FINAL REPORT

Foundation Investigation and Design
Highway 417 Overpass Structures at Bronson Avenue
Rapid Bridge Replacement
Sites: 3-60/1 & 3-60/2
Ottawa, Ontario

G.W.P. 4173-15-00
W.P. 4073-13-01 & 4074-13-01

Submitted to:

WSP Canada Group Limited
2611 Queensview Drive, Suite 300
Ottawa, Ontario
K2B 8K2

Submitted by:

Golder Associates Ltd.
1931 Robertson Road, Ottawa, Ontario, K2H 5B7, Canada

GEOCRES No.: 31G5-306

Latitude: 45.404900
Longitude: -75.701935

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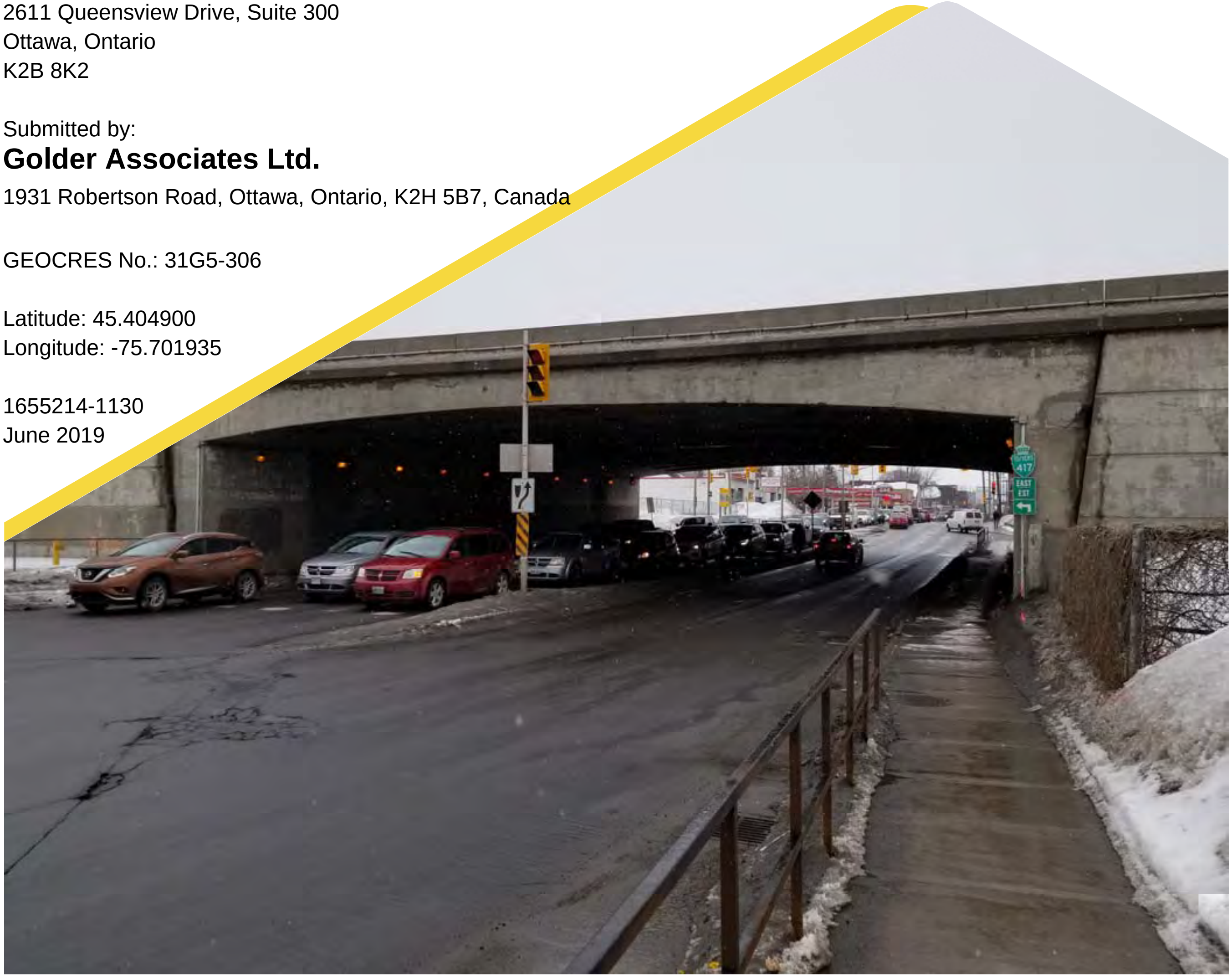

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PART A

Foundation Investigation
Highway 417 Overpass Structures at Bronson Avenue
Rapid Bridge Replacement
Sites: 3-60/1 & 3-60/2
Ottawa, Ontario

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by WSP Canada Group Limited (WSP) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out foundation investigations associated with the detailed design of numerous bridge replacements, overhead signs, noise barrier walls, temporary roadway protection systems, replacement of storm sewers (including trenchless crossings) and a high fill embankment on Highway 417 between Island Park Drive and Kent Street in Ottawa, Ontario (Assignment number 4016-E-0001).

This report presents the results of the foundation investigation carried out for the rapid bridge replacement (RBR) of the Highway 417 eastbound (Site 3-60/1) and westbound (Site 3-60/2) overpass structures at Bronson Avenue, (G.W.P. 4173-15-00, W.P. 4073-13-01 and W.P. 4074-13-01). The replacement of the structures is to be carried out in accordance with the current version of the Canadian Highway Bridge Design Code, S6-14 (CHBDC).

The terms of reference and scope of work for the foundation investigation are outlined in the MTO’s Request for Proposal, dated April 2016, and subsequent addenda. Golder’s scope of work for foundation engineering services associated with the Highway 417 Overpasses at Bronson Avenue is contained in Table 17.8.3 of WSP’s Technical Proposal for this assignment dated June 28, 2016. The work has been carried out in accordance with Golder’s Quality Control Plan for foundation engineering services for the project dated August 29, 2016.

2.0 SITE DESCRIPTION AND GEOLOGY

2.1 Site Description

Sites 3-60/1 and 3-60/2 are located at approximate Station 27+800 on Highway 417, approximately 870 m east of the O-Train Trillium Line, within the City of Ottawa. The location of the overpass structures is shown on the Key Plan on Drawings 1 through 5. Site photographs showing the general conditions at the site are presented in Appendix G.

At this location, Highway 417 is a divided highway with four travel lanes in each direction separated by a concrete barrier wall.

Each of the existing structures is a single-span concrete rigid frame bridge that is supported on shallow foundations founded directly on bedrock. Information provided in the RFP indicates that the structures were built in 1962. The structures have a clear span of 23.8 m measured perpendicular to the abutments and are separated from each other by a longitudinal joint. The average overall deck width of each structure, measured perpendicular to the centerline of the highway, is approximately 19.0 m. Each abutment has two retaining walls located along the north and south sides of the highway embankment for retaining the embankment fill. Noise barrier walls are located only along the north side of the highway west of the west abutment, no noise barriers are located on the structures.

The existing approach embankments are about 6 to 7 m in height relative to the elevation of Bronson Avenue, with side slopes oriented at approximately 2 horizontal to 1 vertical (2H:1V). Based on visual observation at the time of the site investigation, the existing embankment slopes appeared to be performing satisfactorily.

2.2 Regional Geology

As delineated in *The Physiography of Southern Ontario*[1], this section of Highway 417 lies within the minor physiographic region known as the Ottawa Valley Clay Plain, which lies within the major physiographic region of the Ottawa-St. Lawrence Lowland.

The Ottawa Valley Clay Plain region is characterized by relatively thick deposits of sensitive marine clay, silt and silty clay that were deposited within the former Champlain Sea basin. These deposits, known as the Champlain Sea clay or Leda clay, overlie relatively thin, commonly reworked glacial till and glaciofluvial deposits, that in turn overlie bedrock[2].

This region is underlain by a series of sedimentary rocks, consisting of sandstones, dolostones, limestones and shales that are, in turn, underlain at depth by igneous and metamorphic bedrock of the Precambrian Shield. Regional bedrock mapping indicates that the bedrock at this site is primarily limestone of the Verulam Formation.[3] The limestone is described as interbedded bioclastic, sublithographic to fine crystalline, very thin to medium bedded, with shale interbeds up to 8 centimetres thick.

The structures are located between two known faults striking southeast to northeast. The more prominent fault, the Gloucester fault crosses Highway 417 at the approximate location of Preston Street.[4] The second fault crosses Highway 417 some 400 m to the east of Bronson. Bedding which is normally sub-horizontal often dips steeply adjacent to and within fault zones.

The site falls within the Western Québec (WQ) seismic zone according to the Geological Survey of Canada. The WQ zone constitutes a large area which encompasses the urban areas of Montreal, Ottawa-Hull and Cornwall. Within the WQ zone recent seismic activity has been concentrated in two subzones; one along the Ottawa River and another more active subzone along the Montreal-Maniwaki axis. The two major earthquakes that have recently occurred in the WQ zone are the 1935 Témiscaming event, which had a magnitude (i.e., a measure of the intensity of the earthquake) of 6.2, and the 1944 Cornwall-Massena event, which had a magnitude of 5.6.

3.0 INVESTIGATION PROCEDURES

3.1 Current Investigations (2017 and 2018)

The field work for the 2017 investigation was carried out between July 19 and August 8, 2017 and included advancing a total of 24 coreholes, designated 17-C01 to 17-C24, and four boreholes, designated 17-131 to 17-134, that were located along Bronson Avenue. A supplemental investigation was carried out between October 3 and 17, 2018 and November 7 and 22, 2018, that included advancing eleven additional boreholes located within the approach and highway embankments, designated Boreholes 18-1301 to 18-1308. The NAD83 CSRS CBNv6-2010.0 MTM Zone 9 locations and ground surface elevations of the test holes are shown on Drawings 1 to 5. Tables 1 and 2 further outline the location of the testholes with respect to the existing structures.

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[1] Chapman, L. J. and Putnam, D. F., 1984. *The Physiography of Southern Ontario*, Ontario Geological Survey. Special Volume 2, Third Edition. Accompanied by Map P.2715, Scale 1:600,000. Ontario Ministry of Natural Resources.

[2] Belanger, J.R. “Urban Geology of Canada’s National Capital Area”, in *Urban Geology of Canadian Cities*, Geological Association of Canada Special Paper 42, Ed. P.F. Karrow and O.L. White, 1998.

[3] Williams, D.A. Rae, A.M., and Wolf, R.R. 1984: Paleozoic Geology of the Ottawa Area, Southern Ontario, Ontario Geological Survey, Map P.2716. Geological Series-Preliminary Map, scale 1:50,000. Geology 1982.

[4] MacDonald, G. and Harrison, J.E. 1976 : Generalized Bedrock Geology, Ottawa-Hull, Ontario and Quebec, Geological Survey of Canada, Map 1508A, scale 1:125,000. Geology 1967.

Coreholes 17-C01 17-C24 (12 per abutment) were drilled at approximately 3 m spacings along Bronson Avenue through the existing sidewalks and subsequently hydro-excavated to expose the top of the existing footings. Eight of the coreholes (four per abutment) were further advanced into the underlying bedrock to form Drillholes 17-C01D, 17-C04D, 17-C09D, 17-C11D, 17-C13D, 17-C17D, 17-C19D, and 17-C24D. Drillhole 17-C09D was drilled on an incline due to the proximity of the corehole location to the adjacent abutment. The angle of inclination is indicated on the Record of Drillhole and is orientated relative to the horizontal, with an azimuth perpendicular to the abutments.

Boreholes 17-131 to 17-134 were located on Bronson Avenue to the north and south of the existing abutments, while Boreholes 18-1301 to 18-1304 were advanced through the existing Highway 417 embankments. Boreholes 18-1305 to 18-1308 were located within the highway approach embankments behind the existing abutments. Boreholes 18-1309 to 18-1311 were advanced at the proposed staging area located to the southeast of the existing eastbound structure.

The coreholes/drillholes were advanced using a combination of portable rotary drilling and hydro-vac equipment. Boreholes 18-1301 to 18-1304 were advanced using only portable rotary drilling equipment employing a third weight hammer lifted manually and dropped from the SPT height. Where a third weight hammer was used, the N values presented on the Record of Boreholes are “uncorrected” and should be interpreted in consideration of their reduced penetration energy. The remaining boreholes were advanced using a combination of truck-mounted drilling and hydro-excavation equipment. All drilling equipment was supplied and operated by CCC Geotechnical & Environmental Drilling Ltd. of Ottawa, Ontario. Traffic control required to close either the driving lanes of the Highway or Bronson Avenue while carrying out field operations was provided by Beacon Lite Ltd. of Ottawa Ontario.

Soil samples from the portable drilling equipment were obtained in continuous vertical sampling increments of about 0.6 m using a 50 mm outside diameter split spoon sampler in general accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586). Grab samples of the overburden were recovered from within the hydro-excavations carried out at the coreholes/drillholes and at Borehole 17-131. Soil samples from boreholes advanced with truck-mounted drilling equipment were obtained at vertical intervals of about 0.76 m also in accordance with ASTM D1586. Bedrock core samples were obtained using NQ sized equipment.

Monitoring wells were installed in Boreholes 17-134 and 18-1305 to observe the groundwater level across the site. The monitoring wells consist of 32 mm outside diameter PVC tubing with a 1.5 m long screen.
The groundwater levels were measured in the monitoring wells on August 23, 2017 (17-134) and December 6, 2018 (18-1305). The monitoring wells were decommissioned after taking the final water level measurement, according to O.Reg 903 by a licenced well installer.

