Preliminary Foundation Investigation Report
Ormond Street Overpass Replacement - Site No. 16X-0123/B0

Highway 401 Rehabilitation
Brockville, ON

G.W.P. 4003-19-00

Latitude 44.607075
Longitude -75.690899

Geocres No. 31B-106

Prepared for:
Ministry of Transportation Ontario

Prepared by:
Stantec Consulting Ltd.
400 – 1331 Clyde Avenue
Ottawa, ON K2C 3G4

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For
G.W.P 4003-19-00

Highway 401 Rehabilitation, Brockville, Ontario
Highway 401 Ormond Street Overpass (Site No. 16X-0123/B0)

Brockville, Ontario

1.0 INTRODUCTION

The Ministry of Transportation, Ontario (MTO) has retained Stantec Consulting Ltd. (Stantec) to undertake an Environmental Assessment and complete the Preliminary Design for the replacement or rehabilitation of various structures along Highway 401 in the City of Brockville. The project limits extend from about 2 km west of the Highway 401 and Stewart Blvd Interchange to 750 m east of the Highway 401 and North Augusta Road Interchange, for a total length of approximately 4.5 km (G.W.P. 4003-19-00).

The foundation engineering services for the project include the preparation of preliminary foundation investigation and design reports at four (4) bridge (overpass or underpass) sites where replacement of the existing structures is planned. This report presents the results of the preliminary foundation investigation related to the replacement of the Ormond Street overpass structure at Site No. 16X-0123/B0. An existing structural culvert (Buells Creek Culvert - Site No. 16X-0237/C0) that currently passes beneath the Highway 401 embankment approximately 50 m west of Ormond Street is proposed to be abandoned and replaced with an open creek channel that will be located beneath the westernmost span of the new replacement bridge.

Separate Preliminary Foundation Investigation and Design Reports will be prepared for the other structure sites included in this assignment.

The purpose of the preliminary foundation investigation was to supplement existing information on the subsurface conditions at the location of the proposed bridge reconstruction by drilling four boreholes, carrying out in-situ testing and completing a laboratory testing program on selected soil samples obtained from the boreholes.

This Preliminary Foundation Investigation and Design Report (Preliminary FIDR) has been prepared specifically and solely for the proposed replacement of the Ormond Street overpass structure at Highway 401 (Site No. 16X-0123/B0). This preliminary report is not to be used for the detail design of this project; a Final Foundation Investigation and Design Report will need to be completed in the future after additional site investigation is completed.

2.0 SITE DESCRIPTION

2.1 SITE LOCATION

Ormond Street crosses beneath Highway 401, near Station 22+551, in the City of Brockville, Ontario. The site location is shown on the Key Plan inset on the Borehole Locations and Soil Strata Plan, Drawing No. 1 in Appendix A.

2.2 SITE DESCRIPTION

At the Ormond Street overpass, Highway 401 is a four-lane divided freeway with two lanes in each direction that is aligned in an approximate southwest-northeast orientation. At the bridge location, Ormond Street is a two-lane undivided roadway, with an asphalt-surface pedestrian pathway running adjacent to the southbound lane, that crosses below Highway 401 under a single-span bridge structure. For the purposes of this report, the overpass structure will be referenced as being orientated west to east.

The existing bridge is a single-span, rigid frame structure constructed in 1958 (Contract 57-165). The overpass structure has a width of approximately 29 m and carries four lanes of traffic over Ormond Street. Curved retaining walls are present adjacent to the abutments in all four quadrants of the bridge. A photo of the bridge looking towards the north is provided below.

The ground surface surrounding the overpass site is relatively flat with a gentle slope towards the Buells Creek channel to the west. The lands immediately adjacent to the highway consist of parkland and other undeveloped properties that contain vegetative cover consisting of grass, brush and/or trees.

The pavement surface elevations on Highway 401 at the overpass vary from approximately 100.4 m (west side) to 99.8 m (east side) while the asphalt surface on Ormond Street is at an elevation of about 93 m.

Buells Creek currently crosses beneath Highway 401 about 50 m west of Ormond Street (~Station 22+503). The Buells Creek culvert (Site No. 16X-0237/C0) consists of an elliptical shaped Corrugated Steel Pipe (CSP) arch culvert with a clear span of 5.0 m, a height of 3.0 m, and a length of about 58.0 m. Based on the preliminary design plans, the existing culvert is planned to be removed and replaced with a new open channel to the west of Ormond Street below a new, longer overpass structure that will span over both Ormond Street and the realigned creek channel.

2.3 SITE RECONNAISSANCE

The following items were noted during a site visit completed by a member of Stantec's geotechnical/foundation group:

- No visible signs of settlement or deformation of the existing bridge structure were noted.
- The bridge soffit exhibits areas of delamination and spalls with exposed rebar, especially near the fascia, and there are narrow to wide vertical cracks in the abutment walls.
- The asphalt on the bridge surface displayed only minor cracking (one longitudinal crack/joint running down the centerline of the EBL and occasional transverse cracks).
- No signs of embankment settlement or significant instability were observed.

The Buells Creek culvert is in fair to poor condition with a bulge in the soffit, delamination and spalling of the grout at both ends, and areas of rusting and evidence of leakage at the water line.

2.4 SITE DRAINAGE

Regionally, surface water flow in the area is typically from north to south towards the Saint Lawrence River, located approximately 2 km from the site. Locally, surface water discharges towards Buells Creek located to the west of the overpass structure.

Highway 401 slopes down towards the east and pavement drainage is provided by a series of catch basins located adjacent to the median barrier and on the paved shoulders of the highway.

2.5 GEOLOGICAL INFORMATION

The Physiography of Southern Ontario indicates that the site is located within a physiographic region known as the Smiths Falls Limestone Plain. The Surficial Geology Map of Southern Ontario indicates that the Ormond Street bridge structure is located within massive to well laminated fine-textured glaciomarine deposits comprised of silt and clay with minor amounts of sand and gravel. The mapping also shows areas of stone-poor sandy silt to silty sand-textured till on Paleozoic terrain to the west, southeast and northeast of the bridge and bedrock-drift complex in Paleozoic terrain east of the bridge.

The Paleozoic Geology Map of the Brockville Mallorytown Area indicates that the bedrock at the site location is of March Formation consisting of interbedded sandstone, dolostone, sandy dolostone, and dolomitic sandstone.

A review of available water well records for wells located in proximity to the bridge site indicates that bedrock was encountered at depths of approximately 1 m to 10 m below ground surface.

3.0 PREVIOUS INVESTIGATIONS / AVAILABLE INFORMATION

Subsurface information at the site of the Ormond Street overpass at Highway 401 was obtained from the following document contained in the MTO GEOCRES database/library:

- A report titled 'Report of Foundation Investigation for Proposed Overpass Bridge – Highway 401 at Ormond Street, Brockville' for Project 55-F-9 (GEOCRES No. 31B00-015).

The report included the results of test boring and/or penetration tests at four locations advanced at the site to a maximum depth of approximately 7.5 m below ground surface in May 1955. Two boreholes, designated as Borehole No. 2 and Borehole No. 8, were advanced at the site: one near each abutment location. Penetration tests were advanced near each of the four corners of the existing structure.

The subsurface stratigraphy encountered in the boreholes consisted of a layer of medium to stiff clay that was underlain by limestone bedrock. The borehole records indicate that a 250 lb (~113.6kg) hammer, with an unspecified drop height, was used to advance 2 in. or 3 in. diameter, thin-walled open tube samplers; it is noted that this is not the standard hammer size or sampling equipment used for Standard Penetration Tests (SPTs).

The report indicated that consolidation testing was completed, and that the clay deposit was preconsolidated. The natural moisture content of the clay samples tested varied from 24 to 36 percent, expressed as a percentage of the dry weight of the soil. The shear strength of the clay ranged from about 65 kPa to 190 kPa, and the unit weight of the clay ranged from 15.7 kN/m^3 to 19.2 kN/m^3.

The limestone bedrock or penetration test refusal was encountered at depths varying from approximately 4.8 m to 6.4 m below ground surface, corresponding to elevations of approximately 86.6 m to 87.8 m. Approximately 2.2 m of bedrock was cored in Boring No. 2.

The General Arrangement drawing, and test hole records contained in the above noted report are included in Appendix B for reference.

4.0 INVESTIGATION PROCEDURES

4.1 FIELD INVESTIGATION

The current subsurface investigation program consisted of advancing four boreholes, identified as Boreholes BC21-1, BC21-2, OS21-1, and OS21-2 at the site. Borehole OS21-1 was drilled near the Ormond Street level within the grassed area to the east of Ormond Street and the south of the existing bridge abutment, while Borehole OS21-2 was drilled at the Highway 401 level on the westbound shoulder of the highway adjacent to the west abutment of the existing bridge. The current design includes

abandonment of the existing culvert and realignment of the creek channel beneath a new, longer bridge structure. However, at the time of the investigation, consideration was being given to replacing the Buells Creek culvert, and Boreholes BC21-1 and BC21-2 were advanced near the ends of the existing culvert to assess culvert replacement options; these boreholes are located near to the west abutment of the planned overpass structure. The locations of these boreholes are shown on the Borehole Locations and Soil Strata Plan, Drawing No. 1, in Appendix A.

Prior to carrying out the investigation, Stantec contacted the public utility authorities to clear the borehole locations of utilities.

The boreholes were advanced using truck and track-mounted drill rigs equipped for soil sampling and rock coring between the dates of May 5th and May 11th, 2021. The boreholes were typically advanced in the overburden using continuous hollow-stem augers. Casing was advanced below a depth of approximately 6 m in Borehole OS21-2 due to difficult augering conditions. Coring methods were used to advance the boreholes within bedrock below depths of approximately 5.0 m, 3.7 m, 5.5 m, and 13.6 m below ground surface in Boreholes BC21-1, BC21-2, OS21-1, and OS21-2, respectively.

The subsurface stratigraphy encountered in each borehole was recorded in the field by a member of Stantec's geotechnical staff. Standard Penetration Tests (SPTs) were carried out in the overburden and split spoon samples were collected at regular intervals. Relatively undisturbed Shelby tube samples of cohesive soil deposits were also collected at select locations. The bedrock was cored in all boreholes to the termination depths using NQ size equipment. The cores were placed in core boxes, and the boxes labelled and sealed. All recovered soil samples and bedrock cores were returned to our Ottawa laboratory for detailed classification and testing.

In situ shear vane testing was attempted at select locations to assess the undrained shear strengths (undisturbed and remoulded) of cohesive materials; with the exception of one test, the soil stiffness was beyond the range of the testing equipment.

Monitoring wells were installed with well screens located in the bedrock in Boreholes BC21-1 and OS21-1; the screened sections of the wells were provided with a sand filter and bentonite was placed above the sand pack. The water level was measured in the BC21-1 well on May 5th, and in both wells on May 11th, May 13th, June 9th, and October 22nd, 2021. The monitoring wells were decommissioned on October 22nd, 2021. The other boreholes were backfilled using bentonite upon completion of drilling; gravel was used to backfill within the highway embankment portion of Borehole OS21-2.

4.2 LOCATION AND ELEVATION SURVEY

The borehole locations and respective ground surface elevations for the boreholes were surveyed by Stantec's Geomatics division. The borehole survey data is considered accurate to 0.1 m for both coordinates and elevations.

Table 4.1 below summarizes the borehole location information with the borehole ground surface elevations, depths, and termination elevations.

Table 4.1: Borehole Coordinate and Elevation Information

Borehole	MTM Zone 11 Coordinates		Approximate Ground Surface Elevation (m)	Borehole Depth (m)	Borehole Termination Elevation (m)
	Northing	Easting			
BC21-1	4941097.5	368969.0	92.3	8.3	83.9
BC21-2	4941050.0	369020.3	92.2	6.9	85.3
OS21-1	4941090.4	369043.8	93.3	8.5	84.9
OS21-2	4941100.2	369004.1	100.4	16.9	83.5

4.3 LABORATORY TESTING

All samples were transported to Stantec's Ottawa laboratory where they were visually examined by a geotechnical engineer. The geotechnical laboratory testing program completed on the borehole samples is summarized in Table 4.2.

Table 4.2: Geotechnical Laboratory Testing Program

Test Description	Number of Tests
Moisture Content	34
Atterberg Limits	7
Grain Size Distribution (sieve & hydrometer)	9
Unconfined Compressive Strength (on soil samples)	2
Unconfined Compressive Strength (on bedrock cores and rockfill pieces)	8
Oedometer (Consolidation) Tests	3

Four soil samples, one from each borehole location, were also tested for pH, soluble sulphate content, chloride content, and resistivity (chemical analysis) by Paracel Laboratories Ltd. of Ottawa.

Samples remaining after testing will be placed in storage for a period of one year after issuance of the final report. After the storage period, the samples will be discarded unless we are directed otherwise by MTO.

5.0 SUBSURFACE CONDITIONS

5.1 FRAMEWORK AND OVERVIEW

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in-situ and laboratory testing are displayed on the Borehole Records included in Appendix C. An explanation of the symbols and terms used to describe the Borehole Records is also provided in Appendix C. The results of geotechnical laboratory testing are presented in Appendix D.

A borehole location plan and stratigraphic section of the soils encountered in the boreholes are provided on Drawing No. 1 in Appendix A. The stratigraphic boundaries on the borehole records and the strata

plot are inferred from non-continuous sampling and therefore represent transitions between soil types rather than exact boundaries between geological units. The conditions will vary beyond the borehole location.

In general, the subsurface stratigraphy encountered at the borehole locations consists of a surficial layer of topsoil or fill materials. The fill materials range in composition from sand and gravel to rockfill in Borehole OS21-2 to clayey silty to silty clay in Boreholes BC21-1 and BC21-2. The surficial topsoil or fill materials are underlain by a native deposit of stiff to very stiff silty clay to clay that is in turn underlain by a deposit of glacial till ranging in composition from very stiff clayey silt to compact to very dense silty sand/silt and sand in some boreholes. The overburden materials are underlain by dolostone bedrock. The boreholes were terminated within the bedrock at depths of 6.9 m to 16.9 m below existing ground surface.

The following sections provide a summary of the subsurface conditions encountered during the investigation.

5.2 OVERBURDEN

5.2.1 Topsoil

An approximately 100 mm to 250 mm thick surficial layer of topsoil was encountered at the locations of Boreholes BC21-1, BC21-2, and OS21-1.

5.2.2 Fill

5.2.2.1 Granular Fill

Borehole OS21-2, which was drilled through the existing asphalt in the north shoulder of the westbound lanes of Highway 401 encountered a surficial asphalt layer that was approximately 480 mm thick.

Predominantly granular fill materials were encountered beneath the asphalt in Borehole OS21-2. An approximately 300 mm thick layer of sand and gravel (road base) was encountered directly beneath the asphalt. The fill directly beneath the road base consisted of sand, containing trace to some gravel and pockets/zones of sandy silt, that extended to a depth of 3.8 m below ground surface. Below the sand fill, rockfill materials comprised of cobbles and boulders in a matrix of sand were encountered to a depth of about 8.4 m below ground surface (~Elev. 92.0 m). Increased drilling resistance and frequent grinding of the augers was noted during drilling through the fill below a depth of about 3.8 m. Casing was required to be advanced below 6 m due to the frequent cobbles and boulders encountered in the rockfill. A photograph of the pieces of rock retrieved during casing advancement from a depth of 6.2 m to 7.6 m in Borehole OS21-2 is provided below.

Standard Penetration Test (SPT) N-values measured within the granular fill material varied from 2 to more than 50 blows per 0.3 m of penetration but were typically between 4 and 20 blows per 0.3 m of penetration indicating the fill is generally in a loose to compact state. Below 6 m depth, N-values of greater than 50 blows per 0.3 m of penetration were recorded in the rockfill materials; the higher N-values are considered to have been influenced by the presence of cobbles and boulders.

Two samples of pieces of rock retrieved within the embankment fill during casing advancement in Borehole OS21-2 were selected for testing to determine their Unconfined Compressive Strengths (UCS). The UCS test results were 116.3 MPa at a depth of 6.7 m and 176.0 MPa at a depth of 7.0 m below ground surface and indicate that the cobbles and/or boulders in the rockfill are classified as very strong (R5).

Laboratory testing of samples of the granular fill materials yielded moisture contents varying between approximately 2% to 7%, expressed as a percentage of the dry weight of the soil.

Gradation analyses were carried out on two representative samples of the sand fill materials. The results of the tests are illustrated on the borehole records in Appendix C and on the gradation plots on Figure No. D1 in Appendix D.

Based on the laboratory results, the USCS group symbols for the sand fill varies from SP to SM.

The granular fill was approximately 7.9 m thick with the base of the layer encountered at an elevation of approximately 92.0 m.

5.2.2.2 Cohesive Fill

Cohesive fill materials were encountered beneath the surficial topsoil in Boreholes BC21-1 and BC21-2. The cohesive fill is comprised of clayey silt to silty clay and contains trace to some sand and trace gravel and organic matter. The cohesive fill extended to depths of about 1.4 m below ground surface in Borehole BH21-1 and approximately 0.8 m below ground surface in Borehole BH21-2.

Standard Penetration Test (SPT) N-values recorded within the cohesive fill materials varied from 6 to 8 blows per 0.3 m of penetration. In-situ shear vane tests conducted at in Borehole BC21-1 using N-vane equipment measured an undrained shear strength of 118 kPa at a depth of about 0.8 m and encountered refusal (i.e. inability to turn vane) at a depth of 1.0 m. Based on the field and laboratory testing and examination of samples obtained, the cohesive fill is considered to generally have a firm to very stiff consistency

Laboratory testing of samples of the cohesive fill materials yielded moisture contents varying between approximately 11% to 28%, expressed as a percentage of the dry weight of the soil.

The cohesive fill was approximately 0.6 m to 1.3 m thick with the base of the layer at elevations of approximately 90.9 m and 91.4 m in Boreholes BC21-1 and BC21-2, respectively.

5.2.3 Silty Clay/Clay

A cohesive deposit comprised of silty clay/clay containing trace sand was encountered below the topsoil in Borehole OS21-1 and beneath the fill materials in Boreholes BC21-1, BC21-2, and OS21-2. The cohesive deposit was approximately 1.6 m to 5.2 m thick.

The deposit was noted to be varved below a depth of 2.0 m and 2.5 m in Boreholes BC21-1 and BC21-2, respectively.

SPT 'N' values varying between 6 to 23 blows per 0.3 m of penetration were measured within the cohesive deposit. In-situ shear vane testing using N-vane equipment attempted at depths of 1.4 m to 3.7 m in Boreholes BC21-1, BC21-2, and OS21-1 encountered refusal (i.e. inability to turn vane). The undrained shear strength of the cohesive deposit was also determined by conducting Unconfined Compressive Strength (UCS) tests on Shelby Tube samples recovered from Boreholes BC21-1 and OS21-2. Undrained shear strengths of approximately 143 kPa and 140 kPa were measured by this testing. Based on the field and laboratory testing, and examination of samples obtained, the cohesive deposit is considered to generally have a very stiff consistency with zones of stiff soils present in Borehole BC21-2.

Laboratory testing of samples of the cohesive soils yielded moisture contents varying between approximately 23% to 40%.

