary geotechnical recommendations for the assessment of the existing culverts and for preliminary design for potential culvert extensions, replacement, and the construction of new wing walls, end sections and/or headwall structures, if required. It is noted that the proposed construction options for this site are not yet defined. The preliminary

recommendations provided below are for assistance in developing and evaluating options and will need to be refined during subsequent design stages.

The existing culverts are CSPs likely founded on firm clay. For culvert extensions, it is preferred that type of foundations and founding elevation match the existing arrangement so as not to undermine the existing foundation. From a foundation perspective for culvert replacements, concrete rigid-frame open-footing culverts could have bearing resistance limitations as well as groundwater concerns during construction. Both concrete closed boxes and CSPs would be preferred.

6.1 Shallow Foundations

For strip footings founded on native very stiff to firm silty clay having a minimum embedment depth of 1.8 m and a width of between 1 m and 2 m, the factored vertical geotechnical resistance at ULS is 120 kPa. The vertical geotechnical reaction at SLS is 100 kPa based on a total footing settlement of 25 mm.

For strip footings founded on native silt having a minimum embedment depth of 1.8 m and a width of between 1 m and 2 m, the factored vertical geotechnical resistance at ULS is 150 kPa. The vertical geotechnical reaction at SLS is less than 50 kPa based on a total footing settlement of 25 mm.

A replacement culvert would likely require a span and an invert elevation similar to the existing. For a closed box culvert founded at the same elevation as the existing culvert on native very stiff to firm clay and a base width of 5.5 m, the factored vertical geotechnical resistance at ULS is 150 kPa. The vertical geotechnical reaction at SLS is 85 kPa based on a total footing settlement of 25 mm.

Resistance to lateral forces and sliding resistance between concrete and steel and underlying materials should be evaluated using an unfactored coefficients of friction provided in Table A.

Table A: Unfactored Coefficients of Friction between Concrete and Steel and Founding Material

	Founding Material	
Culvert Material	**Silt**	**Silty Clay**
Steel	0.20	0.25
Cast-in-place concrete	0.35	0.35
Precast concrete	0.30	0.30

6.2 Excavations, Bedding and Backfilling

All excavations must be conducted in accordance with the requirements of the Occupational Health & Safety Act & Regulations (OHSA) for Construction Projects. The native very stiff to firm silty clay material reported at this site should be classified as Type 3 in accordance with OHSA.

Where excavations will extend below the groundwater level prevailing at the time of construction, the contractor will need to implement groundwater control and ground support systems as are required to carry out the construction in a safe, stable, and unwatered excavation.

It is noted that excavation base instability is possible at this site for some excavation depths due to unbalanced hydrostatic forces in the water bearing silt and glacial till strata. Well point and or sheet pile enclosures to depressurize the silt layer may be needed.

Backfill to the culvert must consist of free draining granular material conforming to OPSS Granular A or B material specifications. The granular material must be placed to the extent shown on OPSD 803.030 or 803.031.

Subgrade preparation and placement of culvert bedding must be carried out in the dry.

6.3 Static Lateral Earth Pressure Coefficients

Lateral earth pressures acting on structures should be computed in accordance with the CHBDC but generally are given by the expression:

$$P_h = K^*(\gamma h + q)$$

where:

P_h = horizontal pressure on the wall (kPa)
K = earth pressure coefficient
γ = unit weight of retained soil
h = depth below top of fill where pressure is computed (m)
q = value of any surcharge (kPa)

The recommended lateral earth pressure parameters for use in the design for both a horizontal and for 2H:1V (Horizontal:Vertical) back-slope are provided in Table B.

Active pressures should be used for the design of unrestrained walls.

A lateral pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with the Section 6.9.3 of the CHBDC.

The parameters provided in Table B are based on the assumption that the backfill is fully drained so that there are no unbalanced hydrostatic pressures. If adequate drainage cannot be confirmed, the potential for hydrostatic pressures should be considered.

Table B: Static Lateral Earth Pressure Coefficients

Parameter	OPSS Granular A & OPSS Granular B Type II	OPSS Granular B Type I	Native Silty Clay
Soil Unit Weight, kN/m^3, γ	21	20	17

Angle of Internal Friction, ϕ	35°	30°	27°
Horizontal Back-Slope			
Coefficient of at Rest Earth Pressure, K_o (Restrained Wall)	0.43	0.5	0.55
Coefficient of Active Earth Pressure, K_a (Unrestrained Wall)	0.27	0.33	0.38
2H:1V Back-Slope			
Coefficient of Active Earth Pressure, K_a	0.39	0.53	0.70

6.4 Erosion Control

Erosion protection should be provided at the culvert inlet and outlet areas. Design of the erosion protection measures must consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field.

Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact. Treatment at the outlets should be in accordance with OPSD 810.010. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS 804.

A concrete cut-off wall or clay seal should be installed at the culvert inlet to minimize the potential for seepage through the granular bedding and backfill material and avoid consequent erosion of these materials. The clay seal should have a minimum thickness of 0.5 m, completely surround the culvert (excluding beneath an open footing culvert), extend laterally the width of the granular backfill material, and extend above the high water level. The material used for the clay seal should conform to the requirements of OPSS 1205.

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Based on the original MTO Foundation Design Report, the embankments would extend approximately 2.7 m above the grades existing at the time of the investigation. Side slopes of 2H:1V were considered to be stable and settlement of less than 25 mm was predicted. It is anticipated that minor grade raises or embankment widening would therefore not induce significant additional settlement or generate stability concerns.

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Further foundation investigations and analysis must be carried out should the culvert structure be replaced or extended or if the height, geometry, or location of the approach fills are to be modified for either short-term construction staging or for vertical or horizontal re-alignments. Should excavations be anticipated within the embankment fills to repair or modify the culvert, consideration should be given to drilling foundation boreholes in the approaches to determine the nature of the fill materials and to allow generation of road way protection design. It is also recommended that piezometers be installed to better define the groundwater level in both the

silty clay and glacial till strata as well as the in-situ hydraulic conductivity. This information will be required to allow for the design of excavation dewatering systems.

THURBER

8 CLOSURE

We trust this information provided in this technical memorandum meets your present purposes. Please let us know if you have any questions or need additional information.

Thurber Engineering Ltd.

Kenton C. Power, P.Eng.
Geotechnical Engineer

Fred Griffiths, P.Eng.
Associate, Senior Geotechnical Engineer

P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact

Attachments

GWP 4074-11-00
Site Photographs

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 417 STRUCTURAL CULVERT (SITE 3-312/C)

Condition of road surface looking north to south

Condition of outlet

GWP 4074-11-00
Site Photographs

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 417 STRUCTURAL CULVERT (SITE 3-312/C)

Overtop looking down on outlet showing condition of gabions

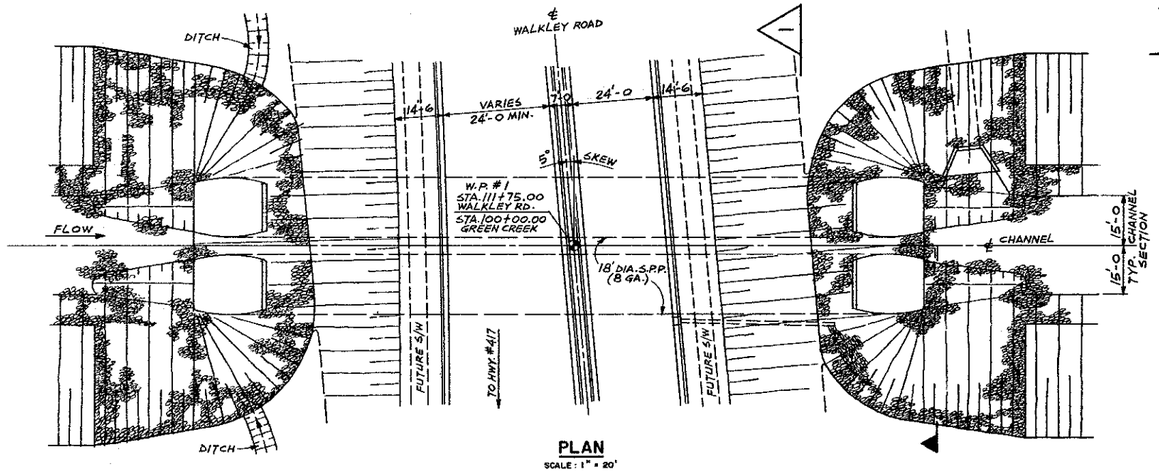
Condition of inlet

GWP 4074-11-00
Site Photographs

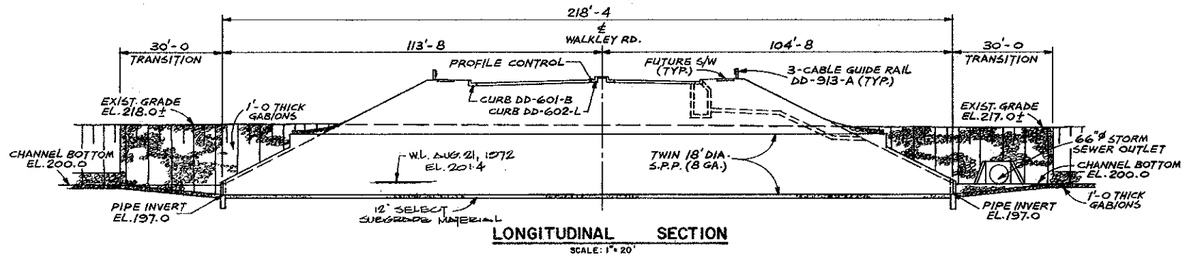
PRELIMINARY FOUNDATION DESIGN
HIGHWAY 417 STRUCTURAL CULVERT (SITE 3-312/C)

Overtop looking down on inlet showing condition of gabions

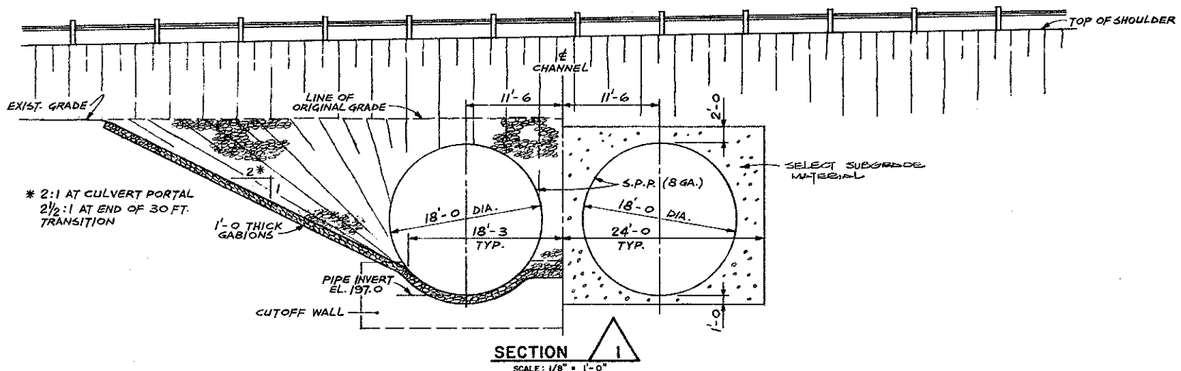
Looking upstream from inlet



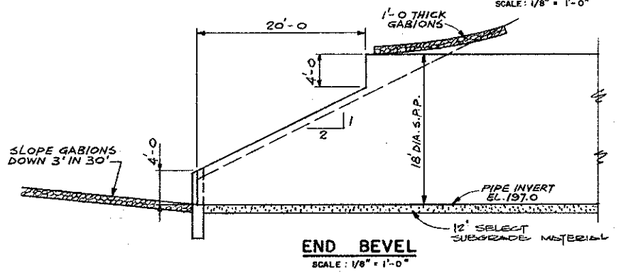
PLAN
SCALE: 1" = 20'



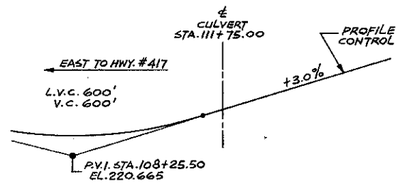
LONGITUDINAL SECTION
SCALE: 1" = 20'



SECTION 1
SCALE: 1/8" = 1'-0"



END BEVEL
SCALE: 1/8" = 1'-0"



PROFILE OF WALKLEY ROAD
N.T.S.

NORTH FOR CONSTRUCTION

LIST OF DRAWINGS
- 3-312-1 - GENERAL LAYOUT
- 3-312-2 - BOREHOLE LOCATION AND SOIL STRATA
- 3-312-3 - CUT OFF WALL DETAILS

SKEW DATA - 5°

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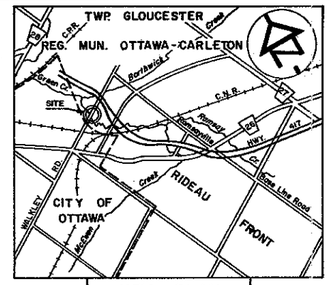
COS = 0.996194
TAN = 0.087488
SEC = 1.003819



99

BENCH MARK

B.M. 215.12 (GEODETIC DATUM)
TOP OF H.E.P.C. CONCRETE MONUMENT 323.0 FT. RT. OF STA. 269+27 E.B.C.

GENERAL NOTES

1 - S.P.P. - STRUCTURAL PLATE PIPE - 6"x2" CORRUGATIONS - GALVANIZED

2 - PROTECTION AGAINST HEAVY CONSTRUCTION EQUIPMENT. PRIOR TO ALLOWING HEAVY CONSTRUCTION EQUIPMENT OVER THE CULVERT, THE DEPTH OF COVER MATERIAL MUST BE A MINIMUM OF 4 FEET, COMPACTED AS SPECIFIED.

3 - CONSTRUCTION STAGING
THIS CULVERT SHALL BE CONSTRUCTED IN SECTIONS OF 30'-0 MAXIMUM LENGTH TO PREVENT INSTABILITY OF SOIL STRATA BENEATH THE CULVERT. EACH SECTION SHALL BE EXCAVATED AND BACKFILLED PRIOR TO EXCAVATING FOR THE NEXT SECTION.

REVISIONS

DATE	BY	DESCRIPTION

G. KNIGHTS
REGISTERED PROFESSIONAL ENGINEER
PROVINCE OF ONTARIO

FOR REDUCED PLAN
USE SCALE BELOW
0 1 2 3
3 INCHES ON ORIGINAL PLAN

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS
ONTARIO
Consulting Engineers & Planners

GREEN CREEK UNDER WALKLEY ROAD IMMEDIATELY SOUTH OF HWY. 417

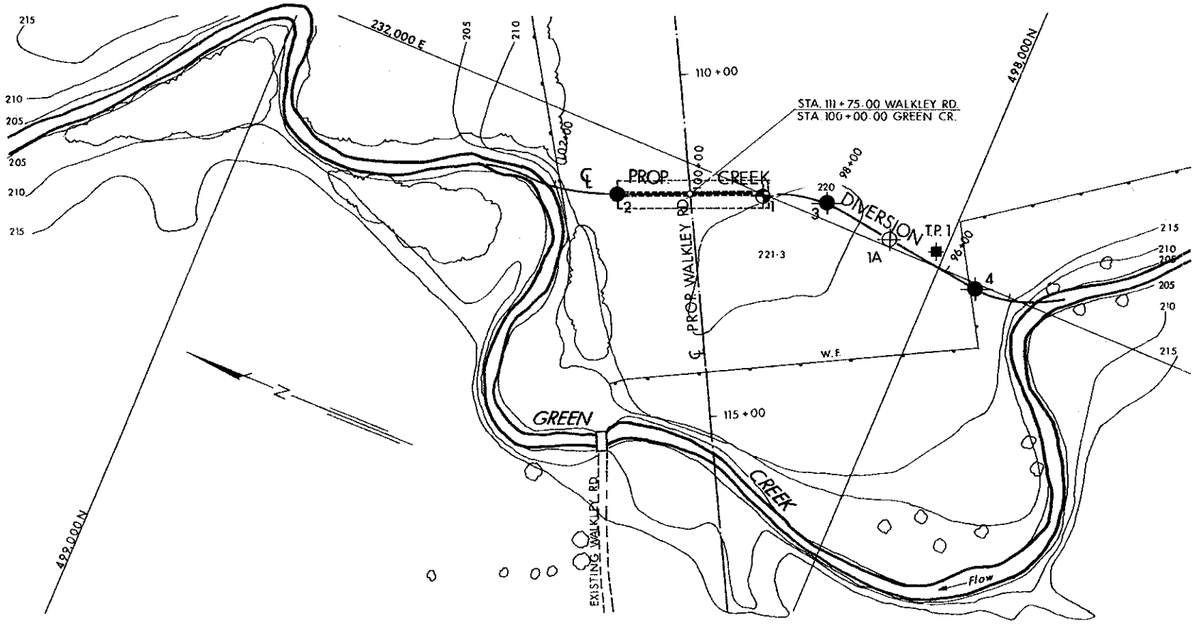
KING'S HIGHWAY No. 417 DIST. No. 9
CO. REG. MUN. OTTAWA - CARLETON
TWP. GLOUCESTER LOT A CON. VI

GENERAL LAYOUT

APPROVED STRUCTURAL ENGINEER

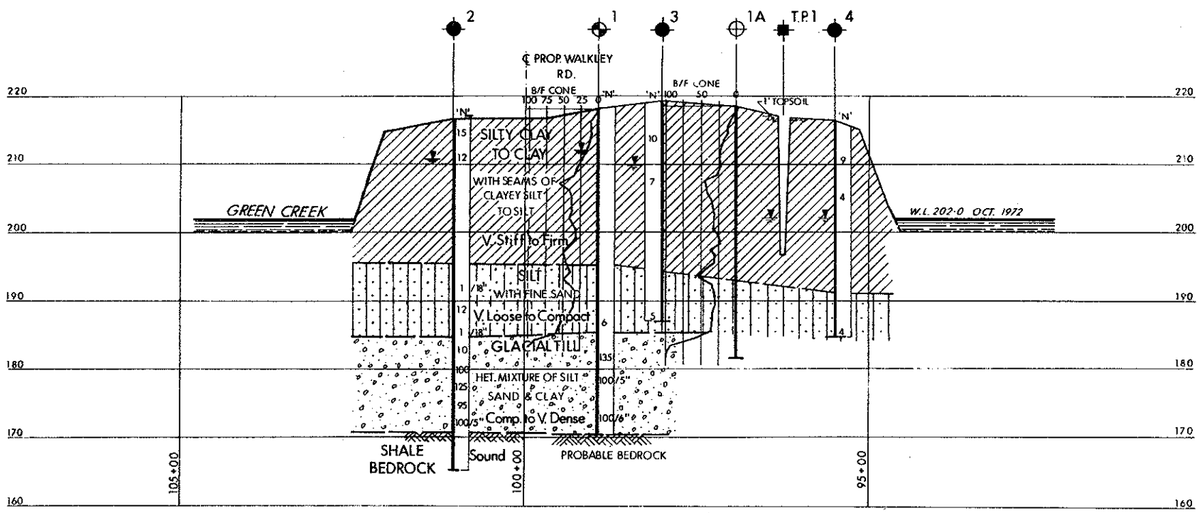
DESIGN	G.K.	CHECK		SITE No. 3-312	W.P. No. 10-69-13
DRAWING	G.L.B.	CHECK	G.K.	CONTRACT Nos.	73-170
DATE	MAR. 73	LOADING	HS20-44	DRAWING No.	3-312-1

100



PLAN

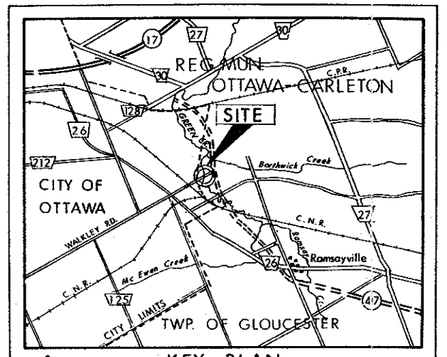
SCALE 100 50 0 100 200 FT.



PROFILE ALONG CREEK DIVERSION

HOR. 100 50 0 SCALE 100 200 FT.

VER. 10 5 0 10 20 FT.



KEY PLAN

SCALE IN MILES 1 0·5 0 1 2 3

LEGEND

- Bore Hole
- Cone Penetration Test
- Bore Hole & Cone Test
- Water Levels established at time of field investigation. OCT. 1972 & FEB. 1973

NO.	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	218·2	498,275	231,995
2	216·8	498,472	231,916
1A	218·8	498,080	232,010
3	219·0	498,187	232,023
4	216·7	497,939	231,990
T.P.1	216·9	498,013	232,019

— 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 soil investigation report for this structure may be examined at the Bridge Office and Foundation Office, Downsview, and at the OTTAWA District Office.

REVISIONS		
DATE	BY	DESCRIPTION
19/4/73	S.O.	BORE HOLES 3,4 & T.P.1 ADDED TO PLAN & PROFILE

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

GREEN CREEK DIVERSION

~~HIGHWAY NO.~~ WALKLEY ROAD DIST. NO. 9

CO. REGIONAL MUNICIPALITY OF OTTAWA—CARLETON

TWP. GLOUCESTER LOT A CON. 6

BORE HOLE LOCATIONS & SOIL STRATA

SUBMTD. C.P.	CHECKED C.P.	W.P. NO. 10-69-13	DRAWING NO. 72—11088A
DRAWN F. L.	CHECKED	W.O. NO. 72—11088	
DATE DEC. 4, 1972		SITE NO. 3 - 312	BRIDGE DRAWING NO. 3 - 312 - 2
APPROVED PRINCIPAL FOUNDATION ENGINEER		CONT. NO. 73-190	

THURBER

APPENDIX 11

SITE3-313/C1

THURBER

MEMORANDUM

To: Laura Donaldson, P.Eng.
McIntosh Perry Consulting Engineers

Date: July 17, 2015

From: Kenton Power, M.A.Sc., P.Eng.
(Reviewed by Fred Griffiths, P.Eng. and P.K. Chatterji, P.Eng.)

File: 19-3405-3

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 417 EASTBOUND STRUCTURAL CULVERT (SITE 3-313/C1)
GWP 4074-11-00 GEOCRES 31G5-262

PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This memo presents a brief summary of the factual findings from a foundation review carried out for the twin culvert structure carrying traffic on Highway 417 eastbound over Green Creek in Ottawa, Ontario. It also presents preliminary geotechnical recommendations for potential culvert extensions or replacement. It is noted that the proposed replacement or extension alternatives are not yet defined however, it is likely that the top of the embankment will be widened towards the existing median as much as 7.0 m to accommodate the addition of another lane. The preliminary recommendations provided below are for assistance in developing and evaluating the options and will need to be refined during subsequent design stages.

The following reference numbers apply to this site:

- Current W.P. -
- Site No. 3-313/C1
- GEOCRES No. 31G5-89
- Construction Contract 73-190
- Historic W.P. 10-69-14

2 SITE DESCRIPTION

The site is located in eastern Ottawa, in the Township of Gloucester approximately 600 m south of the Highway 417 / Walkley Road Interchange. The twin culverts carry the Green Creek flow below the Highway 417 eastbound lanes and the on ramp for the Walkley Road Interchange (three lanes in total plus gravel shoulders). Based on the historic General Layout Drawing (copy attached), the twin circular steel pipe culverts were constructed with bevel inlet and outlet sections. The total length of structure is reported to be 74.5 m. The internal diameter of each pipe culvert is noted as 5.5 m. Prior to construction of the culvert, Green Creek flowed from south to north at a location further to the south. The creek was diverted to an area at an approximate elevation range from 62 to 64 m with an old roadway embankment (Ridge Road)

crossing the culvert alignment at approximate elevation of 66.5 m. The terrain in the vicinity of the inlets and outlets of the culvert is generally flat and is brush and grass covered. Site photos showing the general site conditions are attached.

3 SUBSURFACE CONDITIONS

A site investigation was carried out by the MTO Foundations Office; GEOCRES Report No. 31G5-89 dated September 1972. The investigation was conducted in August 1972 and consisted of two sampled boreholes designated 1 and 3 both accompanied by dynamic cone penetration tests. Drawing No. 72-11092A (copy attached) illustrates the locations of the culvert structures, the investigation boreholes, and the soil strata plot for the investigation. The stratigraphy in the area of the culvert structure is generally characterized by a silty clay, over glacial till material consisting mainly of silt and sand, underlain by shale bedrock.

3.1 Silty Clay

A clay stratum with interspersed seams of silt was encountered in both boreholes. The thickness of the individual seams was noted to range from 13 mm to 25 mm. The top of the clay strata ranged from 66.4 m to 63.6 m in elevation and the layer had a thickness of 6.1 m to 8.8 m. The standard penetration test (SPT) 'N' values ranged from 6 to 16 blows per 0.3 m. The estimated undrained shear strength based on both in-situ field vane and laboratory tests ranged from 38 kPa to 105 kPa. The consistency of the stratum varies from very stiff in the upper portion decreasing to firm with depth.

The results of grain size analysis tests including hydrometer testing completed on five samples of this material indicated a gravel content of 0%, sand content ranging from 0% to 6%, silt content ranging from 46% to 81% and a clay content ranging from 19% to 53%.

Atterberg Limits test results of five samples of the silty clay material indicate a clay of intermediate plasticity to a clay of high plasticity. Three samples were found to be of low plasticity.

Consolidation characteristics determined for the silty clay from oedometer tests on four samples from the Highway 417 east and westbound boreholes indicate an initial void ratio ranging from 1.24 to 1.50 and a compression index ranging from 0.53 to 0.87. The pre-consolidation pressure was found to be in excess of 150 kPa.

The moisture content of the samples tested ranged from 30% to 60%.

3.2 Glacial Till

A glacial till stratum was encountered beneath the silty clay stratum in both boreholes. The till was described as a heterogeneous mixture of silt, sand and gravel with some clay. The top of the glacial till stratum was recorded as 57.5 m in elevation in both boreholes and the layer had a thickness of 4.4 m to 4.6 m. The SPT 'N' values ranged from 5 to 29 blows per 0.3 m indicating a loose to compact condition, but typically compact.

The results of a grain size analysis test including hydrometer testing completed on two samples of this material indicated a gravel content ranging from 16% to 17%, sand content ranging from 41% to 64%, silt content ranging from 10% to 31%, and clay content ranging from 10% to 11%

The moisture content of the samples tested ranged from 10% to 19%.

3.3 Bedrock

A grey shale bedrock was encountered beneath the glacial till in both boreholes as proven by BX size coring. The bedrock surface elevation ranged from 52.9 m to 53.1 m. Bedrock core recovery was recorded as 100% for both boreholes. The bedrock was noted as being in sound condition. Geological mapping suggests the bedrock at this site is shale of the Carlsbad Formation.

3.4 Groundwater

Groundwater levels were measured in the open boreholes prior to backfilling at elevations ranging from 62.4 m to 64.8 m.

The water level of Green Creek at the time of the investigation as indicated on the General Layout Drawing was 62.6 m.

4 SITE OBSERVATIONS

A structure inspection was conducted by MTO in August 2012 for culverts 3-313/C1 with the report issued September 2012. Condition data outlined in the report for the culvert structure ranged from poor to good but typically the culvert was rated in good condition with no proposed recommended work on the structure at the time of the inspection. It was noted that there was a 300 mm thick deposit of sediment inside the culverts and that the south cell would be blocked during low flow conditions.

The site was inspected by Thurber Engineering Ltd. staff during the week of July 14, 2014. Several photographs of the site are attached.

At the time of the inspection, the following observations were made:

East Inlet:

- Gabions were installed at the site for erosion protection
- Vegetation on side slopes was noted
- Creek flow was only through the north culvert as the south culvert was completely blocked by sediment and vegetation growth
- Backslope behind bevel sections was measured at approximately 20°
- No obvious settlement of road surface was observed at the crossing

West Outlet:

- Gabions were installed at the site for erosion protection
- Vegetation on side slopes was noted
- Creek flow was only through the north culvert as the south culvert was completely blocked by sediment and vegetation growth
- Backslope behind bevel sections was measured at approximately 20°
- No obvious settlement of road or ramp surface was observed at the crossing

5 GEOTECHNICAL ASSESSMENT

5.1 Frost Considerations

The frost penetration depth at this site is 1.8 m (OPSD 3090.101).

5.2 Seismic Considerations

This site is classified as a Soil Profile Type III in accordance with Section 4.4.6 of the Canadian Highway Bridge Design Code (CHBDC). The zonal acceleration ratio for this site is 0.20 as per Table A3.1.1 of the CHBDC.

Based on the density of the till and the plasticity of the clay, these materials are classified as “not susceptible” to liquefaction during the design earthquake event.

5.3 Existing Foundations

As indicated on the General Layout Drawing the design invert elevation of the culverts was to range from 60.7 m to 60.7 m. A 457 mm thick layer of select subgrade material was indicated as bedding material for the culverts. With the 457 mm thick bedding layer as noted on the structural drawing the approximate founding elevation for the culvert would be 60.2 m.

