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FOUNDATION INVESTIGATION REPORT
WIDENING OF HWY 12/48 STRUCTURE
OVER WHITE'S CREEK
BROCK TWP. (FORMERLY THORAH TWP.)
NEAR BEAVERTON, ONTARIO

W.P. 611-89-00
SITE: 22-23

DISTRICT 7 - DURHAM
CENTRAL REGION

GEOCRES NO. 31D - 396

Prepared for:

SNC-Lavalin Engineers & Constructors Inc

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1.0 INTRODUCTION & BACKGROUND

It is proposed to widen Hwy 12/48 from a two-lane cross section to four lanes, extending from the south junction of Hwy 48 northerly to Regional Road 48 over a total length of 13 km. In connection with the widening, the existing bridge structure which carries Hwy 12/48 over White's Creek is to be widened to the west to accommodate an additional two (2) lanes.

Shaheen & Peaker Limited (S&P) was retained by SNC-Lavalin Engineers & Constructors Inc. (SLE&C) to conduct a foundation investigation for the proposed structure.

This work was carried out in conjunction with foundation investigations for the nearby Beaver River structure, as well as several culverts located along the proposed widening alignment. The results of the investigation work for these other structures have been reported under separate cover

The existing structure over White's Creek, constructed in 1965, is a 3-span reinforced concrete bridge with post-tensioned concrete deck It has an overall length of 36 45 m.

2.0 SITE DESCRIPTION AND REGIONAL PHYSIOGRAPHY

2.1 Site Description

The structure passes over White's Creek on Hwy 12/48, approximately 200 m south of Thorah Concession 6. The creek flows westward and at the bridge site, there is a slight bend in its course with the south bank forming the 'outside' meander At the time of our field work, the creek was an estimated 6 to 7 m in width below the existing structure, but widens both upstream and downstream of the structure The creek water elevation at the time of our investigation was approximately 233.5 m. Based on data provided by SLE&C, we understand that the Regional Storm and 100 year storm levels are at elevations 238 6 m and 235.7 m respectively. The existing bridge deck elevation is 238.2 m Within the creek bed in the vicinity of the bridge, slabs of limestone are visible. The natural creek banks rise up from the water line at relatively flat (~2.5H:1V) slopes

The areas of the north and south approaches to the bridge in the widening zone are relatively flat-lying cleared land which are currently grass covered. The existing roadway embankment is elevated approximately 3.5 m above the local grades, reaching a maximum of approximately 5 m in height at both header slopes. The existing header slopes are covered with slabs of limestone and concrete for erosion protection. There are several nearby residential houses located to the west of the MTO right-of-way.

Based on Department of Highways of Ontario (DHO) drawings, it is believed that the original gravel roadway and bridge structure were situated approximately 10 m west of the centreline of the existing structure. Details of this original bridge are not known. However, since the currently proposed widening will be constructed in the immediate area of the former roadway and original bridge, there is a potential that remnant foundations, pilings, fill, rubble, etc. could be encountered during the course of the new works. It is also important to note that the creek itself was realigned northward as part of the 1965 reconstruction.

A search was requested of the Ministry of Environment Water Well Records Department for registered water wells located in proximity to the bridge (Lots 10 and 11 of Concession 5, Brock Township). The results of this file search are included in Appendix D. It would appear that there are 7 registered private water wells within a 250 m radius of the bridge site. The nearest known well is located approximately 30 m from the existing White's Creek bridge site. It is quite likely that there are additional nearby water wells which are not registered with the MOE.