Gradation analyses were carried out on five (5) representative samples of the silty clay/clay deposit obtained from the boreholes. The test results are illustrated on the borehole records in Appendix C and on the gradation curves on Figure No. D2 in Appendix D.

Atterberg Limits tests were carried out on portions of the samples referenced above. The tests yielded Liquid Limits ranging from 39% to 62%, Plastic Limits ranging from 21% to 25%, and Plasticity Indices ranging from 18% to 37%. Based on these results, the cohesive soil is classified as silty clay of medium plasticity (CI) to clay of high plasticity (CH). The results of the tests are illustrated on the borehole records in Appendix C and on Figure No. D3 in Appendix D.

Three (3) consolidation tests were carried out on relatively undisturbed Shelby Tube samples recovered from the boreholes. The test results are illustrated on Figure Nos. D4(A to D) to D6(A to D) in Appendix D. The consolidation and index property test results for these samples are summarized below in Table 5.1.

Table 5.1: Consolidation Test Results

Parameter	Sample ID		
	BC21-1, SH3A	OS21-1, SH5	OS21-2, SH13
Sample Depth (m below ground)	2.5	3.3	9.5
Sample Elevation (m)	89.8	90.0	90.9
Effective Vertical Stress (kPa)	25.8	32.0	171.8
Moisture Content	33%	40%	23%
Initial Void Ratio, e_0	0.960	1.127	0.698
Initial Unit Weight, γ	18.1 kN/m^3	17.8 kN/m^3	19.6 kN/m^3
Estimated Preconsolidation Stress, P'_c	580 kPa	900 kPa	650 kPa
Overconsolidation Ratio (OCR)	22.5	28.2	3.8
Recompression Index, C_r	0.06	0.02	0.02
Compression Index, C_c	0.33	0.49	0.23
Coefficient of Consolidation, C_v	0.3 mm^2/s	0.5 mm^2/s	0.5 mm^2/s

Notes: The initial void ratios presented in Table 5.1 are derived from the start of the oedometer test, at which point the sample is entirely unloaded and the degree of saturation is less than 100%
The coefficients of consolidation identified relate to the recompression stress range.

The silty clay/clay deposit extended to depths of about 3.0 m, 3.7 m, 5.5 m and 13.0 m below ground surface in Boreholes BC21-1, BC21-2, OS21-1, and OS21-2, respectively, corresponding to base of deposit elevations ranging from about 87.4 m to 89.2 m.

5.2.4 Glacial TILL

A glacial till deposit varying in composition from clayey silt containing some sand and trace gravel to silty sand/silt and sand containing some gravel and trace to some clay was encountered underlying the clay/silty clay deposit in Boreholes BC21-1 and OS21-2. The till deposit was approximately 2.0 m and 0.6 m thick and extended to the depths of about 5.0 m and 13.6 m, (corresponding to elevations of about 87.3 m and 86.8 m) in Boreholes BC21-1 and OS21-2, respectively.

Auger grinding on inferred cobbles and boulders was encountered within the till below a depth of about 3.8 m in Borehole BC21-1. Cobbles and boulders are known to be present within the till deposits of Southern Ontario and are expected to be present throughout the till deposits at this site.

An SPT 'N' value measured in the clayey silt portion of the till deposit in Borehole BC21-1 was 12 blows per 0.3 m of penetration suggesting the till at that location had a stiff consistency. SPT 'N' values ranging

from 18 to greater than 50 blows per 0.3 m of penetration were measured in the silty sand till deposit suggesting the coarser portions of the till are in a compact to very dense state. The highest SPT 'N' values may have been influenced by the presence of gravel, cobbles and/or boulders within the till.

Laboratory testing of samples of the till materials yielded moisture contents that ranged from approximately 7% to 12%.

Gradation analyses were carried out on two (2) representative samples of the till deposit obtained from the boreholes. The test results are illustrated on the borehole records in Appendix C and on the gradation curves on Figure No. D7 in Appendix D.

Atterberg Limits tests were also carried out on portions of the samples referenced above. The test results indicated that one sample was non-plastic, and the other test yielded a Plastic Limit of 12%, a Liquid Limit of 17%, and a corresponding Plasticity Index of 5%. The results of the tests are illustrated on the borehole records in Appendix C and on Figure No. D8 in Appendix D.

Based on the gradation and Atterberg Limit test results, the USCS group symbol for the samples of the glacial till tested varies from SM (silty sand till) to CL-ML (silt and sand till).

5.3 BEDROCK

Slightly weathered to fresh, dolostone bedrock was encountered underlying the overburden described in the preceding sections in all boreholes. The depth to bedrock is summarized in Table 5.2 below.

Table 5.2: Depth to Bedrock and Bedrock Surface Elevation

Borehole	Depth (m)	Elevation (m)
BC21-1	5.0	87.3
BC21-2	3.7	88.4
OS21-1	5.5	87.9
OS21-2	13.6	86.8

The bedrock type, depths of the coring and corresponding elevations, along with the measured total core recovery (TCR), solid core recovery (SCR) and rock quality designation (RQD) for each core run are summarized in Table 5.3 below. Photographs of the rock cores from each of the boreholes are included in Appendix C.

Table 5.3: Summary of Bedrock Coring Operations

Borehole No.	Run No.	Rock Description	Depth (m below ground)	Geodetic Elevation (m)	Total Core Recovery, TCR (%)	Solid Core Recovery, SCR (%)	Rock Quality Designation, RQD (%)	Weathering Degree (W1=Fresh, W2=Slightly Weathered)	Fracture Index (No. of fractures per m)
BC21-1	7	Slightly weathered to fresh, light grey to grey Dolostone	5.0-6.1	87.3-86.2	100	95	71	W2/W1	8
	8		6.1-7.7	86.2-84.6	98	95	72	W1	7
	9		7.7-8.3	84.6-83.9	100	100	100	W1	2
BC21-2	6	Slightly weathered to fresh, light grey to grey Dolostone	3.7-4.7	88.5-87.5	100	96	96	W2/W1	4
	7		4.7-6.0	87.5-86.2	96	96	82	W1	8
	8		6.0-6.9	86.2-85.3	100	100	72	W1	7
OS21-1	9	Slightly weathered to fresh, light grey to grey Dolostone	5.5-6.2	87.8-87.1	100	100	100	W2/W1	2
	10		6.2-7.6	87.1-85.7	100	96	67	W1	11
	11		7.6-8.5	85.7-84.8	94	94	85	W1	4
OS21-2	16	Slightly weathered to fresh, light grey Dolostone	13.6-14.8	86.8-85.6	100	58	21	W2/W1	13
	17		14.8-16.3	85.6-84.1	96	95	78	W1	7
	18		16.3-16.9	84.1-83.5	100	100	100	W1	0

Based on the RQD range indicated in the table, the bedrock cores obtained from the boreholes can be classified as fair to excellent in quality with the exception of the first core run in Borehole OS21-2 where very poor quality rock was encountered.

Six (6) samples of the rock cores were selected for Unconfined Compressive Strength (UCS) testing. The results of the tests are summarized in Table 5.4 below.

Table 5.4: Results of Unconfined Compressive Strength (UCS) on Rock Core Samples

Borehole No.	Run No.	Sample Depth (m below ground)	Sample Elevation (m)	Unconfined Compressive Strength (MPa)
BC21-1	7	5.3	87.0	113.9
BC21-2	6	4.3	87.9	137.8
OS21-1	9	6.0	87.3	144.9
	11	8.1	85.2	124.5
OS21-2	17	15.6	84.8	60.4
	17	16.1	84.3	159.8

The UCS test results of the rock cores ranged from 60.4 MPa to 159.8 MPa and indicate that the dolostone bedrock can be classified as strong (R4) to very strong (R5).

5.4 GROUNDWATER CONDITIONS

The water levels recorded in the monitoring wells installed within the bedrock in Boreholes BC21-1 and OS21-1 are summarized in Table 5.5 below.

Table 5.5: Water Level Measurements in Monitoring Wells Sealed in Bedrock

Borehole No.	Date	Measured Groundwater Depth (m)	Groundwater Elevation (m)
BC21-1	May 5, 2021	0	92.30
	May 11, 2021	0	92.30
	May 13, 2021	1.09 above ground	93.39
	June 9, 2021	0.50 above ground	92.80
	October 22, 2021	0.05 below ground	92.25
OS21-1	May 11, 2021	0.45 below ground	92.85
	May 13, 2021	0.21 above ground	93.51
	June 9, 2021	0.23 above ground	93.53
	October 22, 2021	0.89 below ground	92.41

The above-ground water level readings indicate that artesian conditions were measured and should be anticipated at the site. As the water levels within the bedrock were originally at or slightly below ground surface, rose to above ground surface, and then returned to levels below ground surface, the artesian conditions appear to be transitory in nature.

Perched water conditions may also develop within and above finer-grained portions of the embankment fill materials, and also within the natural silty clay to clay cohesive deposit.

Groundwater levels at the site will be subject to fluctuations due to seasonal changes, snowmelt and/or precipitation events and the water level in Buells Creek. The water levels should be expected to be higher during the spring season and during and following periods of heavy precipitation or snow melt.

5.5 CHEMICAL ANALYSIS

Chemical analyses related to parameters associated with the potential for corrosion or sulphate attack (i.e., pH, resistivity, and chloride and sulphate content) were completed by Paracel Laboratories Inc. on one representative sample of the soils collected from each borehole. The analysis results are provided in Appendix D and are summarized in Table 5.5.

Table 5.6: Results of Chemical Analysis

Borehole No	Sample No.	Depth (m)	pH	Resistivity (Ohm-m)	Chloride (µg/g)	Sulphate (µg/g)
BC21-1	SS3	1.5-2.1	7.48	16.3	244	72
BC21-2	SS3	1.5-2.1	7.81	15.1	264	49
OS21-1	SS1	0.3-0.6	7.62	44.3	22	8
OS21-2	SS3B	1.8-2.1	7.91	30.2	118	16

6.0 MISCELLANEOUS

The field work was carried out under the supervision of Karl Thom under the direction of Kevin Nelson, P.Eng.

The utility locates for the boreholes were arranged by Stantec personnel.

The drilling equipment was supplied and operated by George Downing Estate Drilling Ltd. of Grenville-sur-la-Rouge, Quebec.

The location and elevation survey of the boreholes was completed by Stantec's Geomatics division.

Traffic control service was provided by Beacon Lite of Ottawa, Ontario.

Geotechnical laboratory testing was carried out at Stantec's Ottawa laboratory. The chemical testing for pH, soluble sulphate and chloride contents, and soil resistivity was carried out by Paracel Laboratories Ltd. of Ottawa.

This report was prepared by Zach Popper, P.Eng. and reviewed by Kevin Nelson, P.Eng., and Raymond Haché, M.Sc., P.Eng., Designated Principal MTO Foundation Contact.

7.0 CLOSURE

A subsurface investigation is a limited sampling of a site. The subsurface conditions given herein are based on information gathered at the specific borehole locations. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information.

Respectfully Submitted,

STANTEC CONSULTING LTD.

Zach Popper, P.Eng.
Geotechnical Engineer

Kevin Nelson, P.Eng.
Principal, Senior Geotechnical Engineer

Raymond Haché, M.Sc., P. Eng.
MTO Designated Principal Foundation Contact

v:\01216\active\other_pc_projects\165001160\05_report_deliv\deliverables\report\ormond street\165001160_fir_ormond_final_20230217.docx

APPENDIX A

A.1 DRAWING NO. 1 – BOREHOLE LOCATION PLAN AND SOIL STRATA PLOT

MINISTRY OF TRANSPORTATION, ONTARIO 88-05 PR-D-707

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

PLATE No
CONT
GWP 4003-19-00

HIGHWAY 401
ORMOND ST., BROCKVILLE
BOREHOLE LOCATIONS & SOIL STRATA

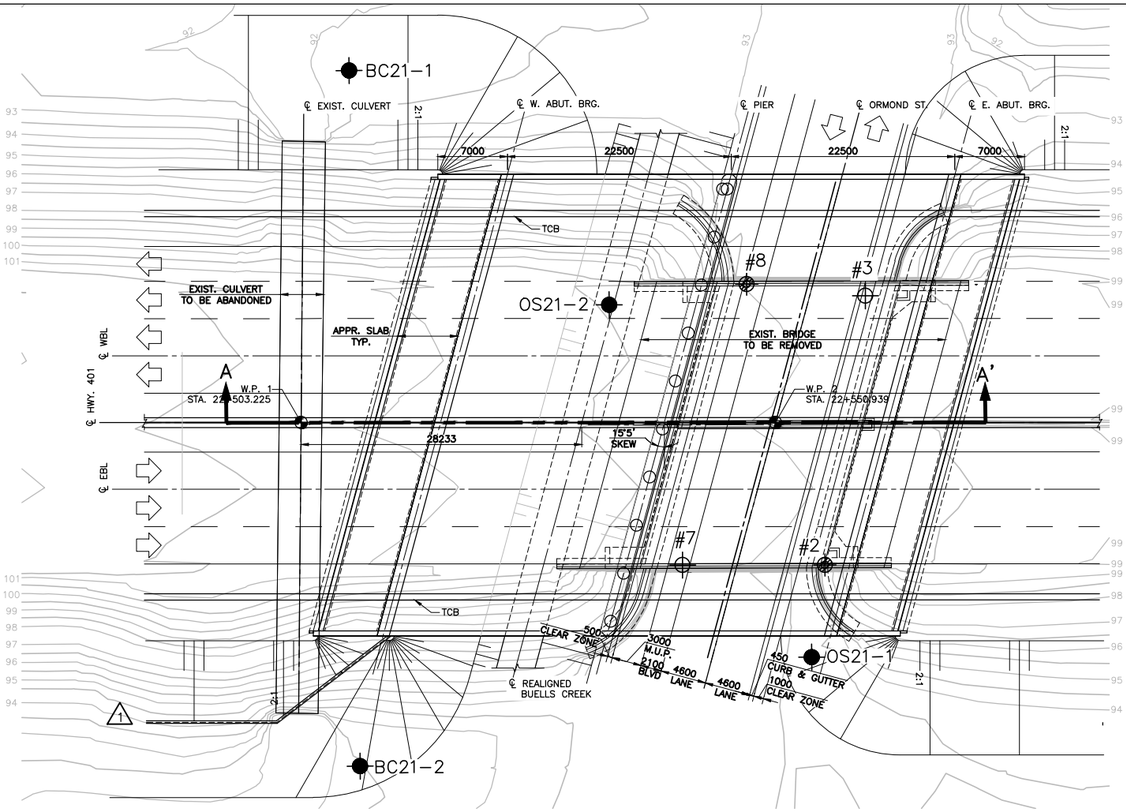
SHEET
–

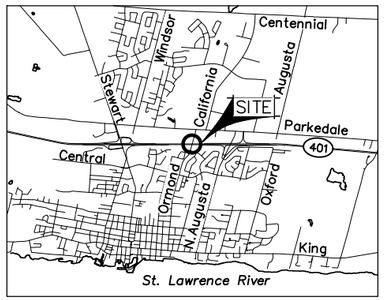
Stantec

LICENSED PROFESSIONAL ENGINEER
K. NELSON
2023-02-15
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
J.G.A.R. HACHÉ
2023-02-15
PROVINCE OF ONTARIO

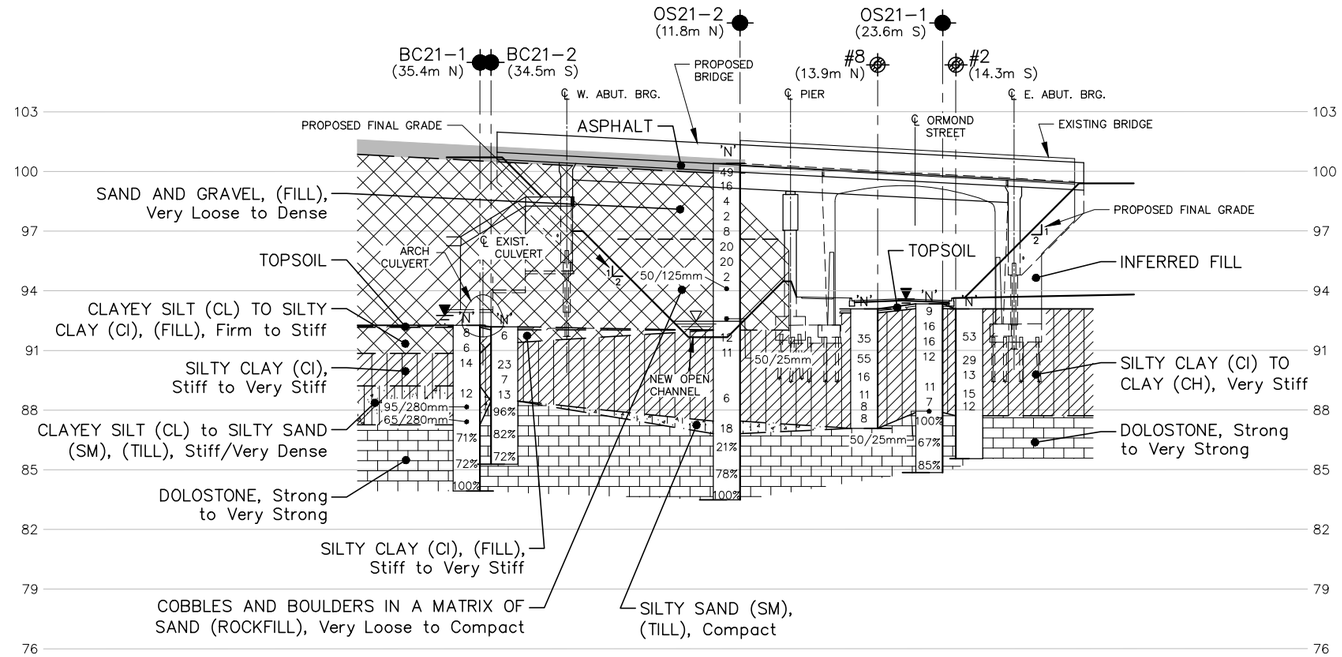
PLAN
SCALE
6m 0 6 12m





KEY PLAN
1 km 0 1 2 km

CROSS SECTION A–A'
SCALE (HORIZONTAL)
6m 0 6 12m
SCALE (VERTICAL)
3m 0 3 6m



LEGEND

- Borehole (Stantec 2021)
- Penetration Test & Borehole (MTO 1955)
- Penetration Test Hole (MTO 1955)
- (x.xm) Offset from Cross Section Line in meters
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- WL Measured on July 2021

No	ELEV	MTM ZONE 9 COORDINATES NORTH	EAST
BC21-1	92.2	4 941 097.5	368 969.0
BC21-2	92.2	4 941 050.0	369 020.3
OS21-1	93.3	4 941 090.4	369 043.8
OS21-2	100.4	4 941 100.2	369 004.1
#2	93.1	4 941 097.8	369 038.2
#3	93.1	4 941 1119.4	369 021.3
#7	93.0	4 941 087.4	369 028.1
#8	93.1	4 941 111.6	369 012.2