The Foundation Design Report recommended that a granular bedding layer 1.4 m thick be placed beneath the culverts so that the increased stress applied to the native clay by the culvert and embankments would not exceed the allowable bearing capacity of the founding soil. The recommended design allowable bearing value as reported in the Foundation Design Report was 100 kPa.

The General Layout Drawing indicates that the design elevation for Walkley Road at the culvert crossing was to be approximately 73.1 m. Therefore embankment fill heights ranging from approximately 6.7 m to 10.0 m with an average height of 8.4 m would have been required to construct Walkley Road in the vicinity of the culverts. A culvert camber of 100 mm was included in the contract drawings to mitigate the effects of settlement.

THURBER

PART 2: ENGINEERING DISCUSSION AND PRELIMINARY RECOMMENDATIONS

6 GEOTECHNICAL RECOMMENDATIONS

Based on the available data regarding the ground conditions at this site, the following sections present preliminary geotechnical recommendations for the assessment of the existing culvert and for preliminary design for potential culvert extensions, replacement, and the construction of new wing walls, end sections and/or headwall structures, if required. It is noted that the proposed construction options for this site are not yet defined however, it is likely that the top of the embankment will be widened towards the existing median as much as 7.0 m to accommodate the addition of another lane. The preliminary recommendations provided below are for assistance in developing and evaluating options and will need to be refined during subsequent design stages.

The existing culverts are CSPs likely founded on firm clay. For culvert extensions, it is preferred that type of foundations and founding elevation match the existing arrangement so as not to undermine the existing foundation. From a foundation perspective for culvert replacements, concrete rigid-frame open-footing culverts could have bearing resistance limitations as well as groundwater concerns during construction. Both concrete closed boxes and CSPs would be preferred.

6.1 Shallow Foundations

For shallow foundations founded on native very stiff to firm silty clay having a minimum embedment depth of 1.8 m and a width of between 1 m and 2 m, the factored vertical geotechnical resistance at ULS is 150 kPa. The vertical geotechnical reaction at SLS is 100 kPa based on a total footing settlement of 25 mm.

A replacement culvert would likely require a span and an invert elevation similar to the existing. For a closed box culvert founded at the same elevation as the existing culvert on native very stiff to firm clay with a 1.8 m embedment and a base width of 6.2 m, the factored vertical geotechnical resistance at ULS is 120 kPa. The vertical geotechnical reaction at SLS is 70 kPa based on a total footing settlement of 25 mm. An increase in the thickness of the bedding layer would allow higher values at ULS to be obtained.

Resistance to lateral forces and sliding resistance between concrete and steel and underlying materials should be evaluated using an unfactored coefficients of friction provided in Table A.

Table A: Unfactored Coefficients of Friction between Concrete and Steel and Founding Material

	Founding Material
Culvert Material	**Silty Clay**
Steel	0.25
Cast-in-place concrete	0.35

Precast concrete	0.30

6.2 Excavations, Bedding and Backfilling

All excavations must be conducted in accordance with the requirements of the Occupational Health & Safety Act & Regulations (OHSA) for Construction Projects. The native very stiff to firm silty clay material reported at this site should be classified as Type 3 in accordance with OHSA.

Where excavations will extend below the groundwater level prevailing at the time of construction, the contractor will need to implement groundwater control and ground support systems as are required to carry out the construction in a safe, stable, and unwatered excavation.

Excavations, bedding and backfill for steel pipe arch culverts should be in accordance with OPSD 802.020 for Type 3 soils. Backfill for the culvert must consist of free draining granular material conforming to OPSS Granular A or B material specifications. The granular material must be placed to the extent shown on OPSD 803.030 or 803.031 and in accordance with OPSS 421 and 401.

Subgrade preparation for foundations and placement of culvert bedding must be carried out in the dry.

6.3 Static Lateral Earth Pressure Coefficients

Lateral earth pressures acting on structures should be computed in accordance with the CHBDC but generally are given by the expression:

$$P_h = K^*(\gamma h + q)$$

where:

P_h = horizontal pressure on the wall (kPa)
K = earth pressure coefficient
γ = unit weight of retained soil
h = depth below top of fill where pressure is computed (m)
q = value of any surcharge (kPa)

The recommended lateral earth pressure parameters for use in the design for both a horizontal and for 2H:1V (Horizontal:Vertical) back-slope are provided in Table B.

Active pressures should be used for the design of unrestrained walls.

A lateral pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with the Section 6.9.3 of the CHBDC.

The parameters provided in Table B are based on the assumption that the backfill is fully drained so that there are no unbalanced hydrostatic pressures. If adequate drainage cannot be confirmed, the potential for hydrostatic pressures should be considered.

Table B: Static Lateral Earth Pressure Coefficients

Parameter	OPSS Granular A & OPSS Granular B Type II	OPSS Granular B Type I	Native Silty Clay
Soil Unit Weight, kN/m^3, γ	21	20	17
Angle of Internal Friction, ϕ	35°	30°	27°
Horizontal Back-Slope			
Coefficient of at Rest Earth Pressure, K_o (Restrained Wall)	0.43	0.5	0.55
Coefficient of Active Earth Pressure, K_a (Unrestrained Wall)	0.27	0.33	0.38
2H:1V Back-Slope			
Coefficient of Active Earth Pressure, K_a	0.39	0.53	0.70

6.4 Embankments

It is anticipated that settlement of the native clay will occur should the embankments be widened and/or the culverts extended. Further settlement of the existing culvert foundations may also occur due to the increase in stress caused by the project works.

6.4.1 Existing Conditions at Culvert 3-313/C1

Based on the original MTO Foundation Design Report, the maximum height of the fill embankments extend 11.0 m a bove the grades existing at the time of the investigation. Side slopes of 2H:1V were considered to be stable provided that mid-height benches were included. Settlement of up to 125 mm was predicted with 50% of the consolidation occurring within 18 months of fill placement. A culvert camber of 100 mm was included in the contract drawings to mitigate the effects of settlement. Minimal additional settlement is anticipated if the culvert were replaced like-for-like in the existing culvert alignment with the embankment reinstated to its current configuration.

6.4.2 Proposed Embankment Widening at Culvert 3-313/C1

The proposed construction options for this site may include the construction of an additional lane. This is to be accomplished by constructing a 7 m median widening of the top of the

embankment while keeping the toe of the slope in its current location and without the use of a mid-height benches.

The existing conditions were modelled based on the survey data provided (copy attached) which indicate that the embankments at Culvert 3-313/C1 are 11 m high and were constructed with side slopes at approximately 2H:1V.

Based on the results of the preliminary slope stability analysis (copies attached), the proposed 7 m median widening can be constructed without the use of mid-height benches from a geotechnical perspective and maintain adequate factors of safety against slope instability in both seismic and static cases. The slope of the new embankment must be constructed of granular material such as OPSS Granular B Type I, at a slope no steeper than 2H:1V and should be built as per OPSD 208.010.

The addition of up to 1.5 m of fill will increase the applied stress on the clay layer and will cause the clay and existing embankment fill to settle. It is estimated that the settlement will be less than 50 mm however, this could impact the pavement surface as well as the culvert.

Headwalls could be added to the culverts, if necessary. However, as noted previously in this memo the available geotechnical resistance for foundations on the underlying soils is limited.

6.5 Erosion Control

Erosion protection should be provided at the culvert inlet and outlet areas. Design of the erosion protection measures must consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field.

Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact. Treatment at the outlets should be in accordance with OPSD 810.010. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS 804.

A concrete cut-off wall or clay seal should be installed at the culvert inlet to minimize the potential for seepage through the granular bedding and backfill material and avoid consequent erosion of these materials. The clay seal should have a minimum thickness of 0.5 m, completely surround the culvert (excluding beneath an open footing culvert), extend laterally the width of the granular backfill material, and extend above the high water level. The material used for the clay seal should conform to the requirements of OPSS 1205. It is noted that a concrete cut off wall was included in the design for this site.

7 ADDITIONAL INVESTIGATIONS

Further foundation investigations and analysis must be carried out should the culvert structure be replaced or extended or if the height, geometry, or location of the approach fills are to be modified for either short-term construction staging or for vertical or horizontal re-alignments. Should excavations be anticipated within the embankment fills to repair or modify the culvert,

consideration should be given to drilling foundation boreholes in the approaches to determine the nature of the fill materials and to allow generation of road way protection design. It is also recommended that piezometers be installed to better define the groundwater level in both the silty clay and glacial till strata as well as the in-situ hydraulic conductivity. This information will be required to allow for the design of excavation dewatering systems.

THURBER

8 CLOSURE

We trust this information provided in this technical memorandum meets your present purposes. Please let us know if you have any questions or need additional information.

Thurber Engineering Ltd.

Kenton C. Power, P.Eng.
Geotechnical Engineer

Fred Griffiths, P.Eng.
Associate, Senior Geotechnical Engineer

P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact

Attachments

GWP 4074-11-00
Site Photographs

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 417 EASTBOUND STRUCTURAL CULVERT (SITE 3-313/C1)

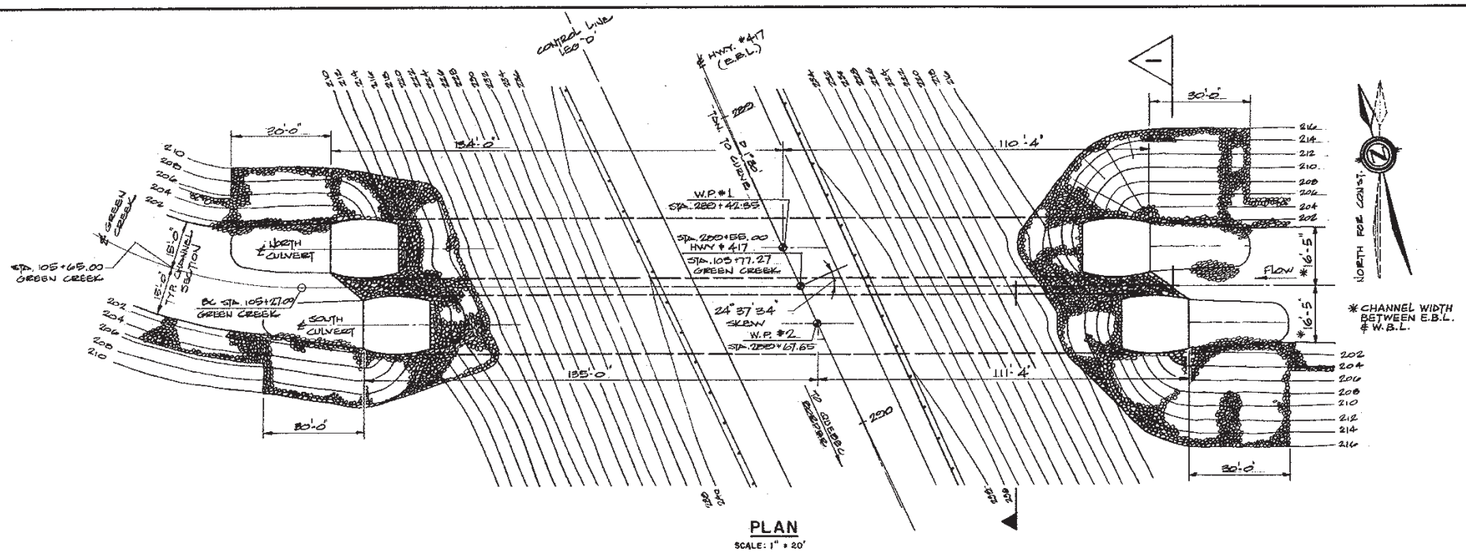
Inlet

Gabions and embankment behind outlet

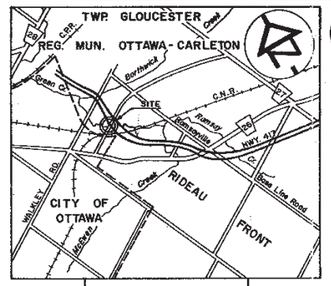
GWP 4074-11-00
Site Photographs

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 417 EASTBOUND STRUCTURAL CULVERT (SITE 3-313/C1)

Overtop of outlet looking downstream



PLAN
SCALE: 1" = 20'



KEY PLAN
SCALE - 1 IN. = 1 MI.

LIST OF DRAWINGS

3-313A-1 - GENERAL LAYOUT
3-313A-2 - BOREHOLE LOCATION AND SOIL STRATA
3-313A-3 - CUT OFF WALL DETAILS

SKEW FUNCTIONS 24° 37' 34"

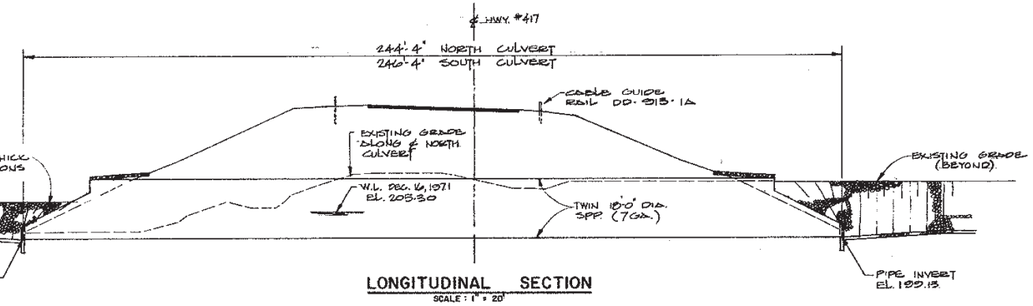
SIN. = 0.41664051
COS. = 0.90900463
TAN. = 0.45883871
SEC. = 1.1000540

CURVE DATA - ℄ E.B.L.

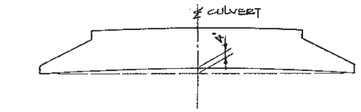
Δc = 50° 46' 10"
Dc = 1° 30' LEFT
T = 1812.43
L = 3384.63
SC = STA. 286+61.24

BENCH MARK

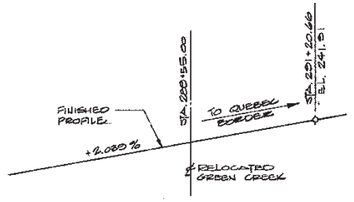
B.M. 221.89
GEODETIC DATUM - TOP NUT ON S.E. CORNER OF HYDRO TOWER 385 FT. RT. OF STA. 288+77. E.B.L.



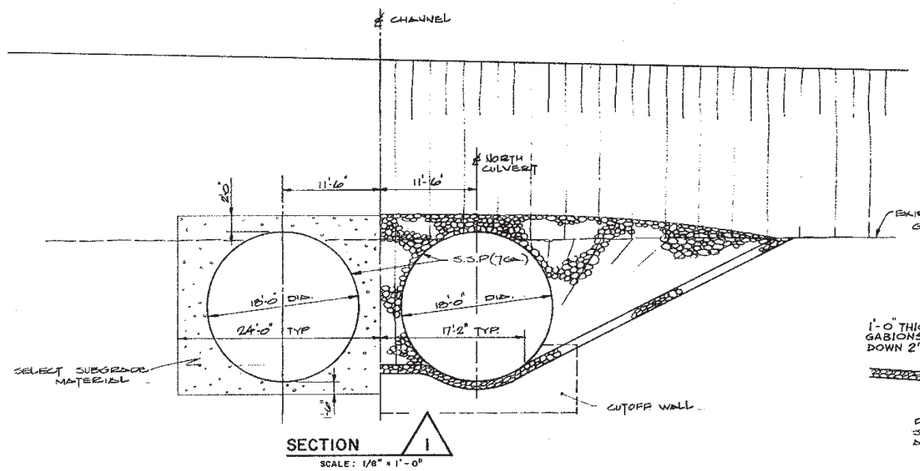
LONGITUDINAL SECTION
SCALE: 1" = 20'



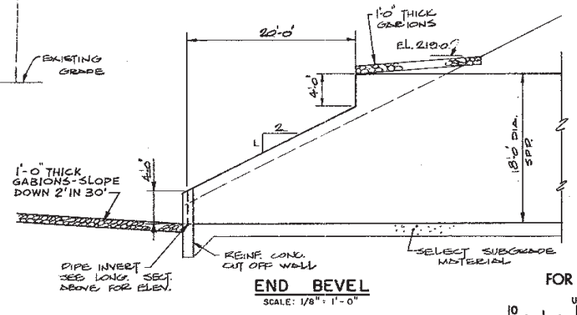
CAMBER DIAGRAM
N.T.S.



PROFILE OF 417 EBL
N.T.S.



SECTION 1
SCALE: 1/8" = 1'-0"



END BEVEL
SCALE: 1/8" = 1'-0"

GENERAL NOTES

STRUCTURAL PLATE - 6"x2" CORRUGATIONS - GALVANIZED

PROTECTION AGAINST HEAVY CONSTRUCTION EQUIPMENT PRIOR TO ALLOWING HEAVY CONSTRUCTION EQUIPMENT OVER THE CULVERT, THE DEPTH OF COVER MATERIAL MUST BE A MINIMUM OF 4 FEET, COMPACTED AS SPECIFIED

FOR REDUCED PLAN
USE SCALE BELOW
0 1 2 3
3 INCHES ON ORIGINAL PLAN

REVISIONS	DATE	BY	DESCRIPTION

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS
ONTARIO
Consulting Engineers & Planners

GREEN CREEK UNDER HWY. 417 EBL
0.4 MI. E OF WALKLEY RD.

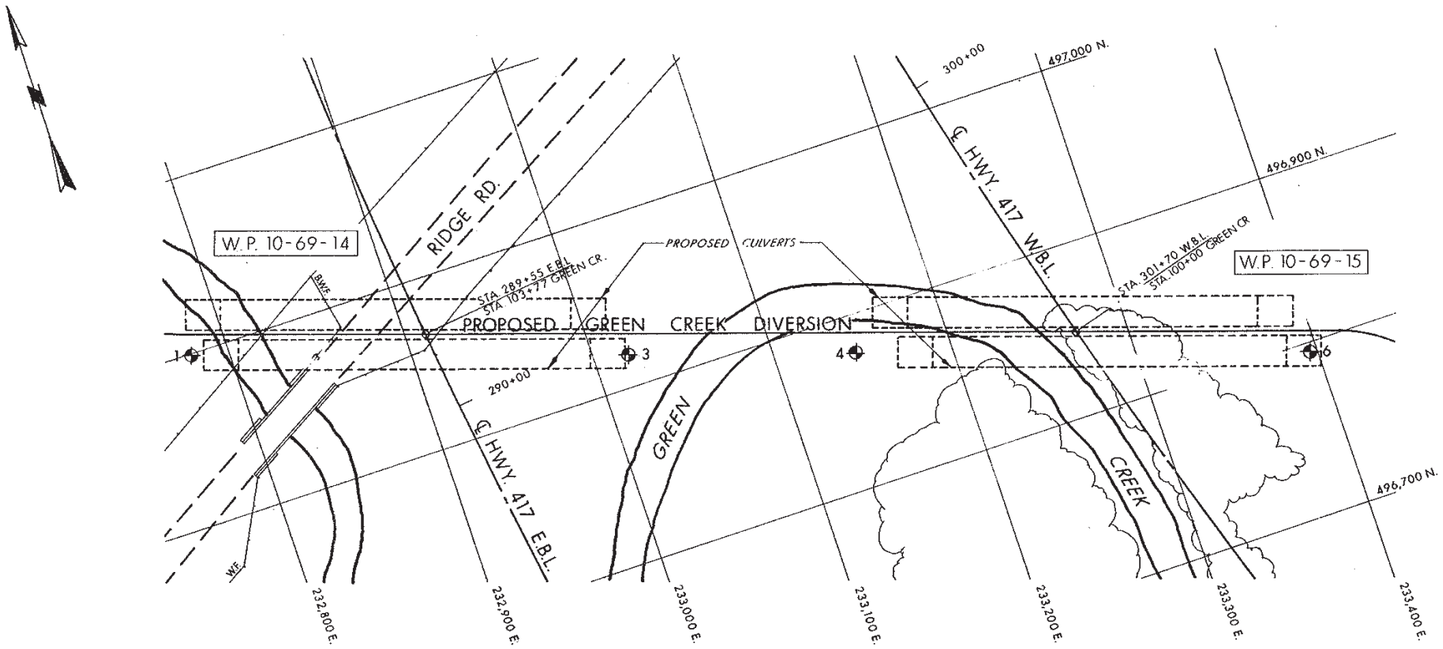
KING'S HIGHWAY No. 417 DIST. No. 9
CO. REG. MUN. OTTAWA - CARLETON
TWP. GLOUCESTER LOTS 1 & 2 CON. VI

GENERAL LAYOUT

APPROVED _____ STRUCTURAL ENGINEER

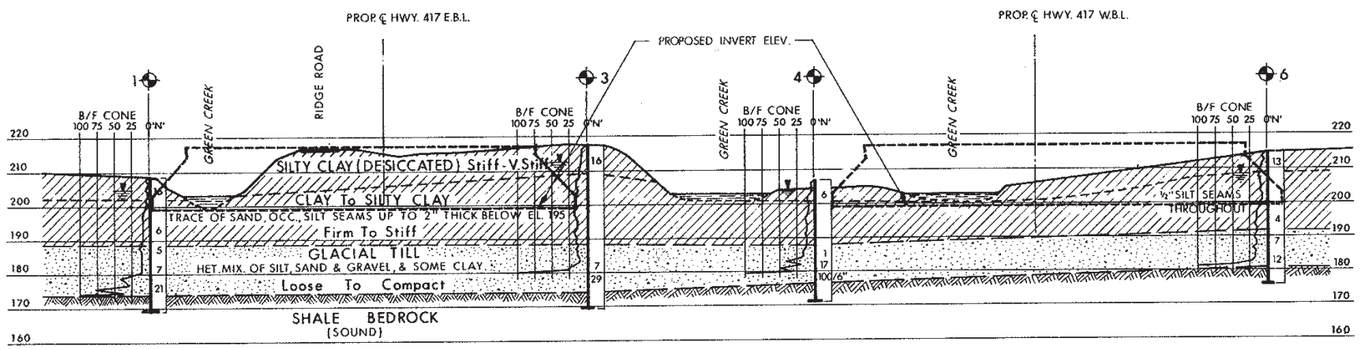
DESIGN	G.K.	CHECK		SITE No. 3-313A	W.P. No. 10-69-14
DRAWING	C.S.	CHECK	G.K.	CONTRACT Nos.	73-190
DATE	MAR. 73	LOADING	HS20-44	DRAWING No.	3-313A-1

R. G. KNIGHTS 100 PROFESSIONAL ENGINEERS PROVINCE OF ONTARIO



PLAN

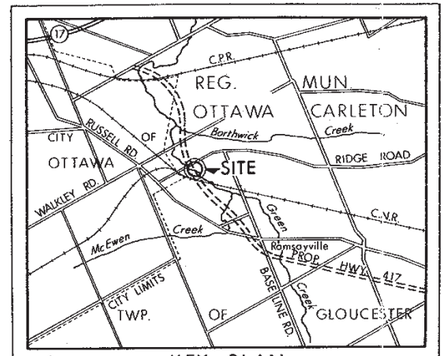
SCALE
40 20 0 40 80 FT.



℄ PROFILE GREEN CREEK DIVERSION

SCALE
HORIZ. 40 20 0 40 80 FT.
VERT. 20 10 0 20 40 FT.

NOTE: The complete soil investigation report for this structure may be examined at the Bridge Office and Foundation Office, Downsview, and at the Ottawa District Office.



LEGEND

- Bore Hole
- Cone Penetration Test
- Bore Hole & Cone Test
- Water Levels established at time of field investigation. AUG. 1972

NO.	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
1	208·7	496,999	232,778
3	217·7	496,919	233,020
4	207·0	496,878	233,146
6	214·5	496,794	233,397

— NOTE —

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

REVISIONS	DATE	BY	DESCRIPTION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS--ONTARIO
DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

GREEN CREEK
(SOUTH OF RIDGE ROAD)

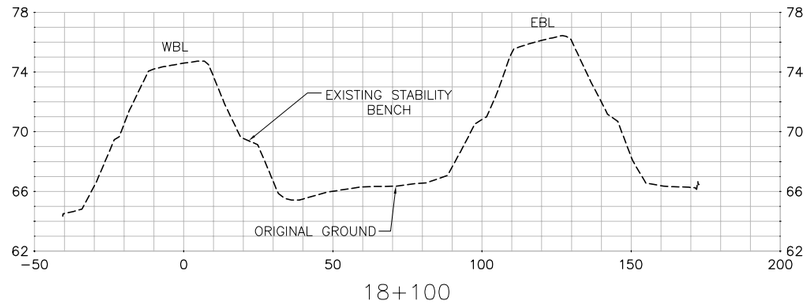
HIGHWAY NO. 417 E.B. ~~& W.B.~~ DIST. NO. 9
CO. REG. MUN. OTTAWA CARLETON
TWP. GLOUCESTER LOT ____ CON. ____

BORE HOLE LOCATIONS & SOIL STRATA

SUBMD. S.A.	CHECKED.	W.P. NO. 10-69-14 ~~30-69-15~~	DRAWING NO. 72-11092 A
DRAWN J.I.G.	CHECKED.	W.O. NO. 72-11092	
DATE 11 SEPT. 1972		SITE NO. 3-313A	BRIDGE DRAWING NO. 3-313A-2
APPROVED PRINCIPAL FOUNDATION ENGINEER		CONT. NO. 73-19D	

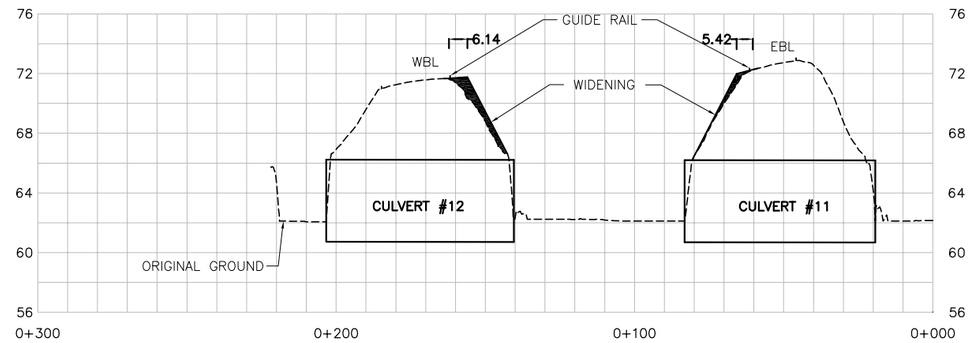
METRIC

STABILITY BENCHING SECTION

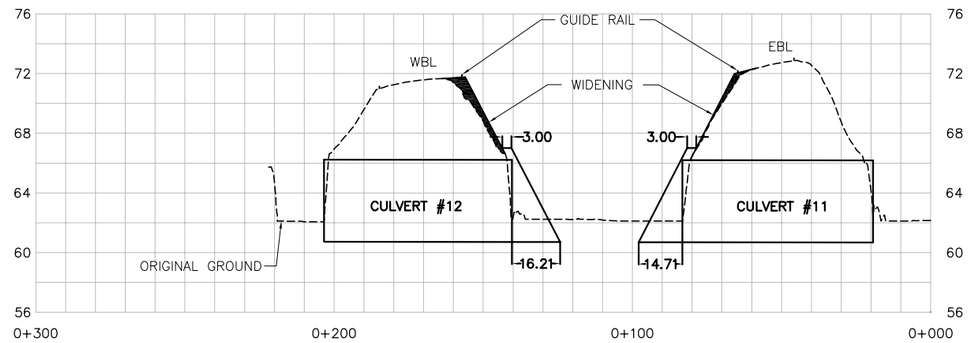


18+100

Site 3−313/C1 and 3−313/C2 Culvert #11 & 12



Site 3−313/C1 and 3−313/C2 Culvert #11 & 12



Ontario

McINTOSH PERRY

HIGHWAY 417
STRUCTURAL CULVERTS #11 & 12

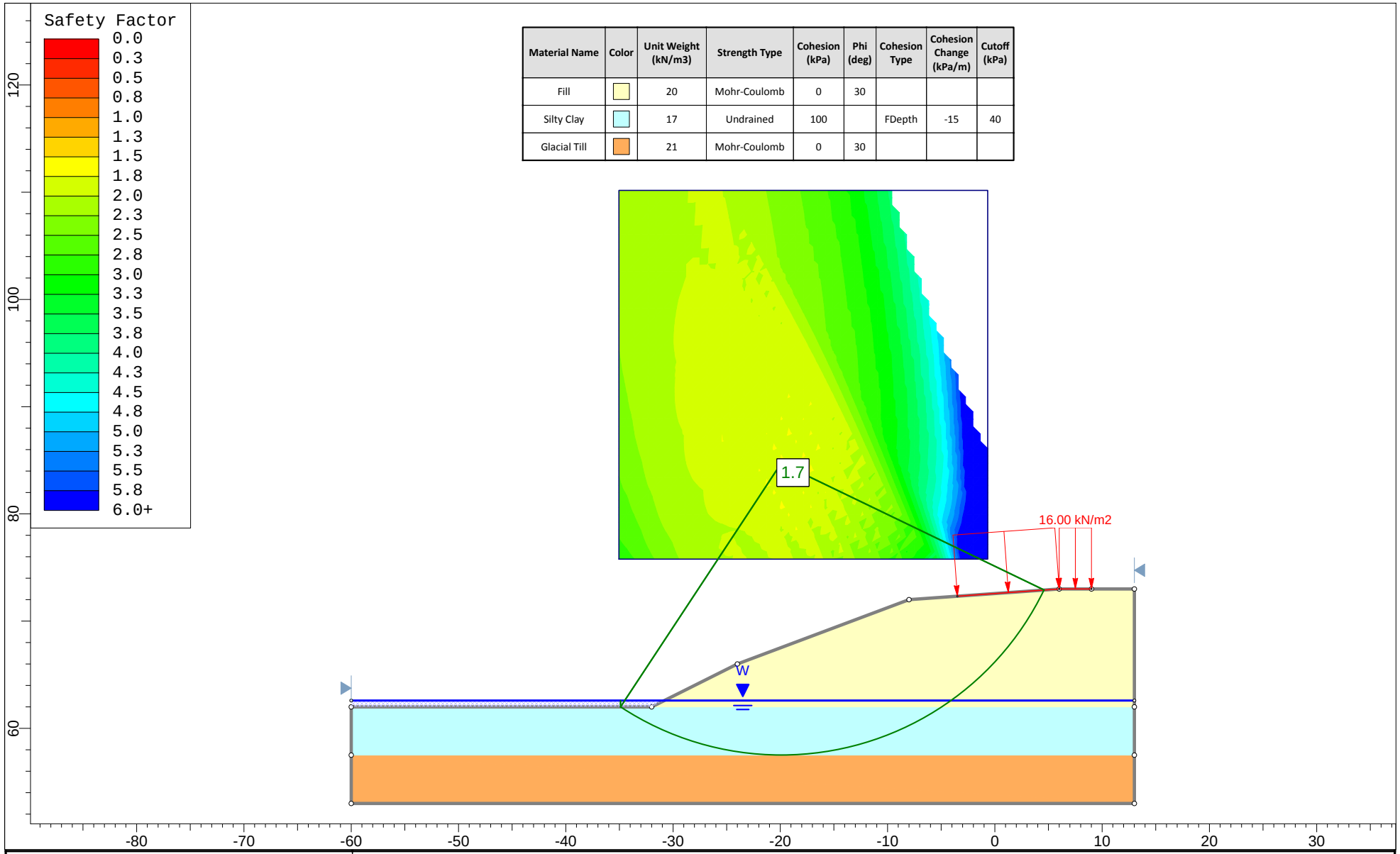
HIGHWAY 417 PRELIMINARY DESIGN
AVIATION PARKWAY TO RAMSAYVILLE ROAD
15 BRIDGES (9 SITES) AND 14 STRUCTURAL CULVERTS
GWP 4074−11−00