2.2 Existing Structure Foundations

The design drawings for the existing White's Creek bridge indicate that the abutments and piers[1] are founded on driven steel tube piles (12 ¾" O.D. by ¼" wall @ 33 lbs/ft) infilled

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[1]Design Drawings: General Plan, Abutment & Pier Dimensions, Abutment & Pier Reinforcing, White's Creek Bridge, Department of Highways Ontario, Bridge Division Site 22-23, WP No. 911-61, 1962.

with concrete after driving (3000 psi/20 MPa). All piles were reportedly fitted with conical pile shoes

Pier piles consisted of two vertical rows of 5 piles of approximate length 20 ft (6.1 m). Abutment piles consisted of a 3:1 battered front row of 4 piles and a back row of 3 vertical piles, each nominally 30 ft in length (9.1 m). Please note that as-built conditions may differ from the foregoing.

2.3 Regional Physiography

The White's Creek bridge site is located approximately 3.5 km east of the eastern shore of Lake Simcoe.

The general site area is relatively flat lying, with a gentle slope to the north-northwest. The area is geologically complex[2], dominated by glacial till, glacio-lacustrine silts and clays, as well as some glacial outwash deposits and isolated areas of organic soils. Ordovician bedrock of the Simcoe Group outcrops approximately 1 km to the southwest, just south of the Beaverton River. This consists of limestone with thin interbeds of shale. Regional geologic mapping[2] indicates that the general site area lies near the contact between varved glaciolacustrine silts and clays to the south of the creek with coarser-grained glaciolacustrine

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[2]Barnett, P.J. and Mate, D.J., 1998, Quaternary Geology, Beaverton Area, Ontario Geological Survey, Map 2560, Scale 1:50,000

sands and silts lying to the north.

3.0 PREVIOUS WORK

A foundation investigation at the site of the existing White's Creek structure was undertaken in 1962 by the Ontario Department of Highways (DHO), which was summarized in the following report:

> Beaverton By-Pass (Proposed Hwy 12)
> & White's Creek Structure - Line 'P'
> District 7, W.J. 62-F-53, W.P. 911-61
> Geocres No. 31D194, dated June 21, 1962

Record of Borehole Sheets from the DHO investigation have been provided in the attached Appendix C. The locations of the DHO boreholes (designated as 'DHO-1' through 'DHO-5') have been superimposed on the attached Drawing No 1 for ease of reference relative to the current series of borings, however, these locations should be considered very approximate since UTM coordinates are not available.

While the encountered stratigraphy is self-evident from the enclosed DHO Record of Borehole Sheets in Appendix C, it is noteworthy that artesian groundwater conditions were encountered within four (4) of the five (5) boreholes advanced by DHO. These artesian levels in Boreholes 1, 2, 3 and 5 ranged from 0.91 m to 1.37 m above the ground surface at that time (maximum artesian head at elevation 235.7 m, minimum artesian head at elevation 235.4 m). At the time of that investigation, the creek level was reported to be at elevation 233.7 m. The stratigraphic zones in which the artesian condition first manifested ranged between elevation 224.9 m (within the glacial till which overlies bedrock) and elevation 221.9 m (within the limestone bedrock).

4.0 INVESTIGATION METHODOLOGY

Six (6) borings were advanced to the west side of the existing White's Creek structure as part of this investigation (designated as Boreholes 01-1 through 01-6). The locations of the boreholes are shown in the attached Drawing No. 1. The boreholes were drilled between May 30 and June 6, 2001 by Eastern Soil Investigations of Courtice, Ontario, using a Bombardier-mounted CME 55 drilling rig equipped with 210 mm O.D. hollow-stem continuous flight augers and 150 mm continuous flight augers. The drilling operation was supervised on a full time basis by engineering staff of Shaheen & Peaker Limited.

All of the boreholes were sampled at 0.76 m intervals to about 6.6 m depth and, thereafter, at 1.5 m intervals using a conventional 50 mm O.D. split spoon sampler in association with the ASTM D1586 Standard Penetration Test. In addition, 'undisturbed' samples of cohesive soil were obtained within Boreholes 01-2, 01-4, 01-5 and 01-6, using 50 mm diameter thin wall sampling tubes. In-situ field vane shear testing was also undertaken at selected depth intervals using the MTO field vane shear apparatus.