NOTES

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

This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REVISIONS	DATE	BY	DESCRIPTION

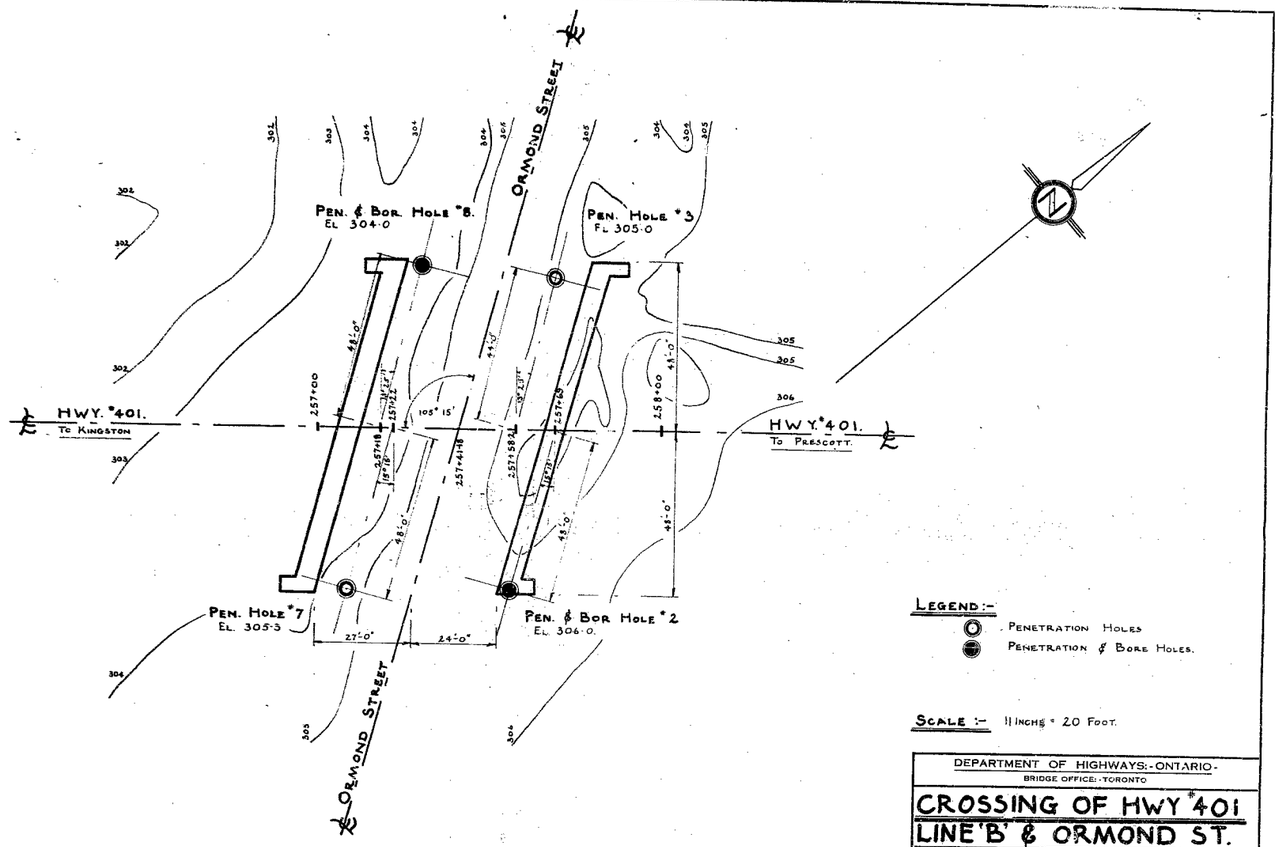
GEOCRES No 31B-106

HWY No 401			DIST
SUBM'D KN	CHECKED	DATE 2023-02-15	SITE 16-123
DRAWN GBB	CHECKED	APPROVED RH	DWG 1

DRAWING NAME: 165001160_Ormond_16-123-ga_2023.dwg
CREATED BY: GBB MODIFIED:
C:\CAD Drawings\Acad2019 Drawings\2023\165001160\Ormond\165001160_Ormond_16-123-ga_2023.dwg (PP) Printed: Feb 15, 2023

APPENDIX B

B.1 AVAILABLE GEOCRES INFORMATION INCLUDING SOIL STRATA PLOT AND BOREHOLE RECORDS



PRINT RECORD

No.	FOR	DATE

LEGEND:-

- Penetration Holes
- Penetration & Bore Holes.

SCALE :- 1 Inch = 20 Foot.

DEPARTMENT OF HIGHWAYS:-ONTARIO-
BRIDGE OFFICE:-TORONTO

CROSSING OF HWY #401 LINE 'B' & ORMOND ST.

THE KING'S HIGHWAY No. 401. DIV. No 8.

CO. LEEDS.

TWP. ELIZABETHTOWN LOT 10 CON. I

PLAN OF POSITIONS OF PEN & BOR HOLES

APPROVED

CHIEF BRIDGE ENGINEER CHIEF ENGINEER

DESIGN		CHECK		CONTRACT NUMBERS	
DRAWING	M.L.F.	CHECK	W.W.Wong		
TRACING		CHECK		LOADING	
DATE	25th JUNE 1955.			DRAWING NUMBER	F-55-9A

REVISIONS:

DATE	BY	DESCRIPTION

TL 199
54-90

MATERIALS LABORATORY - DEPARTMENT OF HIGHWAYS - ONTARIO

OFFICE REPORT ON SOIL EXPLORATION

DRILL RIG Core Drill #4
CASING Bx (STANDARD SAMPLERS TO FIT UNLESS NOTED)
SAMPLER HAMMER WT 250 # DROP — INCHES

JOB F-55-9 Brockville
DATUM Sta 257+69.2 Rt. 48 @ 105°15'
COMPILED BY B.H. CHECKED BY W. Wong

BORING No 2
DATE REPORT
BORING DATE 10 & 11th May 1955

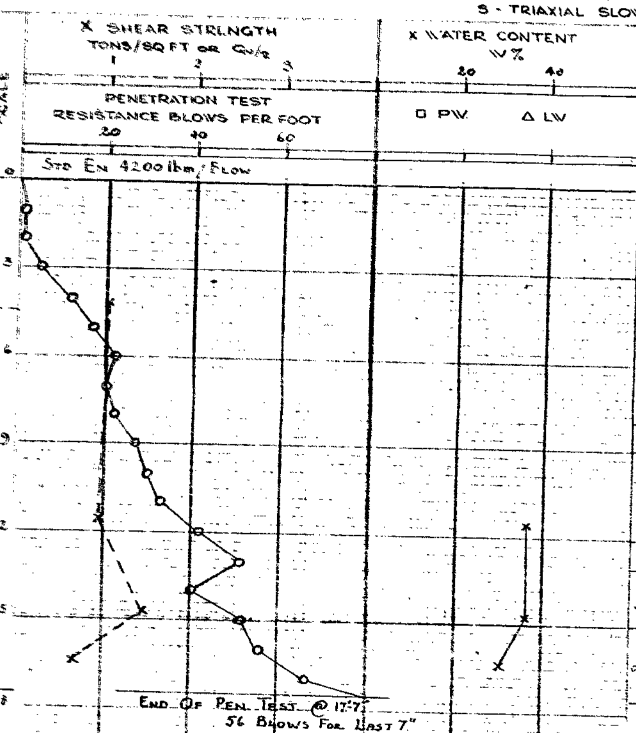
SAMPLE CONDITION
- DISTURBED
- GOOD
- LOST

SAMPLE TYPES
- C.S - CHUNK
- D.O - DRIVE OPEN
- D.F - DRIVE FOOT VALVE
- T.O - THIN WALLED OPEN
- W.S - WASHED SAMPLE
- R.C - ROCK CORE

ABBREVIATIONS
- V - INSITU VANE SHEAR TEST
- M - MECHANICAL ANALYSIS
- U - UNCONFINED COMPRESSION
- Q_c - TRIAXIAL CONSOLIDATED QUICK
- Q - TRIAXIAL QUICK
- S - TRIAXIAL SLOW
- γ - UNIT WEIGHT
- K - PERMEABILITY
- C - CONSOLIDATION
- CA. - CASING
- W.L. - WATER LEVEL IN CASING
- W.T. - WATER TABLE IN SOIL

SOIL PROFILE

ELEV. DEPTH	WATER CONDITIONS	DESCRIPTION	STRAT PLOT
305.3			
304.8 / 0.5		Black Topsoil	
300.9		(Recommended Footings Elev.) 4'-6"	
		Clay (Medium To Stiff)	
287.7 / 17.6		Rock (Very Hard)	
280.6 / 24.7		End Of Bore Hole At 24'-7"	



SAMPLES

OTHER TESTS	CONDITION	TYPE	No	PENETRATION RESISTANCE	ELEV. RECOV. %
				No. Of Blows Per Foot Std. En. 4,200 lb in	305.3
$\gamma = 109$		T.O. 3"	1	53	301.3 / 100
$\gamma = 122$		T.O. 3"	2	29	297.3 / 100
$\gamma = 116$		T.O. 2"	3	13	295.3 / 79
$\gamma = 116$		T.O. 2"	4	15	292.3 / 100
$\gamma = 123$		T.O. 2"	5	12	290.3 / 100
		RC	6		287.7 / 100

TL 199
54-90

MATERIALS LABORATORY - DEPARTMENT OF HIGHWAYS - ONTARIO

OFFICE REPORT ON SOIL EXPLORATION

DRILL RIG Core Drill #4
CASING Bx (STANDARD SAMPLERS TO FIT UNLESS NOTED)
SAMPLER HAMMER WT 250 # DROP — INCHES

JOB F-55-9 Brockville
DATUM Sta 257+18 Lt. 48 @ 76° 75'
COMPILED BY B.H. CHECKED BY W. Wong

BORING No 8
DATE REPORT
BORING DATE 12th May 1955

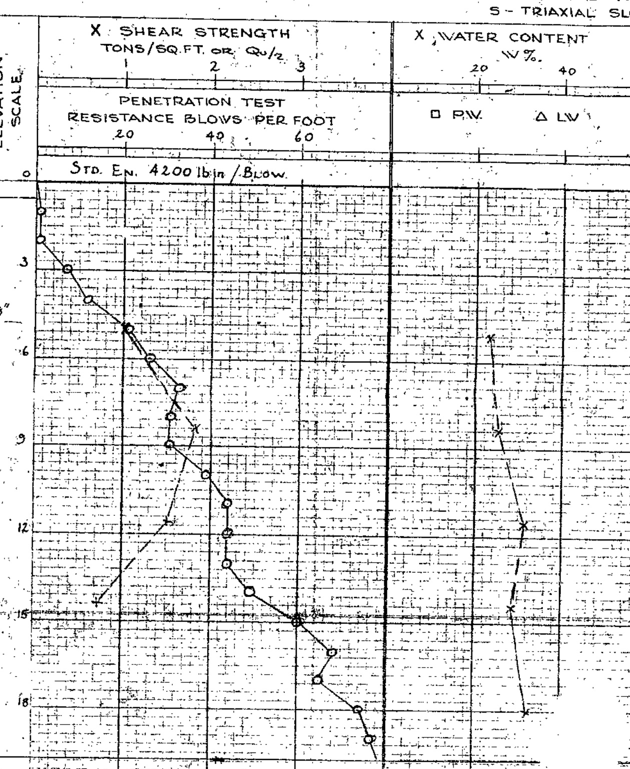
SAMPLE CONDITION
- DISTURBED
- GOOD
- LOST

SAMPLE TYPES
- C.S - CHUNK
- D.O - DRIVE OPEN
- D.F - DRIVE FOOT VALVE
- T.O - THIN WALLED OPEN
- W.S - WASHED SAMPLE
- R.C - ROCK CORE

ABBREVIATIONS
- V - INSITU VANE SHEAR TEST
- M - MECHANICAL ANALYSIS
- U - UNCONFINED COMPRESSION
- Q_c - TRIAXIAL CONSOLIDATED QUICK
- Q - TRIAXIAL QUICK
- S - TRIAXIAL SLOW
- γ - UNIT WEIGHT
- K - PERMEABILITY
- C - CONSOLIDATION
- CA. - CASING
- W.L. - WATER LEVEL IN CASING
- W.T. - WATER TABLE IN SOIL

SOIL PROFILE

ELEV. DEPTH	WATER CONDITIONS	DESCRIPTION	STRAT PLOT
305.5			
304.8 / 0.7		Black Topsoil	
300.8		(Recommended Footing Elev.) 4'-8"	
		Clay (Medium To Stiff)	
285.8 / 19.7		End Of Bore Hole @ 19.7	
		Rock	



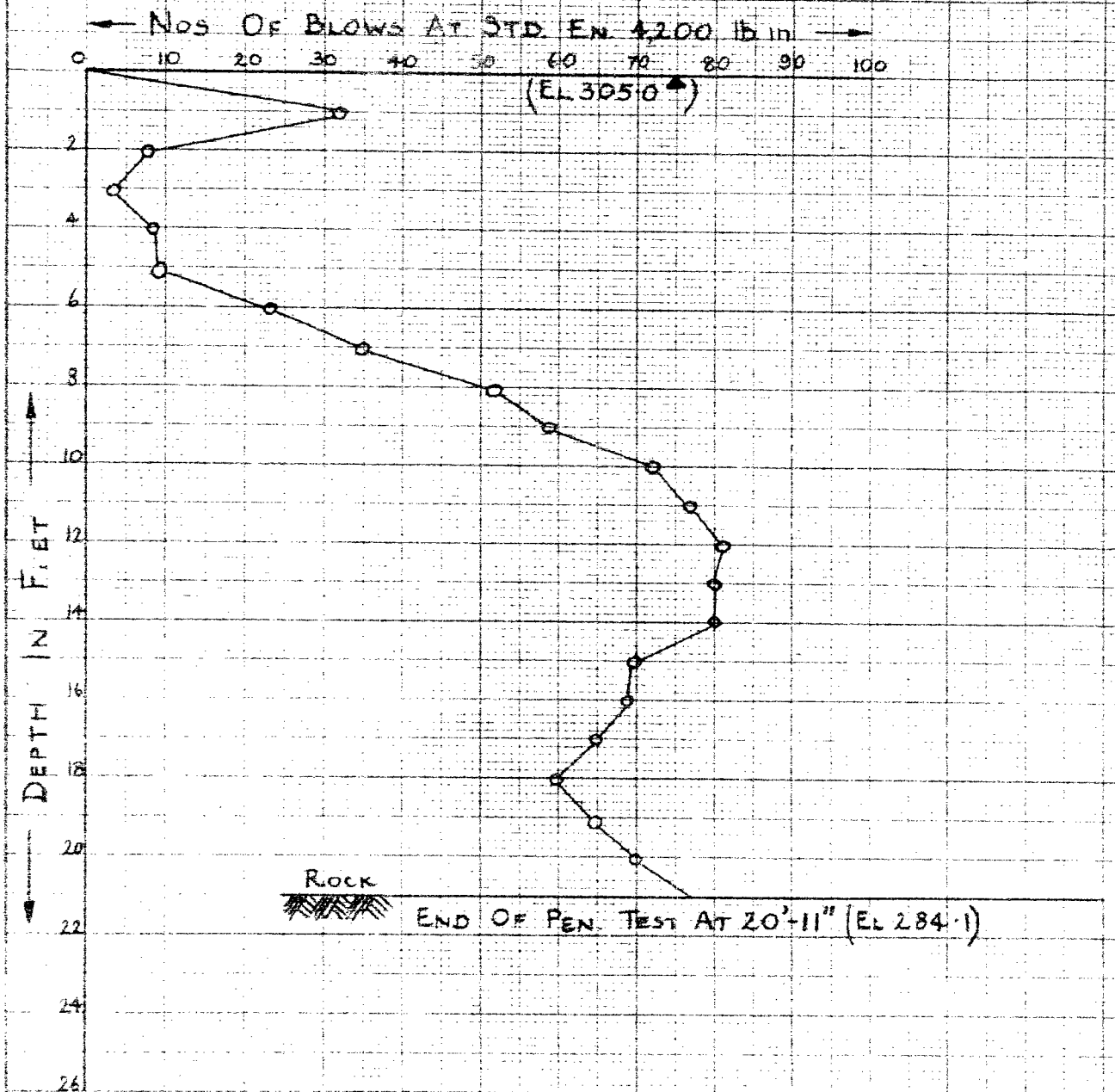
SAMPLES

OTHER TESTS	CONDITION	TYPE	No	PENETRATION RESISTANCE	ELEV. RECOV. %
				Std. En. 4200 lb in per Blow	303.5
$\gamma = 111$		T.O. 3"	1	35	299.5 / 100
$\gamma = 117$		T.O. 3"	2	55	296.5 / 46
$\gamma = 116$		T.O. 2"	3	16	293.5 / 71
		T.O. 2"	4	11	290.5 / 75
		T.O. 2"	5	8	288.5 / 100
		T.O. 2"	6	8	286.5 / 100

Graph Of Cone Penetration Test

Pen. Hole N°3 Job F-55-9

Location Sta. 257+58·2, Lt. 44' @ 76°75'