10m 0 20m — Horizontal 1:2000

2m 0 4m — Vertical 1:400

FIGURE
C-2

DRAWING NAME: M:\02-Documents\2013\OKM-13-7131- MTO ER - Prelim. Design & EA for Rehab, Replacement of 15 Bridges\12 CAD\2 Highway\Drawings\Culve13-7131 Skewed Culvert Sections for Widening.dwg
CREATED: Devin Alliston
MODIFIED: Nov 27, 2014 - 2:49pm

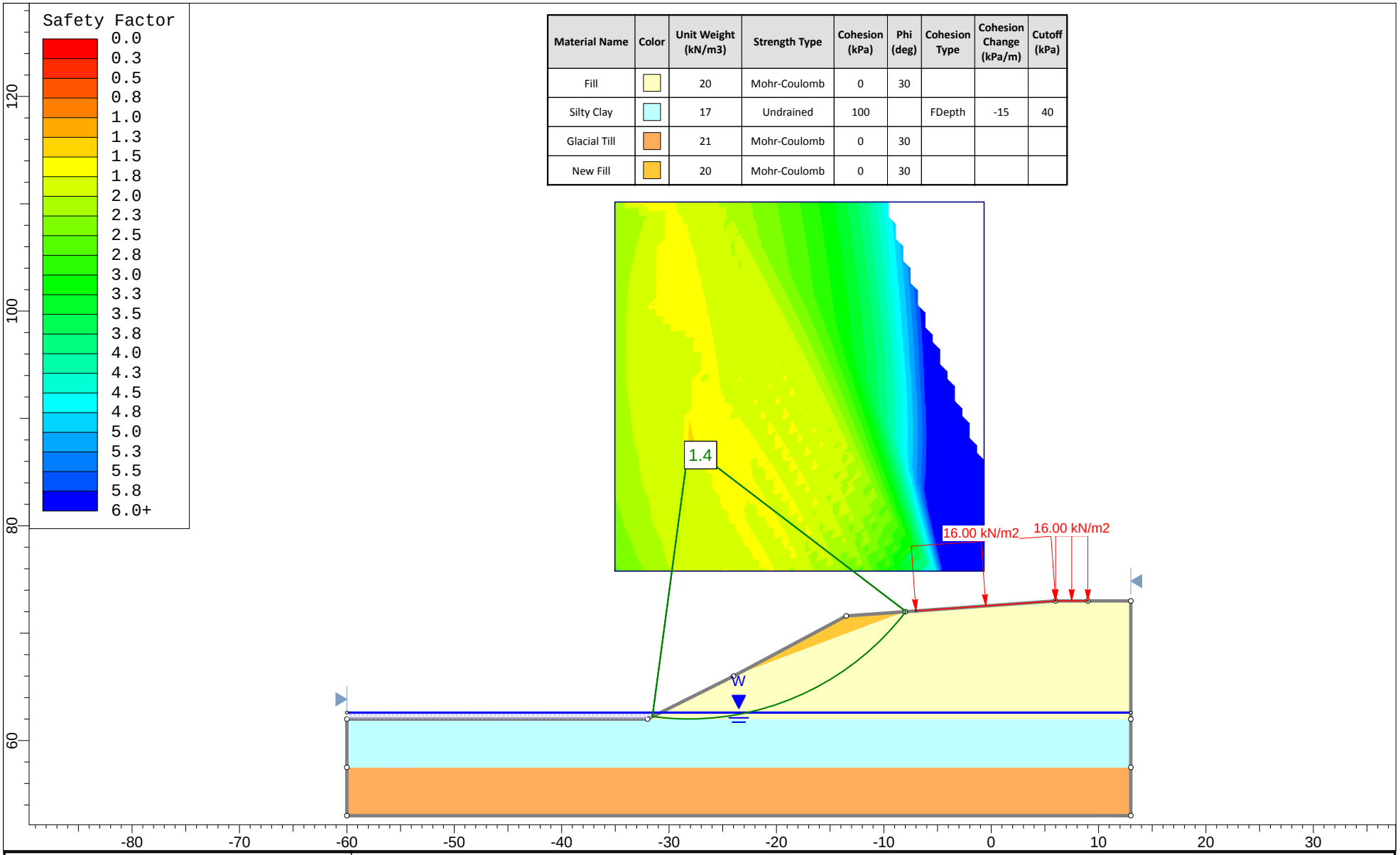


Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion Type	Cohesion Change (kPa/m)	Cutoff (kPa)
Fill		20	Mohr-Coulomb	0	30			
Silty Clay		17	Undrained	100		FDepth	-15	40
Glacial Till		21	Mohr-Coulomb	0	30			

THURBER

SLIDEINTERPRET 6.029

Project	Culvert 11 - Existing Embankment at Culvert		
Analysis Description	Morgenstern-Price		
Drawn By	CM	*Scale* 1:500	*Company* Thurber Engineering
Date	03/12/2014, 2:23:17 PM		*File Name* 3-313C - Existing Embankment at Culvert.slim



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion Type	Cohesion Change (kPa/m)	Cutoff (kPa)
Fill		20	Mohr-Coulomb	0	30			
Silty Clay		17	Undrained	100		FDepth	-15	40
Glacial Till		21	Mohr-Coulomb	0	30			
New Fill		20	Mohr-Coulomb	0	30			

THURBER

SLIDEINTERPRET 6.029

Project	Culvert 11 - Proposed Embankment at Culvert			
Analysis Description	Morgenstern-Price			
Drawn By	CM	*Scale*	1:500	*Company* Thurber Engineering
Date	03/12/2014, 2:23:17 PM			*File Name* 3-313C - Proposed Embankment at Culvert.slim

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APPENDIX 12

SITE 3-313/C2

THURBER

MEMORANDUM

To: Laura Donaldson, P.Eng.
McIntosh Perry Consulting Engineers

Date: July 17, 2015

From: Kenton Power, M.A.Sc., P.Eng.
(Reviewed by Fred Griffiths, P.Eng. and P.K. Chatterji, P.Eng.)

File: 19-3405-3

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 417 WESTBOUND STRUCTURAL CULVERT (SITE 3-313/C2)
GWP 4074-00-00 GEOCRES 31G5-262

PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This memo presents a brief summary of the factual findings from a foundation review carried out for the twin culvert structure carrying traffic on Highway 417 westbound over Green Creek in Ottawa, Ontario. It also presents preliminary geotechnical recommendations for potential culvert extensions or replacement. It is noted that the proposed replacement or extension alternatives are not yet defined however, it is likely that the top of the embankment will be widened towards the existing median as much as 7.0 m to accommodate the addition of another lane. The preliminary recommendations provided below are for assistance in developing and evaluating the options and will need to be refined during subsequent design stages.

The following reference numbers apply to this site:

- Current W.P. -
- Site No. 3-313/C2
- GEOCRES No. 31G5-89
- Construction Contract 73-190
- Historic W.P. 10-69-15

2 SITE DESCRIPTION

The site is located in eastern Ottawa, in the Township of Gloucester approximately 600 m south of the Highway 417 / Walkley Road Interchange. The twin culverts carry the Green Creek flow below the Highway 417 westbound lanes and the off ramp for the Walkley Road Interchange (three lanes in total plus gravel shoulders). Based on the historic General Layout Drawing (copy attached), the twin circular steel pipe culverts were constructed with bevel inlet and outlet sections. The total length of structure is reported to be 74.5 m. The internal diameter of each pipe culvert is noted as 5.5 m. Prior to culvert construction Green Creek flowed from south to north at a location further to the south. The creek was diverted to an area of relatively flat ground at an approximate elevation of 66.5 m. The terrain in the vicinity of the inlets and outlets

of the culvert is generally flat and is brush and grass covered. Site photos showing the general site conditions are attached.

3 SUBSURFACE CONDITIONS

A site investigation was carried out by the MTO Foundations Office; GEOCRES Report No. 31G5-89 dated September 1972. The investigation was conducted in August 1972 and consisted of two sampled boreholes designated 4 and 6 both accompanied by dynamic cone penetration tests. Drawing No. 72-11092A (copy attached) illustrates the locations of the culvert structures, the investigation boreholes, and the soil strata plot for the investigation. The stratigraphy in the area of the culvert structure is generally characterized by a silty clay, over glacial till material consisting mainly of silt and sand, underlain by sound bedrock.

3.1 Silty Clay

A clay stratum with interspersed seams of silt was encountered in both boreholes. The thickness of the individual seams was noted to range from 13 mm to 50 mm. The top of the clay strata ranged from 63.1 m to 65.4 m in elevation and the layer had a thickness of 5.8 m to 7.0 m. The standard penetration test (SPT) 'N' values ranged from 4 to 13 blows per 0.3 m. The estimated undrained shear strength based on both in-situ field vane and laboratory tests ranged from 38 kPa to 105 kPa. The consistency of the stratum varies from very stiff in the upper portion decreasing to firm with depth.

The results of grain size analysis tests including hydrometer testing completed on five samples of this material indicated a gravel content of 0% for all samples, sand content ranging from 3% to 4%, silt content ranging from 46% to 59%, and clay content ranging from 37% to 50%.

Atterberg Limits test results of five samples of the silty clay material indicate a clay of intermediate plasticity to a clay of high plasticity.

Consolidation characteristics determined for the silty clay from oedometer tests on four samples from the Highway 417 east and westbound boreholes indicate an initial void ratio ranging from 1.24 to 1.50 and a compression index ranging from 0.53 to 0.87. The pre-consolidation pressure was found to be in excess of 150 kPa.

The moisture content of the samples tested ranged from 39 % to 60%.

3.2 Glacial Till

A glacial till stratum was encountered beneath the silty clay stratum in both boreholes. The till was described as a heterogeneous mixture of silt, sand and gravel with some clay. The top of the till strata ranged from 57.3 m to 58.4 m in elevation and the layer had a thickness of 3.4 m to 3.5 m. The SPT 'N' values ranged from 1 to 17 blows per 0.3 m indicating a very loose to compact condition, but typically compact.

The results of a grain size analysis test including hydrometer testing completed on a sample of this material indicated a gravel content of 14%, sand content of 29%, silt content of 37%, and clay content of 20%.

The moisture content of the samples tested ranged from 9% to 20%.

3.3 Bedrock

A grey shale bedrock was encountered beneath the glacial till in both boreholes as proven by BX size coring. The bedrock surface elevation ranged from 53.8 m to 55.0 m. Bedrock core recovery was recorded to range from 90% to 100% for both boreholes. The bedrock was noted as being in sound condition. Geological mapping suggests the bedrock at this site is shale of the Carlsbad Formation.

3.4 Groundwater

Groundwater levels were measured in the open boreholes prior to backfilling at elevations ranging from 62.2 m to 63.6 m.

The water level of Green Creek at the time of the investigation as indicated on the General Layout Drawing was 62.6 m.

4 SITE OBSERVATIONS

A structure inspection was conducted by MTO in July 2008 for culverts 3-313/C2 with the report issued July 2008. Condition data outlined in the report for the culvert structure ranged from poor to good but typically the culvert was rated in good condition with only the removal of the vegetation that had overgrown the inlet and out structures as recommended work on the structure at the time of the inspection.

The site was inspected by Thurber Engineering Ltd. staff during the week of July 14, 2014. Several photographs of the site are attached.

At the time of the inspection, the following observations were made:

East Inlet:

- Gabions were installed at the site for erosion protection on both the embankment and creek banks
- Vegetation on side slopes was noted
- Creek flow was only through the north culvert as the south culvert was completely blocked by sediment and vegetation growth
- Backslope behind bevel sections was measured at approximately 20°
- No obvious settlement of road surface was observed at the crossing

West Outlet:

- Gabions were installed at the site for erosion protection
- Vegetation on side slopes was noted
- Creek flow was only through the north culvert as the south culvert was completely blocked by sediment and vegetation growth
- Backslope behind bevel sections was measured at approximately 20°
- No obvious settlement of road or ramp surface was observed at the crossing

5 GEOTECHNICAL ASSESSMENT

5.1 Frost Considerations

The frost penetration depth at this site is 1.8 m (OPSD 3090.101).

5.2 Seismic Considerations

This site is classified as a Soil Profile Type III in accordance with Section 4.4.6 of the Canadian Highway Bridge Design Code (CHBDC). The zonal acceleration ratio for this site is 0.20 as per Table A3.1.1 of the CHBDC.

Based on the density of the till and the plasticity of the clay, these materials are classified as “not susceptible” to liquefaction during the design earthquake event.

5.3 Existing Foundations

As indicated on the General Layout Drawing the design invert elevation of the culverts was to range from 60.7 m to 60.7 m. A 457 mm thick layer of select subgrade material was indicated as bedding material for the culverts. With the 457 mm thick bedding layer as noted on the structural drawing the approximate founding elevation for the culvert would be 60.3 m.

The Foundation Design Report recommended that a granular bedding layer 1.4 m thick be placed beneath the culverts so that the increased stress applied to the native clay by the culvert and embankments would not exceed the allowable bearing capacity of the founding soil. The recommended design allowable bearing value as reported in the Foundation Design Report was 100 kPa.

The General Layout Drawing indicates that design elevation for Walkley Road at the culvert crossing was to be approximately 74.1 m. Therefore embankment fill heights ranging from approximately 8.7 m to 11.0 m with an average height of 9.8 m would have been required to construct Walkley Road in the vicinity of the culverts. A culvert camber of 150 mm was included in the contract drawings to mitigate the effects of settlement.

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PART 2: ENGINEERING DISCUSSION AND PRELIMINARY RECOMMENDATIONS

6 GEOTECHNICAL RECOMMENDATIONS

Based on the available data regarding the ground conditions at this site, the following sections present preliminary geotechnical recommendations for the assessment of the existing culverts and for preliminary design for potential culvert extensions, replacement, and the construction of new wing walls, end sections and/or headwall structures, if required. It is noted that the proposed construction options for this site are not yet defined however, it is likely that the top of the embankment will be widened towards the existing median as much as 7.0 m to accommodate the addition of another lane. The preliminary recommendations provided below are for assistance in developing and evaluating options and will need to be refined during subsequent design stages.

The existing culverts are CSPs likely founded on firm clay. For culvert extensions, it is preferred that type of foundations and founding elevation match the existing arrangement so as not to undermine the existing foundation. From a foundation perspective for culvert replacements, concrete rigid-frame open-footing culverts could have bearing resistance limitations as well as groundwater concerns during construction. Both concrete closed boxes and CSPs would be preferred.

6.1 Shallow Foundations

For shallow foundations founded on native very stiff to firm silty clay having a minimum embedment depth of 1.8 m and a width of between 1 m and 2 m, the factored vertical geotechnical resistance at ULS is 150 kPa. The vertical geotechnical reaction at SLS is 100 kPa based on a total footing settlement of 25 mm.

A replacement culvert would likely require a span and an invert elevation similar to the existing. For a closed box culvert founded at the same elevation as the existing culvert on native very stiff to firm clay with a 1.8 m embedment and a base width of 6.2 m, the factored vertical geotechnical resistance at ULS is 120 kPa. The vertical geotechnical reaction at SLS is 70 kPa based on a total footing settlement of 25 mm. An increase in the thickness of the bedding layer would allow higher values at ULS to be obtained.

Resistance to lateral forces and sliding resistance between concrete and steel and underlying materials should be evaluated using an unfactored coefficients of friction provided in Table A.

Table A: Unfactored Coefficients of Friction between Concrete and Steel and Founding Material

	Founding Material
Culvert Material	**Silty Clay**
Steel	0.25
Cast-in-place concrete	0.35
Precast concrete	0.30

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6.2 Excavations, Bedding and Backfilling

All excavations must be conducted in accordance with the requirements of the Occupational Health & Safety Act & Regulations (OHSA) for Construction Projects. The native very stiff to firm silty clay material reported at this site should be classified as Type 3 in accordance with OHSA.

Where excavations will extend below the groundwater level prevailing at the time of construction, the contractor will need to implement groundwater control and ground support systems as are required to carry out the construction in a safe, stable, and unwatered excavation.

Excavations, bedding and backfill for steel pipe arch culverts should be in accordance with OPSD 802.020 for Type 3 soils. Backfill for the culvert must consist of free draining granular material conforming to OPSS Granular A or B material specifications. The granular material must be placed to the extent shown on OPSD 803.030 or 803.031 and in accordance with OPSS 421 and 401.

Subgrade preparation for foundations and placement of culvert bedding must be carried out in the dry.

6.3 Static Lateral Earth Pressure Coefficients

Lateral earth pressures acting on structures should be computed in accordance with the CHBDC but generally are given by the expression:

$$P_h = K^*(\gamma h + q)$$

where:

P_h = horizontal pressure on the wall (kPa)
K = earth pressure coefficient (see below)
γ = unit weight of retained soil (see below)
h = depth below top of fill where pressure is computed (m)
q = value of any surcharge (kPa)

The recommended lateral earth pressure parameters for use in the design for both a horizontal and for 2H:1V (Horizontal:Vertical) back-slope are provided in Table B.

Active pressures should be used for the design of unrestrained walls.

A lateral pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with the Section 6.9.3 of the CHBDC.

The parameters provided in Table B are based on the assumption that the backfill is fully drained so that there are no unbalanced hydrostatic pressures. If adequate drainage cannot be confirmed, the potential for hydrostatic pressures should be considered.

Table B: Static Lateral Earth Pressure Coefficients

Parameter	OPSS Granular A & OPSS Granular B Type II	OPSS Granular B Type I	Native Silty Clay
Soil Unit Weight, kN/m^3, γ	21	20	17
Angle of Internal Friction, ϕ	35°	30°	27°
Horizontal Back-Slope			
Coefficient of at Rest Earth Pressure, K_o (Restrained Wall)	0.43	0.5	0.55
Coefficient of Active Earth Pressure, K_a (Unrestrained Wall)	0.27	0.33	0.38
2H:1V Back-Slope			
Coefficient of Active Earth Pressure, K_a	0.39	0.53	0.70

6.4 Embankments

It is anticipated that settlement of the native clay will occur should the embankments be widened and the culverts extended. Further settlement of the existing culvert foundations may also occur due to the increase in stress caused by the project works.

6.4.1 Existing Conditions at Culvert 3-313/C2

Based on the original MTO Foundation Design Report, the maximum height of the fill embankments extend approximately 8.5 m above the grades existing at the time of the investigation. Side slopes of 2H:1V were considered to be stable provided that mid-height benches were included. Settlement of up to 125 mm was predicted with 50% of the consolidation occurring within 18 months of fill placement. A culvert camber of 150 mm was included in the contract drawings to mitigate the effects of settlement. Minimal additional settlement is anticipated if the culvert were replaced like-for-like in the existing culvert alignment with the embankment reinstated to its current configuration.

6.4.2 Proposed Embankment Widening at Culvert 3-313/C2

The proposed construction options for this site may include the construction of an additional lane. This is to be accomplished by constructing a 7 m median widening of the top of the embankment while keeping the toe of the slope in its current location and without the use of a mid-height benches.

The existing conditions were modelled based on the survey data provided (copy attached) which indicate that the embankments at Culvert 3-313/C2 are 8.5 m high and were constructed with side slopes at approximately 2H:1V.

Based on the results of the preliminary slope stability analysis (copies attached), the proposed 7 m median widening can be constructed without the use of mid-height benches from a geotechnical perspective and maintain adequate factors of safety against slope instability in

both seismic and static cases. The slope of the new embankment must be constructed of granular material such as OPSS Granular B Type I, at a slope no steeper than 2H:1V and should be built as per OPSD 208.010.

The addition of up to 1.5 m of fill will increase the applied stress on the clay layer and will cause the clay and existing embankment fill to settle. It is estimated that the settlement will be less than 50 mm however, this could impact the pavement surface as well as the culvert.

Headwalls could be added to the culverts, if necessary. However, as noted previously in this memo the available geotechnical resistance for foundations on the underlying soils is limited.

6.5 Erosion Control

Erosion protection should be provided at the culvert inlet and outlet areas. Design of the erosion protection measures must consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field.

Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact. Treatment at the outlets should be in accordance with OPSD 810.010. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS 804.

A concrete cut-off wall or clay seal should be installed at the culvert inlet to minimize the potential for seepage through the granular bedding and backfill material and avoid consequent erosion of these materials. The clay seal should have a minimum thickness of 0.5 m, completely surround the culvert, extend laterally the width of the granular backfill material, and extend above the high water level. The material used for the clay seal should conform to the requirements of OPSS 1205. It is noted that a concrete cut off wall was included in the design for this site.

7 ADDITIONAL INVESTIGATIONS

Further foundation investigations and analysis must be carried out should the culvert structure be replaced or extended or if the height, geometry, or location of the approach fills are to be modified for either short-term construction staging or for vertical or horizontal re-alignments. Should excavations be anticipated within the embankment fills to repair or modify the culvert, consideration should be given to drilling foundation boreholes in the approaches to determine the nature of the fill materials and to allow generation of road way protection design. It is also recommended that piezometers be installed to better define the groundwater level in both the silty clay and glacial till strata as well as the in-situ hydraulic conductivity. This information will be required to allow for the design of excavation dewatering systems.

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8 CLOSURE

We trust this information provided in this technical memorandum meets your present purposes. Please let us know if you have any questions or need additional information.

Thurber Engineering Ltd.

Kenton C. Power, P.Eng.
Geotechnical Engineer

Fred Griffiths, P.Eng.
Associate, Senior Geotechnical Engineer

P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact

Attachments

GWP 4074-11-00
Site Photographs

PRELIMINARY FOUNDATION DESIGN
HIGHWAY 417 WESTBOUND STRUCTURAL CULVERT (SITE 3-313/C2)

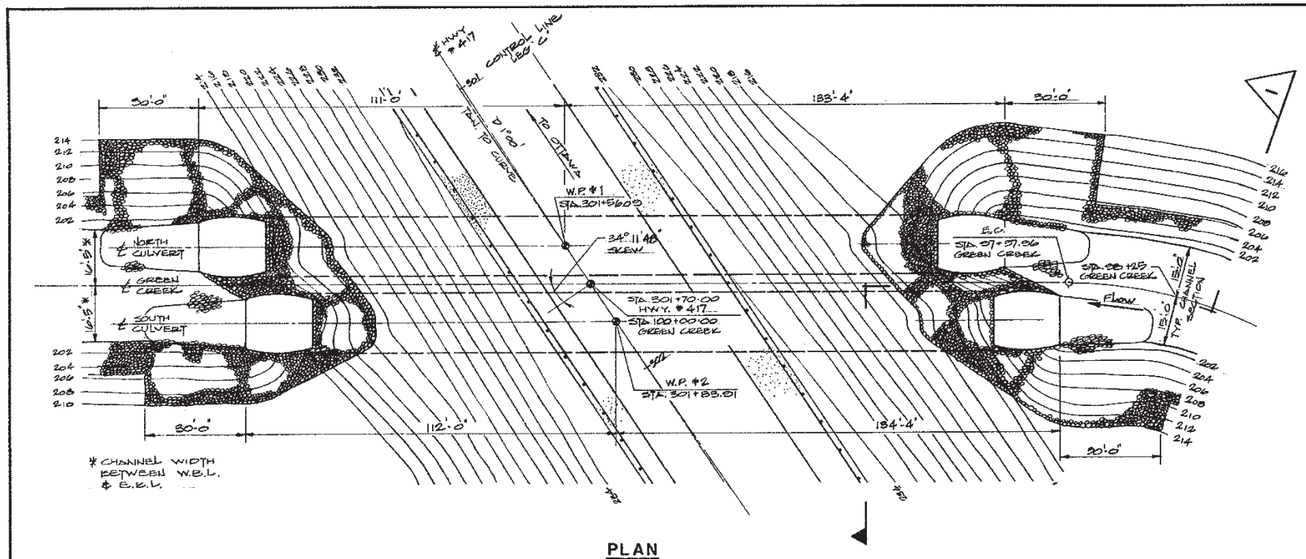
Inlet looking upstream

Gabions and embankment behind outlet

GWP 4074-11-00
Site Photographs

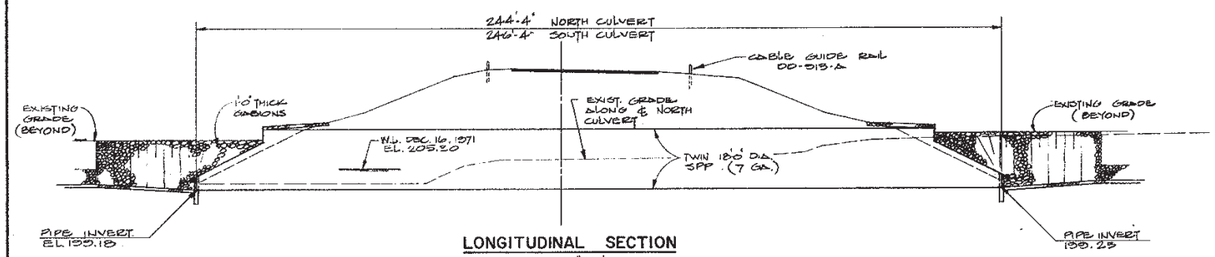
PRELIMINARY FOUNDATION DESIGN
HIGHWAY 417 WESTBOUND STRUCTURAL CULVERT (SITE 3-313/C2)

Condition of Highway 417 road surface at culvert crossing

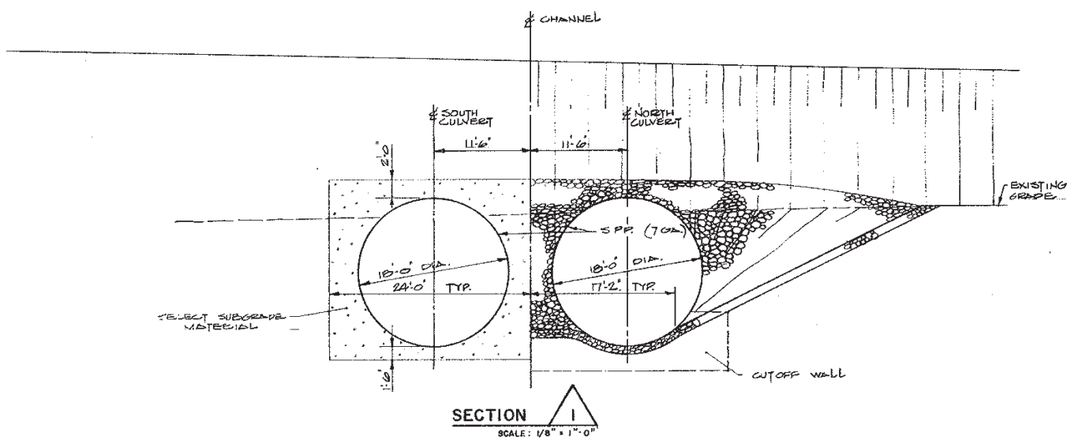


* CHANNEL WIDTH BETWEEN W.E.L. & E.E.L.