At the proposed bridge approaches, Boreholes 01-1 and 01-4 were drilled to depths of 9.6m. The remaining boreholes, located near the proposed piers and abutments, were taken to refusal. Rock coring, using an NQ2 wireline core barrel (47 m diameter rock core), was carried out within abutment Boreholes 01-3 and 01-6 over lengths of approximately 4.4 m and 3.0 m respectively. A photograph of the rock core is provided in the attached Plate 1.

Standpipe-type piezometers were installed within five of the six boreholes (all except Borehole 01-1) with tip elevations as illustrated on the Record of Borehole Sheets provided in Appendix A. The piezometers were constructed from 19 mm I.D. PVC piping, fitted with a 1.5 m long slotted piezometer tip. A sand pack filter was installed to approximately 1.5 m above the piezometer tip, and a bentonite seal was placed above the sand. The remaining portion of the boreholes was grouted using sodium montmorillonite bentonite grout. Following completion of the drilling work, follow-up piezometer measurements were taken on a number of occasions as recorded on the Record of Borehole Sheets.

The soil samples were preserved in the field within plastic jars and then transported to our laboratory where they were re-examined by a Senior Engineer and classified in accordance with the Unified Soil Classification System. All samples were subjected to moisture content determination. Selected samples of the cohesive material were tested for Atterberg consistency limits. Particle size analyses were carried out on representative samples. The results of the Atterberg limits testing and gradational analyses are presented within Appendix B

One (1) sample of the varved clayey silt/silty clay from Borehole 01-4 (TW7) and one (1) sample from Borehole 01-6 (TW5) were tested in one-dimensional consolidation (ASTM D2435) to provide an indication of the compression characteristics of this material. The void ratio versus log pressure plots are presented in Figures 6 and 7 in Appendix B. One (1) undrained unconsolidated (quick) triaxial test was carried out on a sample from Borehole 01-5 (TW7).

Layout of the boreholes was undertaken by S&P staff with respect to the existing structure. On completion of the drilling operations, the borehole MTM coordinates and ground surface elevations were surveyed by Vujeva Surveys Ltd. under contract to SLE&C.

5.0 SUBSURFACE CONDITIONS

5.1 Overview

A simplified description of the encountered stratigraphy follows. For more detailed stratigraphic information, the reader should consult the attached Record of Borehole Sheets in Appendix A, as well as the DHO logs provided in Appendix C.

Beneath a thin veneer of topsoil, alluvium is present at most of the boring locations, consisting of sandy silt to silty sand with inclusions of topsoil, organic matter, wood and shells. This, in turn, is underlain by a glacio-lacustrine deposit of typically firm to stiff varved silty clay and clayey silt, which contains layers or lenses of till-like silt and clayey silt.

Glacial till, primarily of a sand and silt matrix, underlies the clay deposit. The till is typically very dense and becomes gravelly with increasing depth approaching the bedrock surface. Ordovician shaly limestone bedrock is found below the till. The upper surface of the bedrock at the borehole locations lies between elevations 223.0 m and 225.7 m.

At most of the borehole locations, the groundwater table was found to lie less than 1 m below existing grade. The groundwater response to 'equilibrium' conditions in the piezometers was slow. Sub-artesian conditions are present within the lower gravelly glacial till, just above the bedrock surface and possibly within the bedrock as well. An artesian condition was recorded within Borehole 01-2 in July of 2002. In this piezometer located at the North Pier, the water level was measured 0.1 m above existing grade level.

The individual soil units encountered in the boreholes drilled for this investigation are briefly described in the following Section 5.2.

5.2 Stratigraphic Units

Topsoil

A thin veneer of topsoil overlies the ground surface.

Silty Sand/Sandy Silt

Encountered at the ground surface within Boreholes 01-1, 01-3, 01-4 and below a surficial silty clay layer in Borehole 01-6, is a cohesionless sandy silt or silty sand alluvium layer.