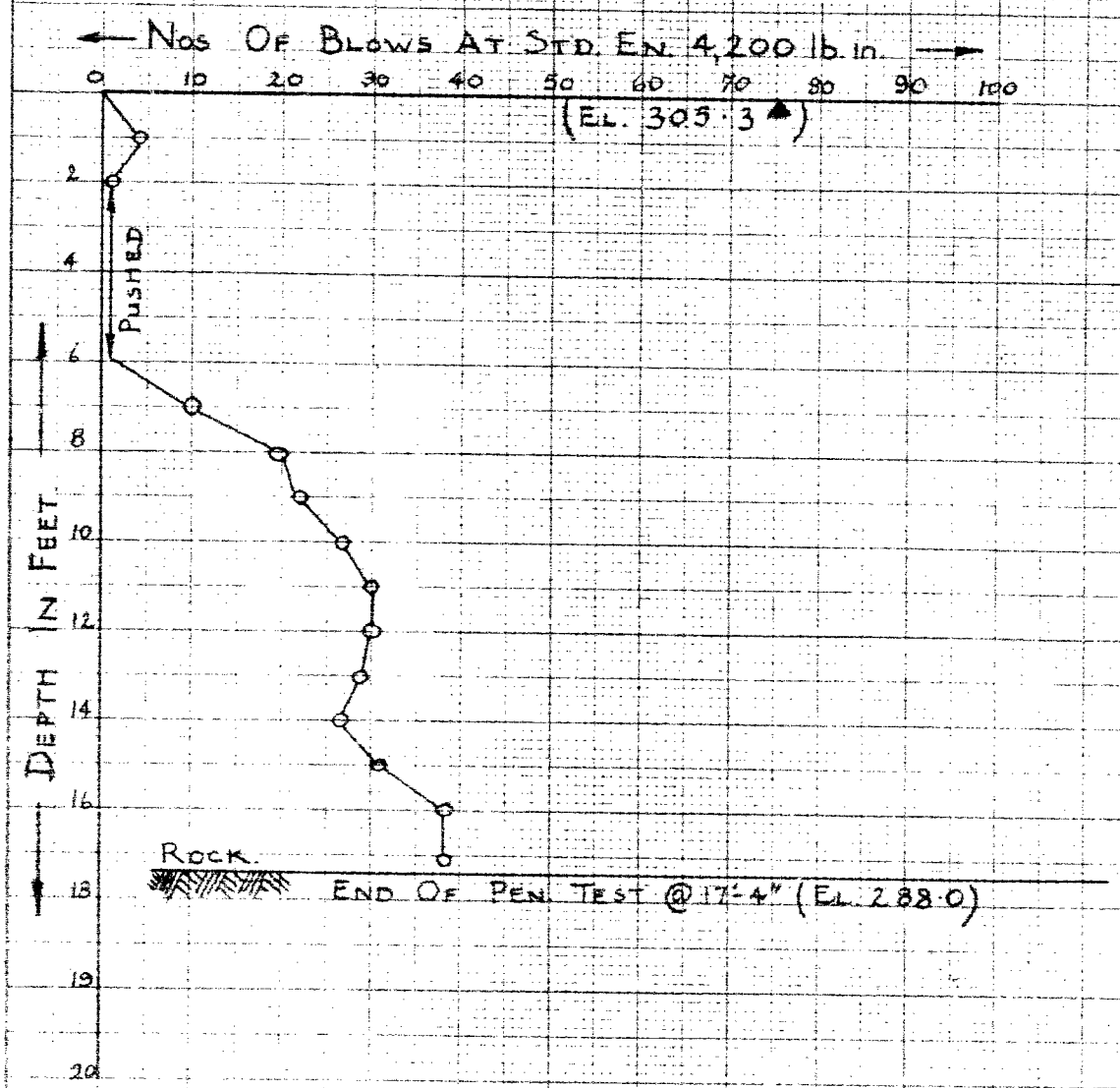


Checked W. Wong

GRAPH OF CONE PENETRATION TEST

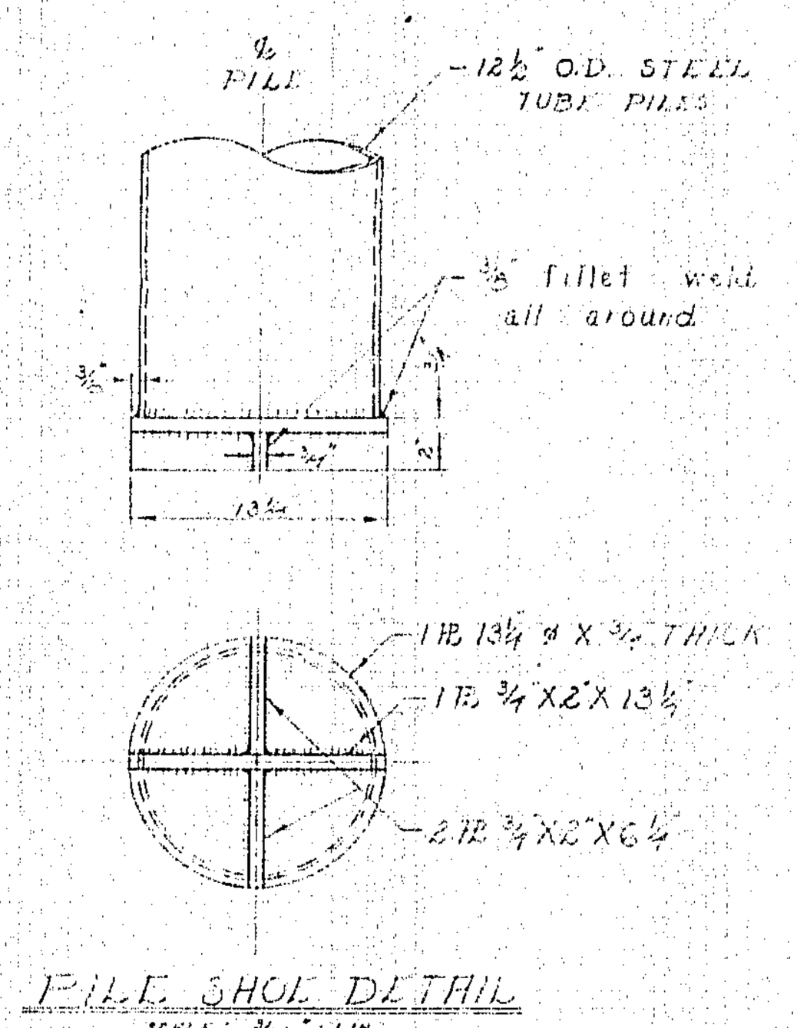
PEN. HOLE N° 7 JOB F-55-9.

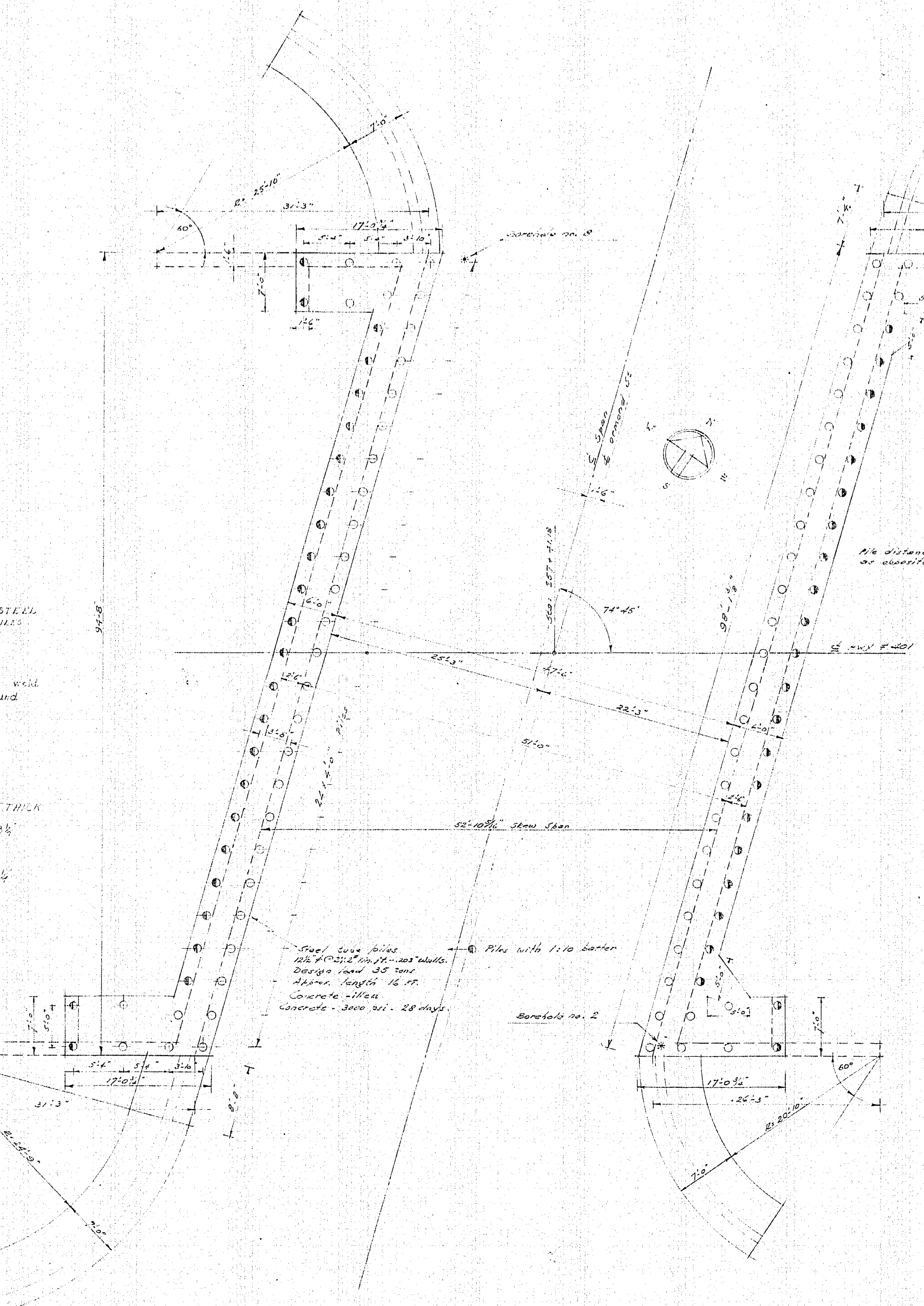
LOCATION STA 257+22; RT 48' @ 105° 15'



CHECKED W. WONG

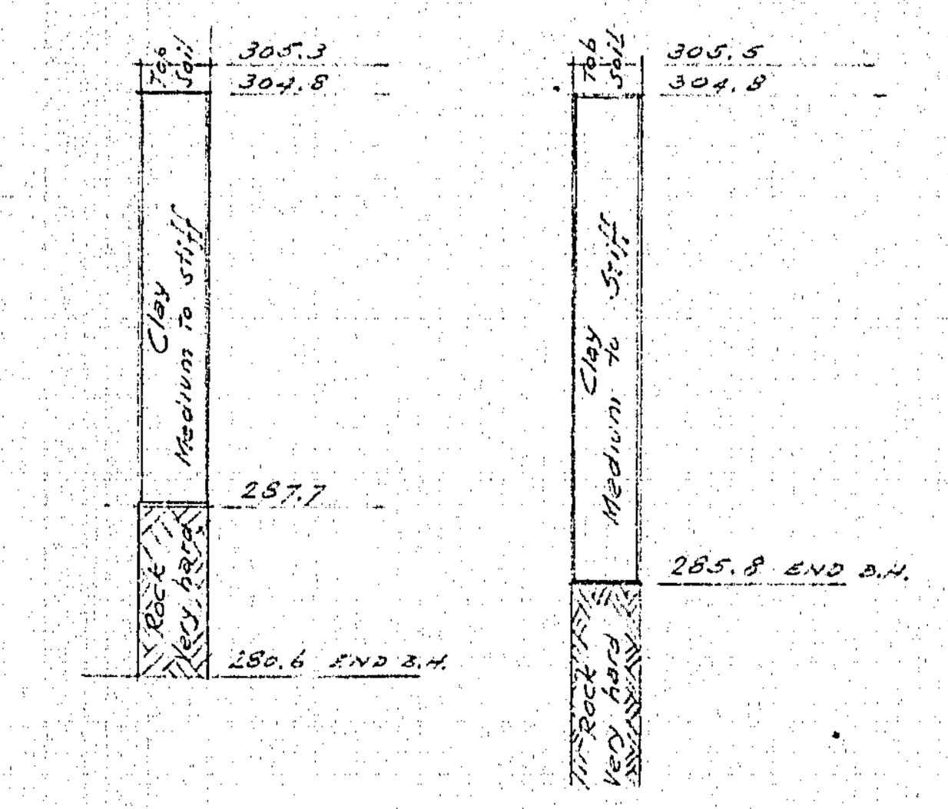

NOTES :
FOR DIVISION ENGINEER :
CONCRETE WORK MUST NOT BE COMMENCED UNTIL MONUMENTS TO FIX LINES AND GRADES HAVE BEEN ERECTED BY THE DIVISION ENGINEER.
FOR CONTRACTOR:
STRUCTURE TO BE BUILT IN ACCORDANCE WITH FORM No. 9 REVISED MARCH 1957 AND THE SPECIAL PROVISIONS, EXTRA COPIES OF WHICH MAY BE OBTAINED FROM THE DISTRICT ENGINEER.
ALL CONSTRUCTION JOINTS TO BE STRAIGHT AND TRUE.
CONSTRUCTION JOINTS IN LOCATIONS NOT SHOWN ON THE PLANS ARE TO BE APPROVED BY THE BRIDGE ENGINEER.
CONCRETE FOR FOOTINGS AND STRUCTURE TO BE 3000 P.S.I. @ 28 DAYS. -
ADD 1/4 lb. POZZOLITH "S" PER BAG OF CEMENT. MAXIMUM AGGREGATE SIZE TO BE 1 1/2"
ALL EXPOSED CORNERS TO BE CHAMFERED 1" UNLESS OTHERWISE NOTED.
REINFORCEMENT SHALL BE "HI-BOND" MEDIUM HARD GRADE STEEL TO CURRENT C.S.A. SPECIFICATIONS UNLESS OTHERWISE NOTED.
MINIMUM CLEAR COVER ON REINFORCEMENT TO BE 2" AT EXPOSED CONCRETE SURFACES, OTHERWISE 3"
Retaining wall see dwg. no. D 3774-5
NOTE: ELEVATIONS SHOWN AT TOP OF FINISHED PAVEMENT
TO KINGSTON WEST
℄ Highway 401
TO PRESCOTT EAST
3% Slope down.
CATCH BASIN DOWN TO FOOTING DRAIN TO BE TAKEN TO AN OUTLET SATISFACTORY TO DIVISION ENGINEER.
8" DIAM. C.M. PIPE
Skew span 52'-10 9/16"
Vee joint on face caulking at back.
PLAN OF BRIDGE.
Scale: 1/8" = 1 FT.
ELEVATION.
Scale: 1/8" = 1 FT.
Square dimensions
98'-1 1/2" Skew dim.
SECTION THROUGH DECK PORTION IN ℄ OF BRIDGE
Scale: 1/8" = 1 FT.
Site Plan.
BROCKVILLE
St. Lawrence River
WP 590-56.
FEBR. 14. SIZE AGGREGATE ADDED J.L.H.
DUNCAN HOPPER & ASSOCIATES
CONSULTING ENGINEERS
1593 WILSON AVENUE,
DOWNSVIEW — ONTARIO
DRAWING No. 5638 - 2
DEPARTMENT OF HIGHWAYS:-ONTARIO-
BRIDGE OFFICE:-TORONTO
ELIZABETHTOWN TWP. BRIDGE NO. 13.
ORMOND STREET
THE KING'S HIGHWAY No. 401
DIV. No. 8
CO. LEEDS
TWP. ELIZABETHTOWN
LOT 10
CON. 1
PLAN, ELEVATION, & DECK SECTION.
APPROVED
BRIDGE ENGINEER
CHIEF ENGINEER
DESIGN J.L.H. CHECK
DRAWING J.L.H. CHECK
TRACING H. CHECK
DATE Nov. 20, 1956.
CONTRACT NUMBERS
GENERAL 57-165
LOADING H20S16
DRAWING NUMBER D 3774-1
REVISIONS
REFERENCE PLANS
TWP. # 25-123-1-A
16-123
B3774
56287
PRINT RECORD

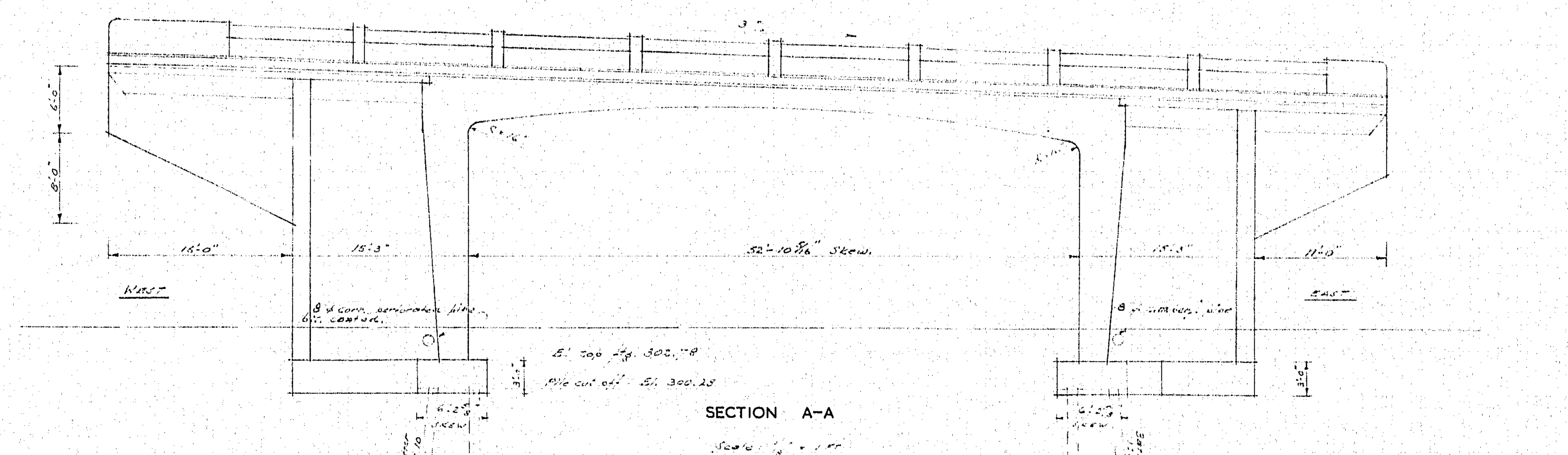




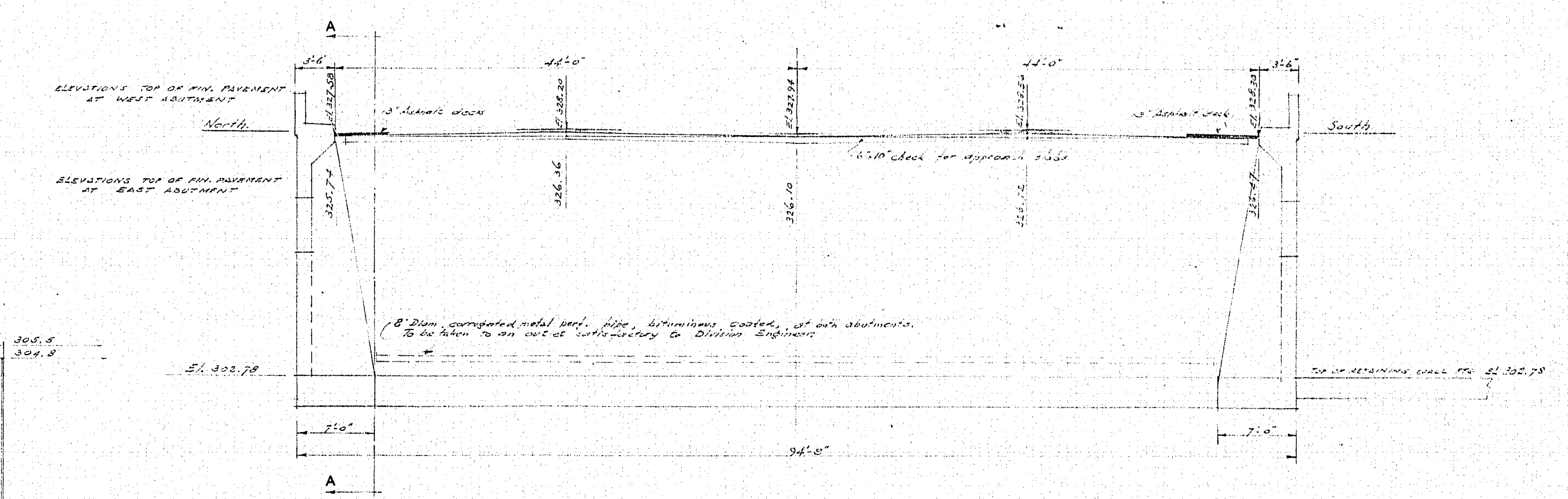
FOUNDATION & PILE PLAN

Scale: 1/8" = 1 FT.