PLAN
SCALE : 1" = 20'



LONGITUDINAL SECTION
SCALE : 1" = 20'



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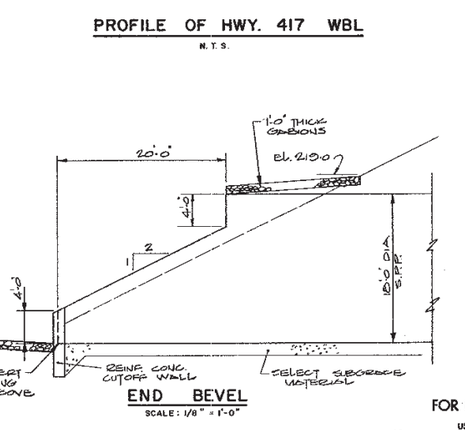
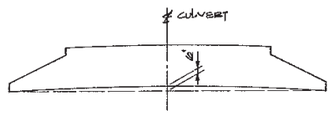
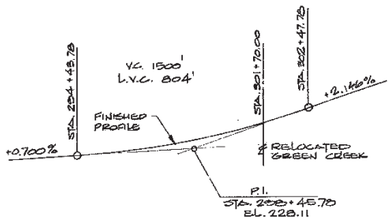


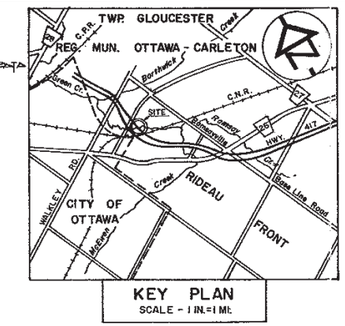
END BEVEL
SCALE : 1/8" = 1'-0"



CAMBER DIAGRAM
N.T.S.



PROFILE OF HWY. 417 WBL
N. T. S.



KEY PLAN
SCALE - 1 IN. = 1 MI.

105

LIST OF DRAWINGS
3-313B-1 - GENERAL LAYOUT
3-313B-2 - BOREHOLE LOCATION AND SOIL STRATA
3-313B-3 - CUT OFF WALL DETAILS

SKEW DATA 34° 11' 48"
SIN. = 0.5620353
COS. = 0.8271153
TAN. = 0.6795142
SEC. = 1.2090242

CURVE DATA ℄ W.B.L.
Δc = 47° 46' 40"
Dc = 1° 00' 00" LEFT
T = 2557.67'
L = 4777.78'
SC = STA. 251+46.83

BENCH MARK
B.M. 221.39
GEODETIC DATUM - TOP NUT ON S.E. CORNER OF HYDRO TOWER 305 FT RT. OF STA. 295+77 E.B.L.

GENERAL NOTES
STRUCTURAL PLATE - 6" x 2" CORRUGATIONS
- GALVANIZED

PROTECTION AGAINST HEAVY CONSTRUCTION EQUIPMENT
- PRIOR TO ALLOWING HEAVY CONSTRUCTION EQUIPMENT OVER THE CULVERT, THE DEPTH OF COVER MATERIAL MUST BE A MINIMUM OF 4 FEET, COMPACTED AS SPECIFIED

FOR REDUCED PLAN
USE SCALE BELOW
0 1 2 3
3 INCHES ON ORIGINAL PLAN

REVISIONS		
DATE	BY	DESCRIPTION

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS
ONTARIO
Consulting Engineers & Planners

GREEN CREEK UNDER HWY. 417 WBL
0.5 MI. E OF WALKLEY RD.

KING'S HIGHWAY No. 417 DIST. No. 9
CO. REG. MUN. OTTAWA - CARLETON
TWP. GLOUCESTER LOT 2 CON. VI

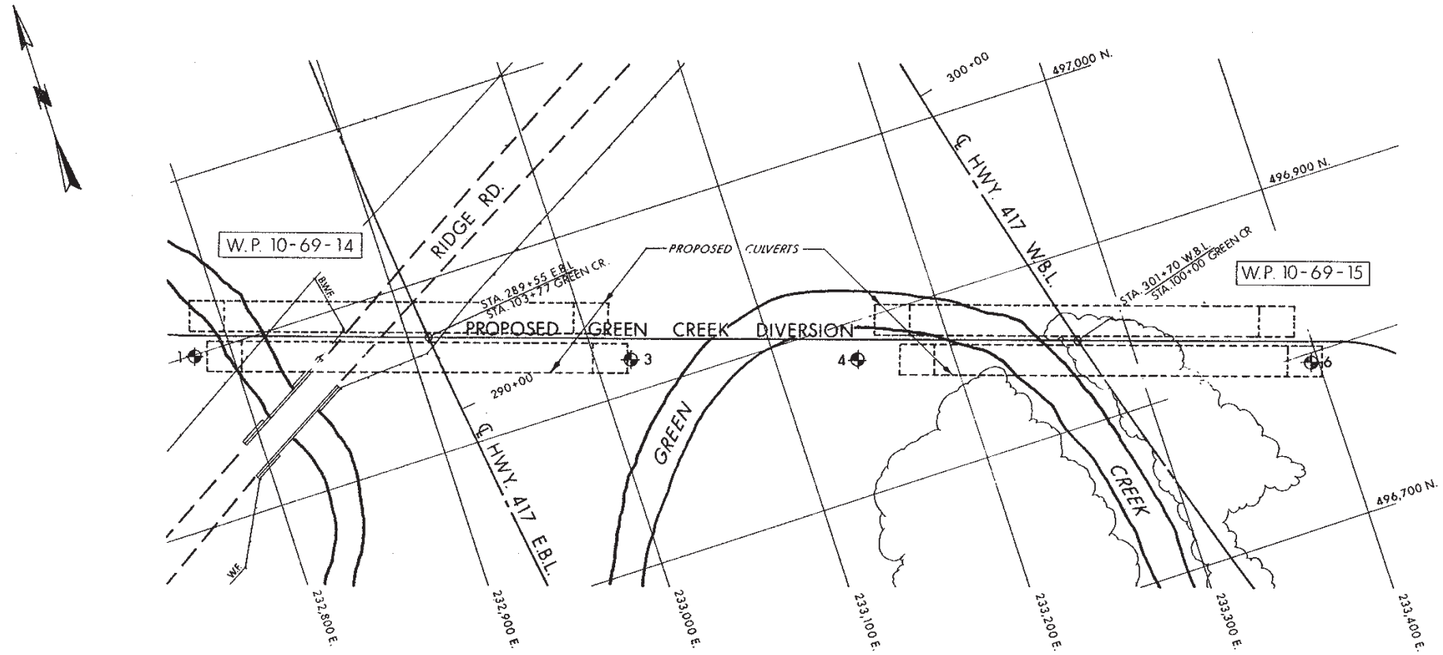
GENERAL LAYOUT

APPROVED _____ STRUCTURAL ENGINEER

SITE No. 3 - 313B				W.P. No. 10-69-15	
CONTRACT Nos.				'73-19	
DESIGN	G.K.	CHECK		DRAWING No.	3 - 313B - 1
DRAWING	C.S.	CHECK	G.K.		
DATE	MAR. 73	LOADING	HS20-44		

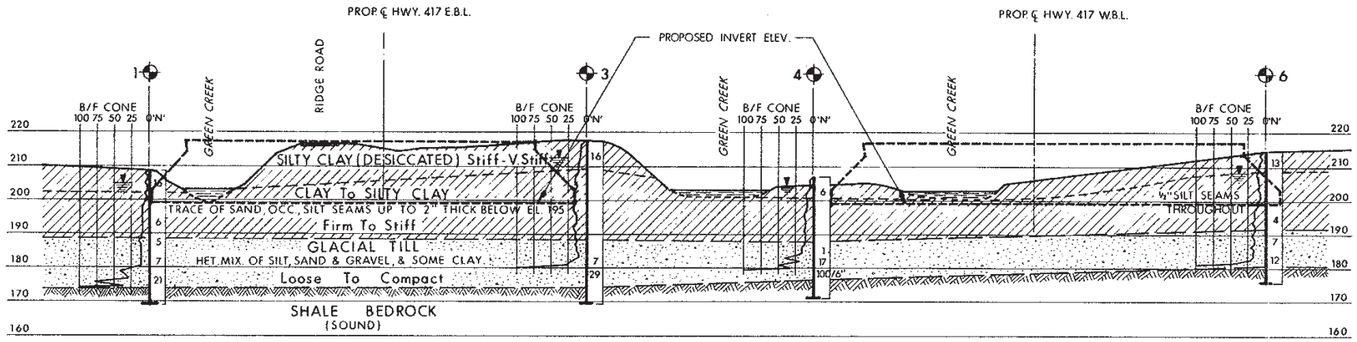
REGISTERED PROFESSIONAL ENGINEER G. KNIGHTS PROVINCE OF ONTARIO

106



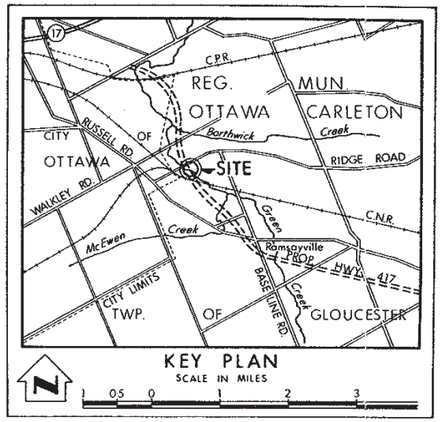
PLAN

SCALE 40 20 0 40 80 FT.



℄ PROFILE GREEN CREEK DIVERSION

HORIZ. 40 20 0 40 80 FT.
VERT. 20 10 0 20 40 FT.



KEY PLAN
SCALE IN MILES
1 0.5 0 1 2 3

LEGEND

- Bore Hole
- Cone Penetration Test
- Bore Hole & Cone Test
- Water Levels established at time of field investigation. AUG. 1972

NO.	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
1	208·7	496,999	232,778
3	217·7	496,919	233,020
4	207·0	496,878	233,146
6	214·5	496,794	233,397

— 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 soil investigation report for this structure may be examined at the Bridge Office and Foundation Office, Downsview, and at the Ottawa District Office.

REVISIONS	DATE	BY	DESCRIPTION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

GREEN CREEK
(SOUTH OF RIDGE ROAD)

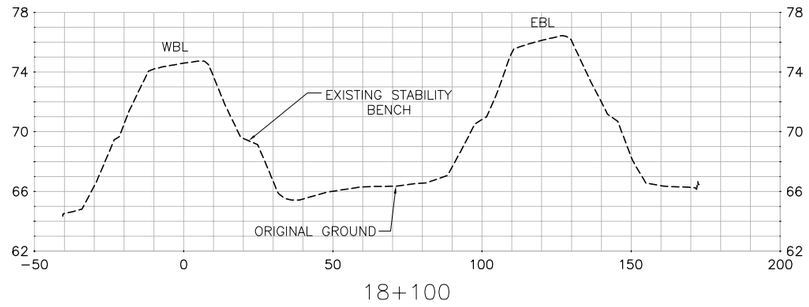
HIGHWAY NO. 417 ~~E.B.~~ & W.B. DIST. NO. 9
CO. REG. MUN. OTTAWA CARLETON
TWP. GLOUCESTER LOT CON.

BORE HOLE LOCATIONS & SOIL STRATA

SUBMD. S.A.	CHECKED	W.P. NO. ~~10-69-14~~ 10-69-15	DRAWING NO. 72-11092 A
DRAWN J.I.G.	CHECKED	W.O. NO. 72-11092	
DATE 11 SEPT. 1972		SITE NO. 3-313 B	BRIDGE DRAWING NO. 3-313B-2
APPROVED PRINCIPAL FOUNDATION ENGINEER		CONT. NO. 72-190	

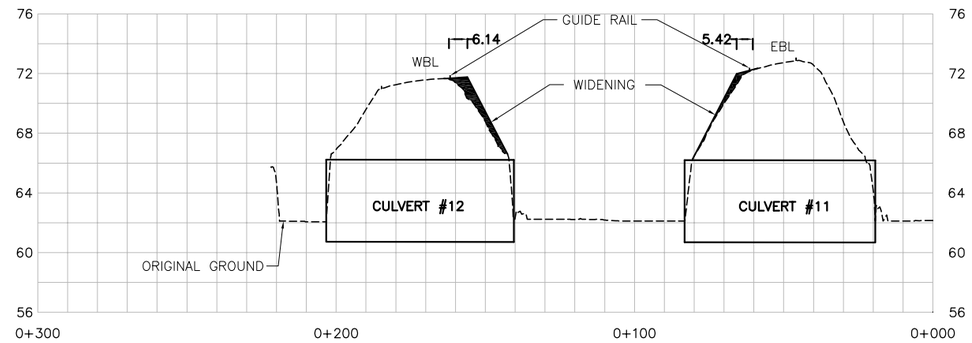
METRIC

STABILITY BENCHING SECTION

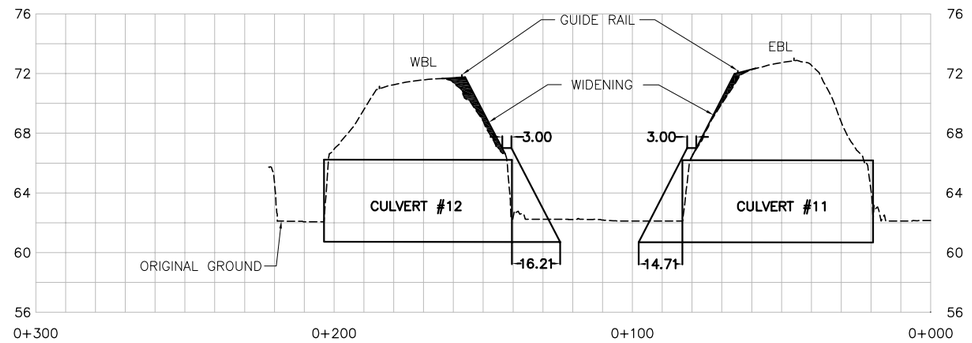


18+100

Site 3−313/C1 and 3−313/C2 Culvert #11 & 12



Site 3−313/C1 and 3−313/C2 Culvert #11 & 12



Ontario

McINTOSH PERRY

HIGHWAY 417
STRUCTURAL CULVERTS #11 & 12

HIGHWAY 417 PRELIMINARY DESIGN
AVIATION PARKWAY TO RAMSAYVILLE ROAD
15 BRIDGES (9 SITES) AND 14 STRUCTURAL CULVERTS
GWP 4074−11−00

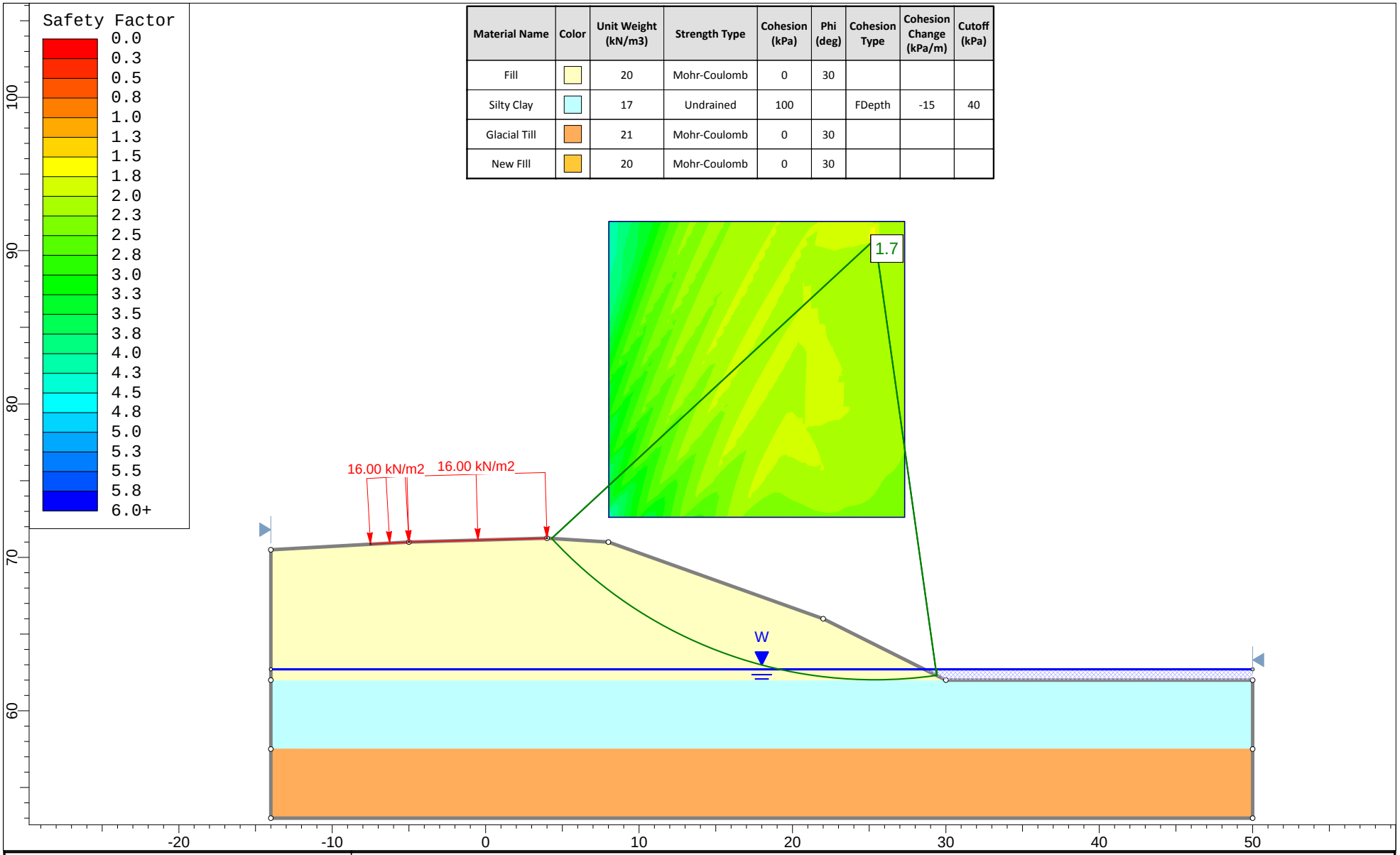
10m 0 20m — Horizontal 1:2000

2m 0 4m — Vertical 1:400

FIGURE
C-2

DRAWING NAME: M:\02-Documents\2013\OKM-13-7131- MTO ER - Prelim. Design & EA for Rehab, Replacement of 15 Bridges\12 CAD\2 Highway\Drawings\Culve13-7131 Skewed Culvert Sections for Widening.dwg
CREATED: Devin Alliston
MODIFIED: Nov 27, 2014 - 2:49pm

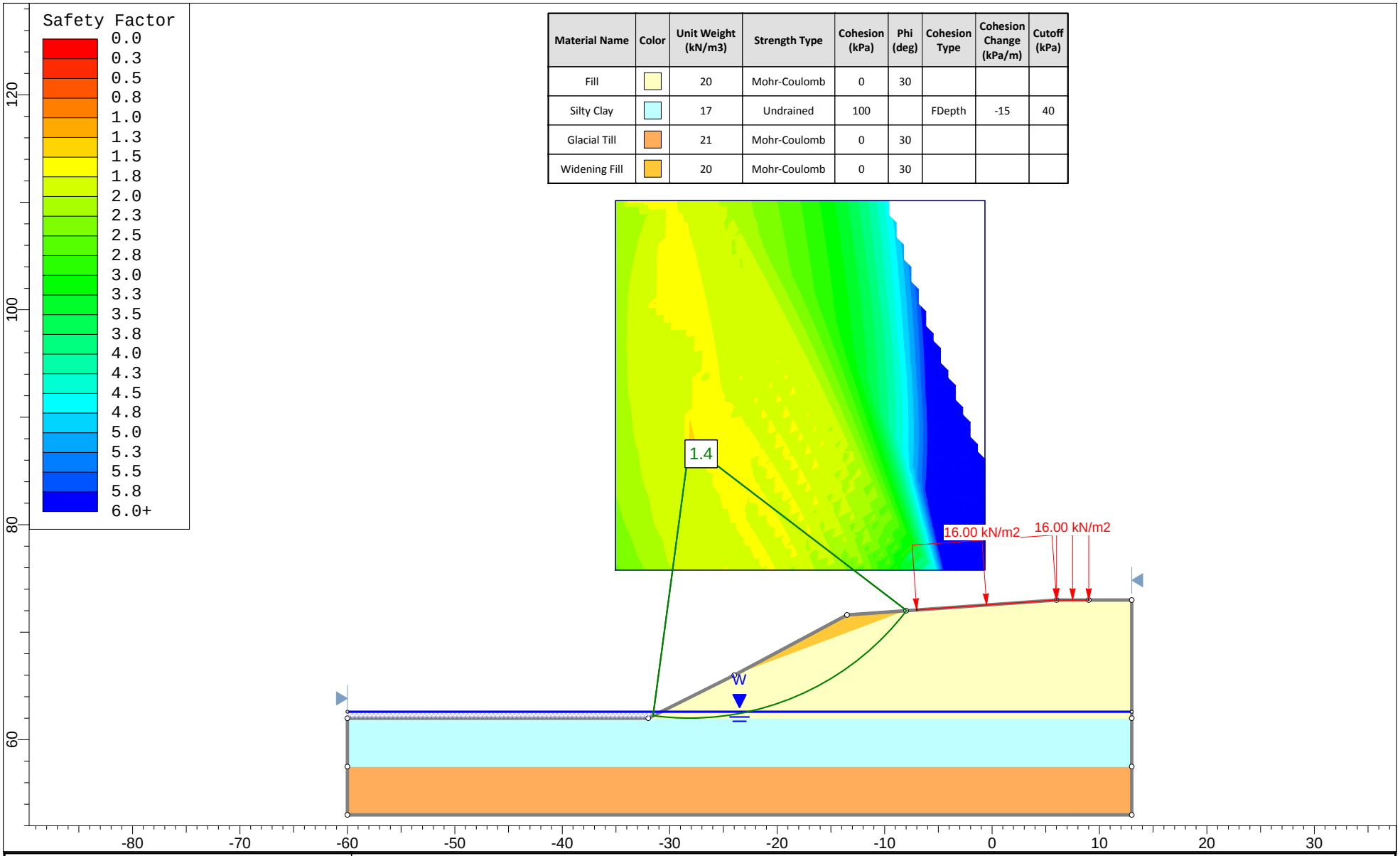
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion Type	Cohesion Change (kPa/m)	Cutoff (kPa)
Fill		20	Mohr-Coulomb	0	30			
Silty Clay		17	Undrained	100		FDepth	-15	40
Glacial Till		21	Mohr-Coulomb	0	30			
New FIll		20	Mohr-Coulomb	0	30			



THURBER

SLIDEINTERPRET 6.029

Project	Culvert 12 - Existing Embankment at Culvert				
Analysis Description	Morgenstern-Price				
Drawn By	CM	*Scale*	1:350	*Company*	Thurber Engineering
Date	03/12/2014, 2:23:17 PM			*File Name*	3-313C2 - Existing Embankment at Culvert.slim

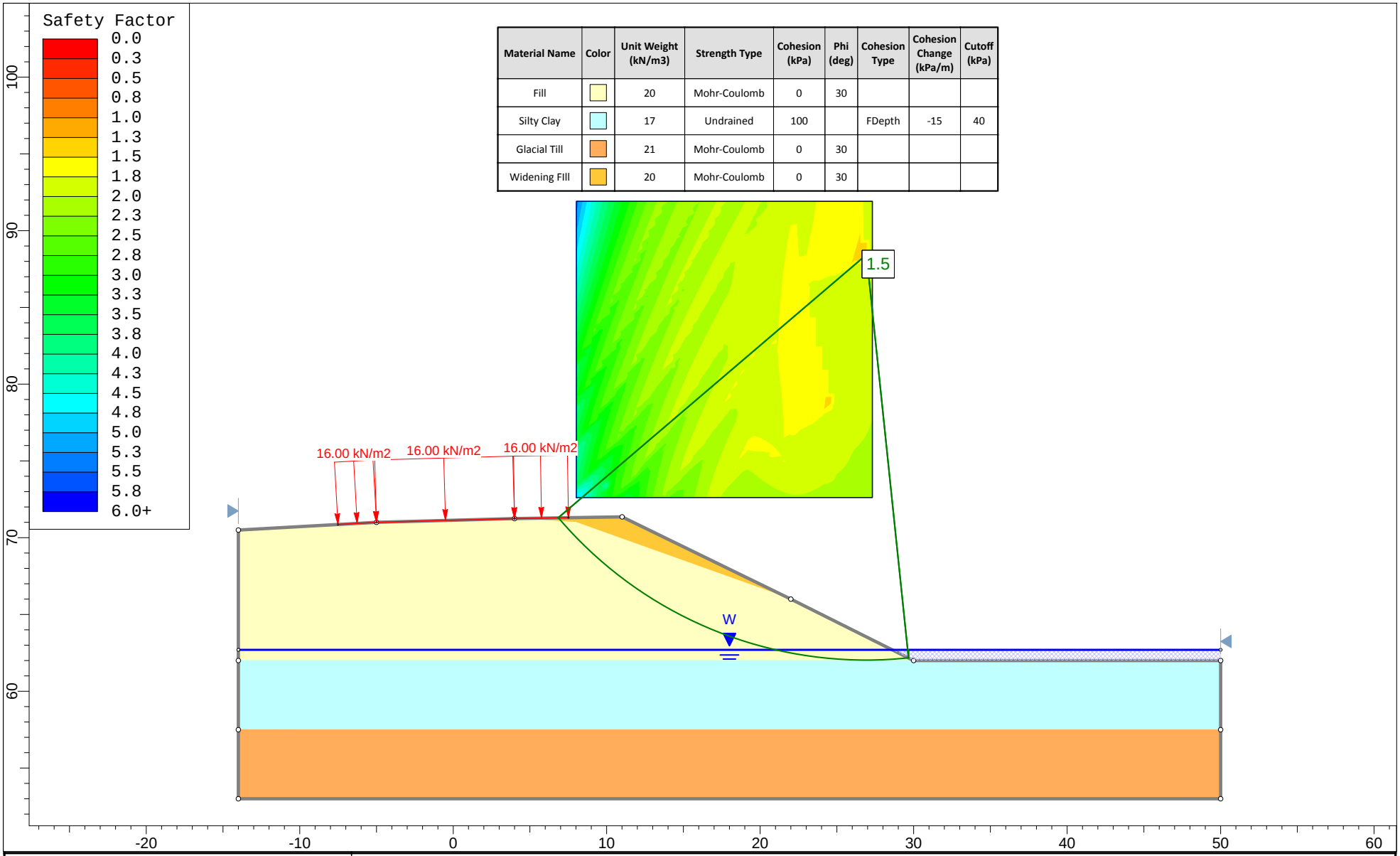


Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion Type	Cohesion Change (kPa/m)	Cutoff (kPa)
Fill		20	Mohr-Coulomb	0	30			
Silty Clay		17	Undrained	100		FDepth	-15	40
Glacial Till		21	Mohr-Coulomb	0	30			
Widening Fill		20	Mohr-Coulomb	0	30			

THURBER

SLIDEINTERPRET 6.029

Project	Site 3-313/C1 (Culvert 11) - Proposed Embankment at Culvert			
Analysis Description	Morgenstern-Price			
Drawn By	CM	*Scale*	1:500	*Company* Thurber Engineering
Date	03/12/2014, 2:23:17 PM			*File Name* 3-313C - Proposed Embankment at Culvert.slim



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion Type	Cohesion Change (kPa/m)	Cutoff (kPa)
Fill		20	Mohr-Coulomb	0	30			
Silty Clay		17	Undrained	100		FDepth	-15	40
Glacial Till		21	Mohr-Coulomb	0	30			
Widening FIll		20	Mohr-Coulomb	0	30			

THURBER

SLIDEINTERPRET 6.029

Project	Site 3-313/C2 (Culvert 12) - Proposed Embankment at Culvert		
Analysis Description	Morgenstern-Price		
Drawn By	CM	*Scale* 1:350	*Company* Thurber Engineering
Date	03/12/2014, 2:23:17 PM		*File Name* 3-313C2 - Proposed Embankment at Culvert.slim

THURBER

APPENDIX 13

SITE 3-315/C

THURBER

MEMORANDUM

To: Laura Donaldson, P.Eng.
McIntosh Perry Consulting Engineers

Date: July 17, 2015

From: Kenton Power, M.A.Sc., P.Eng.
(Reviewed by Fred Griffiths, P.Eng. and P.K. Chatterji, P.Eng.)