Where cored, the holes advanced through the existing footings and bedrock were grouted following completion of work. The coreholes/drillholes were then backfilled with granular material above the existing footing level to the underside of the existing sidewalk, then capped with concrete. The boreholes were backfilled with bentonite within the bedrock and bentonite mixed with soil cuttings within the overburden and capped with either concrete sidewalk patch or asphaltic concrete cold patch, depending on the surrounding surface cover. The boreholes were backfilled in general accordance with the intent of Ontario MOE Regulation 903, as amended. The site conditions were restored following completion of the field work.

The field work was supervised on a full-time basis by members of Golder’s staff who located the testholes in the field, directed the drilling, sampling, and in-situ testing operations, logged the testholes and examined and cared for the samples. The soil and bedrock samples were identified in the field, placed in labelled containers, and transported to Golder’s laboratory in Ottawa for further examination and testing. Index and classification tests consisting of water content determinations and grain size distribution analyses were carried out on selected soil samples at Golder’s Ottawa laboratory. Unconfined compressive strength testing was carried out on six samples of the bedrock core at Golder’s Mississauga laboratory. The laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate.

A total of five soil samples were submitted to Eurofins Environment Testing for chemical analysis related to potential corrosion of exposed buried steel and potential sulphate attack on buried concrete elements (corrosion and sulphate attack).

In addition to the borehole investigations at the current sites, shear wave velocity profiling was completed at the nearby Highway 417 Overpass Structures at Rochester Street (Sites 3-56/1 and 3-56/2), located approximately 550 m west of Bronson Avenue. Due to the close proximity and similar nature of the surficial and bedrock geology of the sites, the profiles developed for the Sites 3-56/1 and 3-56/2 are considered relevant to the current structures.

The shear wave velocity profiling was carried out on the Highway 417 eastbound E-N/S off-ramp of the Highway 417 / Rochester Street Interchange, just west of Rochester Street employing the Multichannel Analysis of Surface Waves (MASW) technique. The MASW profiling was carried out on October 18, 2017, by personnel from Golder’s Mississauga and Ottawa offices. A series of low frequency (4.5 Hz) geophones were laid out at 2 m intervals. A 9.9 kg sledge hammer and 34 kg weight drop were used as the seismic source. The source locations were offset at various distances beyond the end and collinear with the geophone array.

The testhole locations and elevations were surveyed by Golder using a Trimble R8 GPS unit. The testhole locations, including northing and easting coordinates, ground surface and top of existing abutment footing elevations referenced to the NAD83 CSRS CBNv6-2010.0 MTM Zone 9 geodetic datum, and drilled/cored depths are summarized in Tables 1 and 2.

Table 1: Summary of Corehole/Drillhole Locations

Corehole / Drillhole	Location	NAD83 CSRS CBNv6-2010.0 MTM Zone 9		Ground Surface Elevation (m)	Top of Existing Footing Elevation (m)	Corehole / Drillhole Depth (m)
		Northing (m)	Easting (m)			
17-C01/D	Sidewalk along Bronson Avenue at east abutment	5029769.3	367278.0	69.5	68.5	3.2
17-C02		5029766.5	367279.1	69.4	68.4	1.0
17-C03		5029763.6	367280.3	69.4	68.4	1.1
17-C04/D		5029761.0	367281.5	69.5	68.5	2.8
17-C05		5029757.8	367282.8	69.5	69.0[1]	0.5
17-C06		5029754.8	367284.0	69.5	69.0[1]	0.6
17-C07		5029751.7	367285.3	69.7	69.2[1]	0.5
17-C08		5029748.6	367286.6	69.7	68.9[1]	0.8
17-C09/D		5029745.6	367287.8	69.8	68.7	5.7
17-C10		5029742.5	367289.2	69.8	68.6	1.2
17-C11/D		5029739.3	367290.6	69.9	68.9	3.7
17-C12		5029736.4	367291.7	70.0	69.0	1.0

Corehole / Drillhole	Location	NAD83 CSRS CBNv6-2010.0 MTM Zone 9		Ground Surface Elevation (m)	Top of Existing Footing Elevation (m)	Corehole / Drillhole Depth (m)
		Northing (m)	Easting (m)			
17-C13/D	Sidewalk along Bronson Avenue west abutment	5029728.0	367270.1	70.0	68.8	3.1
17-C14		5029730.7	367268.9	69.9	69.5[1]	0.4
17-C15		5029733.8	367267.7	69.8	69.4[1]	0.4
17-C16		5029736.4	367266.5	69.8	69.4[1]	0.4
17-C17/D		5029739.4	367265.3	69.7	68.6	3.0
17-C18		5029742.5	367264.0	69.6	68.4	1.2
17-C19/D		5029745.3	367262.7	69.6	68.4	2.5
17-C20		5029748.4	367261.6	69.6	68.5[2]	1.1
17-C21		5029751.0	367260.5	69.5	69.1[1]	0.4
17-C22		5029753.9	367259.2	69.5	68.5	1.0
17-C23		5029756.8	367258.0	69.5	68.5[2]	1.0
17-C24/D		5029759.8	367256.8	69.5	68.4	2.5

Notes: C = Corehole only
C/D = Combination Corehole and Drillhole
[1] Refusal to hydro-excavation on conduit
[2] Refusal to hydro-excavation on inferred wood formwork

Table 2: Summary of Borehole Locations

Borehole	Location	NAD83 CSRS CBNv6-2010.0 MTM Zone 9		Ground Surface Elevation (m)	Top of Existing Footing Elevation (m)	Borehole Depth (m)
		Northing (m)	Easting (m)			
17-131	Bronson Avenue Southwest of west abutment	5029723.5	367276.0	70.0	N/A	4.9
17-132	Bronson Avenue Southeast of east abutment	5029729.5	367290.4	70.1		5.3
17-133	Bronson Avenue Northwest of west abutment	5029764.9	367258.1	69.4		4.1
17-134	Bronson Avenue Northeast of east abutment	5029772.1	367272.0	69.3		5.8
18-1301	Highway 417 Embankment Northwest of west abutment	5029759.9	367250.0	71.6	69.3	5.5
18-1302	Highway 417 Embankment Southwest of west abutment	5029724.1	367265.0	72.3	69.5	6.5
18-1303	Bronson Avenue Northeast of east abutment	5029772.9	367281.5	69.5	68.4	4.5
18-1304	Highway 417 Embankment Southeast of east abutment	5029737.0	367296.7	69.7	69.0	3.8

Borehole	Location	NAD83 CSRS CBNv6-2010.0 MTM Zone 9		Ground Surface Elevation (m)	Top of Existing Footing Elevation (m)	Borehole Depth (m)
		Northing (m)	Easting (m)			
18-1305	Highway 417 Westbound West of west abutment	5029743.1	367253.1	75.7	N/A	7.9
18-1306	Highway 417 Eastbound West of west abutment	5029727.0	367259.4	76.0		6.6
18-1307	Highway 417 Westbound East of east abutment	5029771.2	367290.2	75.5		7.7
18-1308	Highway 417 Eastbound East of east abutment	5029754.4	367294.6	75.8		8.3
18-1309	Staging Area Southeast of eastbound structure	5029734.2	367312.9	70.1		3.2
18-1310	Staging Area Southeast of eastbound structure	5029707.8	367353	71.9		6.3
18-1311	Staging Area Southeast of eastbound structure	5029774.9	367417.2	70.1		7.3

3.2 Previous Investigations (1961)

A previous investigation was carried out for the design of the existing structures in 1961 by H.Q Golder and Associates Ltd. The subsurface information and results of the original investigation are contained in the report titled:

- *Site Investigation, Proposed Queensway-Bronson Overpass, Bridge No. 18, Ottawa, Ontario*", dated August 1961, (Report No. 6105, GEOCRES No. 31G05-043).

As part of the current assignment, previously collected subsurface information pertinent to the site was reviewed and compiled.

A total of six boreholes (each with an adjacent dynamic penetration test - DPT) and one additional DPT were advanced at the site as part of the original investigation along the then proposed bridge alignment over Bronson Avenue. The Record of Borehole sheets and laboratory testing results from the previous investigation are provided for reference in Appendix C. The approximate borehole locations and ground surface elevations are shown on Drawings 1 to 2.

The locations of the previous boreholes should be considered approximate since the locations were referenced to an imperial borehole location plan rather than metric MTM coordinates. Further, the boreholes from the previous investigation were advanced prior to construction of the bridge and the ground surface conditions shown may not be representative of the post-construction subsurface conditions, particularly with respect to the composition and thickness of overburden and fill. It is also unknown if the surface of the bedrock as encountered in the 1961 investigation was altered during construction of the overpass structure. Therefore, the stratigraphy encountered in the 1961 boreholes was not included in the stratigraphic profiles shown on Drawings 1 to 2.

4.0 DESCRIPTION OF SUBSURFACE CONDITIONS

4.1 General

The subsurface soil, bedrock and groundwater conditions encountered in the boreholes and the results of in-situ testing from the current investigation are given on the Record of Borehole, Corehole, and Drillhole sheets presented in Appendix A. The results of the laboratory testing carried out during the current investigation are presented on the Record of Borehole sheets as well as on Figures B1 to B8 in Appendix B. The borehole locations and the interpreted stratigraphic profile projected along each abutment and staging area are provided on Drawings 1 to 5.

Photographs of the core recovered from the concrete footings and underlying bedrock are shown on Figures A1 to A32 provided in Appendix A. An assessment of the condition of the Portland Cement Concrete (PCC) footing cores is provided in Table A1 of Appendix A. The results of basic chemical analysis completed on select soil samples are provided in Appendix D.

The MASW test results and report from Sites 3-56/1 and 3-56/2 are presented in Appendix E and include the calculated shear wave velocity profile measured from the field testing and a graphical representation of the shear wave velocity profile with depth for those sites.

The stratigraphic boundaries shown on the testhole sheets and on the interpreted stratigraphic sections from Drawings 1 to 5, are inferred from observations of drilling progress and noncontinuous sampling and therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

4.2 Overburden

In general, the subsurface conditions at the testhole locations advanced along Bronson Avenue consist of PCC sidewalk at surface, overlying granular fill overlying PCC footing and/or limestone bedrock. At the embankment, approach and staging area boreholes the subsurface conditions consisted of asphalt/concrete or topsoil surface cover, overlying fill materials, overlying native silt sand and glacial till all underlain by limestone bedrock. Due to the age of the structures, it is possible that remnants of temporary works abandoned after construction of the existing structure may be buried in the fill.

The groundwater level was measured at the site at depths ranging from 1.5 to 7.5 m, corresponding to Elevations 65.8 and 68.3 m.

A more detailed description of the overburden soil deposits, concrete footings, bedrock geology and groundwater conditions encountered during the field investigation is provided in the following sections.

4.3 Highway 417 Approach Embankments

4.3.1 Surface Cover / Surficial Materials

A layer of topsoil was encountered at the ground surface of the embankment at Boreholes 18-1301, 18-1302 and 18-1304. The thickness of the topsoil at the borehole locations ranges from 100 to 400 mm.

Boreholes 18-1305 to 18-1308 were advanced through the Highway 417 pavement structure. The thickness of the asphaltic concrete at the borehole locations ranges from 300 mm in Boreholes 18-1305 and 18-1308 to 100 mm in Boreholes 18-1307 and 18-1306.

Portland cement concrete was encountered below the asphaltic concrete in Boreholes 18-1306 and 18-1307 and is 300 and 500 mm in thickness, respectively.

4.3.2 Fill

Pavement Structure – Sand and Gravel to Sand

A fill layer consisting predominantly of sand and gravel with varying amounts of silt was encountered below the concrete layers in approach Boreholes 18-1305 to 18-1308. The top of this layer was encountered at elevations ranging from 74.9 to 75.6 m. The thickness of the fill ranges from 1.6 to 2.8 m. The SPT N values ranged from 35 to 85, indicating a dense to very dense condition.

The moisture content of the samples tested ranged from 3 to 6 percent. The results of a grain size analysis test carried out on a single sample of this material are provided on Figure B1 in Appendix B.

Sand

Fill consisting predominantly of sand with varying amounts of gravel and silt was encountered below the pavement structure in Boreholes 18-1301 to 18-1308. The top of this layer was encountered at elevations ranging from 69.4 to 73.9 m. The thickness of the layer ranges from 0.6 to 5.4 m. The SPT N values ranged from 3 to greater than 100, indicating a very loose to very dense condition, but more typically compact to dense.

The moisture content of the samples tested ranged from 4 to 10 percent. The results of grain size analysis tests carried out on seven samples of this material are provided on Figures B2 and B3 in Appendix B.

4.3.3 Glacial Till

A non-cohesive glacial till deposit consisting of a heterogeneous mixture of sand, gravel and silt was encountered beneath the fill materials in Boreholes 18-1305 to 18-1308. The till is classified as a silty sand some gravel and clay to gravelly silty sand. The top of this deposit was encountered at elevations ranging from 68.2 to 70.7 m. The thickness of the till ranges from 0.4 to 1.4 m, as inferred from auger refusal. The SPT N values ranged from 6 to greater than 100, indicating a loose to very dense condition, but more typically compact.

The moisture content of the samples tested ranged from 5 to 18 percent. The results of grain size analysis tests carried out on two samples of this material are provided on Figure B8 in Appendix B.

4.4 Bronson Avenue

4.4.1 Surface Cover / Surficial Materials

A Portland cement concrete sidewalk was encountered at the ground surface of all coreholes/drillholes advanced along Bronson Avenue. The thickness of the concrete ranges from 100 to 200 mm at the test hole locations.