SECTION A–A



REAR VIEW WEST ABUTMENT.

PRINT RECORD		
No.	FOR	DATE
36	TENDER	
13		

WP 590-56

DUNCAN HOPPER & ASSOCIATES
CONSULTING ENGINEERS
1593 WILSON AVENUE,
DOWNSVIEW — ONTARIO

Drawing No. 5638-3

DEPARTMENT OF HIGHWAYS:-ONTARIO-

BRIDGE OFFICE:-TORONTO

ELIZABETHTOWN TWP. BRIDGE NO. 13.

ORMOND STREET

THE KING'S HIGHWAY No. 401 DIV. No. 8
CO. LEEDS
TWP. ELIZABETHTOWN LOT 10 CON. 1

FOUNDATION & PILE PLAN – ELEVATION & SECTION

APPROVED

BRIDGE ENGINEER CHIEF ENGINEER

DESIGN		CHECK		CONTRACT NUMBERS			GENERAL 57-165
DRAWING		CHECK					
TRACING		CHECK		LOADING H20-S16	DRAWING NUMBER		
DATE Nov. 20 1956							

REVISIONS: | DATE | BY | DESCRIPTION | REFERENCE PLANS

TWP # 25-123-2-A

APPENDIX C

C.1 SYMBOLS AND TERMS USED ON BOREHOLE RECORDS

C.2 BOREHOLE RECORDS (CURRENT INVESTIGATION)

C.3 BEDROCK CORE PHOTOS

SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

Rootmat	- vegetation, roots and moss with organic matter and topsoil typically forming a mattress at the ground surface
Topsoil	- mixture of soil and humus capable of supporting vegetative growth
Peat	- mixture of visible and invisible fragments of decayed organic matter
Till	- unstratified glacial deposit which may range from clay to boulders
Fill	- material below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

Desiccated	- having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
Fissured	- having cracks, and hence a blocky structure
Varved	- composed of regular alternating layers of silt and clay
Stratified	- composed of alternating successions of different soil types, e.g. silt and sand
Layer	- > 75 mm in thickness
Seam	- 2 mm to 75 mm in thickness
Parting	- < 2 mm in thickness

Terminology describing soil types:
The classification of soil types are made on the basis of grain size and plasticity in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488) which excludes particles larger than 75 mm. For particles larger than 75 mm, and for defining percent clay fraction in hydrometer results, definitions proposed by Canadian Foundation Engineering Manual, 4th Edition are used. The USCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing cobbles, boulders, and non-matrix materials (organic matter or debris):
Terminology describing materials outside the USCS, (e.g. particles larger than 75 mm, visible organic matter, and construction debris) is based upon the proportion of these materials present:

Trace, or occasional	Less than 10%
Some	10-20%
Frequent	> 20%

Terminology describing compactness of cohesionless soils:
The standard terminology to describe cohesionless soils includes compactness (formerly "relative density"), as determined by the Standard Penetration Test (SPT) N-Value - also known as N-Index. The SPT N-Value is described further on page 3. A relationship between compactness condition and N-Value is shown in the following table.

Compactness Condition	SPT N-Value
Very Loose	<4
Loose	4-10
Compact	10-30
Dense	30-50
Very Dense	>50

Terminology describing consistency of cohesive soils:
The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests. Consistency may be crudely estimated from SPT N-Value based on the correlation shown in the following table (Terzaghi and Peck, 1967). The correlation to SPT N-Value is used with caution as it is only very approximate.

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

ROCK DESCRIPTION

Except where specified below, terminology for describing rock is as defined by the International Society for Rock Mechanics (ISRM) 2007 publication "The Complete ISRM Suggested Methods for Rock Characterization, Testing and Monitoring: 1974-2006"

Terminology describing rock quality:

RQD	Rock Mass Quality
0-25	*Very Poor Quality*
25-50	*Poor Quality*
50-75	*Fair Quality*
75-90	*Good Quality*
90-100	*Excellent Quality*

Alternate (Colloquial) Rock Mass Quality	
Very Severely Fractured	*Crushed*
Severely Fractured	*Shattered or Very Blocky*
Fractured	*Blocky*
Moderately Jointed	*Sound*
Intact	*Very Sound*

RQD (Rock Quality Designation) denotes the percentage of intact and sound rock retrieved from a borehole of any orientation. All pieces of intact and sound rock core equal to or greater than 100 mm (4 in.) long are summed and divided by the total length of the core run. RQD is determined in accordance with ASTM D6032.

SCR (Solid Core Recovery) denotes the percentage of solid core (cylindrical) retrieved from a borehole of any orientation. All pieces of solid (cylindrical) core are summed and divided by the total length of the core run (It excludes all portions of core pieces that are not fully cylindrical as well as crushed or rubble zones).

Fracture Index (FI) is defined as the number of naturally occurring fractures within a given length of core. The Fracture Index is reported as a simple count of natural occurring fractures.

Terminology describing rock with respect to discontinuity and bedding spacing:

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

Terminology describing rock strength:

Strength Classification	Grade	Unconfined Compressive Strength (MPa)
Extremely Weak	R0	<1
Very Weak	R1	1 – 5
Weak	R2	5 – 25
Medium Strong	R3	25 – 50
Strong	R4	50 – 100
Very Strong	R5	100 – 250
Extremely Strong	R6	>250

Terminology describing rock weathering:

Term	Symbol	Description
Fresh	W1	No visible signs of rock weathering. Slight discoloration along major discontinuities
Slightly	W2	Discoloration indicates weathering of rock on discontinuity surfaces. All the rock material may be discolored.
Moderately	W3	Less than half the rock is decomposed and/or disintegrated into soil.
Highly	W4	More than half the rock is decomposed and/or disintegrated into soil.
Completely	W5	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.
Residual Soil	W6	All the rock converted to soil. Structure and fabric destroyed.

STRATA PLOT

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.

Boulders Cobbles Gravel | Sand | Silt | Clay | Organics | Asphalt | Concrete | Fill | Igneous Bedrock | Meta-morphic Bedrock | Sedi-mentary Bedrock

SAMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)
ST	Shelby tube or thin wall tube
DP	Direct-Push sample (small diameter tube sampler hydraulically advanced)
PS	Piston sample
BS	Bulk sample
HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond coring bits.

WATER LEVEL MEASUREMENT

measured in standpipe, piezometer, or well

inferred

RECOVERY

For soil samples, the recovery is recorded as the length of the soil sample recovered. For rock core, recovery is defined as the total cumulative length of all core recovered in the core barrel divided by the length drilled and is recorded as a percentage on a per run basis.

N-VALUE

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (63.5 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (300 mm) into the soil. In accordance with ASTM D1586, the N-Value equals the sum of the number of blows (N) required to drive the sampler over the interval of 6 to 18 in. (150 to 450 mm). However, when a 24 in. (610 mm) sampler is used, the number of blows (N) required to drive the sampler over the interval of 12 to 24 in. (300 to 610 mm) may be reported if this value is lower. For split spoon samples where insufficient penetration was achieved and N-Values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75). Some design methods make use of N-values corrected for various factors such as overburden pressure, energy ratio, borehole diameter, etc. No corrections have been applied to the N-values presented on the log.

DYNAMIC CONE PENETRATION TEST (DCPT)

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to 'A' size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone one foot (300 mm) into the soil. The DCPT is used as a probe to assess soil variability.

OTHER TESTS

S	Sieve analysis
H	Hydrometer analysis
k	Laboratory permeability
γ	Unit weight
G_s	Specific gravity of soil particles
CD	Consolidated drained triaxial
CU	Consolidated undrained triaxial with pore pressure measurements
UU	Unconsolidated undrained triaxial
DS	Direct Shear
C	Consolidation
Q_u	Unconfined compression
I_p	Point Load Index (I_p on Borehole Record equals $I_p(50)$ in which the index is corrected to a reference diameter of 50 mm)

	Single packer permeability test; test interval from depth shown to bottom of borehole
	Double packer permeability test; test interval as indicated
	Falling head permeability test using casing
	Falling head permeability test using well point or piezometer

RECORD OF BOREHOLE No BC21-1

1 OF 1 **METRIC**

W.P. GWP 4003-19-00 LOCATION Highway 401 - Brockville N:4941097.5 E:368969.0 ORIGINATED BY KT

DIST East HWY HWY 401 BOREHOLE TYPE Hollow Stem Auger + NQ Rock Coring COMPILED BY KL

DATUM Geodetic DATE 2021.05.05 - 2021.05.05 LATITUDE 44.607024 LONGITUDE -75.691582 CHECKED BY KN

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
92.3											
92.2	100 mm TOPSOIL										
0.1	CLAYEY SILT (CL) to SILTY CLAY (Cl), some sand, trace gravel and organic matter, (FILL) Firm to very stiff Brown Moist		1	SS	8		92				
			2	SS	6			+ 2.8	○		Su > 118 kPa Vane Refusal
90.9							91				
1.4	SILTY CLAY (Cl) Very stiff Grey Moist Varved below 2 m		3	SS	14			+	○		Su > 118 kPa Vane Refusal
			3A	SH	-		90		⊢○⊣	18.1	0 1 44 55 Consolidation UCS= 143 kPa
89.2											
3.0	CLAYEY SILT (CL), some sand, trace gravel, (TILL) Contains cobbles and boulders Stiff Grey Wet Auger grinding below 3.8m Transitions to SILTY SAND (SM), some gravel, trace clay, (TILL) Very dense Grey Moist		4	SS	12		89		○		
			5	SS	95/ 280mm		88		○		
			6	SS	65/ 280mm				○		4 62 28 6 Non-Plastic
87.3											
5.0	DOLOSTONE Light grey to grey Fair quality Fresh to slightly weathered Very strong		7	NQ	-		87				UCS=113.9 MPa TCR = 100% RQD = 71%
			8	NQ	-		86				TCR = 98% RQD = 72%
	Excellent quality below 7.7 m		9	NQ	-		85				TCR = 100% RQD = 100%
83.9							84				
8.3	End of Borehole Water levels measured in monitoring well: At ground surface on May 5, 2021 At ground surface on May 11, 2021 1.09 m above ground on May 13, 2021 0.50 m above ground on June 9, 2021 0.05 m below ground on October 22, 2021										

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

RECORD OF BOREHOLE No BC21-2

1 OF 1

METRIC

W.P. GWP 4003-19-00 LOCATION Highway 401 - Brockville N:4941050.0 E:369020.3 ORIGINATED BY KT

DIST East HWY HWY 401 BOREHOLE TYPE Hollow Stem Auger + NQ Rock Coring COMPILED BY KL

DATUM Geodetic DATE 2021.05.05 - 2021.05.05 LATITUDE 44.606592 LONGITUDE -75.690941 CHECKED BY KN

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
92.2								
92.0 / 0.0	150 mm TOPSOIL		1A	SS				
0.2	SILTY CLAY (CL), trace sand and organic matter, (FILL) Stiff Brown Moist		1B	SS	6			
91.4								
0.8	SH2 contains 70 mm organic matter on top SILTY CLAY (CL), trace sand Brown Stiff to very stiff Moist		2	SH	-			0 2 58 40 Su > 118 kPa Vane Refusal
			3	SS	23			
	Contains clayey silt layers/varves below 2.5 m Trace gravel		4	SS	7			
			5	SS	13			
88.4								
3.7	Auger Refusal at 3.7 m DOLOSTONE Light grey to grey Fair to excellent quality Fresh to slightly weathered Very strong		6	NQ	-			TCR = 100% RQD = 96% UCS=137.8 MPa
			7	NQ	-			TCR = 96% RQD = 82%
			8	NQ	-			TCR = 100% RQD = 72%
85.3								
6.9	End of Borehole Groundwater not observed in borehole prior to initiation of bedrock coring.							

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

SHEAR STRENGTH kPa (20 40 60 80 100)
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × 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

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

RECORD OF BOREHOLE No OS21-1

1 OF 1 **METRIC**

W.P. GWP 4003-19-00 LOCATION Highway 401 - Brockville N: 4941090.4 E:369043.8 ORIGINATED BY KT

DIST East HWY HWY 401 BOREHOLE TYPE Hollow Stem Auger + NQ Rock Coring COMPILED BY KL

DATUM Geodetic DATE 2021.05.07 - 2021.05.07 LATITUDE 44.606953 LONGITUDE -75.690641 CHECKED BY KN

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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
93.3											
0.0 / 93.1	250 mm TOPSOIL: Sandy Silt, containing organic matter										
0.3	Dark brown Moist		1	SS	9		93				
	SILTY CLAY (CI) to CLAY (CH), trace sand Very stiff Grey-Brown Moist		2	SS	16		92				
			3	SS	16						0 8 46 46
			4	SS	12		91				
	Stiff to very stiff and grey below 3 m										
			5	SH	-		90			17.8	0 1 37 62 Consolidation Su > 118 kPa Vane Refusal
			6	SS	11						
			7	SS	7		89				
	Auger grinding at 5.2 m depth										
87.9	SS8 contains wood pieces		8	SS	50/25		88				
5.5	DOLOSTONE Light grey to grey Fair to excellent quality Slightly weathered to fresh Very strong Auger Refusal at 5.5 m		9	NQ	-						TCR = 100% RQD = 100% UCS=144.9 MPa
			10	NQ	-		87				TCR = 100% RQD = 67%
			11	NQ	-		86				TCR = 94% RQD = 85% UCS=124.5 MPa
84.9							85				
8.5	End of Borehole										
	Water levels in monitoring well: 0.45 m below ground on May 11, 2021 0.21 m above ground on May 13, 2021 0.23 m above ground on June 9, 2021 0.89 m below ground on October 22, 2021										

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

ONTARIO MTO 165001160_HWY 401_BROCKVILLE.GPJ ONTARIO MTO.GDT 12/1/21

RECORD OF BOREHOLE No OS21-2 1 OF 2 METRIC

W.P. GWP 4003-19-00 LOCATION Highway 401 - Brockville N:4941100.2 E:369004.1 ORIGINATED BY KT

DIST East HWY HWY 401 BOREHOLE TYPE Hollow Stem Auger (0 to 6m), NW casing below 6 m, NQ Rock Coring COMPILED BY KL

DATUM Geodetic DATE 2021.05.11 - 2021.05.11 LATITUDE 44.607044 LONGITUDE -75.691139 CHECKED BY KN

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 ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
100.4											
0.0	480 mm ASPHALT										
99.9			1	SS	49		100		○		
0.5	SAND and GRAVEL, trace silt (FILL) Dense Brown Moist										
99.6											
0.8	SAND, trace to some gravel, (FILL) Contains pockets/zones of sandy silt Very loose to compact Brown Moist		2	SS	16				○		13 65 19 3
			3	SS	4		99		○ ○		
			4	SS	2		98		○		2 93 4 1
	Rock in tip of the split spoon		5	SS	8		97		○		
96.6											
3.8	Cobbles and boulders in a matrix of SAND, trace gravel (ROCKFILL) Very loose to compact Brown Moist		6	SS	20						No Recovery
	Auger grinding noted below 4.5 m		7	SS	20		96		○		
			8	SS	2		95		○		
	NW casing advanced below 6 m										
	Pieces of rock retrieved during casing advancement		9	SS	50/ 125mm		94				No Recovery
											UCS= 116.3 MPa
											UCS= 176 MPa
			10	SS	50/ 25mm		93				No Recovery
92.0											
8.4	SILTY CLAY (CI) to CLAY (CH), trace sand Very stiff Grey Moist		11	SS	12		92		○		
	Contains stiff zones below 9 m		12	SS	11		91		○		

Continued Next Page

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

RECORD OF BOREHOLE No OS21-2

2 OF 2 **METRIC**

W.P. GWP 4003-19-00 LOCATION Highway 401 - Brockville N:4941100.2 E:369004.1 ORIGINATED BY KT

DIST East HWY HWY 401 BOREHOLE TYPE Hollow Stem Auger (0 to 6m), NW casing below 6 m, NQ Rock Coring COMPILED BY KL

DATUM Geodetic DATE 2021.05.11 - 2021.05.11 LATITUDE 44.607044 LONGITUDE -75.691139 CHECKED BY KN

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 ● QUICK TRIAXIAL + FIELD VANE × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILTY CLAY (CI) to CLAY (CH), trace sand Very stiff Grey Moist *(continued)*		13	SH	-		90			19.6	0 1 51 48 Consolidation UCS=140 kPa
			14	SS	6		89				
87.4							88				
13.0	SILT and SAND (CL-ML), some clay and gravel (TILL) Compact Grey Wet		15	SS	18		87				14 39 35 12
86.8											
13.6	Auger Refusal at 13.6 m DOLOSTONE Light grey Very poor quality Slightly weathered to fresh Strong to very strong		16	NQ	-		86				TCR = 100% RQD = 21%
	Good to excellent quality below 14.8 m		17	NQ	-		85				TCR = 96% RQD = 78% UCS=60.4 MPa UCS=159.8 MPa
83.5			18	NQ	-		84				TCR = 100% RQD = 100%
16.9	End of Borehole Groundwater not observed in borehole prior to initiation of casing advancement.										