File: 19-3405-3

PRELIMINARY FOUNDATION DESIGN
McEWEN CREEK CULVERT (SITE 3-315/C)
GWP 4074-11-00 GEOCRES 31G5-262

PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This memo presents a brief summary of the factual findings from a foundation review carried out for the culvert structure carrying McEwen Creek under Highway 417 in Ottawa, Ontario. It also presents preliminary geotechnical recommendations for potential culvert extensions or replacement. It is noted that the proposed construction options for this site are not yet defined though concrete rehabilitation work is proposed for this structure. The preliminary recommendations provided below are for assistance in developing and evaluating the options and will need to be refined during subsequent design stages.

The following reference numbers apply to this site:

- Current W.P. -
- Site No. 3-315/C
- GEOCRES No. 31G5-90, 31G5-237, 31G5-240, 31G5-267
- Construction Contract 73-190
- Historic W.P. 10-69-16

2 SITE DESCRIPTION

The site is located in eastern Ottawa, in the Township of Gloucester at the Highway 417 / Hunt Club Road Interchange. The concrete box culvert carries McEwen Creek flow below both the Highway 417 east and westbound lanes (four lanes in total plus paved shoulders) and the on and off ramps for the Highway 417 Interchange. Based on the historical General Layout Drawing (copy attached) the culvert was originally constructed in seven, concrete box sections plus two additional concrete headwall sections; one at each of the inlet and outlet. The total length of structure is reported to be 74.2 m, with a span of 6.1 m and a height of 3.7 m. The culvert was extended to the east as part of the construction of the Hunt Club Road Interchange,

completed in 2014. It is noted that Hunt Club Road crosses above Highway 417 and the west end of the culvert is directly below the Hunt Club Road Structure.

The terrain in the vicinity of the culvert is generally flat and is brush, and grass covered. The creek banks at the outlet (east end) slope up to form parts of the embankments for the Hunt Club Road Interchange. Flow through the culvert is from west to east. Site photos showing the general site conditions are attached.

3 SUBSURFACE CONDITIONS

A site investigation for the initial construction of the culvert was carried out by the MTO Foundations Office; GEOCRES Report No. 31G5-90. The investigation was carried out in 1972 and consisted of four boreholes. Consolidation testing was carried out for samples of the silty clay encountered at the site. The results indicate that the preconsolidation pressures ranged from 165 kPa to 300 kPa and a compression index ranging from 0.36 to 1.25.

Several more recent foundation investigations have been carried out in the general vicinity of Culvert 3-315/C; the most recent of which were for the construction of the Highway 417 / Hunt Club Road Interchange by Thurber. The first investigation was for the underpass bridge structure; GEOCRES Report No. 31G5-237, dated February 2011 and the second was for the extension of the Culvert 3-315/C; GEOCRES Report No. 31G5-240, dated March 2011. As part of the scope of work for the current detail design investigation for this site, one additional borehole was advanced in the vicinity of Culvert 3-315/C in order to provide a detailed Foundation Investigation Report for this site. The results of the current investigation have also been incorporated into this Preliminary Foundation Design memo for completeness.

3.1 GEOCRES 31G5-237 Investigation

The underpass bridge structure investigation consisted of 14 sampled boreholes (designated 10-01 to 10-16) which were advanced to depths ranging from 4.4 m to 9.0 m including bedrock coring and sampling.

For reference, the report indicates the stratigraphy in the area of the culvert structure is generally characterized as follows:

- 100 to 175 mm thick layer of top soil ground surface cover; overlying
- 2.9 m to 4.5 m thick stratum of firm to very stiff silty clay; overlying
- 0.3 m to 2.0 m thick stratum of soft to hard silt till; underlain by
- Shale bedrock with limestone interbedding
- Groundwater levels were measured at elevations ranging from 64.0 m to 65.0 m

3.2 GEOCRES 31G5-240 Investigation

The investigation for the extension of Culvert 3-315/C consisted of two sampled boreholes (designated 10-13 and 10-14) which were advanced to depths of 3.8 m to 5.5 m. No bedrock coring was carried out for this investigation.

For reference, the report indicates the stratigraphy in the area of the culvert structure is generally characterized as follows:

- 4.1 m of sand fill material (Borehole 10-13 only);
- 125 mm thick layer of top soil ground surface cover (Borehole 10-14 only); overlying
- 1.1 m to 2.9 m thick stratum of firm to stiff silty clay; overlying
- 0.3 m to 0.8 m thick stratum of soft to hard silt till; and
- Both boreholes were terminated at auger refusal on probable bedrock.

3.3 2014 Detailed Design Investigation for Culvert 3-315/C

A site investigation was carried out by Thurber for the proposed rehabilitation of Culvert 3-315/C. The investigation consisted of one sampled borehole designated 14-4. Drawing No. 1 (copy attached) illustrates the approximate location of Culvert 3-315/C and the investigation boreholes. A detailed description of the investigation methodology can be found in Thurber's Foundation Investigation Report for this site, GEOCRES No. 31G5-267.

The stratigraphy at this site is generally characterized by an asphalt pavement, overlying a granular fill, overlying a silty clay, overlying a silt till, underlain by inferred shale bedrock. The borehole for the 2014 investigation was terminated on the probable bedrock stratum. Further details are provided in the following sub-sections.

3.3.1 Asphalt

A 150 mm thick asphalt layer was encountered at the ground surface.

3.3.2 Fill – Sand and Gravel

A fill layer was encountered below the asphalt pavement consisting predominately of sand and gravel with varying amounts of silt and trace amounts of clay size particles. The top of this stratum was at elevation 67.7 m and the layer had a thickness of 2.0 m. The standard penetration test (SPT) 'N' values ranged from 18 to 46 blows per 0.3 m of penetration; indicating a dense to compact condition. The results of grain size analysis completed on a sample of this material indicated a gravel content of 35%, sand content of 47%, and a fines content (combined silt and clay size particles) of 18%.

The moisture content of the samples tested ranged from 4% to 6%.

3.3.3 Silty Clay

The fill layer was underlain by a 3.9 m thick stratum of silty clay. The top of this stratum was at elevation 65.7 m. The SPT 'N' values recorded in the silty clay layer generally ranged from 2 to 12 blows per 0.3 m penetration. The measured undrained shear strength values ranged from 90 kPa to 30 kPa based on the results of in-situ shear vane testing carried out in Borehole 14-4. The shear strength values indicate the silty clay to have a stiff to firm consistency that decreased in strength with depth.

The results of a grain size analysis test including hydrometer testing completed on two samples of this material indicated a gravel content of 0% for both samples, sand content of 1% and 7%, silt content of 40% and 56%, and clay content of 43% and 53%.

The moisture content of the samples tested ranged from 25% to 50%.

Atterberg Limits measured for two samples of this material revealed liquid limits of 30 and 52, plastic limits of 16 and 18 and plasticity indices of 14 and 34. These results indicate a clay of high plasticity at the top of the stratum to a clay of low plasticity at a depth of 5.1 m.

3.3.4 Silt Till

A glacial till stratum consisting predominately of silt and clay with varying amounts of sand and gravel was encountered below the silty clay stratum in Borehole 14-4. The top of this stratum was at elevation 61.8 m and the layer had a thickness of 2.6 m. The SPT 'N' values were greater than 100 blows per 0.3 m of penetration; indicating a very dense condition.

Cobbles were inferred to be present within this stratum, based on observed grinding of the augers. It should be noted that cobbles and boulders were also noted within the silt till stratum on the Records of Borehole from previous investigations.

The results of grain size analysis completed on a sample of this material indicated a gravel content of 18%, sand content of 19%, silt content 37% and a clay content of 26%.

The moisture content of the sample tested was 28%.

3.3.5 Bedrock

Bedrock was inferred beneath the glacial till by auger refusal in Borehole 14-4 at an elevation of 59.2 m.

Bedrock coring was carried out as part of the 2011 underpass bridge structure investigation; GEOCRES Report No. 31G5-237. The bedrock / soil interface was proven by coring in 12 of the 14 boreholes advanced as part of the 2011 investigation. The bedrock surface ranged in elevation from 60.7 m to 62.2 m. Bedrock total core recovery ranged from 93% to 100%; solid core recovery ranged from 40% to 100%; and the measured RQD values ranged from 40% to 100%. Based on the RQD values the rock mass quality is classified as ranging from poor to excellent. Based on the results of point load testing the bedrock ranges from weak shale to strong limestone.

Geological mapping suggests the bedrock at this site is shale of the Carlsbad Formation.

3.4 Groundwater

Groundwater was measured as part of the 2014 investigation in the open borehole prior to backfilling at an elevation 60.3 m or 7.6 m below the existing ground surface.

A 19 mm inside diameter PVC monitoring well was installed in each of Boreholes 10-03, 10-5, 10-07, and 10-12 as part of the 2011 investigation. Groundwater levels in the monitoring wells were recorded in July 2010, at depths of 0.94 m to 1.5 m corresponding to elevations ranging from 64.0 m to 65.0 m.

The water level in McEwen Creek was measured at the time of Thurber's site inspection on July 17, 2014, at a depth of 3.5 m below the top of the culvert; corresponding to an elevation of 63.6 m.

4 SITE OBSERVATIONS

A structure inspection was conducted by MTO in August 2012, for Culvert 3-315/C with the report issued September 2012. Condition data outlined in the report for the culvert structure ranged from poor to good but typically the culvert was rated in good condition. The report recommended minor concrete rehabilitation work to be completed for the culvert in 1 to 5 years of the inspection.

The site was inspected by Thurber Engineering staff during the week of July 14th, 2014. Several photographs of the site are attached.

At the time of the inspection, the following observations were made:

West Inlet:

- Gabions were installed at the inlet for erosion protection
- Vegetation was noted on the side slopes, behind the wing walls and on top of the culvert
- The slope behind the wing walls was measured at approximately 22° and was noted as being in generally good condition
- No obvious settlement of the road surface was observed at the crossing

East Outlet:

- Construction of the culvert extension and surrounding creek banks was ongoing at the time of the inspection. As such no erosion protection measures were installed nor had vegetation cover been established, either behind the wing walls or over the culvert
- Erosion behind the wing walls and over the culvert was noted
- No obvious settlement of the road surface was observed at the crossing

5 GEOTECHNICAL ASSESSMENT

5.1 Frost Considerations

The frost penetration depth at this site is 1.8 m (OPSD 3090.101). Foundations for open footing culverts on soil must be provided with frost protection equivalent to at least 1.8 m of cover. Closed box culverts do not typically require frost protection in addition to standard bedding and backfill.

5.2 Seismic Considerations

This site is classified as a Soil Profile Type I in accordance with Section 4.4.6 of the Canadian Highway Bridge Design Code (CHBDC). The zonal acceleration ratio for this site is 0.20 as per Table A3.1.1 of the CHBDC.

Based on the consistency of the native till and the plasticity of the silty clay materials encountered at this site these materials are classified as “not susceptible” to liquefaction during the design earthquake event.

5.3 Existing Foundations

As indicated on the General Layout Drawing, the stream bed had a design top elevation ranging from 63.4 m to 63.2 m and had a thickness of 300 mm. The concrete base for the culvert had a design top elevation ranging from 63.2 m to 62.8 m and had a thickness of 0.4 m. Bedding material is indicated on the drawing to be Select Subgrade Material with a thickness of 800 mm or the depth to sound bedrock whichever is less. Therefore, the underside of the culvert is founded at approximate elevations ranging from 62.8 m to 62.4 m; and the underside of bedding is near the contact between the silty clay and the silt till strata. The recommended design allowable bearing value as reported in the Foundation Design Report was 71 kPa for the clay stratum.

The construction drawings also indicate that the top of the culvert elevation was to range from 67.3 m to 67.0 m. Based on the elevation survey data from Thurber’s 2014 investigation the road surface elevation of the eastbound lanes of Highway 417 is 67.9 m. Original grade in the area was approximately 65.5 m to 65.8 m. Therefore approximately 2.1 m to 2.4 m of fill would have been required to construct the Highway 417 crossing in the vicinity Culvert 3-315/C.

PART 2: ENGINEERING DISCUSSION AND PRELIMINARY RECOMMENDATIONS

6 GEOTECHNICAL RECOMMENDATIONS

Based on the available data regarding the ground conditions at this site, the following sections present preliminary geotechnical recommendations for the assessment of the existing culvert and for preliminary design for potential culvert extensions, replacement, and the construction of new wing walls, end sections and/or headwall structures, if required. It is noted that the proposed construction options for this site are not yet defined though presently concrete rehabilitation work is proposed for this structure. The preliminary recommendations provided below are for assistance in developing and evaluating options and will need to be refined during subsequent design stages.

The existing culvert is a concrete box culvert likely founded on stiff to firm clay. For culvert extensions, it is preferred that type of foundations and founding elevation match the existing arrangement so as not to undermine the existing foundation. From a foundation perspective for a culvert replacement, a concrete rigid-frame open-footing culvert could have bearing resistance

limitations as well as groundwater concerns during construction. Both concrete closed boxes and CSP arches would be preferred.

6.1 Shallow Foundations

For strip footings founded on native very stiff to soft silty clay having a minimum embedment depth of 1.8 m and a width of between 1 m and 2 m, the factored vertical geotechnical resistance at ULS is 120 kPa. The vertical geotechnical reaction at SLS is 100 kPa based on a total footing settlement of 25 mm.

A replacement culvert would likely require a span and an invert elevation similar to the existing. For a closed box culvert founded at the same elevation as the existing culvert on native very stiff to firm clay and a base width of 6.9 m, the factored vertical geotechnical resistance at ULS is 150 kPa. The vertical geotechnical reaction at SLS is 85 kPa based on a total footing settlement of 25 mm.

If higher geotechnical resistances are required the culvert could be lowered to be founded on the dense till. A vertical geotechnical reaction at SLS of 150 kPa based on a total footing settlement of 25 mm can be used for preliminary design for a 6.9 m wide closed box culvert in the till.

Resistance to lateral forces and sliding resistance between concrete and underlying materials should be evaluated using an unfactored coefficient of friction of 0.35 for cast-in-place concrete and 0.30 for pre-cast concrete on native silty clay.

6.2 Excavations, Bedding and Backfilling

All excavations must be conducted in accordance with the requirements of the Occupational Health & Safety Act & Regulations (OHSA) for Construction Projects. The anticipated native soils and embankment fill at the site should be classified as Type 3 in accordance with OHSA.

Where excavations will extend below the groundwater level prevailing at the time of construction, the contractor will need to implement groundwater control, creek diversions, and ground support systems as are required to carry out the construction in a safe, stable, and unwatered excavation.

Excavations, bedding and backfill for rigid structures should be in accordance with OPSS 422 and 902. Backfill for the culvert must consist of free draining granular material conforming to OPSS Granular A or B material specifications. For preliminary purposes the bedding layer should be 300 mm in thickness.

Subgrade preparation and placement of culvert bedding must be carried out in the dry.

6.3 Static Lateral Earth Pressure Coefficients

Lateral earth pressures acting on structures should be computed in accordance with the CHBDC but generally are given by the expression:

$$P_h = K^*(\gamma h + q)$$

where:

P_h = horizontal pressure on the wall (kPa)
K = earth pressure coefficient
γ = unit weight of retained soil
h = depth below top of fill where pressure is computed (m)
q = value of any surcharge (kPa)

The recommended lateral earth pressure parameters for use in the design for both a horizontal and for 2H:1V (Horizontal:Vertical) back-slope are provided in Table A.

For rigid structures such as Culvert 3-315/C, it is recommended that at-rest horizontal lateral earth pressures be used for design. Active pressures should be used for the design of unrestrained walls.

A lateral pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with the Section 6.9.3 of the CHBDC.

The parameters provided in Table A are based on the assumption that the backfill is fully drained so that there are no unbalanced hydrostatic pressures. If adequate drainage cannot be confirmed, the potential for hydrostatic pressures should be considered.

Table A: Static Lateral Earth Pressure Coefficients

Parameter	OPSS Granular A & OPSS Granular B Type II	OPSS Granular B Type I & Existing Highway Fill	Native Silty Clay	Native Silt Till
Soil Unit Weight, kN/m^3, γ	21	20	17	19
Angle of Internal Friction, ϕ	35°	30°	27°	30°
Horizontal Back-Slope				
Coefficient of at Rest Earth Pressure, K_o (Restrained Wall)	0.43	0.50	0.55	0.50
Coefficient of Active Earth Pressure, K_a (Unrestrained Wall)	0.27	0.33	0.38	0.33
2H:1V Back-Slope				
Coefficient of Active Earth Pressure, K_a	0.39	0.53	0.7	0.53

6.4 Embankments

Given the anticipated shallow bedrock and the soil type prevalent in this area settlement would be minimal for minor widening and/or minor grade increases. Embankment side slopes of no steeper than 2H:1V are appropriate for preliminary design.

6.5 Erosion Control

During Thurber's site inspection no erosion protection measures were observed at the culvert outlet as construction activities at the site were ongoing. However, erosion protection measures were noted at the culvert inlet.

Active erosion of the embankment was noted on both sides of the outlet of Culvert 3-315/C. Erosion protection should be established at these locations. Design of the erosion protection measures must consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field.

Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact. Treatment at the outlets should be in accordance with OPSD 810.010. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS 804.

A concrete cut-off wall or clay seal should be installed at the culvert inlet to minimize the potential for seepage through the granular bedding and backfill material and avoid consequent erosion of these materials. The clay seal should have a minimum thickness of 0.5 m, completely surround the culvert, extend laterally the width of the granular backfill material, and extend above the high water level. The material used for the clay seal should conform to the requirements of OPSS 1205. It is noted that a concrete cut off wall was included in the design for this site.

7 Future Investigation

There is a significant data base available for Culvert site 3-315/C. Further foundation investigations are not likely required, however, the need must be re-assessed once the proposed works are defined.

THURBER

8 CLOSURE

We trust this information provided in this technical memorandum meets your present purposes. Please let us know if you have any questions or need additional information.

Thurber Engineering Ltd.

Kenton C. Power, P.Eng.
Geotechnical Engineer

Fred Griffiths, P.Eng.
Associate, Senior Geotechnical Engineer

P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact

Attachments

GWP 4074-11-00
Site Photographs

PRELIMINARY FOUNDATION DESIGN
McEWEN CREEK CULVERT STRUCTURE (SITE 3-315/C)

West inlet

Northwest inlet wing wall

GWP 4074-11-00
Site Photographs

PRELIMINARY FOUNDATION DESIGN
McEWEN CREEK CULVERT STRUCTURE (SITE 3-315/C)

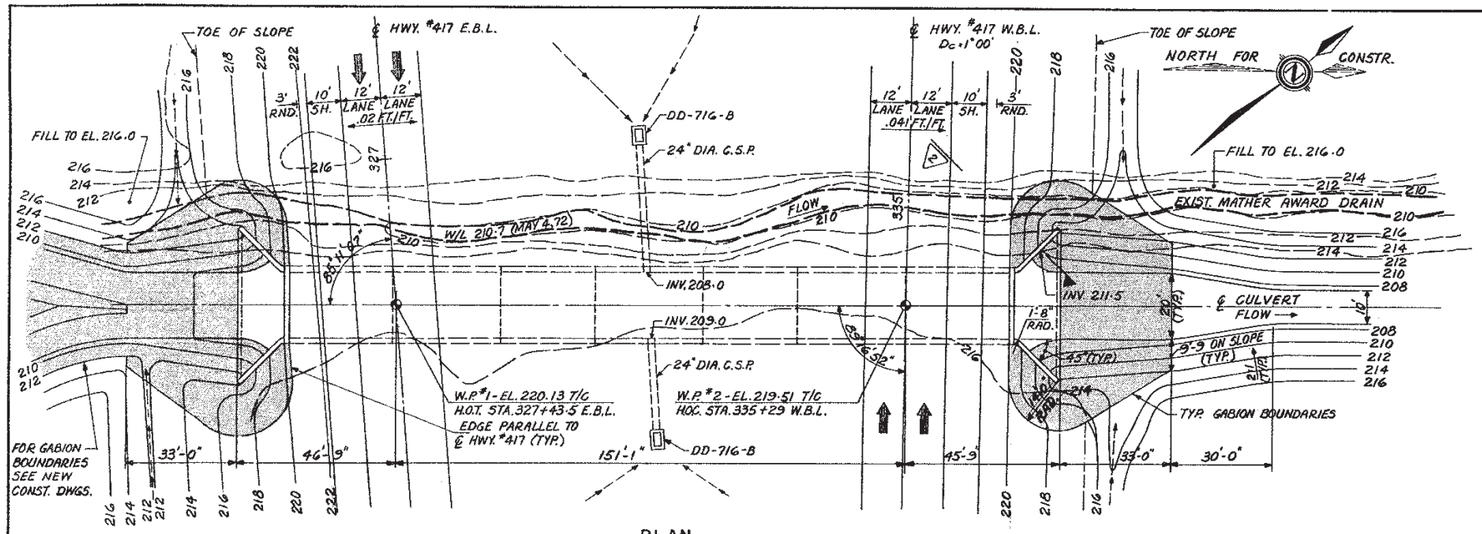
West inlet looking upstream

East outlet

GWP 4074-11-00
Site Photographs

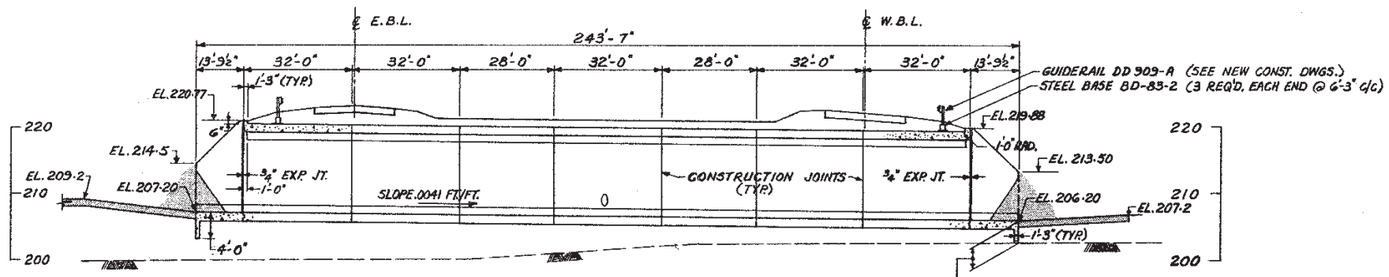
PRELIMINARY FOUNDATION DESIGN
McEWEN CREEK CULVERT STRUCTURE (SITE 3-315/C)

East outlet note erosion of material behind wingwall



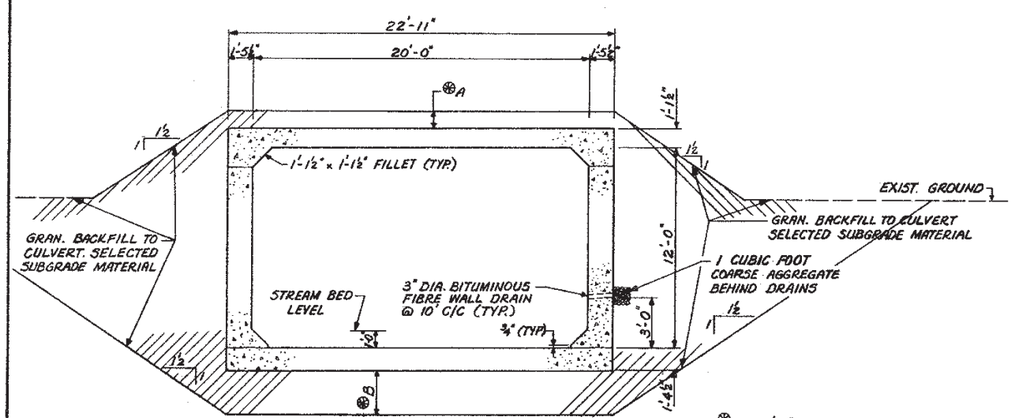
PLAN

SCALE: 1" = 20'



ELEVATION

SCALE: HOR. 1" = 20' VER. 1" = 10'

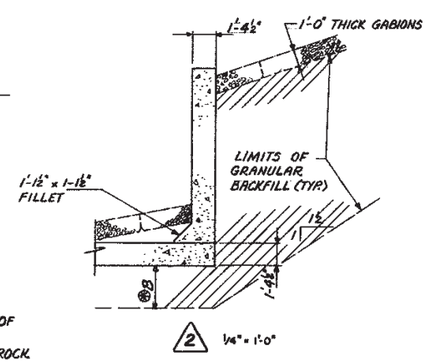


SECTION THRU CULVERT

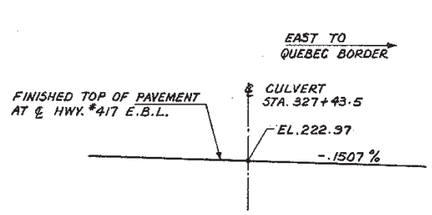
SCALE: 1/8" = 1'-0"

℄A = 1'-0" OR DEPTH FROM UNDERSIDE OF GRANULAR 'A' WHICHEVER IS LESS

℄B = 2'-7½" OR DEPTH TO SOUND BEDROCK WHICHEVER IS LESS.

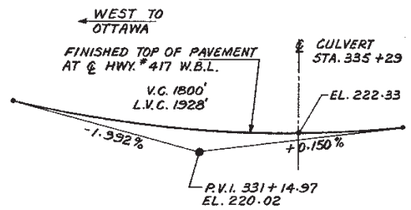


2 1/4" = 1'-0"



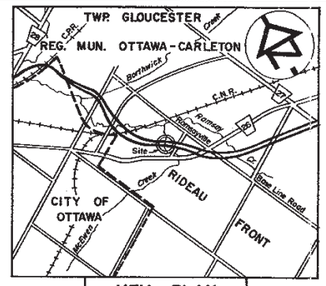
PROFILE OF HWY. #417 E.B.L.

N.T.S.



PROFILE OF HWY. #417 W.B.L.

N.T.S.



KEY PLAN

SCALE - 1 IN. = 1 MI.

REFERENCE BENCH MARK

M.T.C. B.M. 227-083

LARGE CONC. CULV. CARRYING SMALL CREEK UNDER RUSSEL. RD. (REG. RD. 26) BEING 1·05 MILES S. OF WALKLEY RD. IN THE CITY OF OTTAWA AND 0·2 MILES S. OF ST. GEORGE ANGLICAN CHURCH. TABLET IS SET HORIZONTALLY IN N. FACE OF W. END BEING 4.1 FEET E. OF N.W. CORNER, 1.4 FEET BELOW TOP AND 37·5 FEET W. OF ℄ OF RUSSELL RD.

NOTES:

W.P. DENOTES WORKING POINT
T/C DENOTES TOP OF CONCRETE CULVERT
W/L DENOTES WATER LEVEL

CLASS OF CONCRETE:

ALL -3000 P.S.I.

CLEAR COVER TO REINF. STEEL:

BOTTOM OF TOP SLAB - 1½"
REMAINDER - 3"

CONSTRUCTION NOTE:

BACKFILL TO BE PLACED SIMULTANEOUSLY ON BOTH SIDES OF THE CULVERT.