Boreholes 17-131 to 17-134 were advanced through the Bronson Avenue pavement structure. The thickness of the asphaltic concrete at the borehole locations was 100 mm.

Portland cement concrete was encountered below the asphalt layer in Boreholes 17-131, to 17-134. The thickness of this layer ranged from 200 to 300 mm.

4.4.2 Fill

Gravely Sand, Sand and Gravel, Sand

A fill layer consisting predominantly of sand with varying amounts of gravel and silt was encountered below the Portland cement concrete at the Bronson Avenue testhole locations. The top of this layer was encountered at elevations ranging from 69.3 to 69.9 m. The thickness of the layer ranges from 0.7 to 1.4 m. The SPT N values ranged from 15 to greater than 100, indicating a compact to very dense condition, but more typically compact. As noted in Table 1 in Section 3.1, refusal to hydro-excavation was encountered on conduits or wood formwork in Coreholes 17-C05, 17-C06, 17-C20, 17 C21, and 17-C23.

The moisture content of the samples tested ranged from 4 to 11 percent. The results of grain size analysis tests carried out on two samples of this material are provided on Figures B1 and B2 in Appendix B.

4.4.3 Glacial Till

A non-cohesive glacial till deposit consisting of a heterogeneous mixture of sand, gravel and silt was encountered beneath the fill materials in Borehole 17-132. The till is classified as gravelly silty sand. The top of this layer was encountered at elevation 69.1 m. The thickness of this layer is 0.9 m, as inferred from auger refusal. The SPT N values ranged from 93 to greater than 100, indicating a very dense condition.

4.5 Staging Area

4.5.1 Surface Cover / Surficial Materials

Asphaltic concrete, 50 mm in thickness, was encountered at the ground surface at Boreholes 18-1310 and 18-1311.

4.5.2 Fill

Gravelly Sand, Sand and Gravel, Sand

A fill layer consisting predominantly of sand with varying amounts of gravel and silt was encountered below the asphaltic concrete at Boreholes 18-1310 and 18-1311 and at the ground surface at Borehole 18-1309. The top of the fill was encountered at elevations ranging from to 70.0 to 71.8 m. The thickness of the layer ranges from 1.4 to 3.1 m. The SPT N values ranged from 6 to 33, indicating a loose to dense condition, but typically compact.

The moisture content of the samples tested ranged from 5 to 15 percent. The results of a grain size analysis test carried out on a single sample of this material from Borehole 18-1310 are provided on Figure B5.

Silt

Fill consisting predominantly of silt, with varying amounts of sand, was encountered below the sand fill at Boreholes 18-1309 and 18-1310. The top of this layer was encountered at elevations 68.2 and 68.6 m and the thickness of the silt fill layer is 1.2 m. The SPT N values ranged from 1 to 3, indicating a very loose condition.

The moisture content of the samples tested was 18 and 19 percent. The results of grain size analysis tests carried out on two samples of this material are provided on Figure B4 in Appendix B.

It should be noted that strong hydrocarbon odour was noted in the fill materials in the staging area boreholes. Samples of the possibly impacted materials were collected for environmental testing by WSP. Further details with regards to the material handling, reuse and/or disposal are provided in WSP’s 2018 Phase II ESA and Earth 2019 Management Plan Reports, which are provided under separate cover.

4.5.3 Silty Sand

A silty sand layer was encountered below the fill at Borehole 18-1311. The top of this layer was encountered at elevation 68.6 m and the thickness of this layer is 3.8 m. The SPT N values ranged from 4 to 15, indicating a loose to compact condition.

The moisture content of the single sample tested was 13 percent. The results of a grain size analysis test carried out on a single sample of this material are provided on Figure B6 in Appendix B.

4.5.4 Silt

A silt deposit was encountered below the sand layer in Borehole 18-1311. The top of this layer was encountered at elevation 64.8 m and the thickness of the layer is 1.0 m. The SPT N value was 11, indicating a compact condition.

The moisture content of the sample tested was 21 percent. The results of a grain size analysis test carried out on a single sample of this material are provided on Figure B7 in Appendix B.

4.5.5 Glacial Till

A non-cohesive glacial till deposit consisting of a heterogeneous mixture of sand, gravel and silt was encountered beneath the fill materials in Boreholes 18-1309 to 18-1310 and below the silt layer in Borehole 18-1311. The till is classified as a silty sand and gravel to silty sand some gravel. The top of this deposit was encountered at elevations ranging from 63.9 to 67.4 m. The thickness of the till ranges from 0.6 to 1.4 m, as inferred from auger refusal. The SPT N values ranged from 10 to greater than 100, indicating a compact to very dense condition, but more typically compact to dense.

The moisture content of the sample tested 8 percent. The results of grain size analysis tests carried out on a single sample of the till are provided on Figure B8 in Appendix B.

4.6 Concrete Footings

The existing concrete footings were encountered in coreholes/drillholes 17-C01 to 17-C24 and embankment Boreholes 18-1301 to 18-1304. The top of the concrete footing was encountered at elevations ranging from 68.3 to 69.5 m. The thickness of the footings ranges from 0.8 to 3.9 m, as indicated by coring through the existing footing to the underlying bedrock. Tables 1 and 2 in Section 3.1 provide the top of footing elevation at each of the testhole locations. An assessment of the condition of the Portland Cement Concrete (PCC) footing cores is provided in Table A1 of Appendix A.

4.7 Bedrock

The overburden materials and concrete footings are underlain by limestone bedrock with shale partings and interbeds. Bedrock geology mapping indicates that the limestone bedrock is of the Verulam Formation.

Bedrock was proven by coring using NQ sized equipment in Boreholes 17-131 to 17-134 and 18-1301 to 18-1304, and Drillholes 17-C01, 17-C04, 17-C09, 17-C11, 17-C13, 17-C17, 17-C19, and 17-C24. Photographs of the bedrock core are provided in Appendix A. Bedrock was also proven by coring using BX sized coring equipment in Boreholes 1 to 6 during the 1961 investigation.

Table 3 summarizes the depth to, and the elevation of the bedrock surface as encountered at the testhole locations from the current and previous investigations.

Table 3: Summary of Bedrock Surface Depths and Elevations

Drillhole / Borehole	Drillhole / Borehole Location	Existing Ground Surface Elevation (m)	Depth to the Bedrock Surface (m)	Bedrock Surface Elevation (m)
17-C01D	Sidewalk along Bronson Avenue at east abutment	69.5	2.5	67.0
17-C04D		69.5	2.0	67.5
17-C09D		69.8	5.1	64.8
17-C11D		69.9	3.1	66.8
17-C13D	Sidewalk along Bronson Avenue at west abutment	70.0	2.3	67.7
17-C17D		69.7	1.9	67.8
17-C19D		69.6	1.8	67.8
17-C24D		69.5	1.8	67.7
17-131	Bronson Avenue Southwest of west abutment	70.0	1.8	68.2
17-132	Bronson Avenue Southeast of east abutment	70.1	1.9	68.1
17-133	Bronson Avenue Northwest of west abutment	69.4	1.1	68.3
17-134	Bronson Avenue Northeast of east abutment	69.3	1.9	67.4
18-1301	Highway 417 Embankment Northwest of west abutment	71.6	3.7	67.9
18-1302	Highway 417 Embankment Southwest of west abutment	72.3	4.4	67.9
18-1303	Bronson Avenue Northeast of east abutment	69.5	2.5	67.0
18-1304	Highway 417 Embankment Southeast of east abutment	69.7	1.8	67.9
1	East Approach of Bronson Avenue	68.5	4.9	63.6
2	East approach	68.6	2.6	66.0
3	East approach	68.8	5.4	63.5
4	East approach	68.6	2.5	66.1
5	East abutment	69.4	1.0	68.4
6	West abutment	71.1	2.0	69.1

The bedrock encountered was slightly weathered to fresh and thinly to medium bedded. Thin shale interbeds were also present in the bedrock core. Rock Quality Designation (RQD) values measured on recovered bedrock core samples typically ranged from about 0 to 100 percent, but more generally ranging from about 70 to 100 percent indicating good to excellent quality rock.

Results of unconfined compressive strength (UCS) testing carried out on six bedrock core samples are presented on Figure B9 provided in Appendix B. The samples tested had UCS values ranging from 54 and 93 MPa, indicating a strong bedrock.

4.8 Groundwater Conditions

Monitoring wells were installed in Boreholes 17-134, 18-1305 and 18-1310 to monitor the groundwater level across the site.

Table 4 summarizes the depths to, and the elevations of the groundwater level measured in the monitoring wells installed at the site.

Table 4: Summary of Groundwater Conditions

Borehole	Location	Screened Interval	Depth to the Groundwater Level (m)	Groundwater Elevation (m)	Date of Reading
17-134	Bronson Avenue Northeast of east abutment	Bedrock	1.5	67.8	August 23, 2017
18-1305	Highway 417 Westbound West of west abutment	Fill Glacial till	7.4	68.3	December 6, 2018
18-1310	Staging Area Southeast of eastbound structure	Silt and till	4.3	65.8	December 6, 2018

It is expected that the groundwater level will be subject to fluctuations both seasonally and as a result of precipitation events.

4.9 Steel Corrosion and Sulphate Attack, Chemical Analysis

A total of five soil samples were submitted to Eurofins Environment Testing for chemical analysis related to potential corrosion of exposed buried steel and potential sulphate attack on buried concrete elements (corrosion and sulphate attack). The test results are provided in Appendix D and are summarized in Table 5.

Table 5: Steel Corrosion and Sulphate Attack, Chemical Analysis

Borehole	Sample	Sample Depth (m)	Sample Type	Chloride (%)	Sulphate (%)	Electrical Conductivity (mS/cm)	pH	Resistivity (ohm-cm)
17-132	SS2	0.9 – 1.4	Till	0.050	0.06	1.26	8.2	794
18-1301	SS4	1.8 – 2.4	Fill	0.007	0.04	0.10	8.4	10,000
18-1304	SS2	0.6 – 0.7	Fill	< 0.002	0.06	<0.05	8.8	25,000
18-1309	SS5	3.0 – 3.2	Sand	0.006	0.06	0.32	8.0	3,120
18-1311	SS9	6.1 – 6.7	Till	0.005	0.03	0.12	7.8	8,330

5.0 CLOSURE

This report was prepared by Mr. Kenton Power, P.Eng. It was reviewed by Mr. Bill Cavers, P.Eng., a Senior geotechnical engineer and Associate of Golder. Mr. Fintan Heffernan, P.Eng. a Senior Consultant with Golder and the Designated MTO Foundations Contact for this project, carried out an independent quality control review of this report.

Golder Associates Ltd.

Kenton C. Power, P.Eng, M.A.Sc.
Geotechnical Engineer

LICENSED PROFESSIONAL ENGINEER
K. T. C. POWER
100130652
2019/06/04
PROVINCE OF ONTARIO

William Cavers, P.Eng
Associate, Senior Geotechnical Engineer

LICENSED PROFESSIONAL ENGINEER
W. CAVERS
100077934
2019/06/04
PROVINCE OF ONTARIO

Fintan J. Heffernan, P.Eng.
Designated MTO Foundations Contact

REGISTERED PROFESSIONAL ENGINEER
F. J. HEFFERNAN
2019/06/04
PROVINCE OF ONTARIO

KCP/WC/FJH/mvrd

https://golderassociates.sharepoint.com/sites/18579g/foundations/6 - reports/1130 bronson/final/1655214-1130-001-r-rev0-bronson ave bridge-06-2019_fidr.docx

PART B

Foundation Design
Highway 417 Overpass Structures at Bronson Avenue
Rapid Bridge Replacement
Sites: 3-60/1 & 3-60/2
Ottawa, Ontario

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides geotechnical input for the rapid bridge replacement (RBR) of the Highway 417 eastbound (Site 3-60/1) and westbound (Site 3-60/2) overpass structures at Bronson Avenue, (G.W.P. 4173-15-00, W.P. 4073-13-01 and W.P. 4074-13-01). The input provided herein is based on interpretation of the factual data obtained from the testholes advanced during the current subsurface investigation as well as the available GEOCRES information for the site and in accordance with the current Canadian Highway Bridge Design Code CAN/CSA-S6-14 (CHBDC).

The foundation investigation report, discussion, and recommendations are intended for the use of the Ministry of Transportation, Ontario (MTO) and shall not be used or relied upon for any other purpose or by any other parties, including the construction contractor. The contractor must make their own interpretation based on the factual data in Part A (Foundation Investigation) of the report. Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project. Those requiring information on the aspects of construction must make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

6.2 Existing Conditions

Each of the existing structures is a single-span concrete rigid frame bridge that are supported on shallow foundations founded directly on bedrock. Information provided in the RFP indicates that the structures were built in 1962. The structures have a clear span of 23.8 m measured perpendicular to the abutments and are separated from each other by a longitudinal joint. The average overall deck width of each structure, measured perpendicular to the centerline of the highway, is approximately 19.0 m. Each abutment has two retaining walls located along the north and south sides of the highway embankment for retaining the embankment fill. Noise barrier walls are located along the north side of the highway on the east approach only, no noise barriers are located within the limits of the structures.

Based on the base plan mapping provided for this project and the ground surface elevations at the borehole locations surveyed during the field investigation, the top of pavement elevation of Highway 417 ranges from 76.0 to 75.7 m at the west abutment, and from 75.8 to 75.5 mm at the east abutment in the eastbound and westbound directions respectively. The top of pavement elevation of Bronson Avenue ranges from about Elevation 69.3 m to 70.1 m. The existing approach embankments are about 6 to 7 m high relative to the elevation of Bronson Avenue. The existing abutments are supported on shallow foundations bearing directly on the bedrock.