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

Stantec	Project No.: 165001160 Project Name: Hwy 401-Ormond St. Overpass	Rock Core Photographs

Rock Core Photo No.: 1	Borehole: BC21-1	Depth: 5.0 m to 8.3 m

Rock Core Photo No.: 2	Borehole: BC21-2	Depth: 3.7 m to 6.9 m

Stantec	Project No.: 165001160 Project Name: Hwy 401-Ormond St. Overpass	Rock Core Photographs

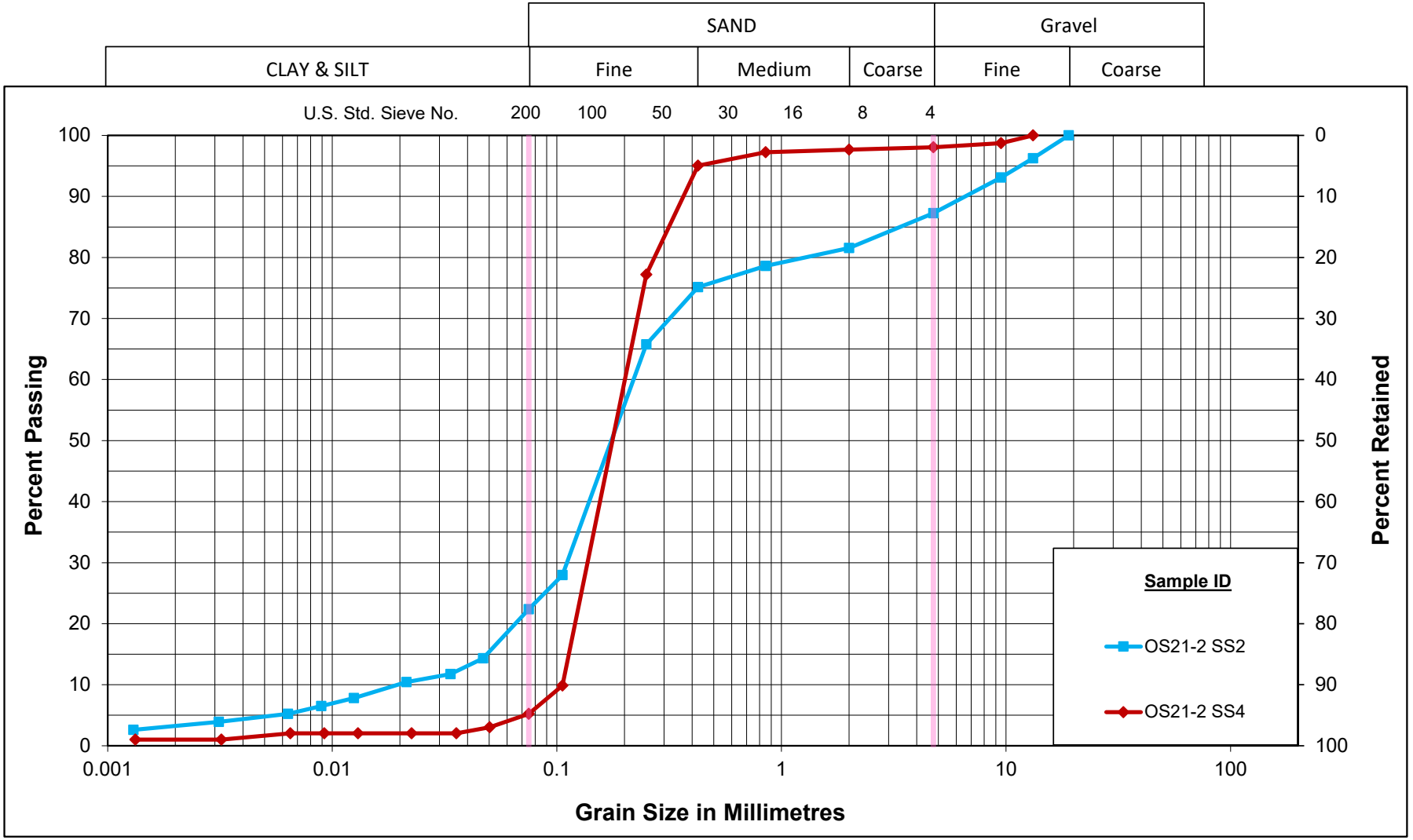
Rock Core Photo No.: 1	Borehole: OS21-1	Depth: 5.2 m to 8.5 m

Rock Core Photo No.: 2	Borehole: OS21-2	Depth: 13.6 m to 16.9 m

APPENDIX D

D.1 LABORATORY TEST RESULTS

Unified Soil Classification System



Stantec

GRAIN SIZE DISTRIBUTION

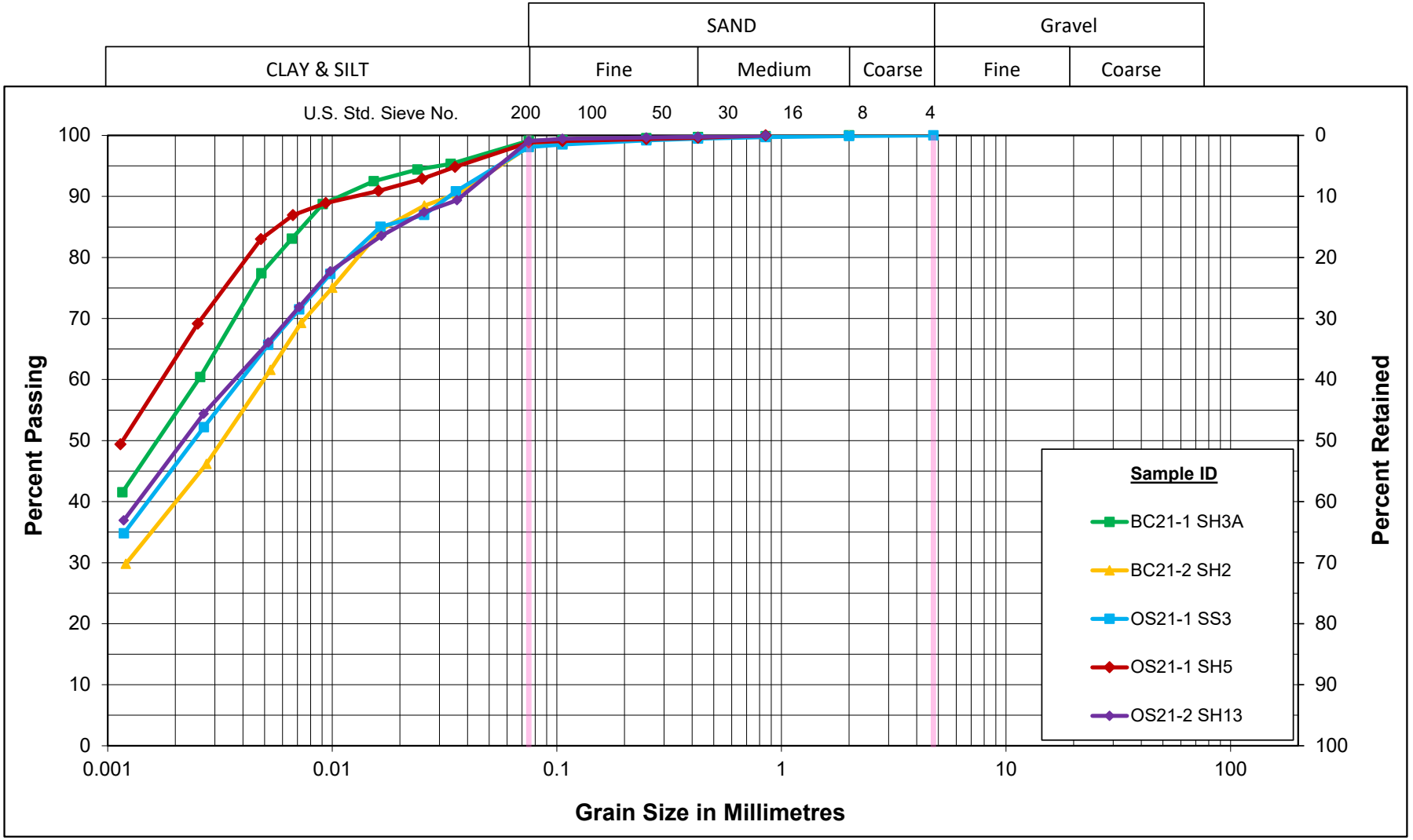
FILL: SAND to Silty SAND (SP to SM)

Hwy 401 Brockville - Ormond Street Overpass

Figure No. D1

Project No. 165001160

Unified Soil Classification System



Stantec

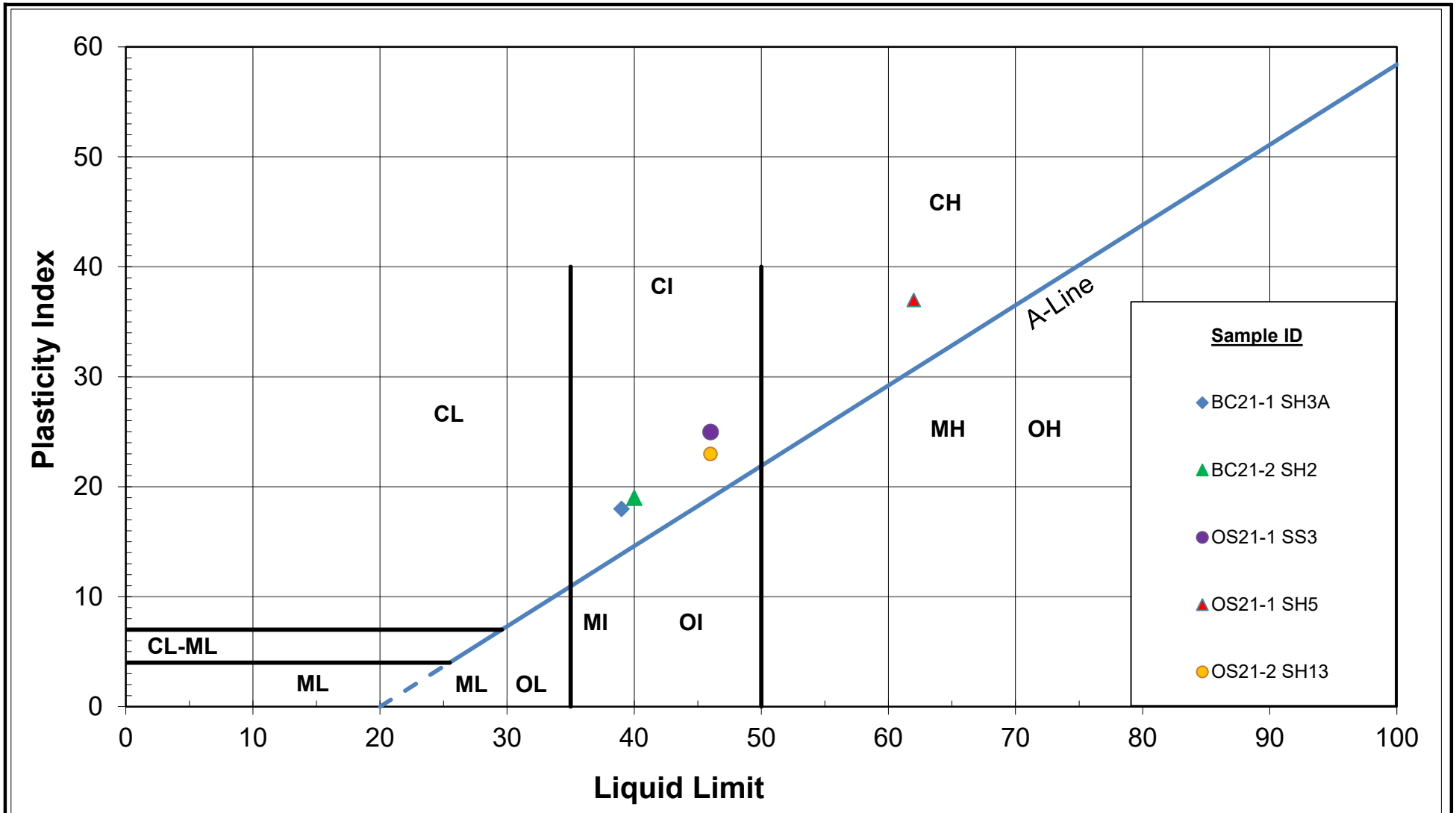
GRAIN SIZE DISTRIBUTION

SILTY CLAY (CI) to CLAY (CH)

Hwy 401 Brockville - Ormond Street Overpass

Figure No. D2

Project No. 165001160



Stantec

SILTY CLAY (CI) to CLAY (CH)

Hwy 401 Brockville - Ormond Street Overpass

PLASTICITY CHART

Figure No. D3

Project No. 165001160

Stantec

One-Dimensional Consolidation Properties of Soils Using Incremental Loading
ASTM D2435/D2435M - 11(2020)

Project	**Hwy 401 Brockville - Ormond Street Overpass**
Project No.	**165001160(309)**
Borehole No.	**BC 21-1**
Sample No.	**SH-3A**
Sample Depth	**2.13 - 2.74 m.**

Figure No. D4

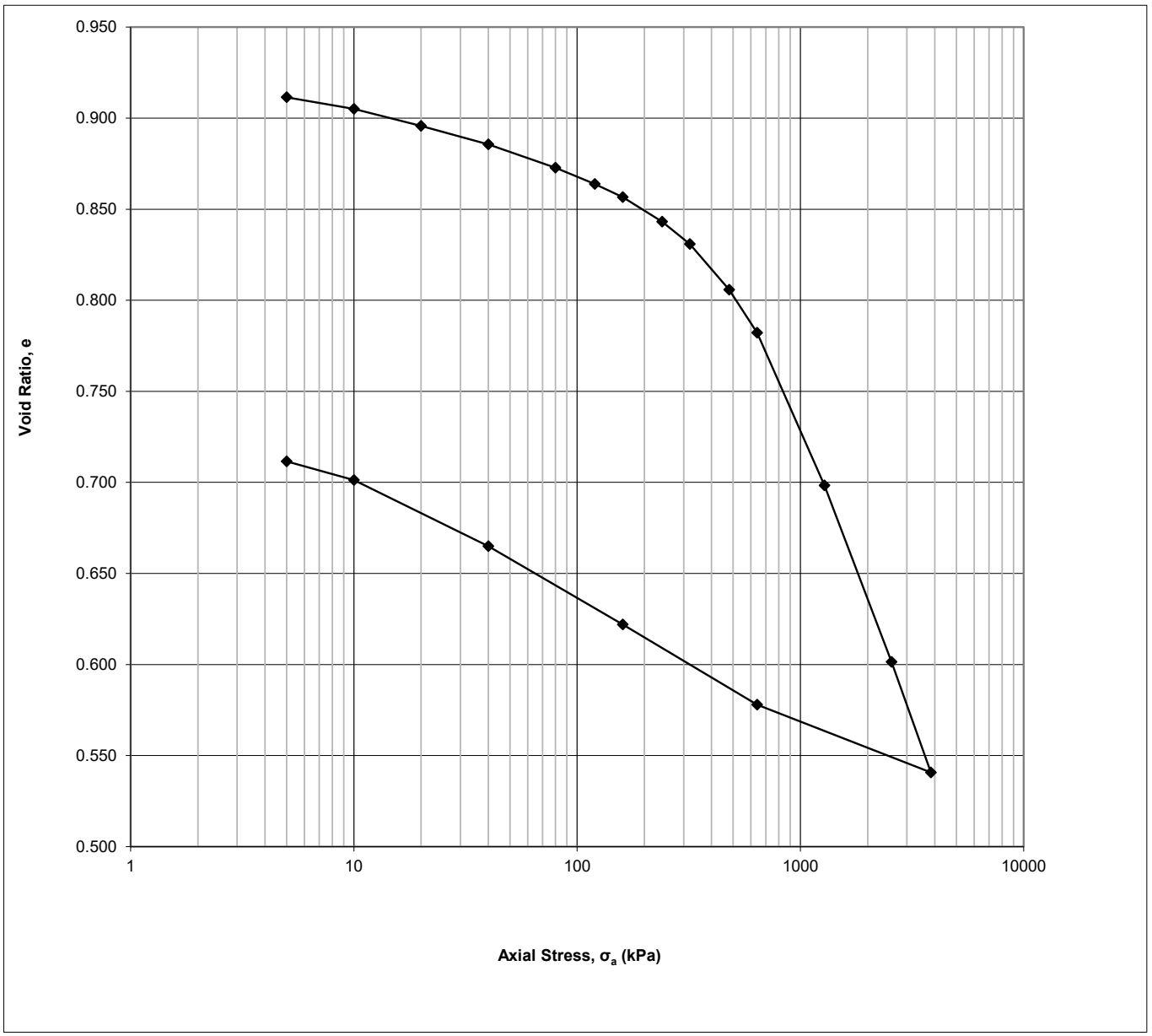


Figure D4A

Date: January 14, 2022
Date: January 14, 2022
D. Boateng
R. Dey
Checked by:
Approved by:

Stantec

Stantec Consulting Ltd.

One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11(2020)

Specimen Details

Project Name	Hwy 401 Brockville - Ormond Street Overpass
Project Location	Brockville, Ontario
Borehole	BC 21-1
Sample No.	SH-3A
Depth	2.13 - 2.74 m.
Sample Date	May 5, 2021
Test Number	One
Technician Name	Daniel Boateng

Soil Description & Classification

Silty clay, firm to stiff, dark grey, varved/desiccated, moist		
Specific Gravity of Solids		2.728
Average water content of trimmings	%	32.93
Additional Notes (information source, occurence and size of large isolated particles etc.)		

Initial Specimen Conditions

Height	mm	20.00
Diameter	mm	50.00
Area	mm^2	1963
Volume	mm^3	39270
Mass	g	72.67
Dry Mass	g	54.67
Density	Mg/m^3	1.851
Dry Density	Mg/m^3	1.392
Water Content	%	32.92
Degree of Saturation	%	93.6
Height of Solids	mm	10.21
Initial Void Ratio		0.960

Final Specimen Conditions

Water Content	%	29.49
Final Void Ratio		0.712
Final Height	mm	17.47

Figure D4B

Stantec

Stantec Consulting Ltd.

Filename: V:\01216\active\other_pc_projects\165001160\05_report_deliv\deliverables\report\Orr
Date: January 14, 2022
Checked by: D. Boateng
Approved by: R. Dey
Date: January 14, 2022
Date: January 14, 2022

One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11(2020)

Specimen Details

Project Name	Hwy 401 Brockville - Ormond Street Overpass
Project Location	Brockville, Ontario
Borehole	BC 21-1
Sample No.	SH-3A
Depth	2.13 - 2.74 m.
Sample Date	May 5, 2021
Test Number	One
Technician Name	Daniel Boateng

Test Procedure

Date Started		June 8, 2021
Date Finished		June 9, 2021
Machine Number		Frame C
Cell Number		C
Ring Number		C
Trimming Procedure		Trimming turntable/cutting ring
Moisture Condition		Inundated
Axial Stress at Inundation	kPa	5
Water Used		De-aired tap water
Test Method		B
Interpretation Procedure for c_v		2

All Departures from Outlined ASTM D2435/D2435M-11 (2020) Procedure

Calculations

Load Increment	Increment Duration min	Axial Stress σ_a kPa	Corrected Deformation ΔH mm	Specimen Height H mm	Axial Strain ε_a %	Void Ratio e
Seating	0.0	0	0.0000	20.0000	0.00	0.960
1	20.0	5	0.4860	19.5140	2.46	0.911
2	20.0	10	0.5528	19.4472	2.78	0.905
3	20.0	20	0.6485	19.3515	3.26	0.896
4	20.0	40	0.7489	19.2511	3.77	0.886
5	21.5	80	0.8796	19.1204	4.43	0.873
6	24.8	120	0.9698	19.0302	4.89	0.864
7	24.8	160	1.0429	18.9571	5.26	0.857
8	28.3	240	1.1776	18.8224	5.94	0.843
9	34.8	320	1.2903	18.7097	6.57	0.831
10	43.3	480	1.5384	18.4616	7.84	0.806
11	56.5	640	1.7601	18.2399	9.06	0.782
12	83.3	1280	2.5136	17.4864	13.33	0.698
13	91.3	2560	3.4279	16.5721	18.27	0.601
14	96.5	3840	4.0705	15.9295	21.37	0.541
15	28.3	640	3.8786	16.1214	19.47	0.578
16	48.0	160	3.4346	16.5654	17.22	0.622
17	73.0	40	3.0135	16.9865	15.03	0.665
18	109.5	10	2.6413	17.3587	13.18	0.701
19	54.8	5	2.6093	17.3907	12.66	0.712

Figure D4C

Stantec

Stantec Consulting Ltd.