Within Borehole 01-2, this layer appears to have been replaced by fill. Inclusions of topsoil are often encountered in this deposit as are rootlets, wood fragments, shells, wood and variable amounts of clay. The thickness of this deposit is approximately 0.8 m within Boreholes 01-1 and 01-3, and 2.1 m at Borehole 01-4. A grain size analysis is presented within Figure 1 of Appendix B.

Based on Standard Penetration Test (SPT) 'N' values in the range of 4 to 15 blows/0.3 m, this deposit is considered to be in a loose to compact state of compactness. The natural moisture content of selected samples of this unit was highly variable, from 14% to 35%.

Silty Clay and Clayey Silt and Embedded Till-Like Layers

A glacio-lacustrine deposit of varved silty clay and clayey silt was encountered in all of the boreholes. Grain size analyses for selected samples are presented in Figure 2 of Appendix B. This deposit contains very thin sand partings and a trace of gravel. The thickness of this unit, including till-like layers embedded within the deposit, ranges from about 4.5 m at Borehole 01-2 to 6.5 m at Borehole 01-1 and its lower contact lies between approximate Elevation 228.0 m at Borehole 01-4 and Elevation 229.7 m at Borehole 01-1.

The natural moisture content in test samples of the varved silty clay/clayey silt ranged from 19% to 47%, but most typically 25 to 30%. The following range of plasticity parameters was measured (refer to Figure 4, Appendix B):

Plastic limit:	14-21%
Liquid limit:	23-49%
Plasticity index:	9-29%

This interlayered deposit would be classified as a low (CL) to intermediate (CI) plasticity clay.

Field shear vane tests performed in this deposit gave undrained shear strength values ranging from 65 kPa to over 100 kPa, while an unconsolidated undrained triaxial test on a sample from Borehole 01-5 yielded an undrained shear strength of 45 kPa.

The consistency of the varved deposit based on the in-situ field vane shear tests and to a lesser degree on SPT 'N' values from 0 to 19, is inferred to be firm to very stiff, but generally stiff. Very stiff conditions were found in Boreholes 01-1 and 01-3 only.

Consolidation characteristics of the silty clay deposit were assessed by means of two (2) oedometer tests performed on thin-wall samples from Boreholes 01-4 and 01-6. These results are presented in Appendix B.

As previously mentioned, the varved clay/silt contains layers or lenses of heterogeneous deposits of sandy clayey silt to sandy silt with some clay and trace to some gravel. Gradation curves for selected samples of the cohesive till-like layers are given in Figure 3 of Appendix B, which reveals a broad range in particle size from 8-22% gravel, 22-44% sand, 34-47% silt and 9-21% clay.

The natural moisture content of test samples of the till-like soils ranged from about 9% to 16%, but was commonly about 9%. The following range of plasticity indices were measured in samples of this deposit (Figure 5, Appendix B):

Plastic limit:	10-16%
Liquid limit:	16-22%
Plasticity index:	5-9%

This would classify the soil as a CL-ML material in the Unified Soil Classification System.

SPT 'N' values measured in the boreholes through these layers were between 7 and 15, corresponding to a firm to stiff consistency.

Sand and Silt to Silty Sand Glacial Till

The deepest soil unit overlying bedrock is a weakly cemented to cohesionless deposit of glacial till, having a broad range in texture from sand and silt to a silty sand. It contains a trace to some clay, trace to some gravel and limestone fragments. Gradation analyses of selected samples of the till are provided in Figure 3A of Appendix B. These reveal the following range of particle sizes: 4-43% gravel, 15-39% sand, 17-54% silt, 1-19% clay. The bottom 1 m to 3 m of this unit is gravel and sand or gravelly sand (primarily limestone fragments) and contains some cobbles. Some difficulties were experienced in augering through the gravelly zones in several of the borings. Although boulders were not directly encountered in any of the borings, their presence in glacial till soils is always a distinct possibility.