LIST OF DRAWINGS

FOR REDUCED PLAN

USE SCALE BELOW

0 1 2 3

3 INCHES ON ORIGINAL PLAN

REVISIONS	DATE	BY	DESCRIPTION

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS
ONTARIO

Consulting Engineers & Planners

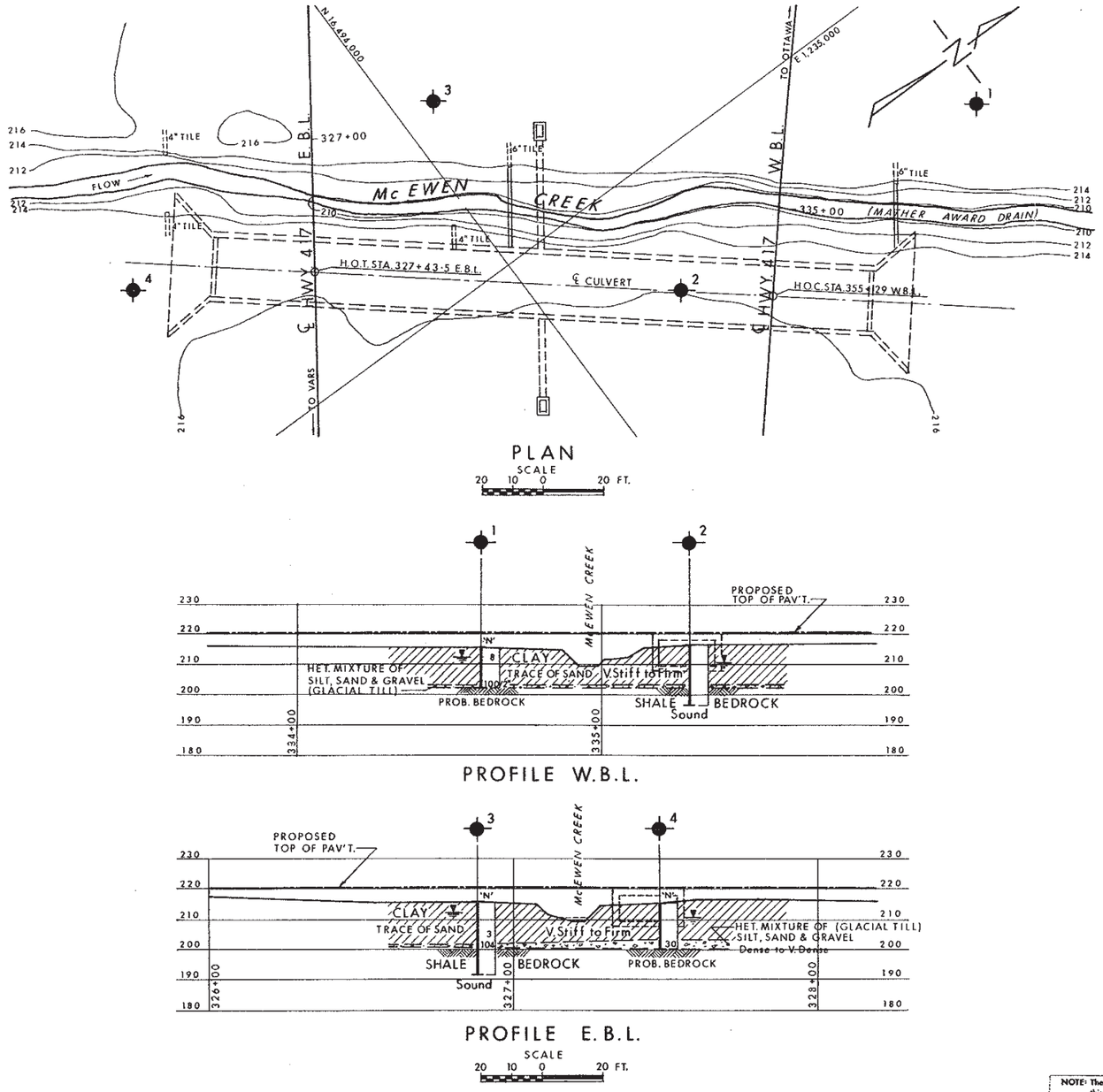
McEWEN CREEK
(MATHER DRAIN)
1·2 MILES EAST OF WALKLEY RD.

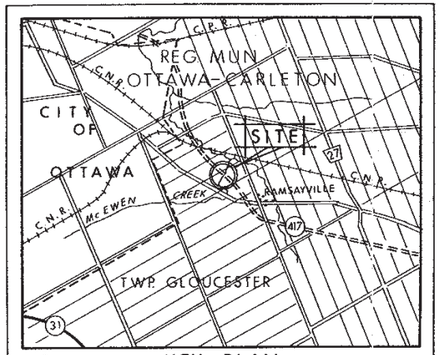
KING'S HIGHWAY No. 417 DIST. No. 9
CO. REG. MUN. OTTAWA-CARLETON
TWP. GLOUCESTER LOT 2 CON. VI

GENERAL LAYOUT

APPROVED	STRUCTURAL ENGINEER			SITE No. 3-315	W.P. No. 10-69-16
				CONTRACT Nos.	73-192
DESIGN	W.W.I.	CHECK			
DRAWING	A.G.Y.	CHECK	C.M.G.	DRAWING No.	3-315-1
DATE	MAR. 73	LOADING	MS20-44		

REGISTERED PROFESSIONAL ENGINEER — W. W. IRWIN — 1037 — PROVINCE OF ONTARIO





LEGEND

- Bore Hole
- Cone Penetration Test
- Bore Hole & Cone Test
- Water Levels established at time of field investigation. OCT. 1972

NO.	ELEVATION	STATION	OFFSET
1	214·9	334+60	62'LT. WBL.
2	216·0	335+29	30'RT. WBL.
3	215·6	326+88	40'LT. EBL
4	215·1	327+48	60'RT. EBL

— 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 soil investigation report for this structure may be examined at the Bridge Office and Foundation Office, Downsview, and at the Ottawa District Office.

REF. No. E-5232-1

REVISIONS		
DATE	BY	DESCRIPTION

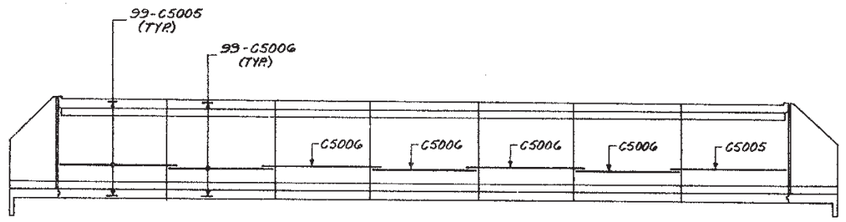
MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

McEWEN CREEK (MATHER AWARD DRAIN)

HIGHWAY NO. 417 E.B.L. & W.B.L. DIST. NO. 9
CO. REGIONAL MUNICIPALITY OF OTTAWA-CARLETON
TWP. GLOUCESTER LOT 4 CON. 6

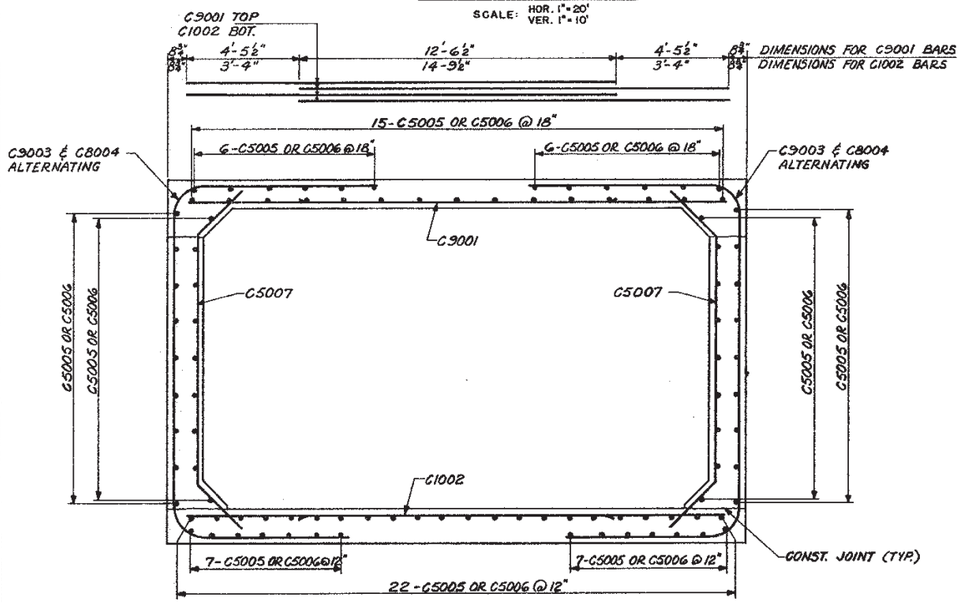
BORE HOLE LOCATIONS & SOIL STRATA

SUBMD. J. C.	CHECKED	W.P. NO. 10-69-16	DRAWING NO. 72-11104A
DRAWN OL. J.	CHECKED	W.O. NO. 72-11104	
DATE 29 NOV. 1972		SITE NO. 3-315	BRIDGE DRAWING NO. 3-315-2
APPROVED PRINCIPAL FOUNDATION ENGINEER		CONT. NO. 73-190	



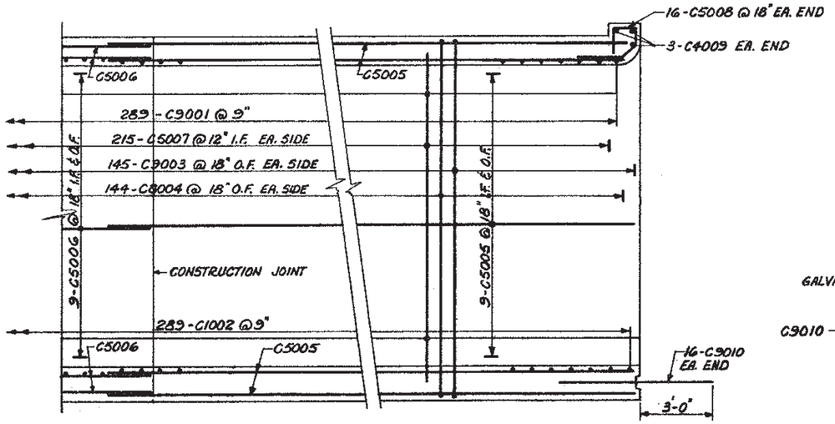
SECTIONAL ELEVATION

SCALE: HOR. 1"=20' VER. 1"=10'



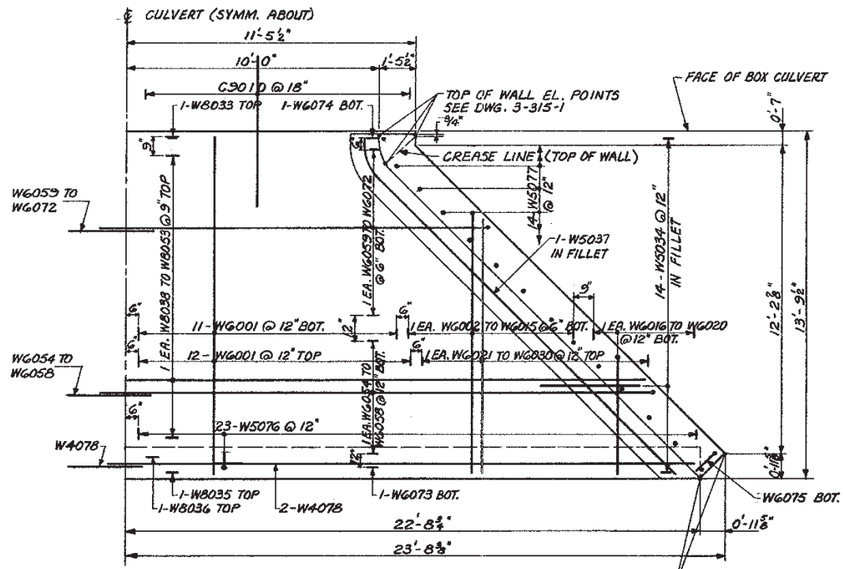
TRANSVERSE SECTION

SCALE: 3/8"=1'-0"



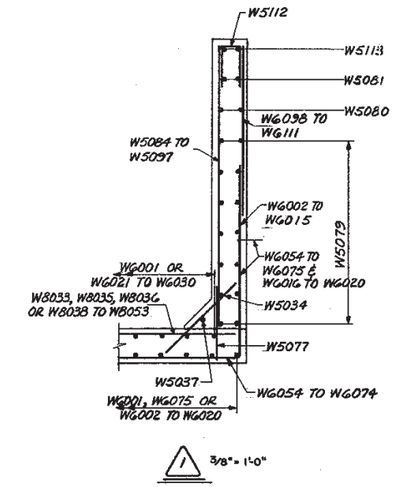
LONGITUDINAL SECTION

SCALE: 3/8"=1'-0"

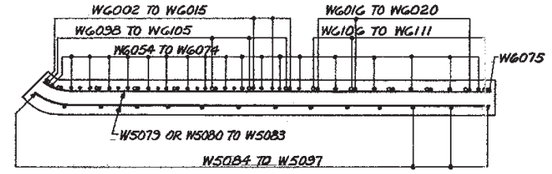


HALF PLAN OF INLET/OUTLET SLAB

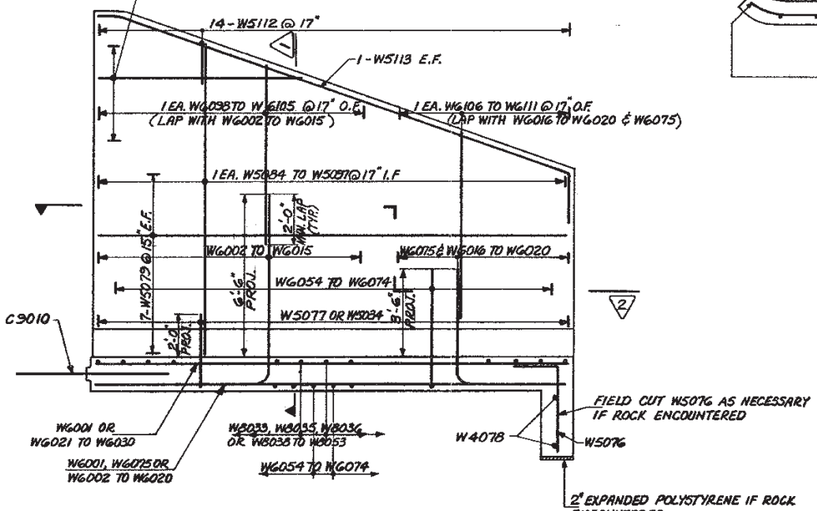
SCALE: 3/8"=1'-0"



1 3/8"=1'-0"

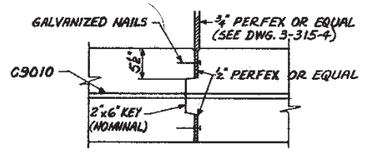


2 3/8"=1'-0



ELEVATION

SCALE: 3/8"=1'-0"



HINGE DETAIL

SCALE: 1" = 1'-0"

NOTES:

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

REVISIONS		
DATE	BY	DESCRIPTION

FOR REDUCED PLAN

USE SCALE BELOW

0 1 2 3

3 INCHES ON ORIGINAL PLAN

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS
ONTARIO

Consulting Engineers & Planners

McEWEN CREEK
(MATHER DRAIN)
1-2 MILES EAST OF WALKLEY RD.

KING'S HIGHWAY No. 417 DIST. No. 9
CO. REG. MUN. OTTAWA-CARLETON
TWP. GLOUCESTER LOT 2 CON. VI

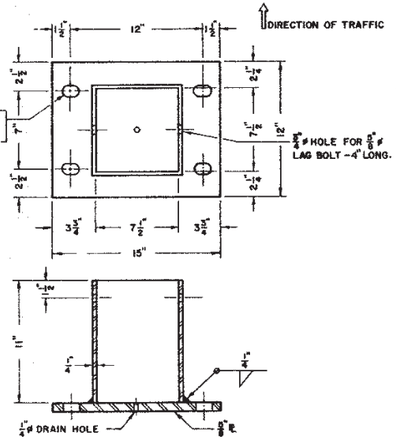
DETAILS

APPROVED STRUCTURAL ENGINEER				SITE No. 3-315	W.P. No. 10-69-16
DESIGN	WJ	CHECK		CONTRACT Nos.	73-190
DRAWING	A.G.Y.	CHECK	E.M.B.	DRAWING No.	3-315-3
DATE	MAR. 73	LOADING	HS20-44		

REGISTERED PROFESSIONAL ENGINEER W. W. IRWIN PROVINCE OF ONTARIO

STEEL BASE FOR 8"x8" GUIDE RAIL POSTS

BD-83-2
REV. JAN. 71

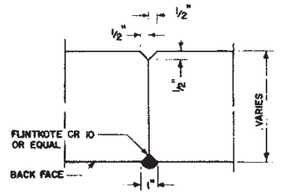


NOTES:

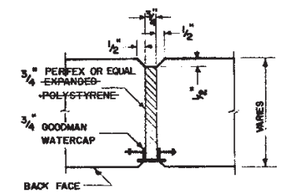
STEEL FOR BASE SHALL BE IN ACCORDANCE WITH C.S.A. STANDARD G 40.12 OR EQUAL.
BASE SHALL BE HOT DIPPED GALVANIZED IN ACCORDANCE WITH C.S.A. G164.
ALL WELDS SHALL BE TO A LOW HYDROGEN CLASSIFICATION. MANUAL ELECTRODES SHALL BE E 7015, E 7016 OR E 7018. WELDS SHALL BE CONTINUOUS.
SOCKETS SHALL BE FABRICATED FROM SQUARE HOLLOW SECTIONS OR FROM PLATES OR ROLLED SECTIONS.
BASE SHALL BE INSTALLED PERPENDICULAR TO GRADE.
TRANSVERSELY TO ℄ OF HWY. BASE SHALL BE INSTALLED LEVEL.
WHERE CONCRETE UNDER BASE IS NOT LEVEL, BASE SHALL BE INSTALLED ON A PAD OF EPOXY GROUT.
WHERE BASE IS TO BE INSTALLED ON EXISTING CONCRETE, BASE SHALL BE ANCHORED INTO CONCRETE USING 4-TWO UNIT THREADED "CINCH" ANCHORS, 5/8" DIA.
BOLTS ARE NOT REQUIRED WHEN BASE IS EMBEDDED 4" OR MORE INTO CONCRETE.

~~RETAINING WALLS~~ TYPICAL JOINT DETAILS

BD 41-5
FEB 1971



CONSTRUCTION JOINTS



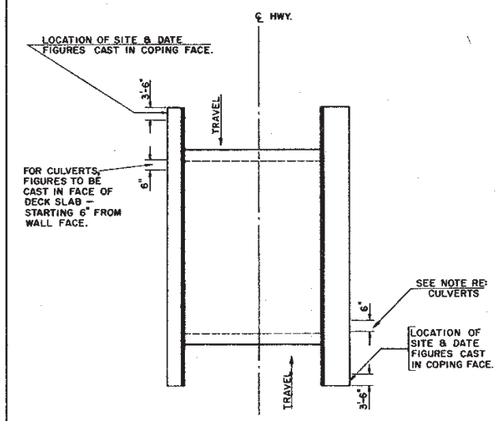
EXPANSION JOINTS

NOTES:

- ~~EXPANSION JOINTS IN FOOTINGS TO BE 3/4" EXPANDED POLYSTYRENE.~~
- HOLD ~~EXPANDED POLYSTYRENE~~ PERFEX IN PLACE WITH LIGHT GALV. NAILS.

LOCATION OF BRIDGE SITE & DATE FIGURES

BD 100-3
APRIL-1970



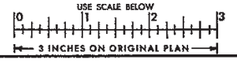
PLAN

NOTE:

SEE BD 100-2 FOR SIZE & SPACING OF FIGURES.

FOR REDUCED PLAN

USE SCALE BELOW



3 INCHES ON ORIGINAL PLAN

REVISIONS

DATE	BY	DESCRIPTION

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS
ONTARIO

DILLON Consulting Engineers & Planners

McEWEN CREEK
(MATHER DRAIN)
1-2 MILES EAST OF WALKLEY RD.

KING'S HIGHWAY No. 417 DIST. No. 9
CO. REG. MUN. OTTAWA-CARLETON
TWP. GLOUCESTER LOT 2 CON. VI

STANDARD DETAILS

APPROVED _____ STRUCTURAL ENGINEER

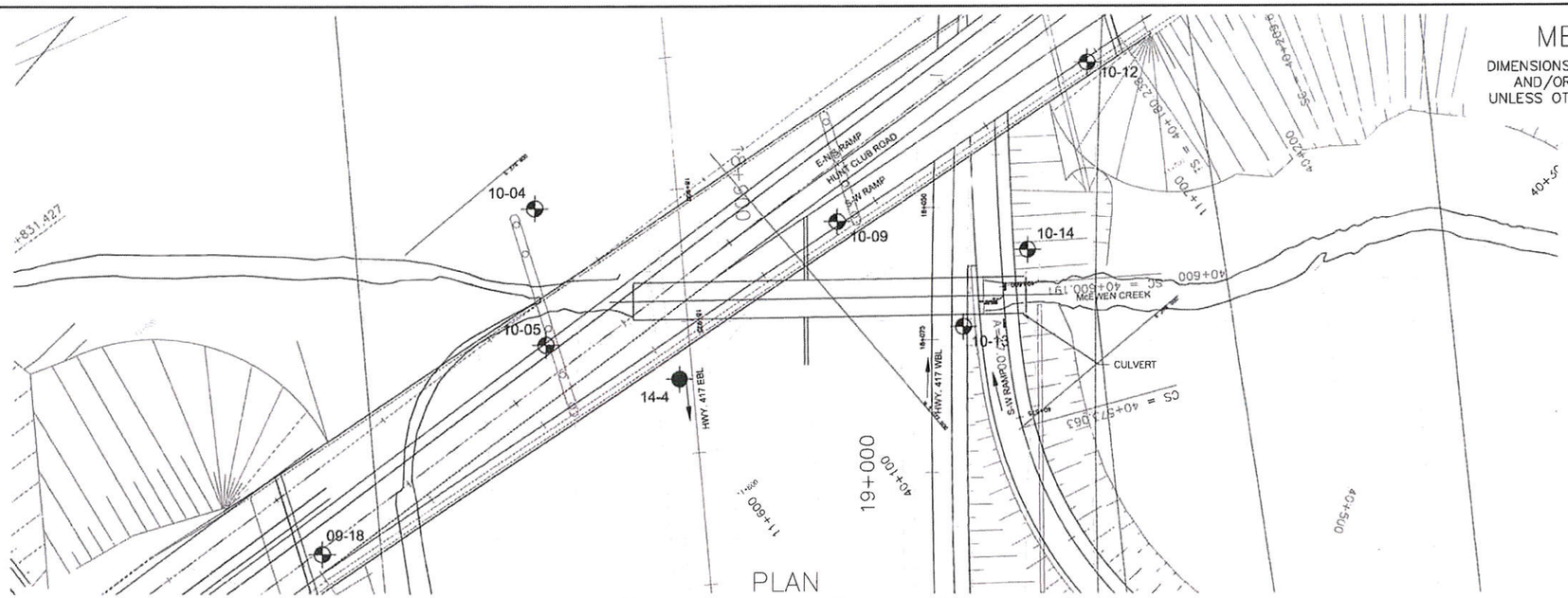
SITE No. 3-315 W.F. No. 10-69-16
CONTRACT Nos.
DRAWING No. 3-315-4

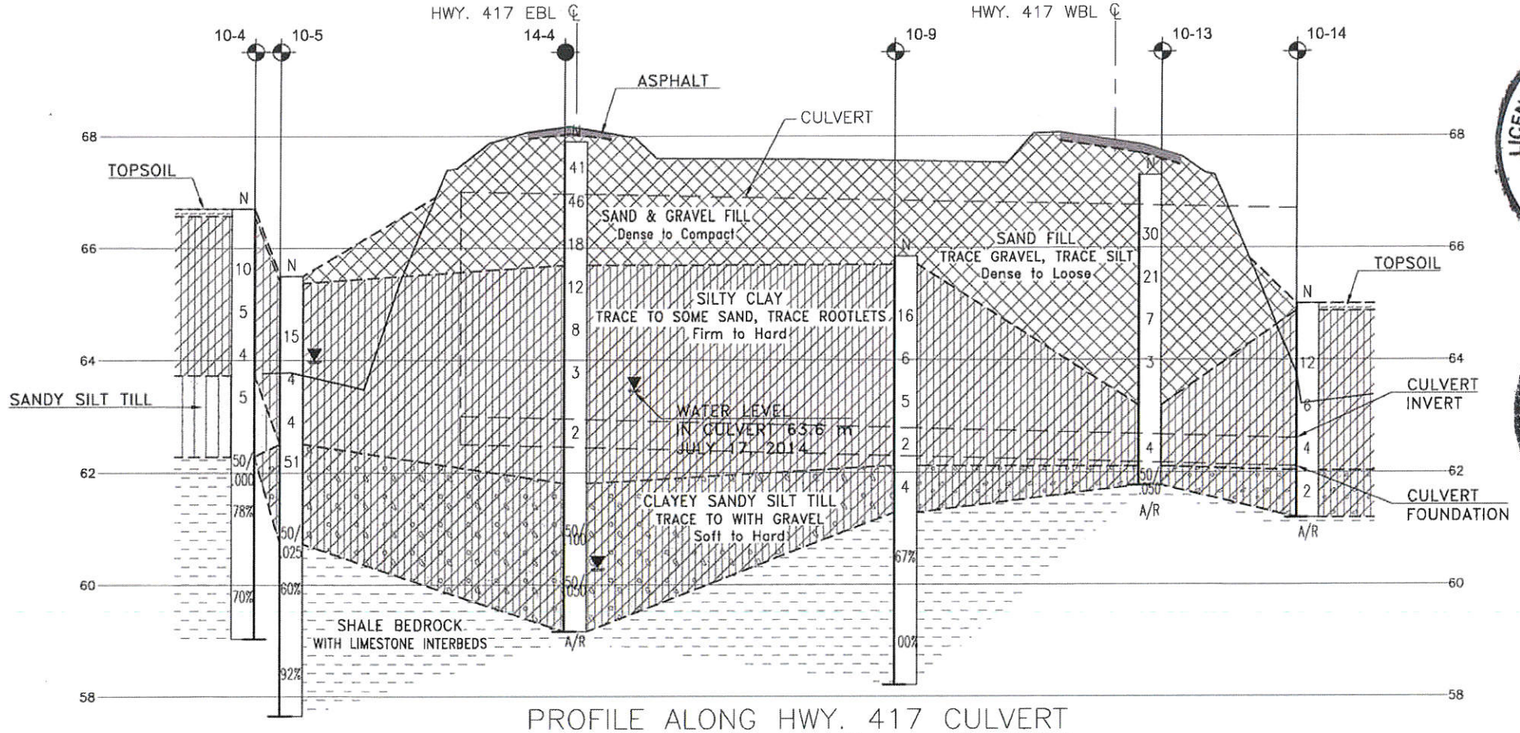
DESIGN	STD.	CHECK	
DRAWING	A.G.Y.	CHECK	C.M.B.
DATE	MAR.73	LOADING	HS20-44

MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN





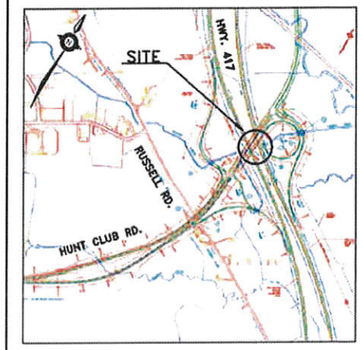
CONT No
WP No 4074-11-00

McEWEN CREEK CULVERT
CULVERT 3-315/C

BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

●	Borehole (Current Investigation)
⊕	Borehole (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
14-4	67.9	5 027 568.3	376 451.3
10-4	66.7	5 027 568.3	376 409.0
10-5	65.5	5 027 553.3	376 430.1
10-9	65.9	5 027 609.9	376 447.7
10-12	65.6	5 027 665.0	376 455.1
10-13	67.3	5 027 615.1	376 478.3
10-14	65.0	5 027 633.7	376 475.0
09-18	66.5	5 027 496.0	376 433.2

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
July 3/15
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
F. J. GRIFFITHS
July 3/15
PROVINCE OF ONTARIO

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 31G5-267

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	CM	CHK	PC	CODE	LOAD	DATE	DEC. 2014
DRAWN	MFA	CHK	CM	SITE	STRUCT	DWG	1

FILENAME: H:\Projects\19\3405\3 - Hwy 417 Aviation to Romeyville\Culverts\Culvert 6 - Site 3-443_CV.CAD from Oakville\std4053-HWY417-CulvertRehab-2.dwg
PLOTDATE: 7/2/2015 10:58 AM

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 14-4 1 OF 1 METRIC

W.P. 4074-11-00 LOCATION McEwen Creek Culvert N 5 027 568.3 E 376 451.3 ORIGINATED BY KMY

HWY 417 BOREHOLE TYPE Hollow Stem Auger COMPILED BY KMY

DATUM Geodetic DATE 2014.08.28 - 2014.08.28 CHECKED BY FJG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
0.0	**Asphalt (150 mm)**										
0.2	Silty Sand and Gravel Dense Grey **FILL**		1	SS	41						
			2	SS	46		67				35 47 18 (SI+CL)
66.5											
1.4	Compact		3	SS	18		66				
65.7											
2.2	**Clay (CH)**, silty Stiff Grey to Brown		4	SS	12						
			5	SS	8		65				0 7 40 53
			6	SS	3		64	11.0			
63.0											
4.9	**Silty Clay (CL)** Firm Grey		7	SS	2		63				0 1 56 43
61.8											
6.1	Clayey Silt some Sand and Gravel Hard Grey **TILL** inferred cobbles and boulders based on auger grinding		8	SS	50/ 100mm	▽	62				
			9	SS	50/ 50mm		61				18 19 37 26
59.2							60				
8.7	Auger Refusal at 8.7 m on probable bedrock Borehole remained open with water at 7.6 m after drilling										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