Filename: V:\01216\active\other_pc_projects\165001160\05_report_deliv\deliverables\repc Date: January 14, 2022
Checked by: D. Boateng Date: January 14, 2022
Approved by: R. Dey Date: January 14, 2022

One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11(2020)

Specimen Details

Job Ref.	Hwy 401 Brockville - Ormond Street Overpass
Job Location	Brockville, Ontario
Borehole	BC 21-1
Sample No.	SH-3A
Depth	2.13 - 2.74 m.
Sample Date	May 5, 2021
Test Number	One
Technician Name	Daniel Boateng

Calculations

		Calculated using Interpretation Procedure 2				Interpretation Procedure 1		Interpretation Procedure 2	
Load Increment	Axial Stress $\sigma_{a,\ average}$ kPa	Corrected Deformation ΔH_{50} mm	Specimen Height H_{50} mm	Axial Strain $\varepsilon_{a,50}$ %	Void Ratio e_{50}	Time t_{50} sec	Coeff. Consol. c_v mm^2/s	Time t_{90} sec	Coeff. Consol. c_v mm^2/s
Seating	0								
1	3	0.4653	19.5347	2.33	0.914			110	7.36E-01
2	8	0.5437	19.4563	2.72	0.906			238	3.37E-01
3	15	0.6355	19.3645	3.18	0.897			311	2.56E-01
4	30	0.7326	19.2674	3.66	0.888			248	3.17E-01
5	60	0.8622	19.1378	4.31	0.875			327	2.37E-01
6	100	0.9529	19.0471	4.76	0.866			389	1.98E-01
7	140	1.0253	18.9747	5.13	0.859			388	1.97E-01
8	200	1.1521	18.8479	5.76	0.847			416	1.81E-01
9	280	1.2636	18.7364	6.32	0.836			327	2.28E-01
10	400	1.4866	18.5134	7.43	0.814			462	1.57E-01
11	560	1.7000	18.3000	8.50	0.793			457	1.55E-01
12	960	2.3493	17.6507	11.75	0.729			152	4.34E-01
13	1920	3.1301	16.8699	15.65	0.653			124	4.85E-01
14	3200	3.8877	16.1123	19.44	0.579			172	3.20E-01
15	2240	4.0156	15.9844	20.08	0.566				
16	400	3.6349	16.3651	18.17	0.603				
17	100	3.2230	16.7770	16.11	0.644				
18	25	2.8217	17.1783	14.11	0.683				
19	8	2.6228	17.3772	13.11	0.703				

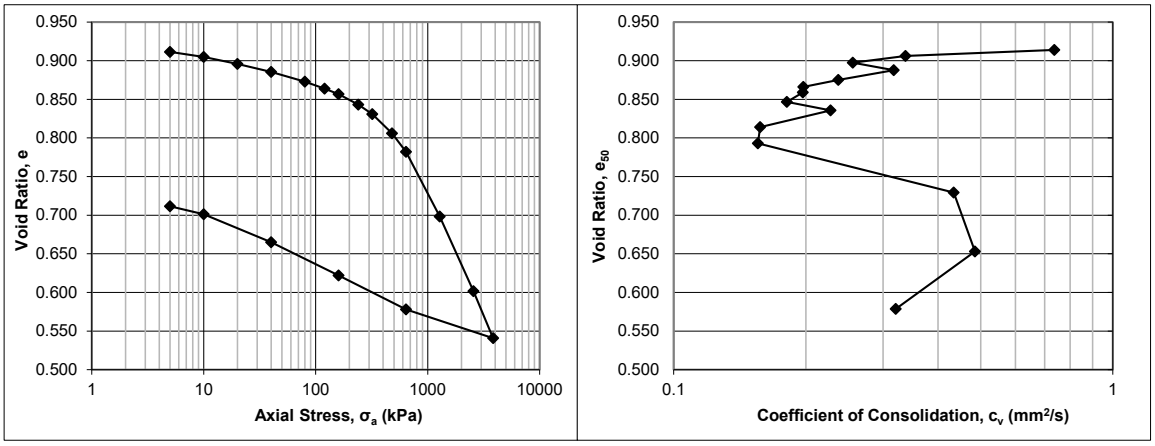


Figure D4D

Stantec

One-Dimensional Consolidation Properties of Soils Using Incremental Loading
ASTM D2435/D2435M - 11(2020)

Project	**Hwy 401 Brockville - Ormond Street Overpass**
Project No.	**165001160(309)**
Borehole No.	**OS 21-1**
Sample No.	**SH-5**
Sample Depth	**3.05 - 3.66 m.**

Figure No. D5

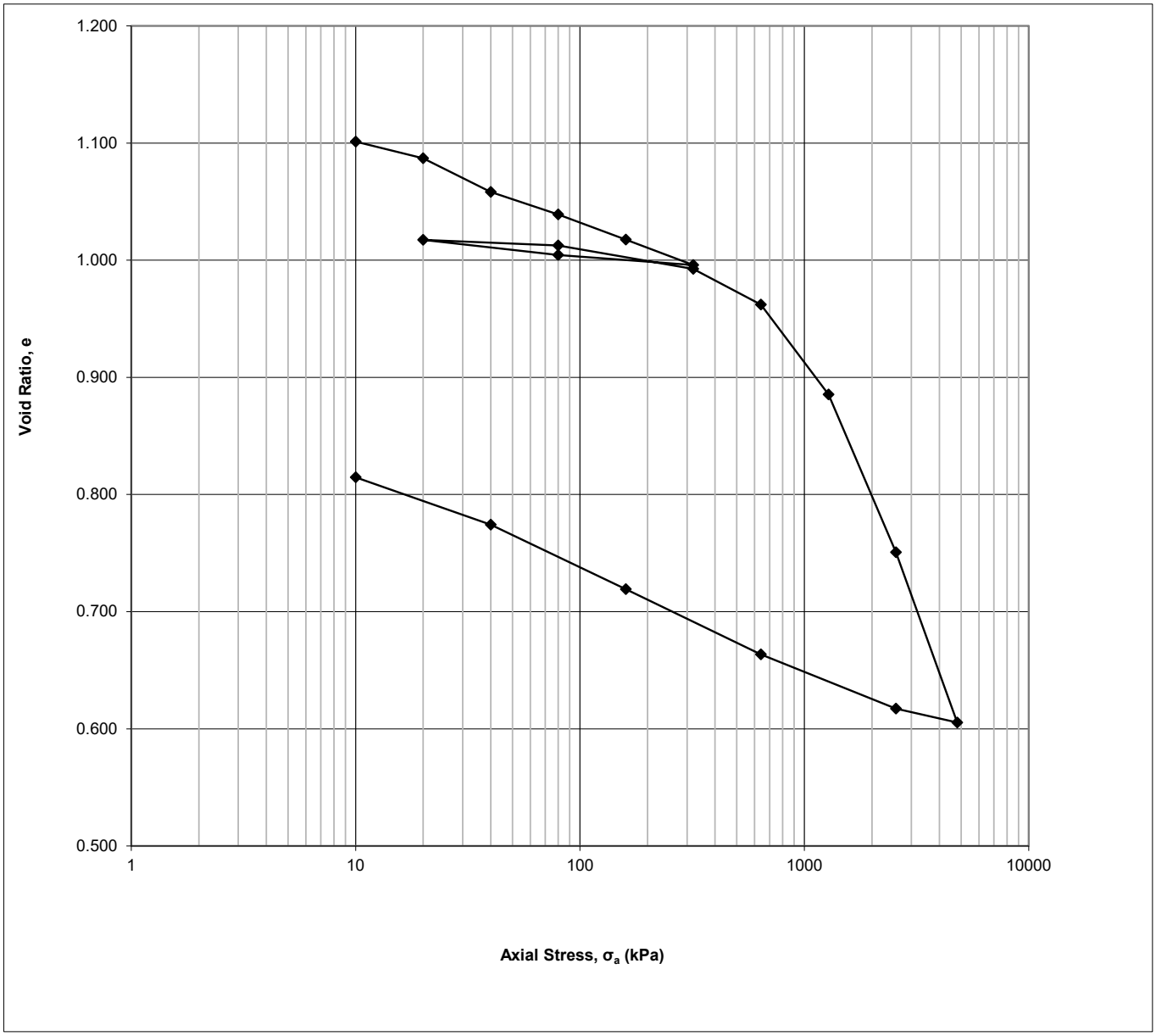


Figure D5A

Stantec

Stantec Consulting Ltd.

Date: January 14, 2022 Date: January 14, 2022

D. Boateng R. Dey

Checked by: Approved by:

One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11(2020)

Specimen Details

Project Name	Hwy 401 Brockville - Ormond Street Overpass
Project Location	Brockville, Ontario
Borehole	OS 21-1
Sample No.	SH-5
Depth	3.05 - 3.66 m.
Sample Date	May 7, 2021
Test Number	Four
Technician Name	Daniel Boateng

Soil Description & Classification

Silty clay, very stiff to hard, brown, friable, moist		
Specific Gravity of Solids		2.760
Average water content of trimmings	%	39.61
Additional Notes (information source, occurence and size of large isolated particles etc.)		
Test sample taken from lower half of tube		

Initial Specimen Conditions

Height	mm	20.00
Diameter	mm	50.00
Area	mm^2	1963
Volume	mm^3	39270
Mass	g	71.14
Dry Mass	g	50.96
Density	Mg/m^3	1.812
Dry Density	Mg/m^3	1.298
Water Content	%	39.60
Degree of Saturation	%	97.0
Height of Solids	mm	9.40
Initial Void Ratio		1.127

Final Specimen Conditions

Water Content	%	33.95
Final Void Ratio		0.815
Final Height	mm	17.06

Figure D5B

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Date: January 14, 2022
Checked by: D. Boateng
Approved by: R. Dey
Date: January 14, 2022
Date: January 14, 2022

One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11(2020)

Specimen Details

Project Name	Hwy 401 Brockville - Ormond Street Overpass
Project Location	Brockville, Ontario
Borehole	OS 21-1
Sample No.	SH-5
Depth	3.05 - 3.66 m.
Sample Date	May 7, 2021
Test Number	Four
Technician Name	Daniel Boateng

Test Procedure

Date Started		June 9, 2021
Date Finished		June 10, 2021
Machine Number		Frame C
Cell Number		C
Ring Number		C
Trimming Procedure		Trimming turntable/cutting ring
Moisture Condition		Inundated
Axial Stress at Inundation	kPa	10
Water Used		De-aired tap water
Test Method		B
Interpretation Procedure for c_v		2

All Departures from Outlined ASTM D2435/D2435M-11 (2020) Procedure

Calculations

Load Increment	Increment Duration (min)	Axial Stress σ_a (kPa)	Corrected Deformation ΔH (mm)	Specimen Height H (mm)	Axial Strain ε_a (%)	Void Ratio e
Seating	0.0	0	0.0000	20.0000	0.00	1.127
1	20.0	10	0.2416	19.7584	1.21	1.101
2	20.0	20	0.3717	19.6283	1.87	1.087
3	20.0	40	0.6364	19.3636	3.23	1.058
4	20.0	80	0.8151	19.1849	4.13	1.039
5	20.0	160	1.0156	18.9844	5.14	1.018
6	28.3	320	1.2123	18.7877	6.16	0.996
7	20.0	80	1.1503	18.8497	5.76	1.004
8	21.5	20	1.0311	18.9689	5.15	1.017
9	20.0	80	1.0719	18.9281	5.37	1.013
10	21.5	320	1.2562	18.7438	6.32	0.993
11	43.3	640	1.4968	18.5032	7.75	0.962
12	93.3	1280	2.0628	17.9372	11.36	0.885
13	135.3	2560	3.1831	16.8169	17.69	0.751
14	130.8	4800	4.6088	15.3912	24.52	0.605
15	21.8	2560	4.7897	15.2103	23.96	0.617
16	43.5	640	4.3470	15.6530	21.79	0.663
17	82.3	160	3.8352	16.1648	19.17	0.719
18	128.0	40	3.3215	16.6785	16.58	0.774
19	157.0	10	3.2935	16.7065	14.68	0.815

Figure D5C

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Checked by: D. Boateng Date: January 14, 2022
Approved by: R. Dey Date: January 14, 2022

One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11(2020)

Specimen Details

Job Ref.	Hwy 401 Brockville - Ormond Street Overpass
Job Location	Brockville, Ontario
Borehole	OS 21-1
Sample No.	SH-5
Depth	3.05 - 3.66 m.
Sample Date	May 7, 2021
Test Number	Four
Technician Name	Daniel Boateng

Calculations

		Calculated using Interpretation Procedure 2				Interpretation Procedure 1		Interpretation Procedure 2	
Load Increment	Axial Stress $\sigma_{a,\ average}$ kPa	Corrected Deformation ΔH_{50} mm	Specimen Height H_{50} mm	Axial Strain $\varepsilon_{a,50}$ %	Void Ratio e_{50}	Time t_{50} sec	Coeff. Consol. c_v mm^2/s	Time t_{90} sec	Coeff. Consol. c_v mm^2/s
Seating	0								
1	5	0.2357	19.7643	1.18	1.102			169	4.90E-01
2	15	0.3532	19.6468	1.77	1.089			136	6.00E-01
3	30	0.5994	19.4006	3.00	1.063			127	6.27E-01
4	60	0.8017	19.1983	4.01	1.042			116	6.74E-01
5	120	0.9967	19.0033	4.98	1.021			128	5.96E-01
6	240	1.1845	18.8155	5.92	1.001			160	4.68E-01
7	200	1.1661	18.8339	5.83	1.003				
8	50	1.0567	18.9433	5.28	1.014				
9	50	1.0666	18.9334	5.33	1.013			127	5.96E-01
10	200	1.2440	18.7560	6.22	0.995			247	3.02E-01
11	480	1.4419	18.5581	7.21	0.974			169	4.31E-01
12	960	1.8881	18.1119	9.44	0.926			147	4.74E-01
13	1920	2.7718	17.2282	13.86	0.832			256	2.46E-01
14	3680	4.0806	15.9194	20.40	0.693			419	1.28E-01
15	3680	4.8211	15.1789	24.11	0.614				
16	1600	4.5249	15.4751	22.62	0.646				
17	400	4.0890	15.9110	20.44	0.692				
18	100	3.5768	16.4232	17.88	0.746				
19	25	3.3000	16.7000	16.50	0.776				

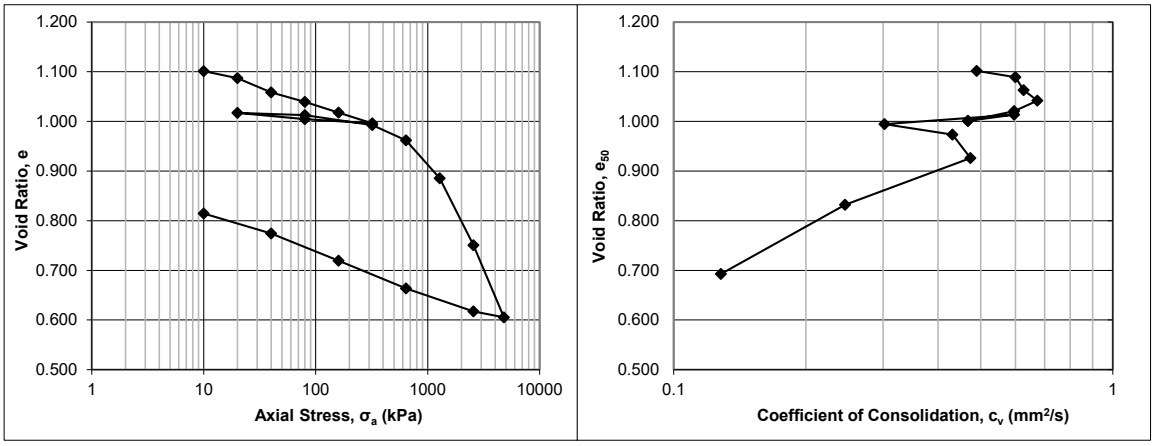

Figure D5D

Stantec

One-Dimensional Consolidation Properties of Soils Using Incremental Loading
ASTM D2435/D2435M - 11(2020)

Project	**Hwy 401 Brockville - Ormond Street Overpass**
Project No.	**165001160(309)**
Borehole No.	**OS 21-2**
Sample No.	**SH-13**
Sample Depth	**9.91 - 10.52 m.**

Figure No. D6

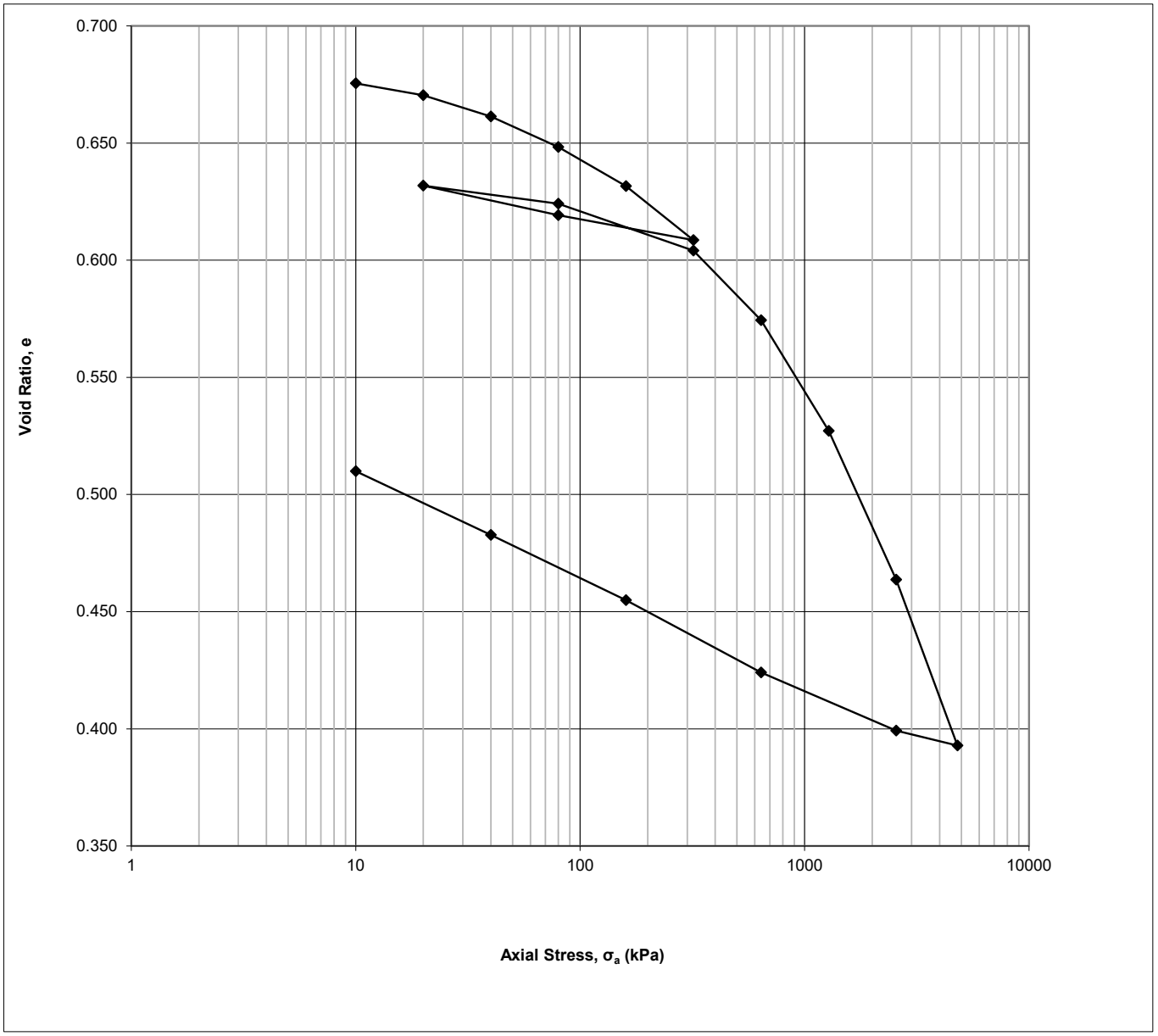

Figure D6A

Stantec

Stantec Consulting Ltd.