6.3 Proposed Structure

Based on the February 2019 General Arrangement (GA) Drawing provided by WSP, Highway 417 will not be widened at this location and the bridge structures are to be replaced in kind. It is understood that the preferred replacement alternative involves the use of rapid bridge replacement (RBR) techniques. The existing bridge structures will be demolished in place with removal of the superstructure down to the existing footing level. The new structures will be pre-assembled in the staging area and transported using specialized heavy-lift equipment to their final locations. Consideration is also being given to incorporating the existing spread footings into the new overpass structures.

6.4 Seismic Design

6.4.1 Seismic Hazard and Importance Category

The CHBDC states that the seismic hazard values associated with the design earthquakes should be those established for the National Building Code of Canada (NBCC) by the Geological Survey of Canada (GSC). The current seismic hazard maps (referred to as the 5th generation seismic hazard maps) were developed by the GSC and were made available for public use in December 2015.

In accordance with Section 4.4.2 of the CHBDC, and as specified in the RFP by the MTO, the bridge structures have been given an importance category of “Major Route” bridge.

6.4.2 Seismic Site Classification

In addition to the borehole investigations at the current sites, shear wave velocity profiling was completed at the nearby Highway 417 Overpass Structures at Rochester Street (Sites 3-56/1 and 3-56/2), located approximately 550 m west of Bronson Avenue. Due to the close proximity and similar nature of the surficial and bedrock geology of the sites, the profiles developed for the Sites 3-56/1 and 3-56/2 are considered relevant to the current structures.

The profiling was carried out in the grassy area, beside the Rochester offramp, using the Multichannel Analysis of Surface Waves (MASW) technique. Profiling was carried out on October 18, 2017, by personnel from the Golder’s Mississauga and Ottawa offices.

The shear wave velocities measured at that site are presented in the technical memorandum in Appendix E and indicates that the average shear wave velocity in the upper 30 m of the subsurface stratigraphy at the Rochester Bridge (Sites 3-56/1 and 3-56/2) is 734 m/s.

Based on the results of the MASW testing at the Rochester Street site, an average shear wave velocity of 1,585 m/s was calculated for 30 m of rock at the Bronson Avenue site (3-60/1 & 3-60/2), corresponding to Site Class A in accordance with Table 4.1 of the CHBDC. It should be noted that as indicated in notes for Table 4.1 of the CHBDC a Site Class A is only assigned for structures founded directly on bedrock.

6.4.3 Spectral Response Values and Seismic Performance Category

In accordance with Section 4.4.3.1 of the CHBDC and based on the approximate location of the bridges (Latitude 45.40° N and longitude 75.70° W), Table 6 outlines the reference Site Class C peak seismic hazard values obtained from Earthquakes Canada (www.earthquakescanada.nrcan.gc.ca).

Table 6: Site Class C Spectral Values for Subject Site

Parameter	2% Probability of Exceedance in 50 Years (2,475-year) (g)
PGA	0.280
T <= 0.2 s	0.439
T = 0.5 s	0.237
T = 1.0 s	0.118
T = 2.0 s	0.056
T = 5.0 s	0.015
T => 10.0 s	0.005

The values given above are for the reference ground condition Site Class C and must be modified to the site-specific seismic site classification given in Section 6.4.2 (Site Class A) in accordance with Section 4.4.3 of the CHBDC. As indicated in Section 4.4.3.3 of the CHBDC the value of PGA_{ref} for use with Tables 4.2 to 4.9 shall be taken as 80 percent of the PGA for Site Class C where Sa(0.2)/PGA is less than 2.0. Based on this requirement a PGA_{ref} value of 0.224 was used for the 2,475-year return period. The corresponding site-specific Site Class A seismic hazard values given in the Table 7 can be used for design.

Table 7: Site Class A Spectral Values for Subject Site

Parameter	2% Probability of Exceedance in 50 Years (2,475-year) (g)
PGA	0.252
T <= 0.2 s	0.303
T = 0.5 s	0.135
T = 1.0 s	0.067
T = 2.0 s	0.032
T = 5.0 s	0.009
T => 10.0 s	0.003

The fundamental period of the replacement structures has yet to be confirmed and may depend on the final design of the superstructure. In consideration of the structure's "Major Route" importance category and the site specific seismic hazard values given in Table 7, the bridges would fall in Seismic Performance Category 1, if the fundamental period of the structure is greater than or equal to 0.5 s, or Seismic Performance Category 3, if the fundamental period of the structure is less than 0.5 s, in accordance with Table 4.10 of the CHBDC.

Based on the regular geometry of the bridge (since its skew angle is less than 20°), it is understood that the structure will be designed using a "force-based approach" as defined in the CHBDC, depending on the Seismic Performance Category.

6.5 Foundation Options

6.5.1 Consequence and Site Understanding Classification

In accordance with Section 6.5 of the CHBDC and its Commentary, the existing overpass structures and foundation systems may be classified as having large traffic volumes and its performance as having potential impacts on other transportation corridors, hence having a "typical" consequence level associated with exceeding limits states design. Given the level of foundation investigation completed to date as presented in Sections 3.0 and 4.0, in comparison to the degree of site understanding in Section 6.5 of CHBDC, the level of confidence for design is considered to be a "typical degree of site and prediction model understanding" for these sites. Accordingly, the appropriate corresponding ULS and SLS consequence factor, ψ of 1.0, and geotechnical resistance factors from Tables 6.1 and 6.2 of the CHBDC have been used for design, as indicated in the following sections.

For seismic design, the consequence factor, Ψ, and resistance factor, ϕ_{gu}, should be taken as unity, as per Section 4.6.3 of the CHBDC.

6.5.2 Existing Conditions

The original 1962 GA drawing (Drawing No. D-5001-P1) indicates that the footings were to bear directly on the bedrock, with the design founding level between about Elevations 67.7 and 68.1 m at the abutments.
The coreholes/drillholes advanced through the existing abutment footings into the underlying bedrock as part of the current foundation investigation confirms that the abutment footings are founded directly on the limestone bedrock.

6.5.3 Foundation Design Alternatives

Based on the results current investigation, shallow foundations are considered the preferred alternative from a foundations perspective for the replacement of the overpass structures and the associated retaining walls. Shallow foundations are more cost-effective than deep foundations (discussed below) for both conventional and rapid bridge replacement of the structure, whether by incorporating the existing foundations, or removing the existing foundations and constructing new footings directly on the bedrock. For the RBR option, the re-use of the existing foundations is considered a significant advantage.

Deep foundations, including steel H-piles, steel tube piles or caissons, are not considered warranted or practical at this site in comparison to shallow foundations, since the bedrock surface is located at shallow depth (i.e., less than 1.8 m) below the top of pavement elevation of Bronson Avenue.

A comparison of foundation alternatives, including advantages, disadvantages, risks and relative costs is provided in Table 14 following the text of this report.

6.6 Shallow Foundations

6.6.1 Founding Level

Table 8 provides the founding elevations recommended for design of new abutment footings founded directly on the bedrock surface. The founding elevations were selected based on the bedrock quality as well as to match the founding elevations of the existing structures.

Table 8: Design Footing Founding Elevations

Foundation Element	Footing Founding Elevations (m)
West Abutment	67.5 – 68.3
West Retaining Walls	67.6 to 68.9
East Abutment	64.8 – 68.1
East Retaining Walls (1)	66.8 – 67.5

Note (1):Retaining walls at abutments and extending to, not beyond, expansion joints.

Subexcavation may be required to remove any weathered, loose, or fractured bedrock before construction of the abutment and wingwall footings. For the shallow excavation depths expected (i.e., of less than about 2 m) the bedrock can likely be removed using mechanical methods such as hoe ramming.

Alternatively, the existing foundations may be left in place and new cast-in-place footings constructed or precast footings placed on top of the existing concrete footings. For this case, the surface of the existing west and east abutment footings into the structure are as follows:

Table 9: Summary of Footing Elevations

Footing Location	Elevation of Top of Footing (m)
West Abutment	68.3 – 68.8
East Abutment	68.4 – 68.9

6.6.2 Geotechnical Resistance

6.6.2.1 New Footings Supported on Bedrock Surface

The overpass replacement structures can be supported on cast-in-place strip or spread footings founded at or below the elevations provided in Section 6.6.1. The design should be based on a factored geotechnical resistance of 2 MPa at Ultimate Limit States (ULS). For footings founded on/in the bedrock, settlement is considered negligible under the anticipated loadings and therefore the SLS condition will not govern the design.

The factored geotechnical resistances provided above are given for loads that will be applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the footing, inclination of the load should be taken into account in accordance with Sections 6.10.3 and 6.10.4 of the CHBDC.

6.6.2.2 New Footings Supported on Existing Footings

If the existing footings are left in place and new footings (cast-in-place or precast) are constructed on top, the geotechnical resistances provided above are also applicable. Table A1 provided in Appendix A summarizes the condition of the cores taken from the existing footings at the site.

6.6.3 Resistance to Lateral Forces/Sliding Resistance

6.6.3.1 Footings on Bedrock

Resistance to lateral forces/sliding resistance between new or existing cast-in-place concrete footings and the bedrock surface should be calculated in accordance with Section 6.10.5 of the CHBDC. An unfactored coefficient of friction, tan $\varphi' = 0.70$ can be used for the interface between the concrete footing and bedrock.

If necessary, sliding resistance can be supplemented by doweling the footings into bedrock. The horizontal resistance of the dowels will be dependent on the strength of the bedrock, grout and steel. For this site, where the rock mass is essentially as strong as or is stronger than concrete, the design of the dowels in the rock may be handled in the same way as the dowel embedment into the concrete. The dowels should have a minimum embedded length within the sound bedrock of 1 m, and the structural strength of the dowel and compressive strength of the grout should not be exceeded.

For uplift of the dowels, a factored value of 1 MPa may be assumed for the grout-to-rock bond stress for ULS design. The actual bond stress along the rock-grout interface may vary from the design value given and it should therefore be verified in the field by pull-out testing. In this case, a Special Provision will have to be included in the Contract Documents to cover this testing.

6.6.3.2 New Footings Supported on Existing Footings

Cast-in-place or precast footings could be constructed on top of the existing footings for either a conventional or rapid bridge replacement. It is recommended that consideration be given to roughening the surface of the existing footings prior to constructing cast-in-place footings. In the case of new precast footings, it is anticipated that it would be necessary to place a concrete levelling pad on top of the existing foundations, to ensure a level and even surface on which to place the new footings.

For the assessment of sliding resistance between precast (formed) concrete footings on screened concrete, and assuming the use of post-grouting, it is recommended that a coefficient of friction of 0.6 be used.

To supplement the sliding resistance and provide additional resistance to lateral forces, mechanical attachments such as dowels may be used to secure the new footings to the existing footings; the dowels should be designed by the structural engineer. Lightweight fill could also be used behind the abutment walls to reduce the active thrust on the walls.

6.6.4 Foundation Compliance Springs

Once the preferred foundation design alternative has been confirmed and the footing configurations and dimensions are known, foundation compliance springs for dynamic analysis for the bridge abutments can be provided.

6.6.5 Frost Protection

For spread footings placed on fresh limestone bedrock, existing footings or mass concrete, frost protection cover is not required.

6.7 Lateral Earth Pressures for Design

The lateral earth pressures acting on the abutment walls and any associated wing walls will depend on the type and method of placement of the backfill materials, the nature of the soils behind the backfill, the magnitude of surcharge including construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the walls. Seismic (earthquake) loading must also be taken into account in the design.

The following recommendations are made concerning the design of the walls:

- Select, free draining granular fill meeting the specifications of OPSS.PROV 1010 *(Aggregates)* Granular A or Granular B Type II, should be used as backfill behind the walls. Alternatively, 19 mm clear crushed stone can be used as a backfill material provided a Class II nonwoven geotextile having a Filtration Opening Size (FOS) not exceeding 100 microns in accordance with OPSS 1860 is placed over the existing embankment fill and native soil, with overlaps of at least 0.5 metres between rolls, prior to placement of the clear stone. If clear stone backfill is used it should only be placed once the wing walls are in place, otherwise some type of restraint (e.g., gabion baskets) would need to be provided perpendicular to the abutments (i.e., at the end of the excavation) prior to placement of the clear stone. Longitudinal drains or weep holes should be installed to provide positive drainage of the granular backfill. Compaction (including type of equipment, target densities, etc.) should be carried out in accordance with OPSS.PROV 501 *(Compacting)*. Other aspects of the granular backfill requirements with respect to sub-drains and frost taper should be in accordance with OPSD 3101.150 *(Walls, Abutment, Backfill, Minimum Granular Requirement),* OPSD 3121.150 *(Walls, Retaining, Backfill, Minimum Granular Requirement)*, and 3190.100 *(Walls, Retaining and Abutment, Wall Drain).*

- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the walls, in accordance with CHBDC Section 6.12.3 and Figure 6.6. Care must be taken during the compaction operation not to overstress the wall. Heavy construction equipment should be maintained at a distance of at least 1 m away from the walls while the backfill soils are being placed. Hand-operated compaction equipment should be used to compact the backfill soils within a 1 m wide zone adjacent to the walls. Other surcharge loadings should be accounted for in the design, as required.