The thickness of the sand/silt glacial till deposit ranges at the borehole locations from approximately 2.3 m at Boreholes 01-1 and 01-4 to 5.8 m at Borehole 01-3.

The measured natural moisture content of samples of the till ranged from 5 to 19%, but was typically about 6%.

SPT 'N' values of 77 to in excess of 50 blows/100 mm penetration indicate very dense conditions throughout this deposit. A local exception was SPT 'N' of 19 (compact) and 32 (dense) measured above the bedrock surface within Borehole 01-3.

Bedrock

Bedrock was cored within Boreholes 01-3 and 01-6 between depths of 12.0-16.6 m and 11.4-14.5 m respectively. A photograph of the recovered rock core is provided in the attached Plate 1. Bedrock could not be penetrated with the augers (i.e. refusal) within Boreholes 01-4 and 01-5. Inferred bedrock was augered over a length of 1.3 m to Elevation 222.3 m within

Borehole 01-2.

The upper surface of the bedrock or inferred bedrock was encountered between elevations 223.0 m (Borehole 01-5) and 225.7 m (Borehole 01-4). The range in bedrock elevations encountered in the DHO borings was from 222.8 m (DHO-1) to 224.2 m (DHO-2).

Bedrock consists of dark and light grey shaly limestone horizontally interbedded with shale The contacts between limestone and shale layers are typically wavy.

The Rock Quality Designation (RQD) ranged from 16% to 69% and Total Core Recoveries were from 78% to 100%.

The intact uniaxial rock strength is estimated to be in the range of 25-100 MPa in the limestone and from 5 to 50 MPa in shaly layers

5.3 Groundwater

Groundwater and piezometric levels were monitored in the boreholes on completion of drilling, and then over an approximately two (2) week period following completion of the piezometer installations. The most recent set of piezometric readings was taken in late July of 2002, more than one year after completion of the fieldwork. These measurements are summarized on the individual Record of Borehole Sheets within Appendix A and are tabulated in the following Table 1.

Table 1: Summary of Piezometric Level Measurements

Date of Piezometer Reading	Piezometric Elevation (m)				
	Borehole No. [Ground Surface Elevation]				
	01-2 [234.3]	01-3 [235.5]	01-4 [235.3]	01-5 [234.1]	01-6 [235.2]
June 1/01	-	234.5	232.1	233.2	-
June 7/01	226.2	225.7	233.1	229.1	229.1
June 8/01	226.0	226.0	233.2	229.5	229.5
June 11/01	226.6	226.6	233.6	230.1	230.2
June 12/01	227.4	227.3	233.8	230.8	231.0
June 13/01	227.5	227.4	233.9	231.5	232.4
July 31/02	234.4*	234.5	234.4	233.7	234.4

* Denotes artesian condition.

During augering and/or split-spoon sampling within Boreholes 01-2, 01-3 and 01-5, sub-artesian conditions were encountered when the lower gravelly zone of the sand and silt till deposits were penetrated. This condition occurred between approximate elevations 224 m and 225 m. However, in no case did the groundwater levels rise up above the ground surface. This suggests that the base of the glacial till deposit and/or the limestone bedrock are aquifers confined by the overlying low permeability clayey deposits. Similar findings were reported by DHO in their 1962 investigation.

The most recent July 31, 2002 piezometric readings reveal a consistent piezometric surface at elevation 234 4 to 234.5 m, except in Borehole 01-5 where the piezometric elevation was 233.7 m. Within Borehole 01-2, the piezometric elevation of 234.4 m is slightly artesian with respect to the existing ground elevation of 234.3 m. It is noteworthy that the most recent set of piezometer readings were taken when water levels in White's Creek were actually lower than they were in June of 2001. We therefore consider that the 2001-series of piezometric readings do not represent fully stabilized conditions.

Seasonal and temporal fluctuations in groundwater level are expected.

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