One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11(2020)

Date: January 14, 2022 — Date: January 14, 2022
D. Boateng — R. Dey
Checked by: — Approved by:

Specimen Details

Project Name	Hwy 401 Brockville - Ormond Street Overpass
Project Location	Brockville, Ontario
Borehole	OS 21-2
Sample No.	SH-13
Depth	9.91 - 10.52 m.
Sample Date	May 11, 2021
Test Number	Five
Technician Name	Daniel Boateng

Soil Description & Classification

Silty clay, very stiff to hard, brown, friable, moist		
Specific Gravity of Solids		2.760
Average water content of trimmings	%	22.87
Additional Notes (information source, occurence and size of large isolated particles etc.)		

Initial Specimen Conditions

Height	mm	20.00
Diameter	mm	50.00
Area	mm^2	1963
Volume	mm^3	39270
Mass	g	78.44
Dry Mass	g	63.84
Density	Mg/m^3	1.997
Dry Density	Mg/m^3	1.626
Water Content	%	22.87
Degree of Saturation	%	90.5
Height of Solids	mm	11.78
Initial Void Ratio		0.698

Final Specimen Conditions

Water Content	%	21.22
Final Void Ratio		0.510
Final Height	mm	17.79

Figure D6B

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Date: January 14, 2022
Checked by: D. Boateng
Approved by: R. Dey
Date: January 14, 2022
Date: January 14, 2022

One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11(2020)

Specimen Details

Project Name	Hwy 401 Brockville - Ormond Street Overpass
Project Location	Brockville, Ontario
Borehole	OS 21-2
Sample No.	SH-13
Depth	9.91 - 10.52 m.
Sample Date	May 11, 2021
Test Number	Five
Technician Name	Daniel Boateng

Test Procedure

Date Started		June 9, 2021
Date Finished		June 10, 2021
Machine Number		Frame D
Cell Number		D
Ring Number		D
Trimming Procedure		Trimming turntable/cutting ring
Moisture Condition		Inundated
Axial Stress at Inundation	kPa	10
Water Used		De-aired tap water
Test Method		B
Interpretation Procedure for c_v		2

All Departures from Outlined ASTM D2435/D2435M-11 (2020) Procedure

Calculations

Load Increment	Increment Duration (min)	Axial Stress σ_a (kPa)	Corrected Deformation ΔH (mm)	Specimen Height H (mm)	Axial Strain ε_a (%)	Void Ratio e
Seating	0.0	0	0.0000	20.0000	0.00	0.698
1	20.0	10	0.2641	19.7359	1.31	0.675
2	20.0	20	0.3135	19.6865	1.61	0.670
3	23.0	40	0.4166	19.5834	2.15	0.661
4	24.8	80	0.5655	19.4345	2.91	0.648
5	26.5	160	0.7600	19.2400	3.89	0.632
6	33.0	320	1.0226	18.9774	5.26	0.609
7	20.0	80	0.9256	19.0744	4.63	0.619
8	24.8	20	0.7771	19.2229	3.89	0.632
9	20.0	80	0.8656	19.1344	4.34	0.624
10	24.8	320	1.0925	18.9075	5.52	0.604
11	39.8	640	1.4113	18.5887	7.27	0.574
12	54.8	1280	1.9277	18.0723	10.05	0.527
13	68.3	2560	2.6245	17.3755	13.79	0.464
14	70.0	4800	3.4502	16.5498	17.96	0.393
15	20.0	2560	3.5171	16.4829	17.59	0.399
16	25.0	640	3.2203	16.7797	16.12	0.424
17	43.3	160	2.8571	17.1429	14.31	0.455
18	61.8	40	2.5406	17.4594	12.66	0.483
19	102.0	10	2.2076	17.7924	11.06	0.510

Figure D6C

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Checked by: D. Boateng Date: January 14, 2022
Approved by: R. Dey Date: January 14, 2022

One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11(2020)

Specimen Details

Job Ref.	Hwy 401 Brockville - Ormond Street Overpass
Job Location	Brockville, Ontario
Borehole	OS 21-2
Sample No.	SH-13
Depth	9.91 - 10.52 m.
Sample Date	May 11, 2021
Test Number	Five
Technician Name	Daniel Boateng

Calculations

		Calculated using Interpretation Procedure 2				Interpretation Procedure 1		Interpretation Procedure 2	
Load Increment	Axial Stress $\sigma_{a,\ average}$ kPa	Corrected Deformation ΔH_{50} mm	Specimen Height H_{50} mm	Axial Strain $\varepsilon_{a,50}$ %	Void Ratio e_{50}	Time t_{50} sec	Coeff. Consol. c_v mm^2/s	Time t_{90} sec	Coeff. Consol. c_v mm^2/s
Seating	0								
1	5	0.2507	19.7493	1.25	0.676			250	3.31E-01
2	15	0.3031	19.6969	1.52	0.672			121	6.81E-01
3	30	0.3983	19.6017	1.99	0.664			138	5.90E-01
4	60	0.5426	19.4574	2.71	0.652			121	6.62E-01
5	120	0.7343	19.2657	3.67	0.635			171	4.59E-01
6	240	0.9892	19.0108	4.95	0.614			202	3.79E-01
7	200	0.9435	19.0565	4.72	0.618				
8	50	0.8176	19.1824	4.09	0.628				
9	50	0.8567	19.1433	4.28	0.625			253	3.08E-01
10	200	1.0760	18.9240	5.38	0.606			270	2.81E-01
11	480	1.3614	18.6386	6.81	0.582			190	3.87E-01
12	960	1.8472	18.1528	9.24	0.541			185	3.77E-01
13	1920	2.4695	17.5305	12.35	0.488			109	5.96E-01
14	3680	3.2457	16.7543	16.23	0.422			138	4.32E-01
15	3680	3.5246	16.4754	17.62	0.399				
16	1600	3.2832	16.7168	16.42	0.419				
17	400	2.9863	17.0137	14.93	0.444				
18	100	2.6882	17.3118	13.44	0.470				
19	25	2.3677	17.6323	11.84	0.497				

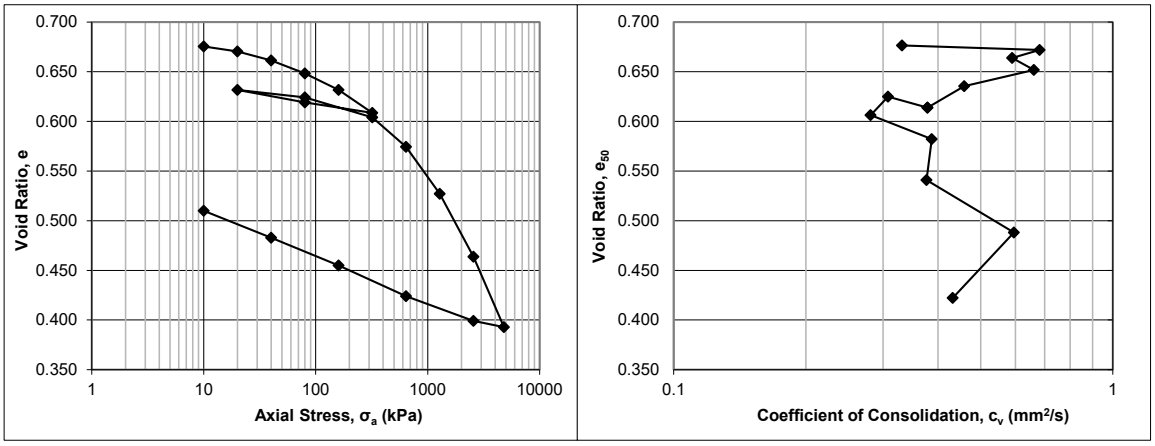
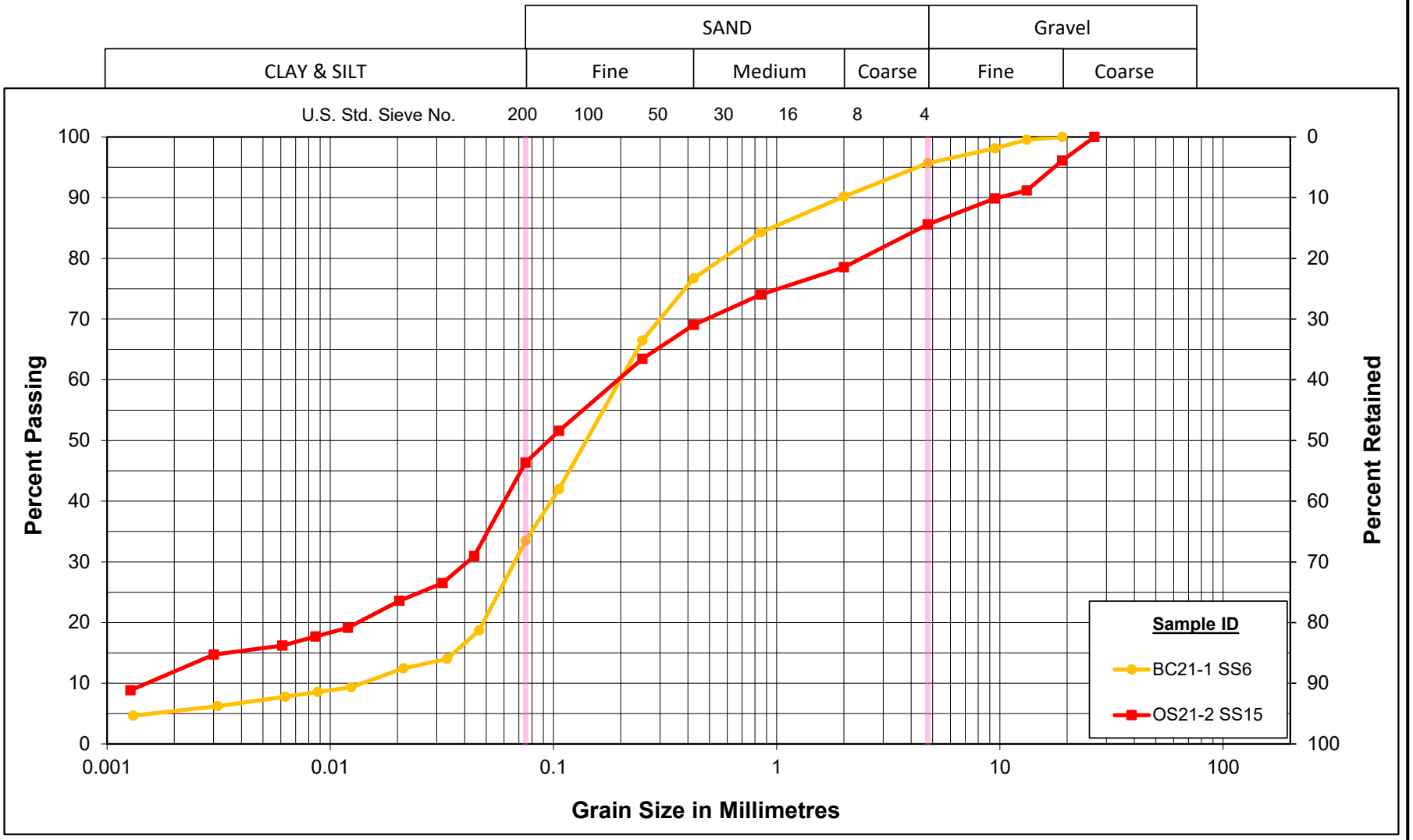


Figure D6D

Unified Soil Classification System



Stantec

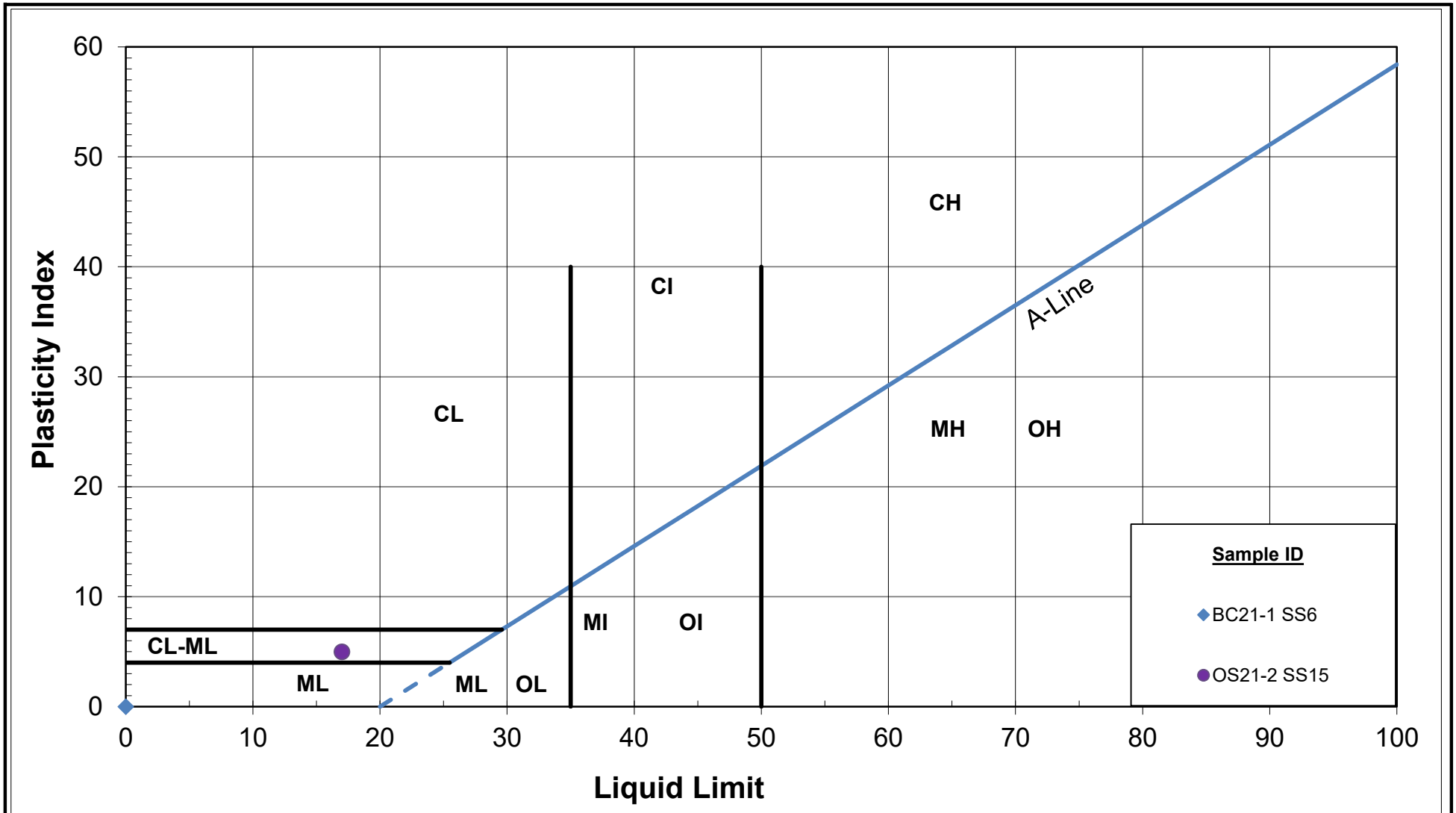
GRAIN SIZE DISTRIBUTION

SILTY SAND to SILT and SAND (TILL) (SM to CL-ML)

Hwy 401 Brockville - Ormond Street Overpass

Figure No. D7

Project No. 165001160



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SILTY SAND (SM) tp SILT and SAND (CL-ML) (TILL)

Hwy 401 Brockville - Ormond Street Overpass

PLASTICITY CHART

Figure No. D8

Project No. 165001160

Certificate of Analysis

Report Date: 16-Jun-2021

Client: Stantec Consulting Ltd. (Ottawa)

Order Date: 11-Jun-2021

Client PO: Hwy 401 Brockville EA

Project Description: 165001160.309

	Client ID:	CP21-1, SS14.10.668-11.278m	BC21-1,SS3.1.524-2.134m	BC21-2,SS3.1.524-2.134m	NA21-1,SS3.1.524-2.134m
	Sample Date:	10-May-21 09:00	05-May-21 09:00	05-May-21 09:00	03-May-21 09:00
	Sample ID:	2124634-01	2124634-02	2124634-03	2124634-04
	MDL/Units	Soil	Soil	Soil	Soil
Physical Characteristics					
% Solids	0.1 % by Wt.	90.5	78.7	77.4	82.1
General Inorganics					
pH	0.05 pH Units	7.90 [1]	7.48 [1]	7.81 [1]	7.45 [1]
Resistivity	0.10 Ohm.m	32.8	16.3	15.1	39.8
Anions					
Chloride	5 ug/g dry	36 [1]	244 [1]	264 [1]	27 [1]
Sulphate	5 ug/g dry	177 [1]	72 [1]	49 [1]	26 [1]

	Client ID:	NA21-2,SS15.12.192-12.802m	OS21-1,SS2.0.254-0.609m	OS21-2, SS3B.1.829-2.134m	SB21-2,SS3.1.524-2.134m
	Sample Date:	06-May-21 09:00	07-May-21 09:00	11-May-21 09:00	04-May-21 09:00
	Sample ID:	2124634-05	2124634-06	2124634-07	2124634-08
	MDL/Units	Soil	Soil	Soil	Soil
Physical Characteristics					
% Solids	0.1 % by Wt.	87.0	80.0	99.5	99.5
General Inorganics					
pH	0.05 pH Units	7.94 [1]	7.62 [1]	7.91 [1]	7.58 [1]
Resistivity	0.10 Ohm.m	12.6	44.3	30.2	80.0
Anions					
Chloride	5 ug/g dry	388 [1]	22 [1]	118 [1]	13 [1]
Sulphate	5 ug/g dry	86 [1]	8 [1]	16 [1]	6 [1]

	Client ID:	SB21-2,SS5.3.048-3.353m	CP21-2,SS5.3.048-3.658m	-	-
	Sample Date:	04-May-21 09:00	12-May-21 09:00	-	-
	Sample ID:	2124634-09	2124634-10	-	-
	MDL/Units	Soil	Soil	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	100	99.2	-	-
General Inorganics					
pH	0.05 pH Units	7.89 [1]	7.81 [1]	-	-
Resistivity	0.10 Ohm.m	102	16.2	-	-
Anions					
Chloride	5 ug/g dry	11 [1]	212 [1]	-	-
Sulphate	5 ug/g dry	10 [1]	51 [1]	-	-