- For restrained walls, granular fill should be placed in a zone with the width equal to at least 1.8 m behind the back of the wall (Case (a) on Figure C6.20 of the *Commentary* to the CHBDC). For unrestrained walls, fill should be placed within the wedge-shaped zone defined by a line drawn at 1.5 horizontal to 1 vertical (1.5H:1V) extending up and back from the rear face of the footing (Case (b) on Figure C6.20 of the *Commentary* to the CHBDC).

6.7.1 Static Lateral Earth Pressures for Design

The following guidelines and recommendations are provided regarding the lateral earth pressures for static (i.e., not earthquake) loading conditions. These lateral earth pressures assume that the ground above the wall will be flat, not sloping. If the inclination of the slope above the wall changes then new lateral earth pressures will need to be calculated.

- For Case (a), the pressures are based on the proposed embankment fill and the following parameters (unfactored) may be used assuming the use of earth fill or Select Subgrade Material (SSM):

Table 10: Static Lateral Earth Pressure Coefficients, Earth Fill or SSM

Soil Type	Internal Angle of Friction (ϕ°)	Soil Unit Weight (γ, kN/m^3)	Coefficients of Earth Pressure		
			Active, Ka	At-Rest, Ko	Passive, Kp
Earth Fill or SSM	30	20	0.33	0.50	3.0

- For Case (b), the pressures are based on using engineered granular fill or clear stone and the following parameters (unfactored) may be used:

Table 11: Static Lateral Earth Pressure Coefficients, Earth Granular A, B Type II and Clear Stone

Soil Type	Internal Angle of Friction (ϕ°)	Soil Unit Weight (γ, kN/m^3)	Coefficients of Earth Pressure		
			Active, Ka	At-Rest, Ko	Passive, Kp
Granular A	35	22	0.27	0.43	3.7
Granular B Type II	35	21	0.27	0.43	3.7
Clear Stone	28	17	0.36	0.53	2.8

- Where the wall support does not allow lateral yielding (i.e., restrained structure where the rotational or horizontal movement is not sufficient to mobilize an active earth pressure condition), at-rest earth pressures (plus any compaction surcharge) should be assumed for geotechnical design.
- Where the wall support and superstructure allow lateral yielding, active earth pressures may be used in the geotechnical design of the structure. The movement to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure for design, should be calculated in accordance with Section C6.12.1 and Table C6.6 of the Commentary to the CHBDC.

6.7.2 Seismic Lateral Earth Pressures for Design

Seismic (earthquake) loading must be taken into account in the design in accordance with Section 4.6 of the CHBDC. In this regard, the following should be included in the assessment of lateral earth pressures:

- Seismic loading will result in increased lateral earth pressures acting on the wall. The wall should be designed to withstand the combined lateral loading for the appropriate static pressure conditions given in Section 6.7.1 above, plus the earthquake-induced dynamic earth pressure.

- In accordance with Sections 4.6.5 and C.4.6.5 of the 2014 CHBDC and its Commentary, for structures which do not allow lateral yielding, the horizontal seismic coefficient (k_h) used in the calculation of the seismic active pressure coefficient is taken as equal to the site adjusted PGA estimated at the ground surface (Site Class C). For structures which allow lateral yielding, k_h is taken as 0.5 times site adjusted PGA estimated at the ground surface.

- The seismic active pressure coefficients (K_{AE}) provided in Table 12 for the two backfill cases (Case (a) and Case (b)) may be used in design. It should be noted that these seismic earth pressure coefficients assume that the back of the wall is vertical and the ground surface behind the wall is flat. Where sloping backfill is present above the top of the wall, the lateral earth pressures under seismic loading conditions should be calculated by treating the weight of the backfill located above the top of the wall as a surcharge.

- The K_{AE} value for a yielding wall is applicable provided that the wall can move up to 250k_h mm, where k_h is the site-specific PGA as given in Table 12. This corresponds to displacements of about 60 mm for the 2,475-year design earthquake at this site.

Table 12: Seismic Active Pressure Coefficients, KAE for Various Materials

	Design Earthquake	Site Specific PGA (g)	Granular A	Granular B Type II	SSM	Clear Stone
Non-Yielding Wall	**2,475 Yr.**	0.252	0.44	0.44	0.52	0.56
Yielding Wall			0.34	0.34	0.42	0.45

- The earthquake-induced dynamic pressure distribution, which is to be added to the static earth pressure distribution, is a linear distribution with maximum pressure at the top of the wall and minimum pressure at its toe (i.e. an inverted triangular pressure distribution). The total pressure distribution (static plus seismic) may be determined as follows:

$$\sigma_h(d) = K_a \gamma d + (K_{AE} - K_a) \gamma (H\text{-}d), \text{ yielding walls}$$

$$\sigma_h(d) = K_o \gamma d + (K_{AE} - K_a) \gamma (H\text{-}d), \text{ non-yielding walls}$$

Where:	$\sigma_h(d)$	is the (static plus seismic) lateral earth pressure at depth, d, (kPa);
	K_a	is the static active earth pressure coefficient;
	K_o	is the static at-rest earth pressure coefficient;
	K_{AE}	is the seismic active earth pressure coefficient;
	γ	is the unit weight of the backfill soil (kN/m^3), as given previously;
	d	is the depth below the top of the wall (m); and,
	H	is the total height of the wall (m).

6.8 Approach Embankments

Based on the February 2019 General Arrangement (GA) Drawing provided by WSP, Highway 417 will not be widened at this location and the bridge structures are to be replaced in kind. It is understood, that the preferred replacement alternative involves the use of rapid bridge replacement (RBR) techniques.

As outlined in Section 4.2 in general, the subsurface conditions at the embankments and approaches consist of asphalt/concrete or topsoil surface cover, overlying fill materials, overlying native silt sand and a gravelly silty sand glacial till, all underlain by limestone bedrock.

6.8.1 Subgrade Preparation and Embankment Construction

Any surficial topsoil, organic matter, and softened/loosened soils or fill containing deleterious material or loose/weathered bedrock should be stripped/removed from within the limits of footprint bridge, including from the existing embankment side slopes and the new footprints. All subgrade soils should be proof-rolled prior to fill placement.

Any new embankment fills for the approach embankments should be placed and compacted in accordance with OPSS.PROV 206 *(Grading)* and OPSS.PROV 501 *(Compacting)*. Benching of the existing embankment side slopes should be carried out to “key in” the new fill materials in areas where the embankment is widened, in accordance with OPSD 208.010 *(Benching of Earth Slopes).*

To reduce erosion of the embankment side slopes due to surface water runoff, placement of topsoil and seeding or pegged sod is recommended as soon as practicable after construction of the embankments. The erosion protection should be in accordance with OPSS.PROV 804 *(Seed and Cover).*

6.8.2 Approach Embankment and Retaining Wall Stability

“Limit equilibrium” static and seismic (pseudo-static) slope stability analyses were carried out to assess the factor of safety against deep-seated global instability of the approach embankments using Slope/W commercial software and the Morgenstern-Price methodology. The results of the slope stability analysis are provided in Figures F1 and F2 in Appendix F.

With appropriate subgrade preparation and proper placement of earth or granular soils, the 6 to 7 m high approach embankments with 2H:1V side slopes, will have a factor of safety greater than 1.3 against deep seated slope instability and a factor of safety greater than 1.1 against deep-seated global instability under seismic loading, based on an acceleration of 0.13g (which corresponds to half the PGA, as per the CHBDC). The results do however indicate that some shallow sloughing (with factors of safety less than 1.1) could occur of the embankment side slopes during seismic loading. That sloughing would not however impair the short-term use of the structure and is mainly a maintenance/repair issue. The potential for sloughing could be reduced by providing well vegetated side slopes, as mentioned above in Section 6.6.1.

The following soil parameters were used in the stability analysis:

Table 13: Parameters used in Slope Stability Analysis

Material	Bulk Unit Weight (kN/m^3)	Internal Angle of Friction (ϕ°)
New Earth or Granular Embankment Fill	20	33
Existing Embankment Fill	20	33
Existing Grade Fill	19	30

Provided the new retaining walls are founded on the bedrock, then they would also have adequate factors of safety against deep seated slope instability for both static and seismic conditions.

6.9 Other Design Considerations

It has been confirmed by boreholes advanced through the abutment footings that these footings are founded on the bedrock. The available construction drawings indicate that the foundation for the retaining wall varies along the length of the walls, from strip footings dowelled into bedrock near the existing bridge location to spread footings supported on the native sand materials, to piled foundations at the east end of the wall (see reference drawing D5001-1 in Appendix C).it is likely that the existing footings for the retaining walls (up to the expansion joints) are founded on the bedrock, however, confirmation of the founding conditions in these areas is outside of the current scope of work.

6.10 Construction Considerations

6.10.1 Open-Cut Excavations

Excavations should be carried out in accordance with the guidelines outlined in the latest edition of the Occupational Health and Safety Act (OHSA) for Construction Activities.

Excavations to depths up to about 3.5 m below the existing Highway 417 grade through the existing fill. The groundwater levels at the abutments are indicated to be at about Elevations 67.8 m within the overburden, just above the bedrock surface (i.e., at or just above the founding level of the existing foundations).

The soils at this site would be generally classified as Type 3 soils (compact to loose fill material above groundwater level) in accordance with the OHSA. Accordingly, excavations should be made with side slopes no steeper than 1H:1V. Any fill which extends below the water table would be classified as Type 4 soil and excavations in these materials should be sloped no steeper than 3H:1V. As indicated in OHSA, if an excavation contains more than one type of soil, the soil type for the excavation shall be classified as the type with the highest number among the soil types present within the excavation.

6.10.2 Temporary Protection Systems

If the required safe side slopes for the open cut excavations cannot be accommodated, then temporary roadway protection (i.e., excavation shoring) will be required to facilitate excavation to the foundation level for the RBR. Temporary excavation support may also be required along Bronson Avenue for construction of the abutment footings due to space restrictions and existing utilities.

The design of the shoring will be entirely the responsibility of the contractor. Where required, temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 *(Temporary Protection Systems)*, and the lateral movement should meet Performance Level 2 provided that any existing adjacent utilities can tolerate this magnitude of deformation. Traffic loading should be included as a surcharge. Traffic loading above the shoring and does not account for construction equipment loadings which may be higher; the contractor’s shoring designer should confirm those load requirements.

Recommendations on suitable types of shoring can be provided once more details are known about the construction staging.

6.10.3 Groundwater and Surface Water Control

The groundwater level at the site is typically at or just below the bedrock surface. Excavations to expose the bedrock surface for founding of spread footings will likely involve minimal groundwater and surface water control. It should be possible to handle ground and surface water inflows by pumping from well filtered sumps established in the floor of the excavations.

6.10.4 Cement Type and Steel Corrosion Potential

A total of five soil samples were submitted to Eurofins Environment Testing for chemical analysis related to potential corrosion of exposed buried steel and potential sulphate attack on buried concrete elements (corrosion and sulphate attack). The test results are provided in Appendix D.

The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with soil and groundwater at the site. The sulphate results in Table 5 were compared with Table 3 of Canadian Standards Association Standards A23.1-14 (CSA A23.1) and generally indicate a low degree of sulphate attack potential on concrete structures at this site. Accordingly, GU cement could be specified for concrete in below grade applications.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. Generally, the test results provided in Table 5 indicate a very low to high potential for corrosion of exposed ferrous metal at the site which should be considered in the design.

7.0 CLOSURE

This report was prepared by Mr. Kenton Power, P.Eng. It was reviewed by Mr. Bill Cavers, P.Eng., a Senior geotechnical engineer and Associate of Golder. Mr. Fintan Heffernan, P.Eng. a Senior Consultant with Golder and the Designated MTO Foundations Contact for this project, carried out an independent quality control review of this report.

Golder Associates Ltd.