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

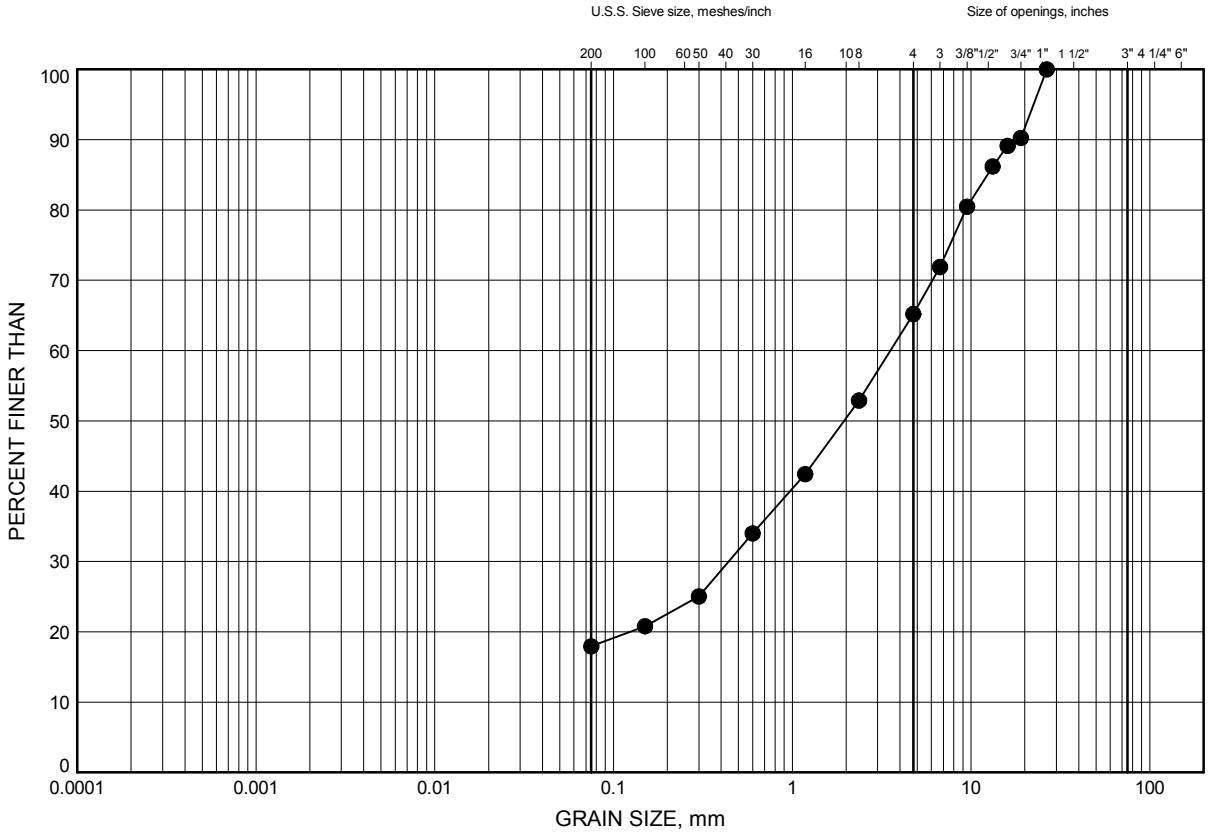
ONTMT4S 19-3405-3-CULVERT 13.GPJ 2012TEMPLATE(MTO).GDT 2/7/15

McEwen Creek Culvert

GRAIN SIZE DISTRIBUTION

FIGURE C1

Fill



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-4	1.07	66.83

Date November 2014

W.P. 4074-11-00

THURBER

Prep'd CM

Chkd. FJG

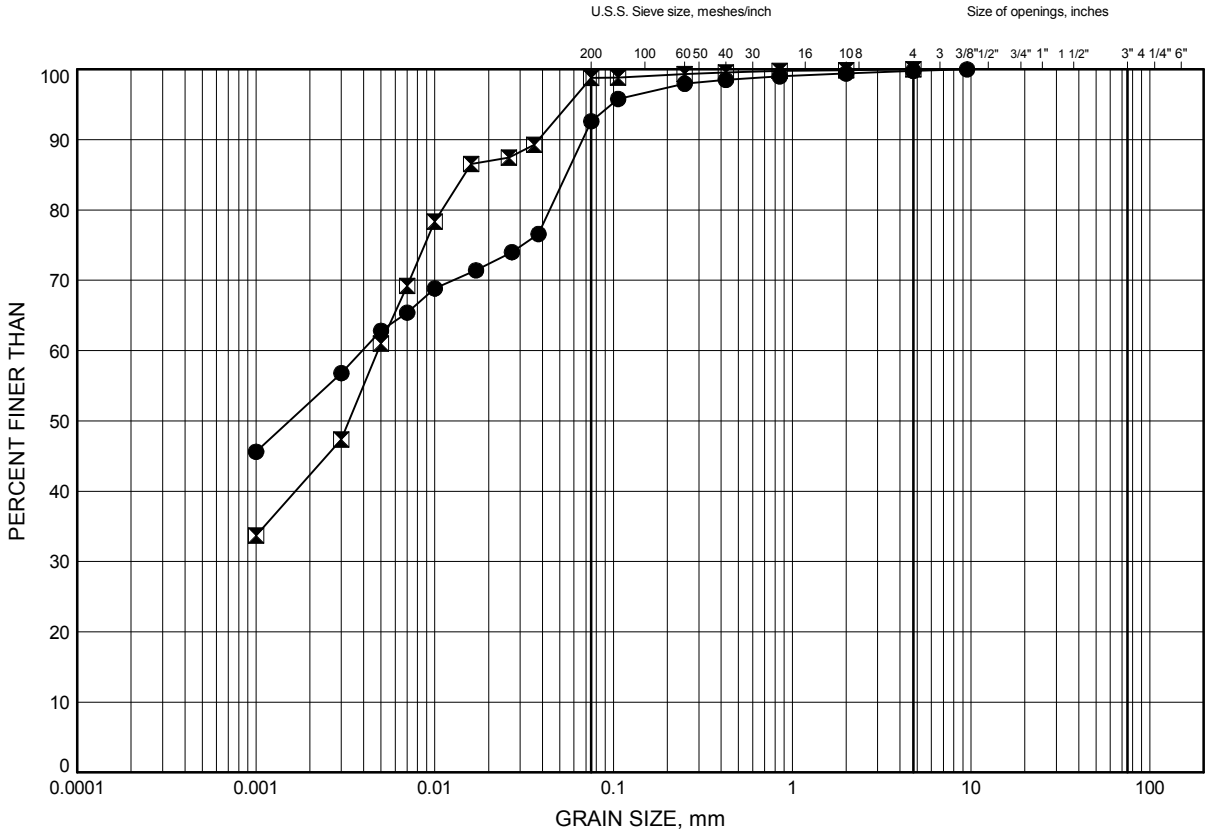
GRAIN SIZE DISTRIBUTION - THURBER 19-3405-3-CULVERT 13.GPJ 10/11/14

McEwen Creek Culvert

GRAIN SIZE DISTRIBUTION

FIGURE C2

Silty Clay



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-4	3.35	64.55
⧓	14-4	5.18	62.72

Date November 2014

W.P. 4074-11-00

THURBER

Prep'd CM

Chkd. FJG

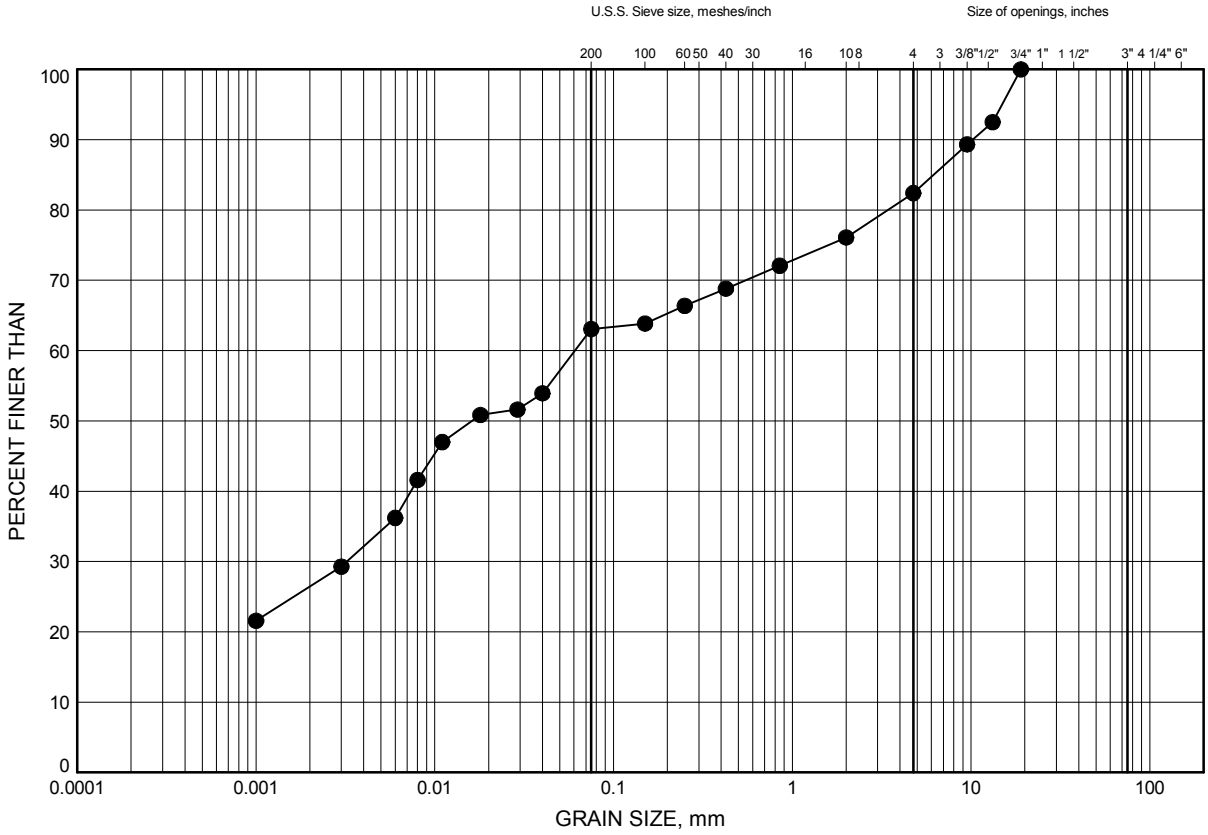
GRAIN SIZE DISTRIBUTION - THURBER 19-3405-3-CULVERT 13.GPJ 10/11/14

McEwen Creek Culvert

GRAIN SIZE DISTRIBUTION

FIGURE C3

Till



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-4	7.01	60.89

Date November 2014

W.P. 4074-11-00

THURBER

Prep'd CM

Chkd. FJG

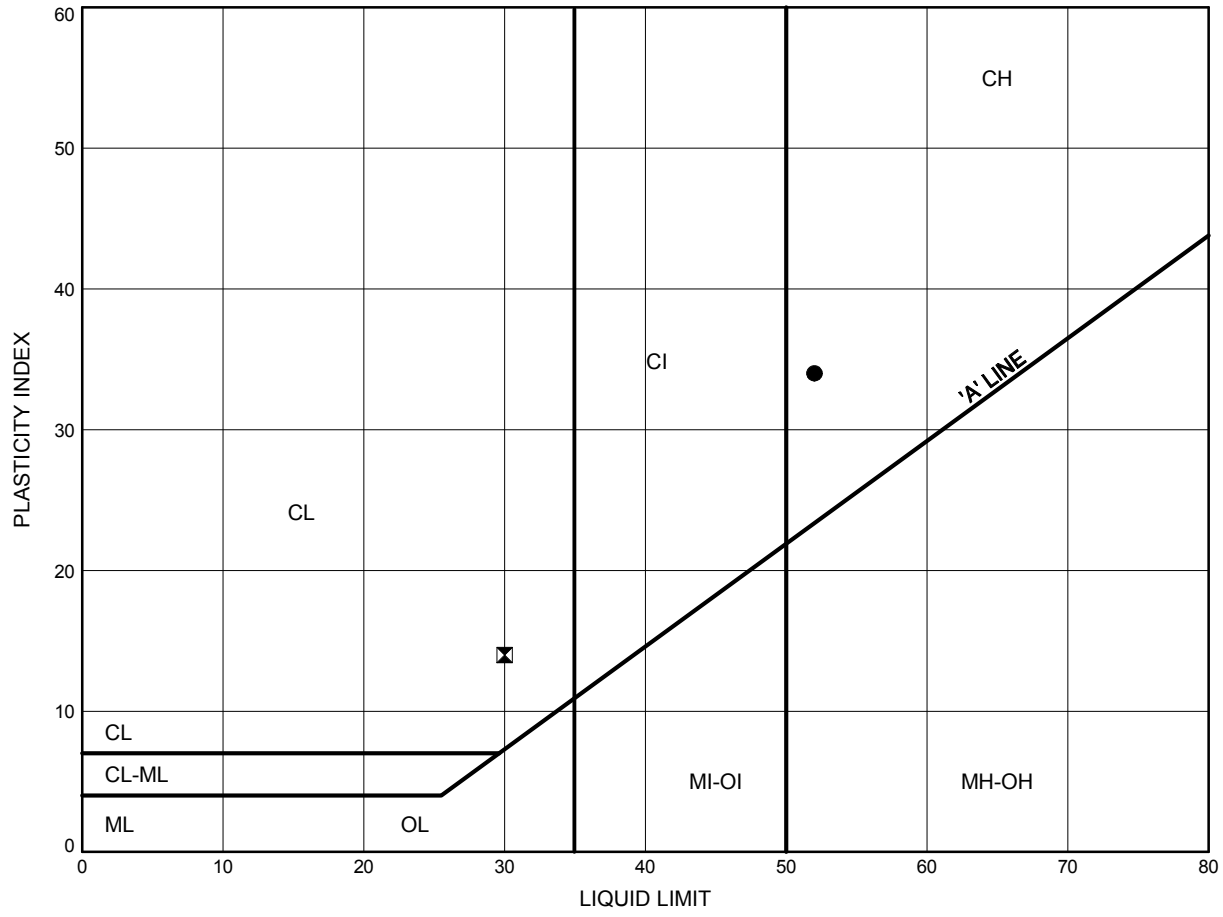
GRAIN SIZE DISTRIBUTION - THURBER 19-3405-3-CULVERT 13.GPJ 10/11/14

McEwen Creek Culvert

ATTERBERG LIMITS TEST RESULTS

FIGURE C4

Silty Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-4	3.35	64.55
⊠	14-4	5.18	62.72

Date November 2014

W.P. 4074-11-00

THURBER

Prep'd CM

Chkd. FJG

THURBER

APPENDIX 14

SITE 3-444/C

THURBER

MEMORANDUM

To: Laura Donaldson, P.Eng.
McIntosh Perry Consulting Engineers

Date: July 17, 2015

From: Kenton Power, P.Eng.
(Reviewed by Fred Griffiths, P.Eng. and P.K. Chatterji, P.Eng.)

File: 19-3405-3

PRELIMINARY FOUNDATION DESIGN
RAMSAY CREEK STRUCTURAL CULVERT (SITE 3-444/C) HIGHWAY 417 AND RAMSAYVILLE ROAD
GWP 4074-11-00, GEOCRES 31G5-262

PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This memo presents a brief summary of the factual findings from a foundation review carried out for the culvert structure that is located to the east of Ramsayville Road and under the eastbound lanes of Highway 417 in Ottawa, Ontario. It also presents preliminary geotechnical recommendations for potential culvert extensions or replacement. It is noted that the proposed replacement or extension alternatives are not yet defined. The preliminary recommendations provided below are for assistance in developing and evaluating the options and will need to be refined during subsequent design stages.

The following reference numbers apply to this site:

- Current W.P. -
- Site No. 3-444/C
- GEOCRES No. 31G05-071
- Construction Contract -
- Historic W.P. 10-69-01

2 SITE DESCRIPTION

The site is located in eastern Ottawa, in the Township of Gloucester approximately 2 km west of Anderson Road. The culvert is located beneath the Highway 417 eastbound bridge overpass of Ramsayville Road, Site 3-265/1. The bridge consists of five spans with four pier foundations. For clarity and site orientation in this report the four pier foundations of the bridge structure have been designated Pier 1 to Pier 4 with the westerly pier being designated Pier 1 and the numbers increasing going east. The culvert is located between Pier 3 and Pier 4 of the bridge structure.

The available site historical documents indicate that the culvert was constructed after completion of the Highway 417 Bridge 3-265/1. The creek had to be diverted to between Piers 3 and 4 to allow construction of Ramsayville Road between Piers 2 and 3. Given the elevation of the road

on the west side of Pier 3 and the elevation of the creek bed on the east side of Pier 3 it was concluded that the unequal loads could cause Pier 3 to tilt. The placement of compensating fill to the east of Pier 3 necessitated the inclusion of the steel pipe arch culvert.

Based on the historic Ramsay Creek Diversion Drawing (copy attached), the steel pipe culvert was constructed with beveled inlet and outlet sections. The total length of structure is reported to be approximately 52.0 m. This SPPA culvert has an arch shape with a span of 6.2 m and a height of 3.9 m.

The Ramsay Creek valley is about 8 m deep with a flat valley floor about 37 m wide. The natural valley walls have a slope about 3H:1V (Horizontal:Vertical). The creek flows from south to north and had about 0.3 m of water in it at the time of Thurber's site inspection.

3 SUBSURFACE CONDITIONS

A site investigation was carried out by the MTO Foundations Office for the Highway 417 eastbound bridge over Ramsayville Road; GEOCRES Report No. 31G05-071 dated September 1968. The investigation consisted of five sampled boreholes designated 1 and 4 to 7 all accompanied by dynamic cone penetration tests.

In order to facilitate the realignment of Ramsayville Road a Design Memorandum was issued by MTO Foundations Office in January 1973 for the construction of Culvert 3-444/C. The report used the results of Borehole 6 from the 1968 investigation to provide design recommendations for the construction of Culvert 3-444/C. The Ramsay Creek Diversion Drawing illustrates the location of the culvert in relation to Highway 417 and Ramsayville Road. Drawing 68-F-54A (copy attached) illustrates the location of the culvert borehole, as well as the soil strata plot for the investigation. The stratigraphy in the area of the culvert structure is generally characterized by a silty clay stratum, overlaying a glacial till material consisting mainly of silt and sand, underlain by shale bedrock.

3.1 Silty Clay

A clay stratum with occasional inclusions of organic matter was encountered in Borehole 6. The top of the clay stratum was 69.6 m in elevation and the deposit had a thickness of 33.5 m. The standard penetration test (SPT) 'N' values range from 1 to 4 blows per 0.3 m. The estimated undrained shear strength based on in-situ field vane tests and laboratory tests ranged from 33 kPa to 96 kPa. The consistency of the stratum varies from firm to stiff.

The results of a grain size analysis test including hydrometer testing completed on a sample of this material indicated a gravel content of 0%, sand content of 2%, silt content of 35%, and clay content of 63%. Atterberg Limits test results for seven samples of the silty clay material indicate a clay of intermediate to high plasticity.

The moisture content of the samples tested was as low as 28% near ground surface but typically ranged from 57% to 96%.

3.2 Glacial Till

A glacial till stratum was encountered at an elevation of 36.1 m beneath the silty clay stratum in Boreholes 6 with a thickness of 11.8 m. The till was described as a clayey silt with sand and some gravel. The SPT 'N' values range from 25 to greater than 100 blows per 0.3 m penetration, indicating a compact to very dense condition.

The results of a grain size analysis test including hydrometer testing completed on a sample of this material indicated a gravel content of 11%, sand content of 44%, silt content of 36%, and clay content of 9%. Atterberg Limits test of the fines portion of this material indicate a clay of low plasticity.

The moisture content of the sample tested was 10%.

3.3 Bedrock

A shale bedrock was inferred beneath the glacial till in Borehole 6 based on SPT sampler refusal. Bedrock was not cored at this location. The bedrock was described to be in sound condition in boreholes drilled nearby. Geological mapping suggests the bedrock at this site is shale of the Carlsbad Formation.

3.4 Groundwater

The groundwater level in Borehole 6 was close to the ground surface at an elevation of 69.5 m. An artesian condition was encountered at a depth of 24.4 m, just above the bedrock surface.

4 SITE OBSERVATIONS

A structure inspection was conducted by MTO in August 2011 for Culvert 3-444/C with the report issued October 2010. Condition data outlined in the report for the culvert structure ranged from poor to good but typically rated as good.

The site was inspected by Thurber Engineering Ltd. staff during the week of July 14, 2014. Several photographs of the site are attached.

At the time of the inspection, the following observations were made:

Southern Inlet:

- Gabions were installed at the site for erosion protection
- No obvious signs of erosion of the embankment slopes were observed
- Vegetation on side slopes was noted
- No obvious tilt of tapered beveled sections was observed

Western Outlet:

- Gabions were installed at the site for erosion protection

- No obvious signs of erosion of the embankment slopes were observed
- Vegetation on side slopes was noted
- No obvious tilt of tapered beveled sections was observed

5 GEOTECHNICAL ASSESSMENT

5.1 Frost Considerations

The frost penetration depth at this site is 1.8 m (OPSD 3090.101).

5.2 Seismic Considerations

This site is best classified as a Soil Profile Type III in accordance with Section 4.4.6 of the Canadian Highway Bridge Design Code (CHBDC). The zonal acceleration ratio for this site is 0.20 as per Table A3.1.1 of the CHBDC.

Based on the density of the till and the plasticity of the clay, these materials are classified as “not susceptible” to liquefaction during the design earthquake event.

5.3 Existing Foundations

As indicated on the Ramsay Creek Diversion Drawing, the design invert elevation of the culvert ranged from 67.0 m to 67.1 m. The drawings indicate a 1.2 m thick Granular A bedding layer was to be installed beneath the culvert; therefore, the culvert is founded at approximate elevations ranging from 65.8 m to 66.0 m which is within the silty clay layer.

Finished grade above the culvert was set at elevation 72.8 m thus approximately 1.8 m of fill would be placed above the culvert.

The recommended design allowable bearing value as reported in the 1973 Foundation Design Report was 72 kPa for the silty clay layer.

PART 2: ENGINEERING DISCUSSION AND PRELIMINARY RECOMMENDATIONS

6 GEOTECHNICAL RECOMMENDATIONS

Based on the available data regarding the ground conditions at this site, the following sections present preliminary geotechnical recommendations for the assessment of the existing culvert and for preliminary design for potential culvert extensions, replacement, and the construction of new wing walls, end sections and/or headwall structures, if required. It is noted that the proposed construction options for this site are not yet defined. The preliminary recommendations provided below are for assistance in developing and evaluating options and will need to be refined during subsequent design stages.

It has been assumed that if the culvert is to be replaced it will be replaced with a similar sized structure thereby not increasing the applied stress to the underlying clay deposit and not inducing further settlement.

The existing culvert is a CSP Arch likely founded on firm clay. For culvert extensions, it is preferred that type of foundations and founding elevation match the existing arrangement so as not to undermine the existing foundation. From a foundation perspective for a culvert replacement, a concrete rigid-frame open-footing culvert could have bearing resistance limitations as well as groundwater concerns during construction. Both a concrete closed box and a CSP would be preferred.

6.1 Shallow Foundations

For shallow foundations founded on native very stiff to firm silty clay having a minimum embedment depth of 1.8 m and a width of between 1 m and 2 m, the factored vertical geotechnical resistance at ULS is 150 kPa. The vertical geotechnical reaction at SLS is 100 kPa based on a total footing settlement of 25 mm.

A replacement culvert would likely require a span and an invert elevation similar to the existing. For a closed box culvert founded at the same elevation as the existing culvert on native very stiff to firm clay with a 1.8 m embedment and a base width of 6.2 m, the factored vertical geotechnical resistance at ULS is 120 kPa. The vertical geotechnical reaction at SLS is 70 kPa based on a total footing settlement of 25 mm. An increase in the thickness of the bedding layer would allow higher values at ULS to be obtained.

Resistance to lateral forces and sliding resistance between concrete and steel and underlying materials should be evaluated using an unfactored coefficients of friction provided in Table A.

Table A: Unfactored Coefficients of Friction between Concrete and Steel and Founding Material

	Founding Material
Culvert Material	**Silty Clay**
Steel	0.25
Cast-in-place concrete	0.35
Precast concrete	0.30

6.2 Excavations, Bedding and Backfilling

All excavations must be conducted in accordance with the requirements of the Occupational Health & Safety Act & Regulations (OHSA) for Construction Projects. The native very stiff to firm silty clay material reported at this site should be classified as Type 3 in accordance with OHSA.

Where excavations will extend below the groundwater level prevailing at the time of construction, the contractor will need to implement groundwater control and ground support systems as are

required to carry out the construction in a safe, stable, and unwatered excavation. The artesian groundwater level observed in Borehole 6 originates at an elevation well below any excavations and should not influence dewatering techniques.

Excavations, bedding and backfill for steel pipe arch culverts should be in accordance with OPSD 802.020 for Type 3 soils. Backfill for the culvert must consist of free draining granular material conforming to OPSS Granular A or B material specifications. The granular material must be placed to the extent shown on OPSD 803.030 or 803.031 and in accordance with OPSS 421 and 401.

It is noted that the Ramsay Creek Structure Protection Drawing (copy attached) indicates that the excavation for the culvert was to be carried out within a sheet piled excavation complete with bracing and was to be completed in sections of less than 6.1 m at a time. Should removal of the culvert be required similar requirements should be anticipated.

Subgrade preparation for foundations and placement of culvert bedding must be carried out in the dry.

6.3 Static Lateral Earth Pressure Coefficients

Lateral earth pressures acting on structures should be computed in accordance with the CHBDC but generally are given by the expression:

$$P_h = K^*(\gamma h + q)$$

where:

P_h = horizontal pressure on the wall (kPa)
K = earth pressure coefficient
γ = unit weight of retained soil
h = depth below top of fill where pressure is computed (m)
q = value of any surcharge (kPa)

The recommended lateral earth pressure parameters for use in the design for both a horizontal and for 2H:1V (Horizontal:Vertical) back-slope are provided in Table B.

Active pressures should be used for the design of unrestrained walls.

A lateral pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with the Section 6.9.3 of the CHBDC.

The parameters provided in Table B are based on the assumption that the backfill is fully drained so that there are no unbalanced hydrostatic pressures. If adequate drainage cannot be confirmed, the potential for hydrostatic pressures should be considered.

Table B: Static Lateral Earth Pressure Coefficients

Parameter	OPSS Granular A & OPSS Granular B Type II	OPSS Granular B Type I	Native Silty Clay
Soil Unit Weight, kN/m^3, γ	21	20	17
Angle of Internal Friction, ϕ	35°	30°	27°
Horizontal Back-Slope			
Coefficient of at Rest Earth Pressure, K_o (Restrained Wall)	0.43	0.50	0.55
Coefficient of Active Earth Pressure, K_a (Unrestrained Wall)	0.27	0.33	0.38
2H:1V Back-Slope			
Coefficient of Active Earth Pressure, K_a	0.39	0.53	0.70

6.4 Embankments

The Ramsay Creek Diversion Drawing indicates that the finished grade beneath the Highway 417 Bridge 3-265/1 would be relatively flat at an approximate elevation of 72.8 m; which is approximately 1.2 m above original grade. Based on the MTO Foundations Office 1973 Design Memorandum, settlement in the order of 75 mm was predicted for the culvert foundations. Minimal additional settlement is anticipated if the culvert was replaced like-for-like on the existing culvert alignment with the embankment reinstated to its current configuration.

It is noted that the slope stability of the forward slope of the east abutment of the westbound Highway 417 structure Site 3-265/2 was assessed to be stable in the 1973 Foundation Memo. That slope was estimated to be 11.5 m high with an overall slope of 3H:1V and cut slopes into the creek channel of 2H:1V.

6.5 Erosion Control

Erosion protection should be provided at the culvert inlet and outlet areas. Design of the erosion protection measures must consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field.

Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact. Treatment at the outlets should be in accordance with OPSD 810.010. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS 804.

A concrete cut-off wall or clay seal should be installed at the culvert inlet to minimize the potential for seepage through the granular bedding and backfill material and avoid consequent erosion of these materials. The clay seal should have a minimum thickness of 0.5 m, completely surround the culvert (excluding beneath an open footing culvert), extend laterally the width of the granular

backfill material, and extend above the high water level. The material used for the clay seal should conform to the requirements of OPSS 1205.

7 ADDITIONAL INVESTIGATIONS

Further foundation investigations and analysis must be carried out should the culvert structure be replaced or extended or if the height, geometry, or location of the fills are to be modified for either short-term construction staging or for vertical or horizontal re-alignments. Should excavations be anticipated within the embankment fills to repair or modify the culvert, consideration should be given to drilling foundation boreholes in the approaches to determine the nature of the fill materials and to allow generation of road way protection design. It is also recommended that piezometers be installed to better define the groundwater level in both the silty clay and glacial till strata as well as the in-situ hydraulic conductivity. This information will be required to allow for the design of excavation dewatering systems.