LICENSED PROFESSIONAL ENGINEER
K. T. C. POWER
100130652
2019/06/04
PROVINCE OF ONTARIO

Kenton C. Power, P.Eng, M.A.Sc.
Geotechnical Engineer

LICENSED PROFESSIONAL ENGINEER
W. CAVERS
100077934
2019/06/04
PROVINCE OF ONTARIO

William Cavers, P.Eng
Associate, Senior Geotechnical Engineer

F. J. Heffernan

REGISTERED PROFESSIONAL ENGINEER
F. J. HEFFERNAN
2019/06/04
PROVINCE OF ONTARIO

Fintan J. Heffernan, P.Eng.
Designated MTO Foundations Contact

KCP/WC/FJH/mvrd
https://golderassociates.sharepoint.com/sites/18579g/foundations/6 - reports/1130 bronson/final/1655214-1130-001-r-rev0-bronson ave bridge-06-2019_fidr.docx

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Table 14 – Comparison of Foundation Alternatives

Foundation Option	Feasibility	Advantages	Disadvantages	Relative Costs	Constructability/Risks
New cast-in-place or precast spread footings supported on existing spread footings	■ Feasible for support of the of the bridge replacement and rapid bridge replacement (RBR) technique ■ Preferred option from a foundation perspective	■ Avoids demolition and removal of existing foundations allowing reduced excavation support ■ Compatible with rapid bridge replacement (RBR) techniques ■ Facilitates shorter construction time compared to casting new footings	■ Structural design must counteract sliding of new footings on existing foundations ■ A levelling layer of grout will likely be required between the new and existing footings if precast footings are used	■ Low cost ■ Less expensive than deep foundations	■ Low risk of settlement; existing overpass structures have performed satisfactorily ■ Low to moderate risk of variation in elevation of top surface of existing footings and can be addressed through the use of a concrete levelling layer on top of footing
New cast-in-place or precast spread footings supported on bedrock	■ Feasible for support of the of the bridge replacement and rapid bridge replacement (RBR) technique	■ Conventional excavation and construction ■ Also compatible with RBR techniques but longer construction schedule would be required to accommodate the demolition of existing footings and construction of new footings in advance of rapid replacement.	■ Would require demolition and removal of existing footings, unless new footings are located behind existing with a longer bridge span length (which would increase structure costs) and would increase construction time ■ Deeper temporary protection required ■ Results in increased time for construction compared to incorporating existing foundations due to excavation, demolition/ removal, forming, reinforcing and casting stages	■ Moderate cost ■ Less expensive than deep foundations	■ Low risk of settlement; existing overpass structures have performed satisfactorily
Deep foundations	■ Feasible but not required or practical	■ High bearing resistance ■ Negligible settlement	■ Shallow bedrock depth would result lengths of less than 2 m which would likely require socketing into the strong limestone bedrock for a stable pile/caisson configuration	■ High cost, compared to other viable alternatives	■ Rock socketing would be required

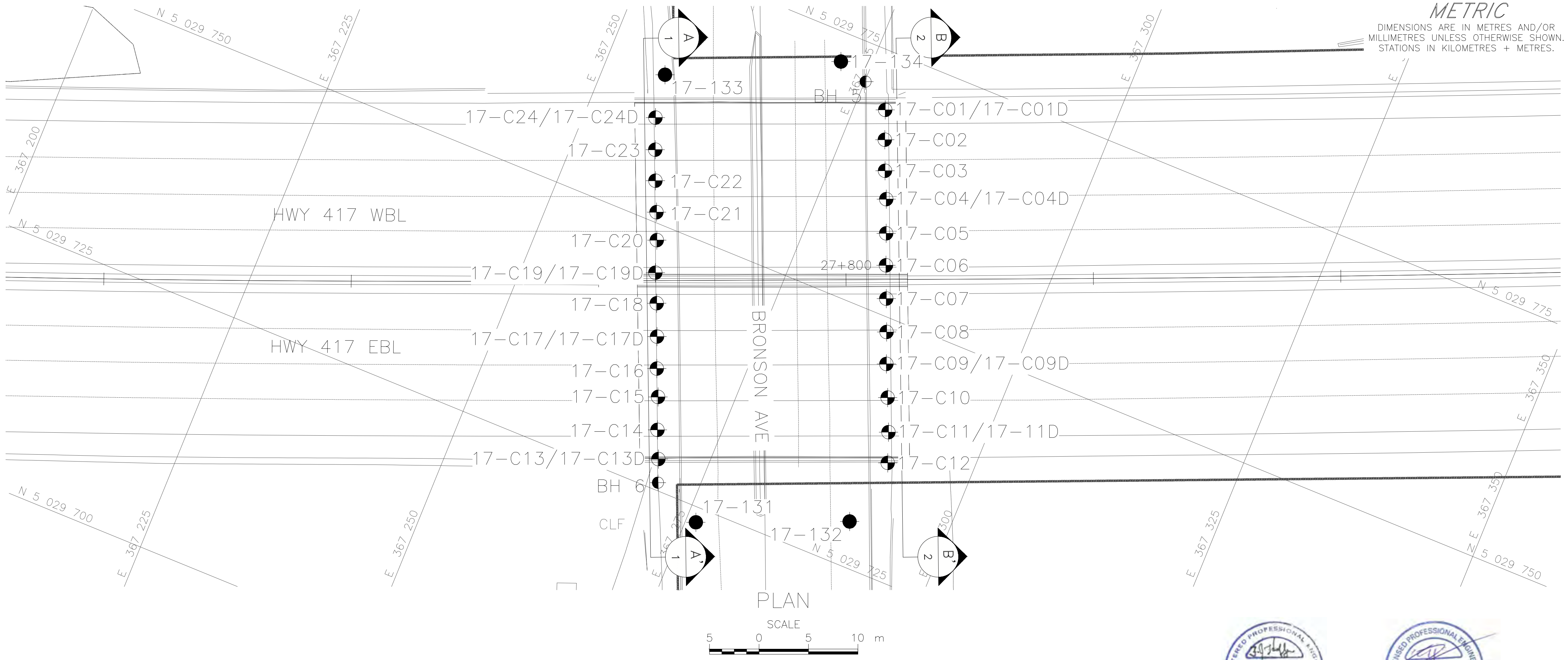
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 4173−15−00

HIGHWAY 417 OVERPASS STRUCTURE AT BRONSON AVENUE
BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.404900 LONG. −75.701935

SHEET

GOLDER



PLAN

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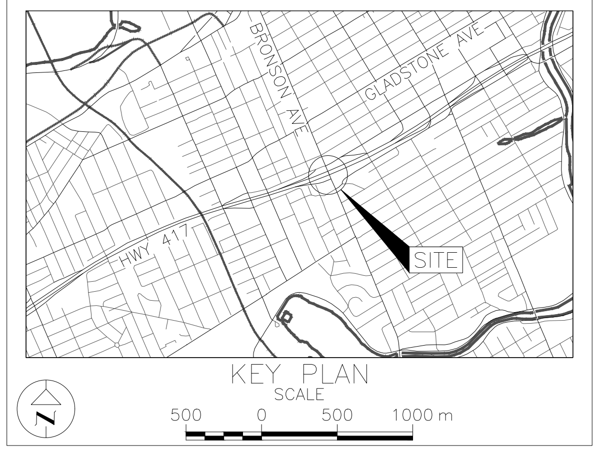
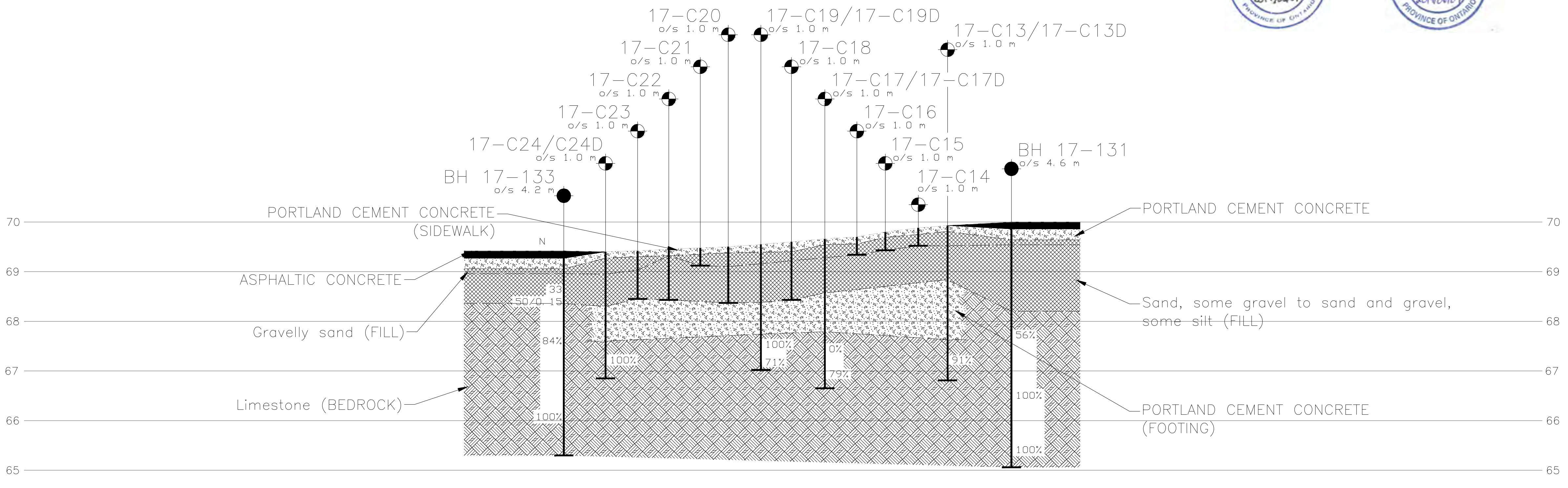


KEY PLAN

LEGEND

●	Borehole − Current Investigation
◐	Corehole − Current Investigation
◐	Borehole − Previous Investigation (Geocres No. 31G05−043)
→	Inclined Borehole Orientation
▮	Seal
▯	Piezometer
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
100%	Rock Quality Designation (RQD)



CROSS−SECTION A−A'

SCALE
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BOREHOLE CO−ORDINATES NAD83 (CSRS)/MTM ZONE 9			
No.	ELEVATION	NORTHING	EASTING
17−131	70.0	5029723.5	367276.0
17−132	70.1	5029729.5	367290.4
17−133	69.4	5029764.9	367258.1
17−134	69.3	5029772.1	367272.0
17−C01/C01D	69.5	5029769.3	367278.0
17−C02	69.5	5029766.5	367279.1
17−C03	69.5	5029763.6	367280.3
17−C04/C04D	69.5	5029761.0	367281.5
17−C05	69.5	5029757.8	367281.5
17−C06	69.5	5029754.8	367282.8
17−C07	69.6	5029751.7	367284.0
17−C08	69.7	5029748.6	367285.3
17−C09/C09D	69.8	5029745.6	367286.6
17−C10	69.8	5029742.5	367287.8
17−C11/C11D	69.9	5029739.3	367289.2
17−C12	69.9	5029736.4	367290.6
17−C13/C13D	69.9	5029728.0	367291.7 367270.1
17−C14	69.9	5029730.7	367268.9
17−C15	69.8	5029733.8	367267.7
17−C16	69.7	5029736.4	367266.5
17−C17/C17D	69.7	5029739.4	367265.3
17−C18	69.6	5029742.5	367264.0
17−C19/C19D	69.6	5029745.3	367262.7
17−C20	69.5	5029748.4	367261.6
17−C21	69.5	5029751.0	367260.5
17−C22	69.5	5029753.9	367259.2
17−C23	69.4	5029756.8	367258.0
17−C24/C24D	69.4	5029759.8	367256.8
5	69.4	5029771.1	367275.1
6	71.1	5029725.8	367271.0

NOTES

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

REFERENCE

Base plans provided in digital format by WSP Canada Group Limited, drawing file nos. MIDTOWN−XB1.dwg and 3416024−XA1−MEDIAN.dwg, received APR. 19, 2017.

NO.	DATE	BY	REVISION

Geocres No. 31G5−306

HWY. 417		PROJECT NO. 1655214−1130	DIST. EASTERN
SUBM'D. KP	CHKD. KP	DATE: 2/28/2019	SITE: 3−60/1&2
DRAWN: JM	CHKD. FJH	APPD. FJH	DWG. 1

PLOT DATE: June 4, 2019
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MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

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CONT No.
GWP No. 4173-15-00

SHEET

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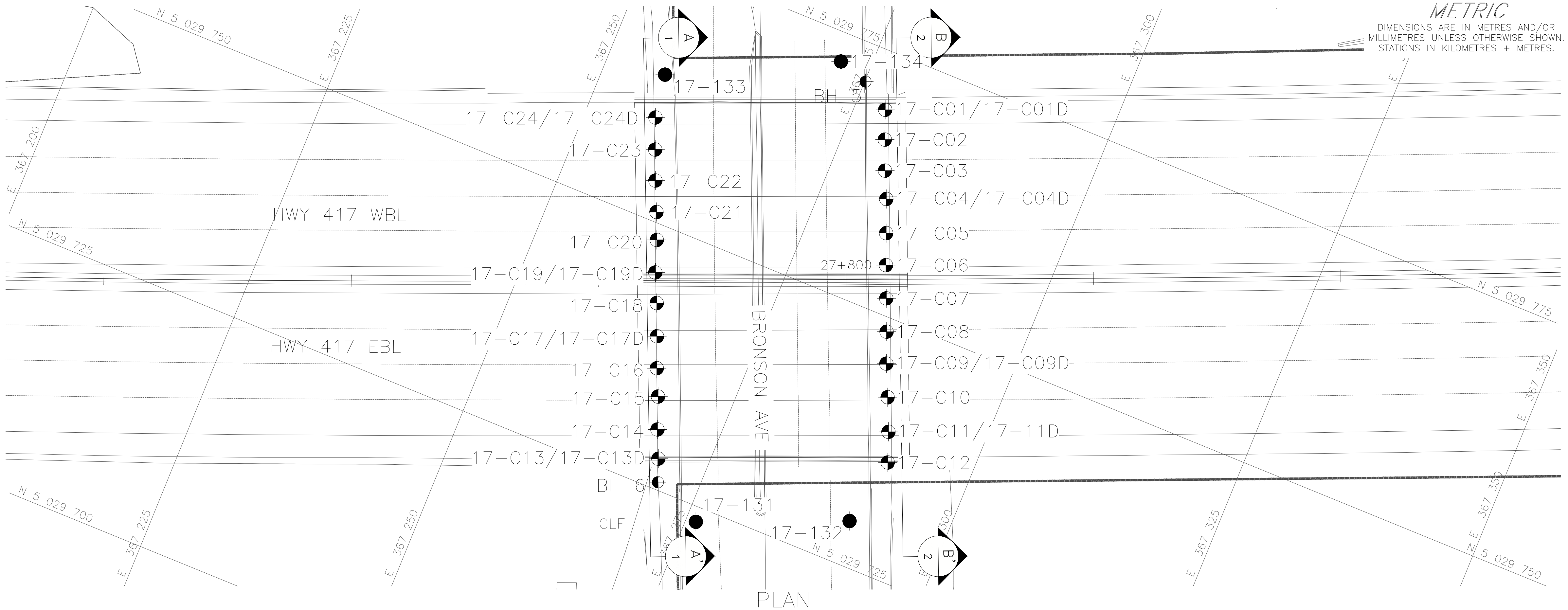
BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.404900 LONG. -75.701935

GOLDER



PLAN

SCALE
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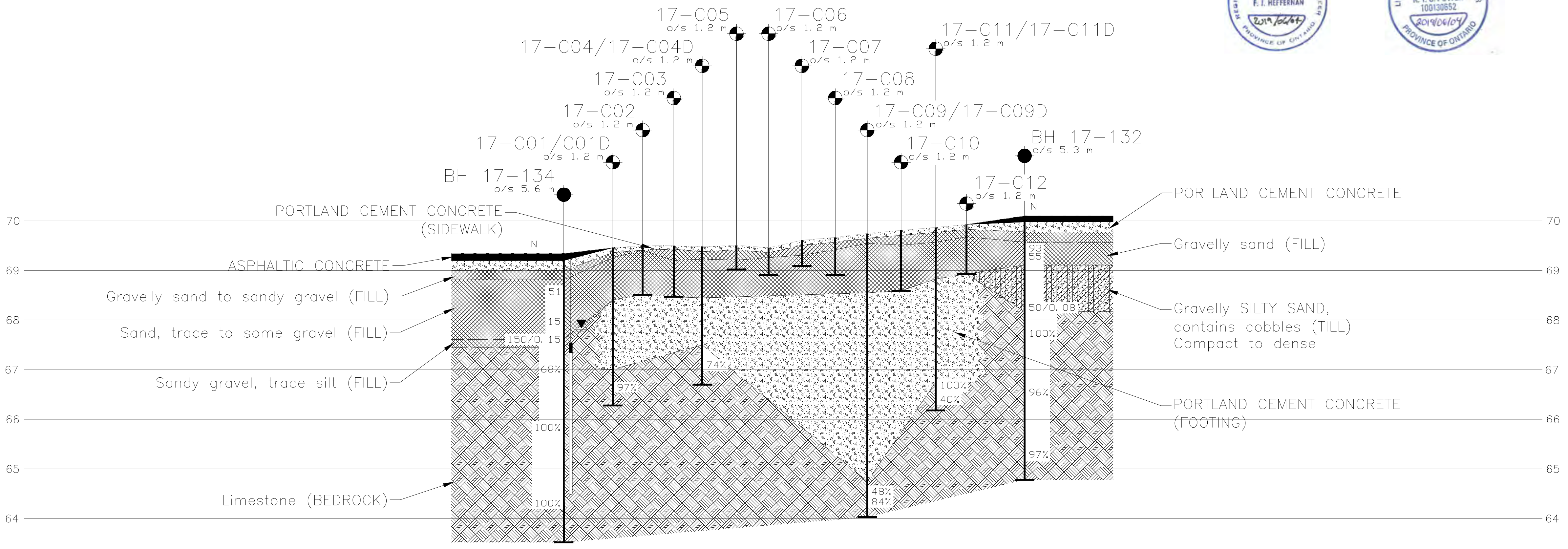
K. T. C. POWER 100130652 2019/06/04



CROSS-SECTION B-B'

SCALE
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1 0 1 2 m

KEY PLAN

SCALE
500 0 500 1000 m

LEGEND

●	Borehole – Current Investigation
◐	Corehole – Current Investigation
◐	Borehole – Previous Investigation (Geocres No. 31G05-043)
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▯	Piezometer
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
100%	Rock Quality Designation (RQD)
▼	WL in piezometer, measured on AUGUST 23, 2017

BOREHOLE CO-ORDINATES NAD83 (CSRS)/MTM ZONE 9

No.	ELEVATION	NORTHING	EASTING
17-131	70.0	5029723.5	367276.0
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17-C12	69.9	5029736.4	367290.6
17-C13/C13D	69.9	5029728.0	367291.7
17-C14	69.9	5029730.7	367270.1
17-C15	69.8	5029733.8	367268.9
17-C16	69.7	5029736.4	367267.7
17-C17/C17D	69.7	5029739.4	367266.5
17-C18	69.6	5029742.5	367265.3
17-C19/C19D	69.6	5029745.3	367264.0
17-C20	69.5	5029748.4	367262.7
17-C21	69.5	5029751.0	367261.6
17-C22	69.5	5029753.9	367260.5
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NO.	DATE	BY	REVISION

Geocres No. 31G5-306

HWY. 417		PROJECT NO. 1655214-1130	DIST. EASTERN
SUBM'D. KP	CHKD. KP	DATE: 2/28/2019	SITE: 3-60/1&2
DRAWN: JM	CHKD. FJH	APPD. FJH	DWG. 2

PLOT DATE: June 4, 2019
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MINISTRY OF TRANSPORTATION, ONTARIO

METRIC
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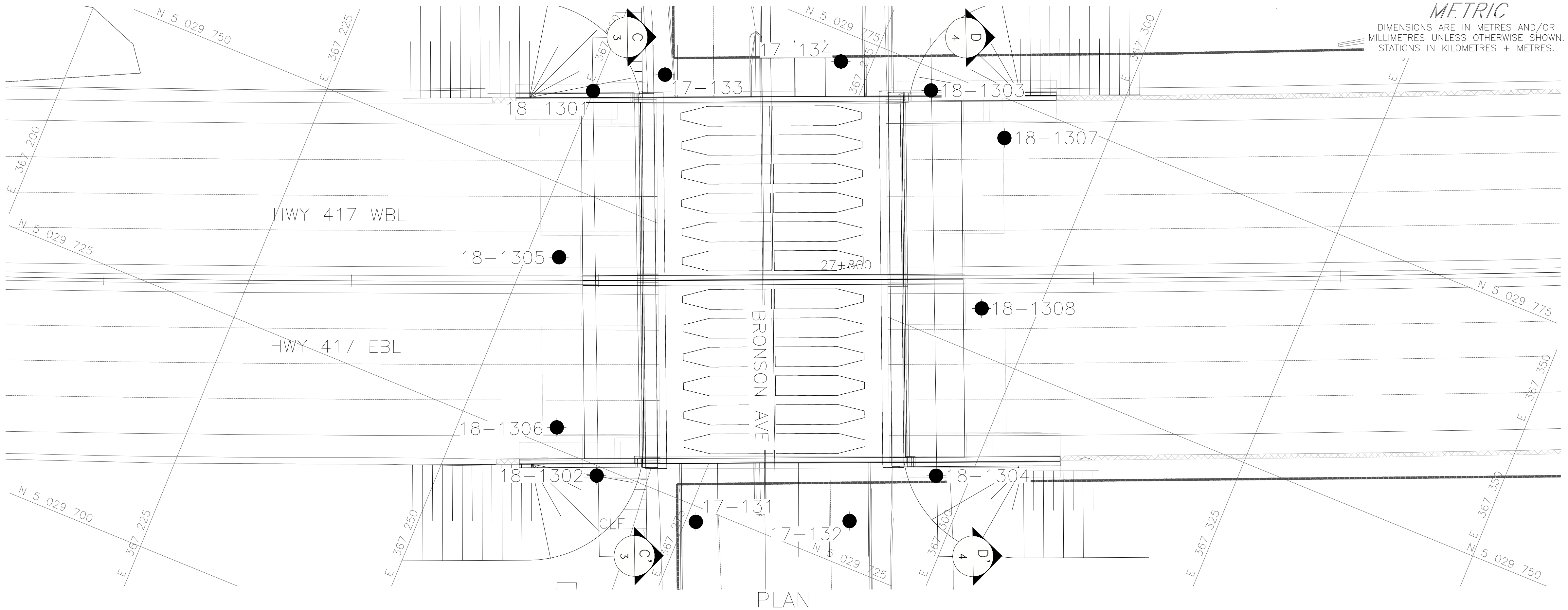
CONT No.
GWP No. 4173–15–00

HIGHWAY 417 OVERPASS
STRUCTURE AT BRONSON AVENUE
BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.404900 LONG. –75.701935

SHEET

GOLDER



PLAN

SCALE
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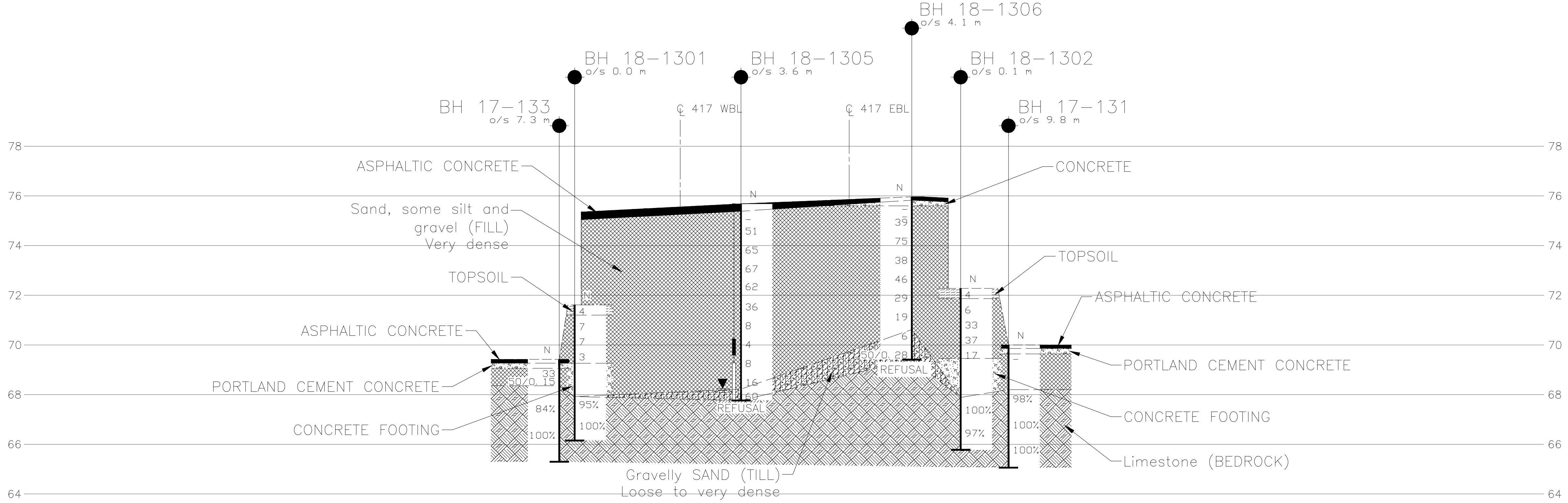
F. J. HEFFERNAN
2019/06/04

K. T. C. POWER
100130652
2019/06/04

KEY PLAN
SCALE
500 0 500 1000 m



CROSS–SECTION C–C'

SCALE
5 0 5 10 m
2 0 2 4 m

LEGEND

●	Borehole – Current Investigation
▮	Seal
▯	Piezometer
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
100%	Rock Quality Designation (RQD)
▼	WL in piezometer, measured on December 6, 2018
▽	WL upon completion of drilling

BOREHOLE CO–ORDINATES NAD83 (CSRS)/MTM ZONE 9

No.	ELEVATION	NORTHING	EASTING
17–131	70.0	5029723.5	367276.0
17–132	70.1	5029729.5	367290.4
17–133	69.4	5029764.2	367256.1
17–134	69.3	5029772.1	367272.0
18–1301	71.6	5029759.9	367250.0
18–1302	72.3	5029724.1	367265.0
18–1303	69.5	5029772.9	367281.5
18–1304	69.7	5029737.0	367296.7
18–1305	75.7	5029743.1	367253.1
18–1306	76.0	5029727.0	367259.4
18–1307	75.5	5029771.2	367290.2
18–1308	75.8	5029754.4	367294.6

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

REFERENCE

Base plans provided in digital format by WSP Canada Group Limited, drawing file no. S3416024–307–001GA–2.dwg, received MAY 17, 2019.