Structural evaluation of the unbalanced forces on Pier 3 of Bridge 3-265/1 needs to be carried out as part of the consideration of culvert removal. Additional slope stability and settlement analyses should also be carried out to assess the resulting geometry should it be proposed to remove the culvert.

THURBER

8 CLOSURE

We trust this information provided in this technical memorandum meets your present purposes. Please let us know if you have any questions or need additional information.

Thurber Engineering Ltd.

Kenton C. Power, P.Eng.
Geotechnical Engineer

Fred Griffiths, P.Eng.
Associate, Senior Geotechnical Engineer

P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact

Attachments

Preliminary Foundation Design
GWP 4074-11-00
Site Photographs

PRELIMINARY FOUNDATION DESIGN
RAMSAY CREEK STRUCTURAL CULVERT (SITE 3-444/C) HIGHWAY 417
AND RAMSSAYVILLE ROAD

Inlet

Gabions at the inlet structure

Preliminary Foundation Design
GWP 4074-11-00
Site Photographs

PRELIMINARY FOUNDATION DESIGN
RAMSAY CREEK STRUCTURAL CULVERT (SITE 3-444/C) HIGHWAY 417
AND RAMSSAYVILLE ROAD

North outlet embankment

Outlet structure and gabions

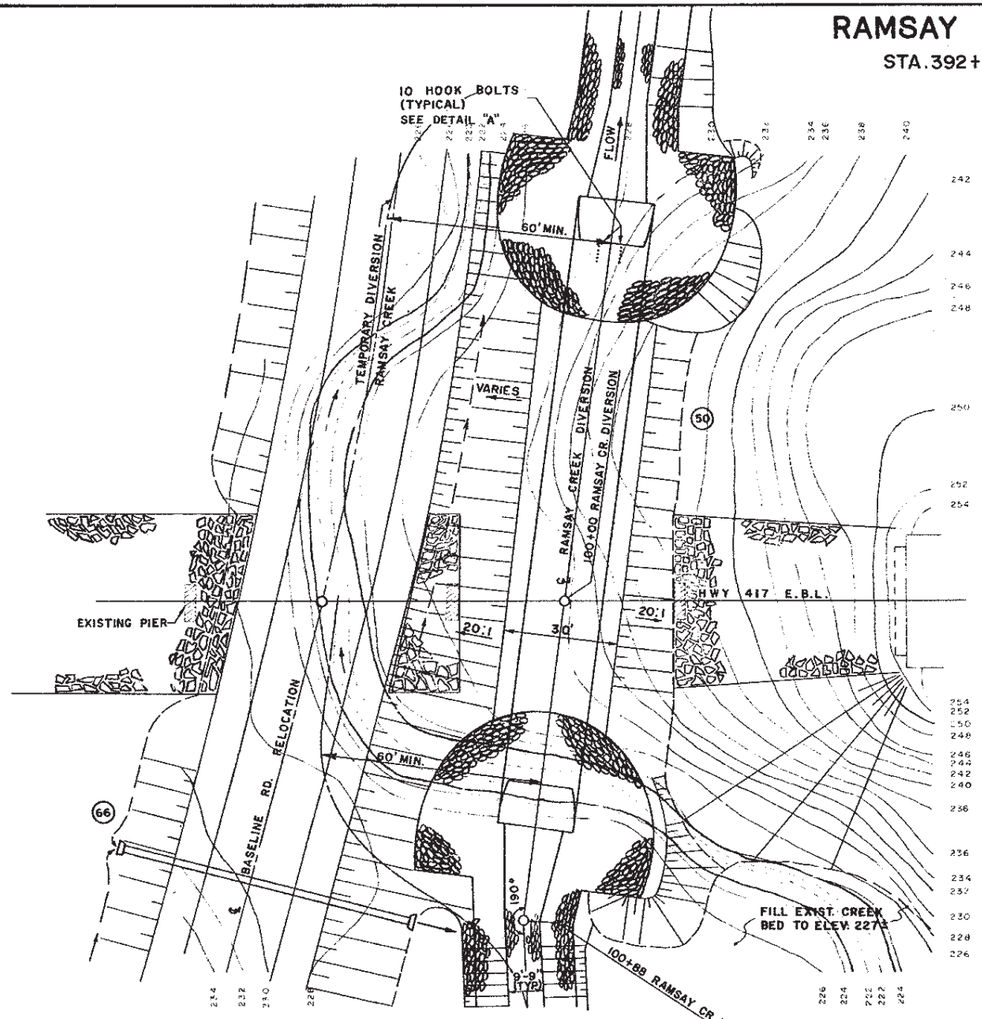
Preliminary Foundation Design
GWP 4074-11-00
Site Photographs

PRELIMINARY FOUNDATION DESIGN
RAMSAY CREEK STRUCTURAL CULVERT (SITE 3-444/C) HIGHWAY 417
AND RAMSSAYVILLE ROAD

Possible concrete cutoff wall in front of outlet structure

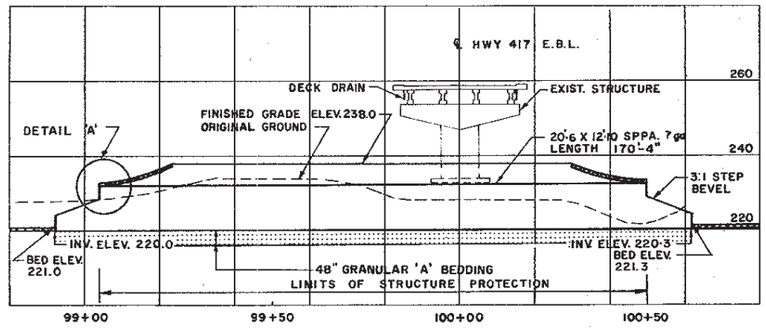
RAMSAY CREEK DIVERSION

STA.392+83 HWY. 417 E.B.L.

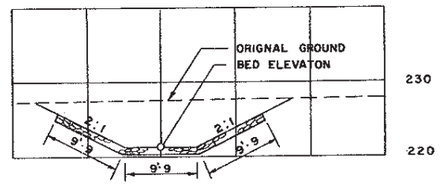


RAMSAY CREEK DIVERSION
STA.392+83 HWY. 417 E.B.L.

FOR FURTHER DETAILS OF RIP-RAP SLOPE PROTECTION SEE SHEET 67



ELEVATION

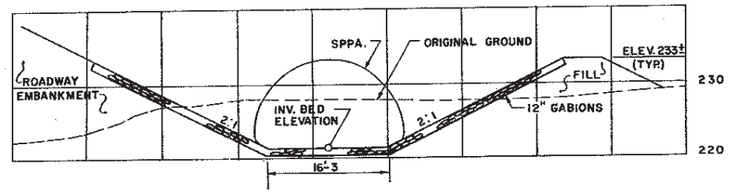


SECTION

STA.100+88 RAMSAY CREEK DIVERSION

(SIMILAR TO STA. 98+66 RAMSAY CREEK DIVERSION)

N.T.S.

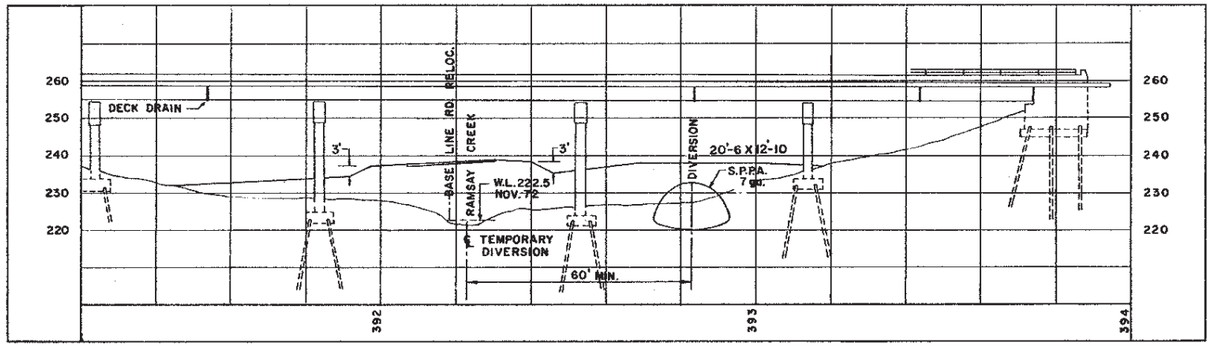


SECTION

STA.100+62 RAMSAY CREEK DIVERSION

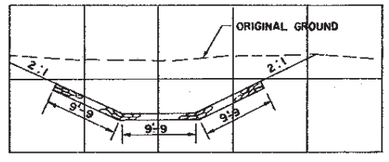
(SIMILAR TO STA. 98+92 RAMSAY CREEK DIVERSION)

N.T.S.



SECTION

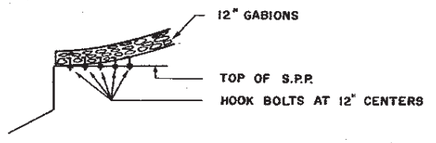
STA.100+00.00 RAMSAY CREEK DIVERSION



TYPICAL SECTION

CHANNEL RELOCATIONS

N.T.S.



DETAIL 'A'

N.T.S.

SCALE

10' 0 20'

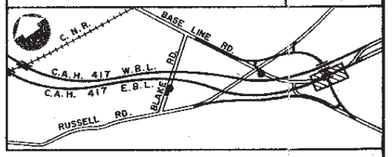
Horizontal & Vertical

DILLON Consulting Engineers & Planners

CONT. No. 73-190
W. P. No. 10-69-01

RAMSAY CREEK DIVERSION

SHEET 60



KEY PLAN

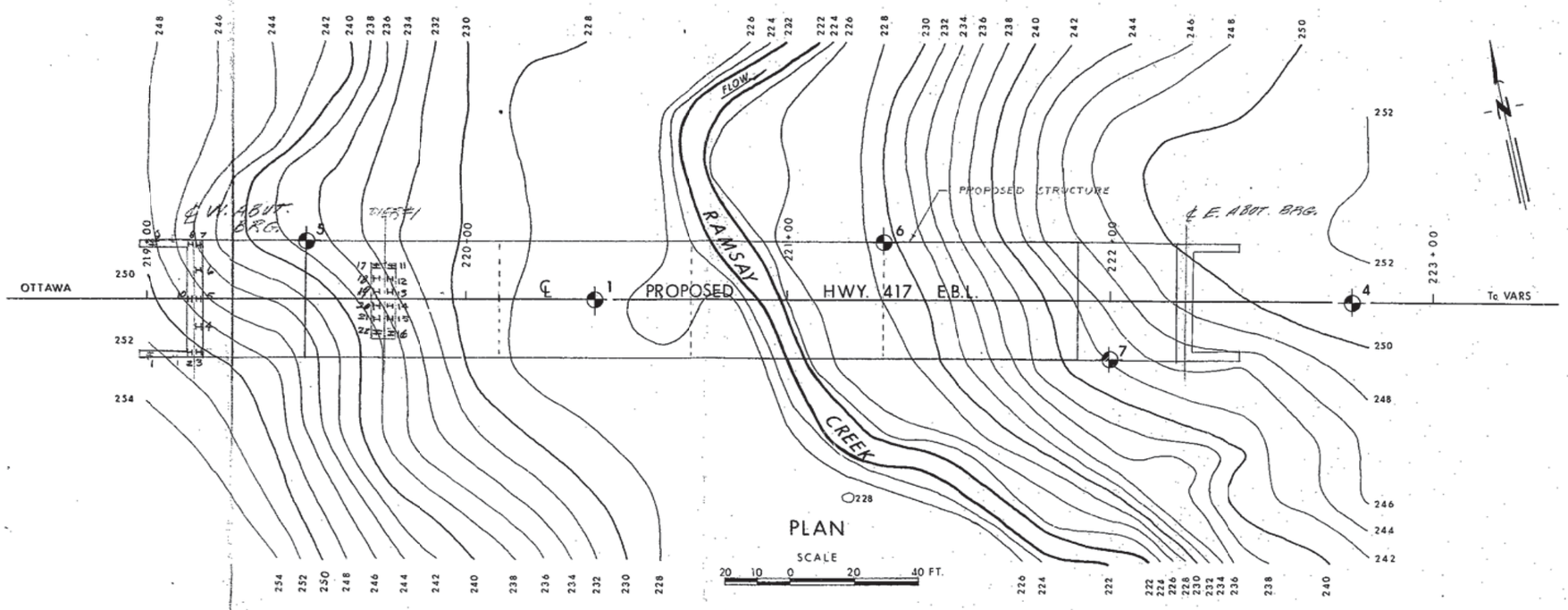
LEGEND

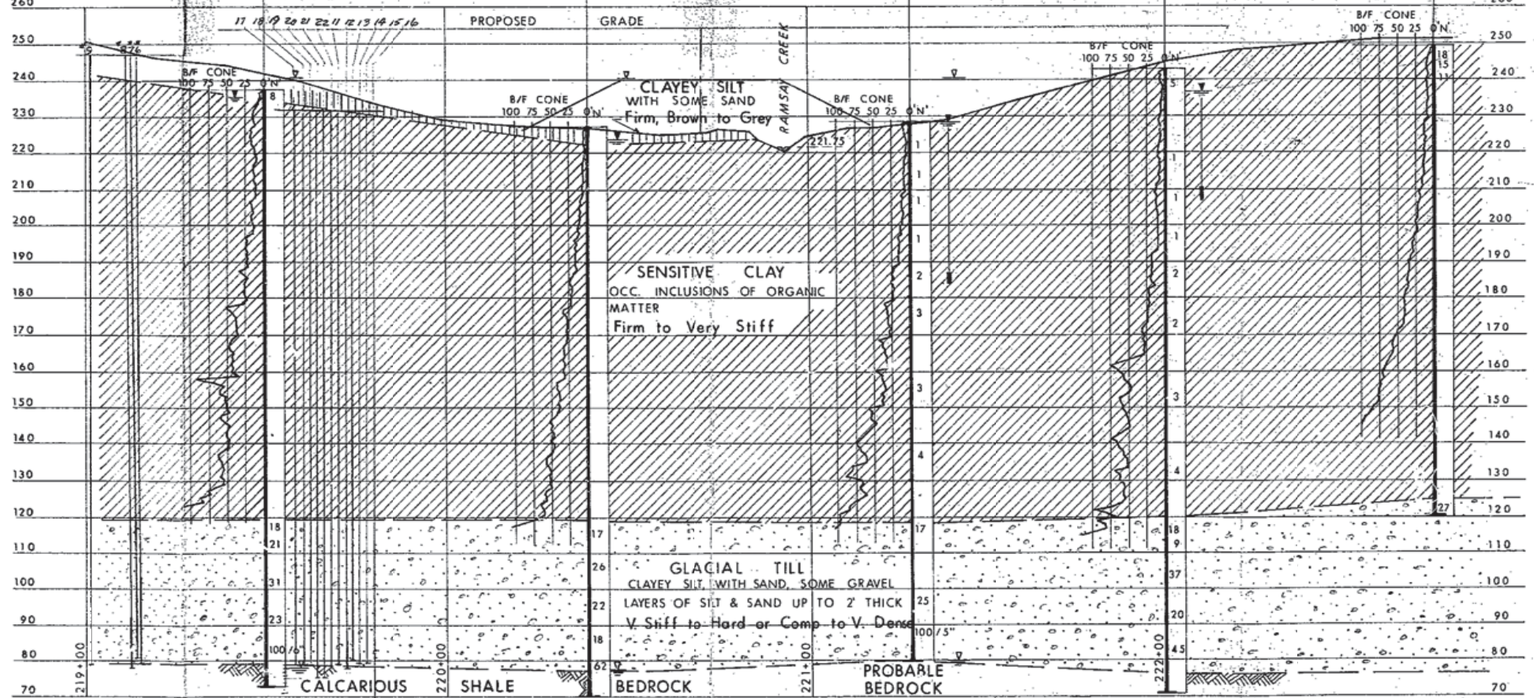
12" HANDLAID RIP-RAP

12" THICK GABIONS

NOTES:

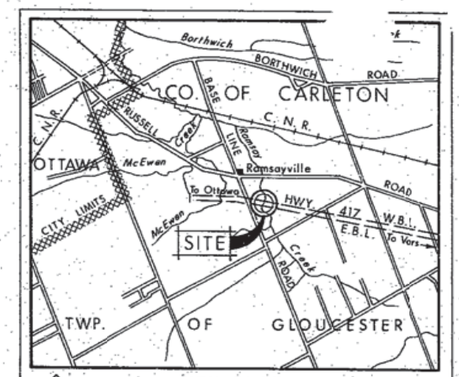
- BEDDING IN ACCORDANCE WITH DD-808-B TYPE 5 EXCEPT THAT DEPTH OF BEDDING TO BE INCREASED FROM 12" TO 48".
- BACKFILL IN ACCORDANCE WITH DD-813-A.
- CULVERT TO BE INSTALLED IN LENGTHS OF 20' MAX. COMMENCING AT THE DOWNSTREAM END.
- PLACE 5'DIA. 12" HANDLAID RIP-RAP UNDER ALL DECK DRAINS.
- GABIONS TO BE WIRED (13ga. GALVANIZED) TO HOOK BOLTS (8" LONG, GALVANIZED) IN TOP OF CULVERT. HOOK BOLTS TO MATCH HOLES IN PLATES, AT 12" CENTRES.
- CUT OFF WALLS EACH END OF CULVERT IN ACCORDANCE WITH BD 90-1.
- FOR DETAILS OF STRUCTURE PROTECTION SEE SHEET 61.
- FOR CONSTRUCTION STAGING SEE SHEET 61.





PILE NO.	TIP ELEVATION
6	79.3
7	80.3
8	79.5
9	79.0
17	79
18	79
19	79
20	75
21	75
22	79
11	79
12	78
13	80
14	79
15	79
*16	40

*NO. 16 ELEV. ASSUMING A STRAIGHT PILE



LEGEND

- Bore Hole
- Cone Penetration Hole
- Bore & Cone Penetration Hole
- Water Levels established at time of field investigation. AUG. 16/1967
- Head Encountered } ARTESIAN CONDITION
- PIEZOMETER

NO.	ELEVATION	STATION	OFFSET
1	227.2	220+40	℄ E.B.L.
4	249.6	222+75	℄ E.B.L.
5	237.8	219+50	18' LT.
6	228.3	221+30	18' LT.
7	243.0	222+00	18' RT.

– NOTE –

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.

REVISIONS		
DATE	BY	DESCRIPTION

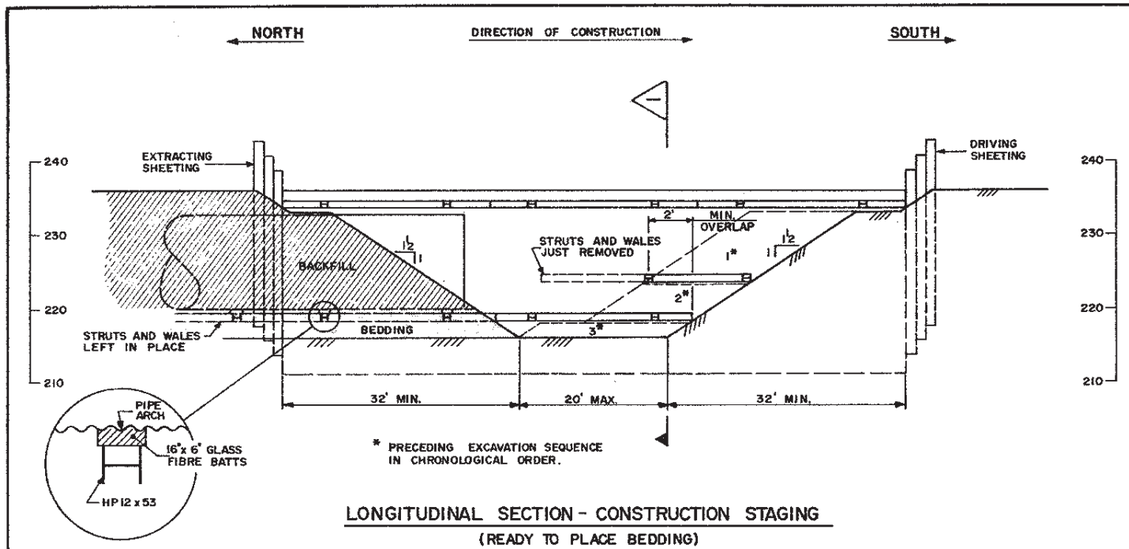
DEPARTMENT OF HIGHWAYS – ONTARIO
MATERIALS & TESTING DIVISION – FOUNDATION SECTION

RAMSAY CREEK

KING'S HIGHWAY NO. 417 E.B.L. DIST. NO. 9
CO. CARLETON
TWP. GLOUCESTER LOT 20 CON. V

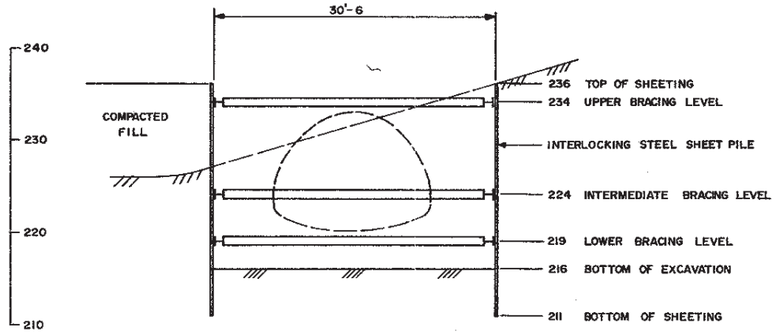
BOREHOLE LOCATIONS & SOIL STRATA

SUBM'D. W.H.	CHECKED W.H.	W.P. NO. 34 - 66 - 01	M.B.T. DRAWING NO. 68 - F - 54A
DRAWN A.N.	CHECKED W.R.	JOB NO. 68 - F - 54	
DATE SEPT. 23/1968		SITE NO.	BRIDGE DRAWING NO.
APPROVED A. Gilliman PRINCIPAL FOUNDATION ENGINEER		CONT. NO.	

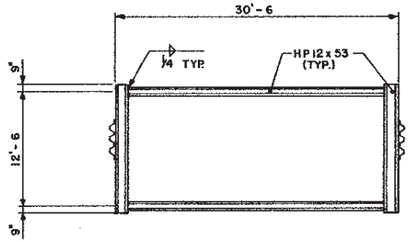


LONGITUDINAL SECTION - CONSTRUCTION STAGING
(READY TO PLACE BEDDING)

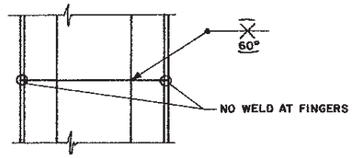
5 0 10
SCALE



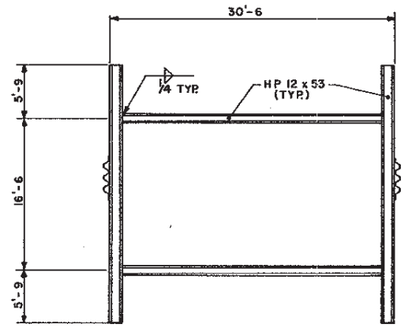
SECTION 1
N.T.S.



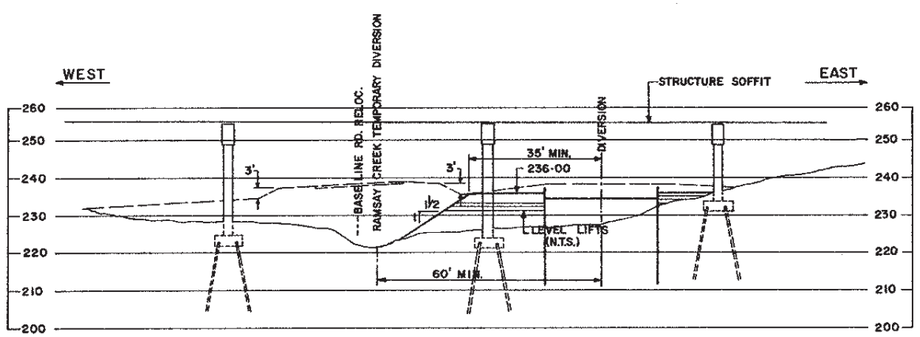
INTERMEDIATE BRACING FRAME
N.T.S.



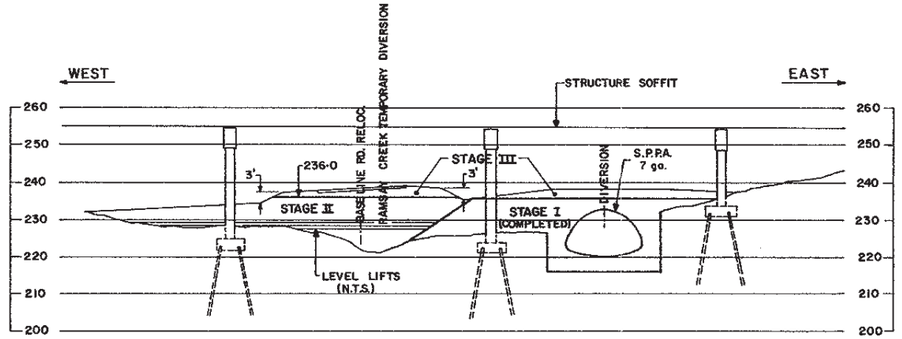
SHEET PILE SPLICE DETAIL
N.T.S.



UPPER & LOWER BRACING FRAMES
N. T. S.



STAGE I
(READY TO EXCAVATE)



STAGES II & III

CONSTRUCTION STAGING

10 0 20
SCALE

Consulting Engineers & Planners
DILLON

CONT. No. 73-190
W. P. No. 10-69-01

STRUCTURE PROTECTION
RAMSAY CREEK BRIDGE E.B.L.

SHEET 61

NOTES:

- SHEETING SHALL BE USS. SECTION MP 116, BETHLEHEM SECTION DP2 OR AN APPROVED EQUAL.
- SHEETING SHALL BE SUPPLIED AND DRIVEN IN ONE LENGTH WHEREVER VERTICAL CLEARANCE PERMITS. WHERE CLEARANCES DICTATE LESS THAN FULL LENGTH SECTIONS THEY SHALL BE SPLICED USING FULL PENETRATION BUTT WELDS. SPLICES ON ADJACENT SECTIONS SHALL BE STAGGERED.
- WELDING SHALL CONFORM TO THE LATEST ISSUE OF C.S.A. SPECIFICATION W59 AND SHALL BE DONE BY A WELDER QUALIFIED UNDER C.S.A. SPECIFICATION W47.
- MAXIMUM LENGTH OF EXCAVATION OPEN AT ANY TIME SHALL BE 20' MEASURED AT THE BOTTOM.
- ALTERNATE SCHEMES OF STRUCTURE PROTECTION WILL BE CONSIDERED SUBJECT TO THE APPROVAL OF THE MINISTRY.
- LOWER BRACING TO BE TEMPORARILY BLOCKED OR TACK WELDED TO SHEETING WHEN PLACED. IF TACK WELDED, WELDS ARE TO BE BROKEN AS SOON AS BEDDING IS BROUGHT UP TO BRACING LEVEL.

CONSTRUCTION SEQUENCE:

STAGE I
1. DIVERT CREEK TEMPORARILY (SEE SHEET 60)
2. DRIVE SHEETING FULL DEPTH (EL. 211-0).
3. PLACE UPPER BRACING AND TACK WELD TO SHEETING.
4. PLACE AND COMPACT FILL OUTSIDE SHEETING TO TOP OF SHEETING (EL. 236-0). FILL MUST BE BROUGHT UP IN UNIFORM LEVEL LIFTS ON BOTH SIDES OF PROTECTED AREA.
5. EXCAVATE TO ELEVATION 223-5
6. PLACE INTERMEDIATE BRACING AND TACK WELD TO SHEETING.
7. EXCAVATE TO ELEVATION 218-5
8. PLACE LOWER BRACING AND THEN REMOVE INTERMEDIATE BRACING.
9. EXCAVATE TO ELEVATION 216-0 AND PLACE PIPE BEDDING. PLACE 6" GLASS FIBRE BATTS OVER LOWER STRUTS. ASSEMBLE PIPE. MAX. LENGTH OF OPEN EXCAVATION 20 FEET.
10. BACKFILL TO TOP OF PIPE.
11. REMOVE UPPER BRACING AND EXTRACT SHEETING.

STAGE II
12. DIVERT CREEK THROUGH COMPLETED CULVERT.
13. PLACE FILL TO WEST OF CULVERT UP TO EL. 236-0 IN UNIFORM LEVEL LIFTS.

STAGE III
14. COMPLETE FILL OVER CULVERT.
15. COMPLETE BASE LINE ROAD.