NO.	DATE	BY	REVISION

Geocres No. 31G5–306

HWY. 417		PROJECT NO. 1655214–1130	DIST. EASTERN
SUBM'D. KP	CHKD. KP	DATE: 2/28/2019	SITE: 3–60/1&2
DRAWN: JM	CHKD. FJH	APPD. FJH	DWG. 3

PLOT DATE: June 4, 2019
FILENAME: N:\Active\Spatial_IM\MTO\Hwy417Rehab&Widening\99_PROJ\1655214_MTO_Hwy417BridgeReplacement\40_PROD\Phase1130_Bronson\1655214–1130–BG–0003.dwg

MINISTRY OF TRANSPORTATION, ONTARIO

METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 4173-15-00

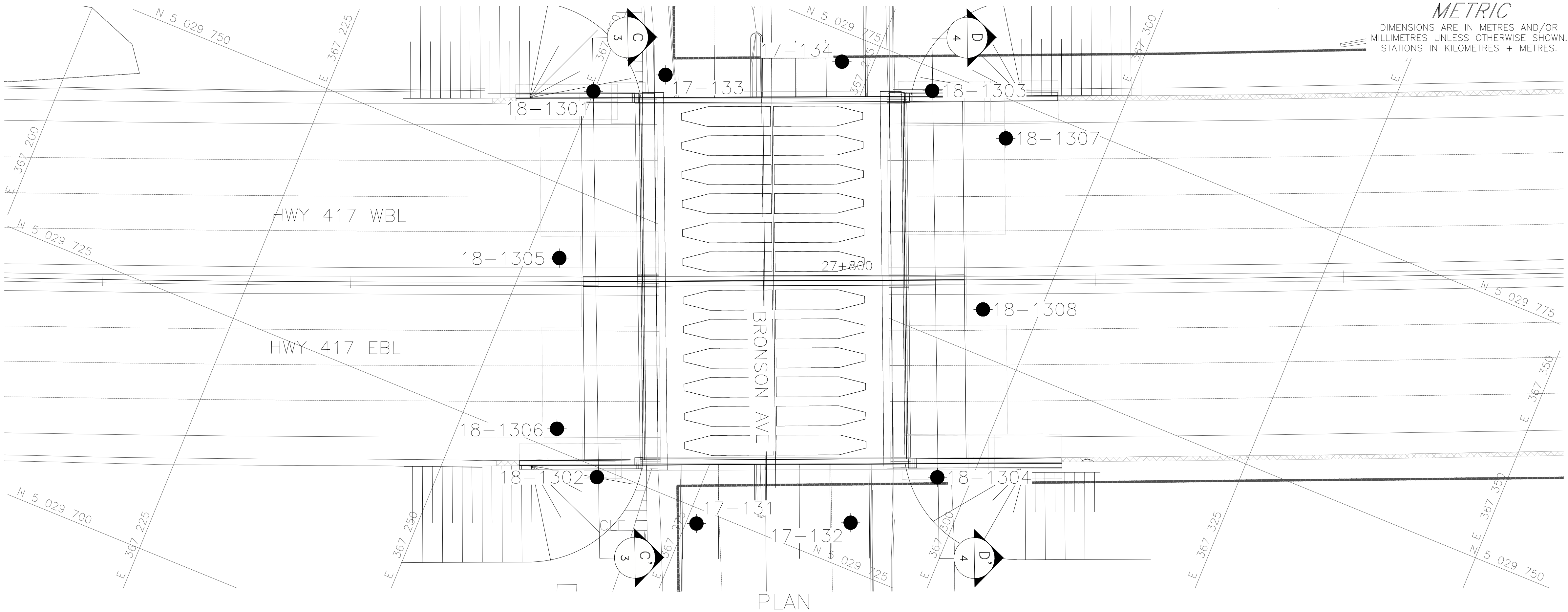
HIGHWAY 417 OVERPASS STRUCTURE AT BRONSON AVENUE

BOREHOLE LOCATIONS AND SOIL STRATA

LAT. 45.404900 LONG. -75.701935

SHEET

GOLDER

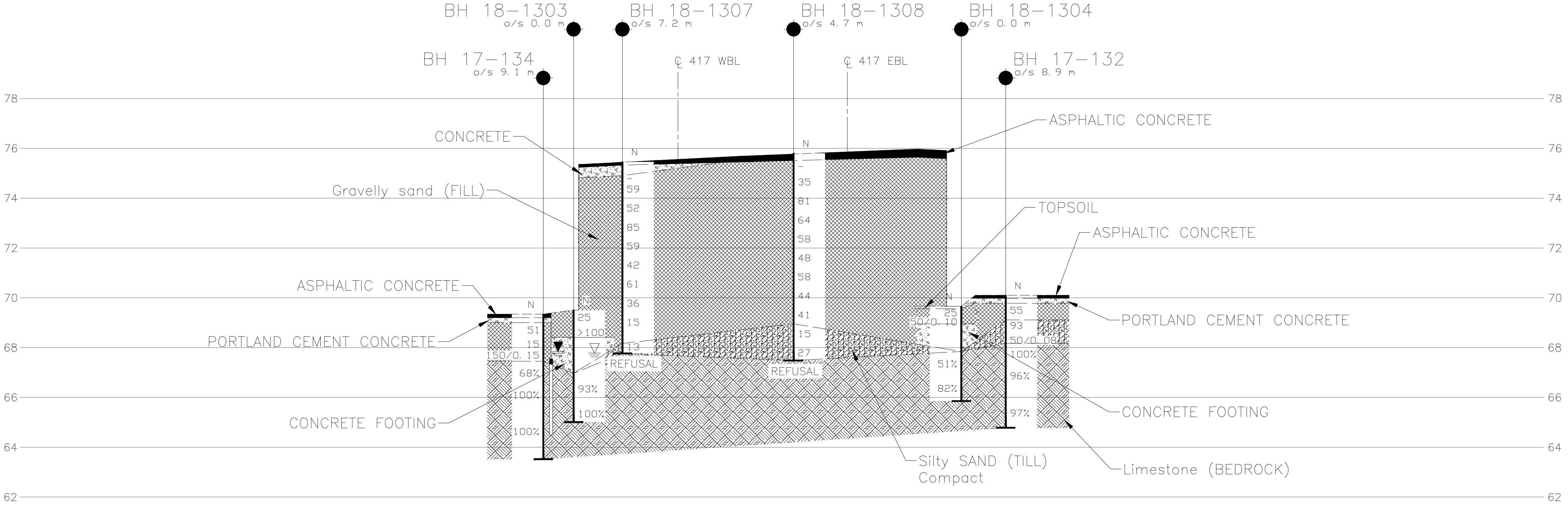


PLAN

SCALE
5 0 5 10 m

F. J. HEFFERNAN 2019/06/04

K. T. C. POWER 100130652 2019/06/04



CROSS-SECTION D-D'

SCALE
5 0 5 10 m
2 0 2 4 m

KEY PLAN
SCALE
500 0 500 1000 m

LEGEND

●	Borehole – Current Investigation
▮	Seal
▯	Piezometer
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
100%	Rock Quality Designation (RQD)
▼	WL in piezometer, measured on August 23, 2017
▽	WL upon completion of drilling

BOREHOLE CO-ORDINATES NAD83 (CSRS)/MTM ZONE 9

No.	ELEVATION	NORTHING	EASTING
17-131	70.0	5029723.5	367276.0
17-132	70.1	5029729.5	367290.4
17-133	69.4	5029764.2	367256.1
17-134	69.3	5029772.1	367272.0
18-1301	71.6	5029759.9	367250.0
18-1302	72.3	5029724.1	367265.0
18-1303	69.5	5029772.9	367281.5
18-1304	69.7	5029737.0	367296.7
18-1305	75.7	5029743.1	367253.1
18-1306	76.0	5029727.0	367259.4
18-1307	75.5	5029771.2	367290.2
18-1308	75.8	5029754.4	367294.6

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

REFERENCE

Base plans provided in digital format by WSP Canada Group Limited, drawing file no. S3416024-307-001GA-2.dwg, received MAY 7, 2019.

NO.	DATE	BY	REVISION

Geocres No. 31G5-306

HWY. 417		PROJECT NO. 1655214-1130	DIST. EASTERN
SUBM'D. KP	CHKD. KP	DATE: 2/28/2019	SITE: 3-60/1&2
DRAWN: JM	CHKD. FJH	APPD. FJH	DWG. 4

PLOT DATE: June 4, 2019
FILENAME: N:\Active\Spatial_IM\MTO\Hwy417Rehab&Widening\99_PROJ\1655214_MTO_Hwy417BridgeReplacement\40_PROD\Phase1130_Bronson\1655214-1130-BG-0004.dwg

MINISTRY OF TRANSPORTATION, ONTARIO

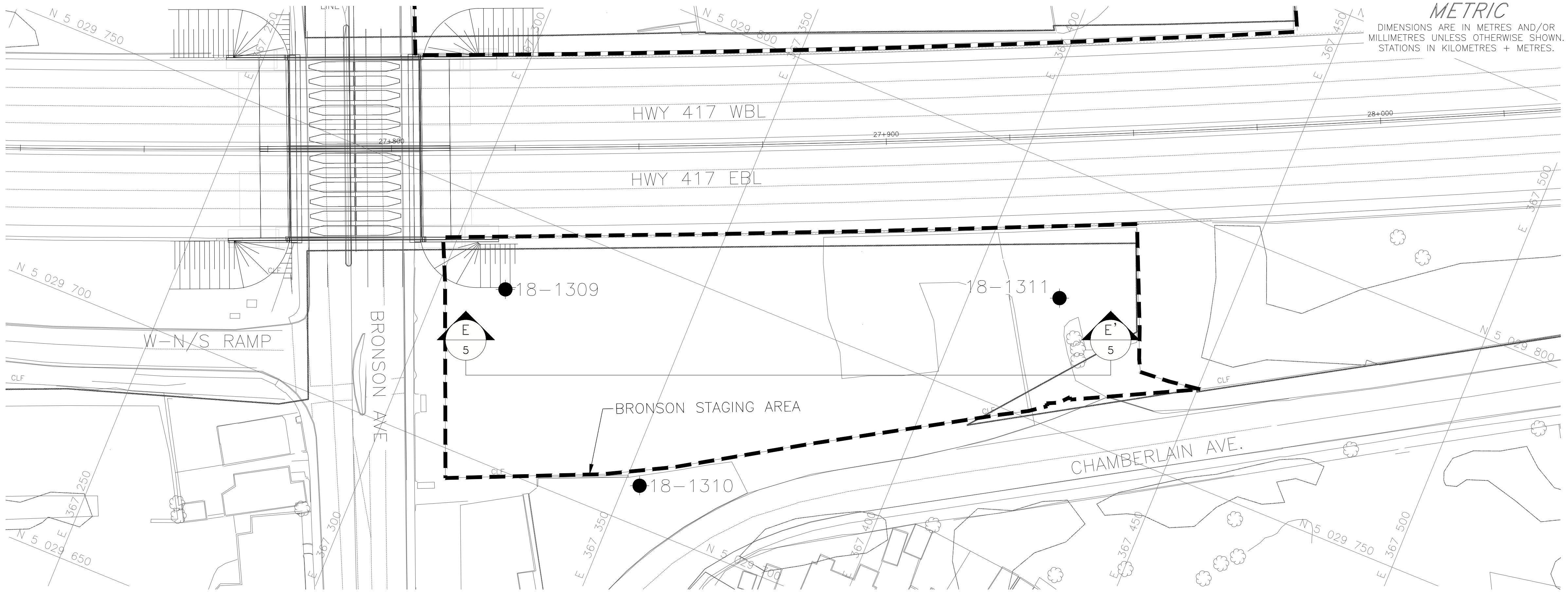
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 4173–15–00

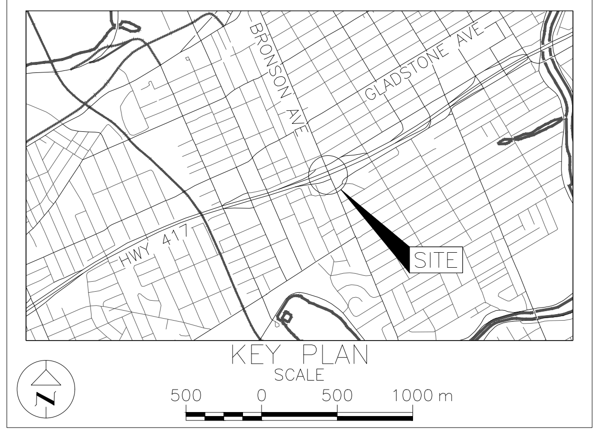
HIGHWAY 417 OVERPASS
STRUCTURE AT BRONSON AVENUE
STAGING AREA
BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.404786 LONG. –75.701075

SHEET

GOLDER



PLAN
SCALE
10 0 10 20 m



KEY PLAN
SCALE
500 0 500 1000 m

F. J. HEFFERNAN 2019/06/04

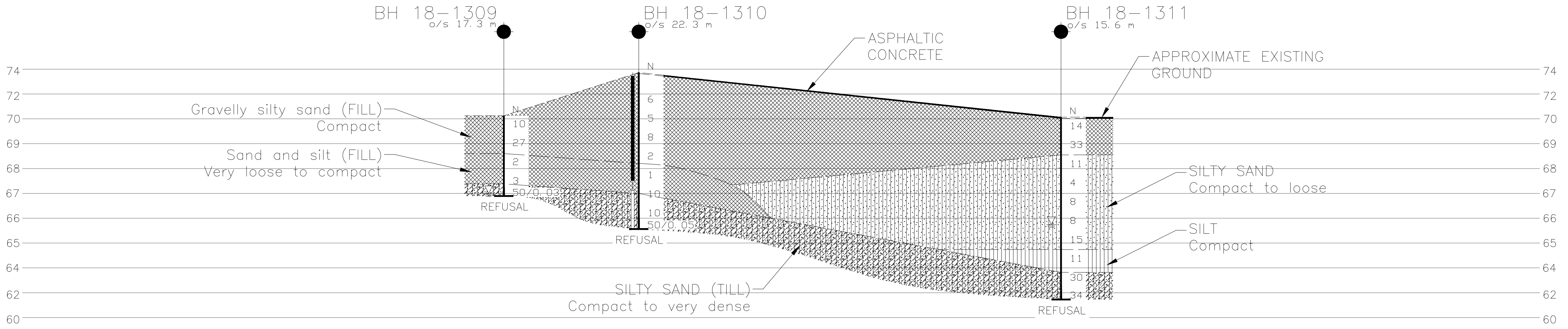
K. T. C. POWER 100130652 2019/06/04

LEGEND

●	Borehole – Current Investigation
▮	Seal
▯	Piezometer
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
100%	Rock Quality Designation (RQD)
▼	WL in piezometer, measured on December 6, 2018
▽	WL upon completion of drilling

BOREHOLE CO-ORDINATES NAD83 (CSRS)/MTM ZONE 9

No.	ELEVATION	NORTHING	EASTING
18–1309	70.1	5029734.2	367312.9
18–1310	71.9	5029707.8	367353.0
18–1311	70.1	5029774.9	367417.2



CROSS–SECTION E–E'
SCALE
10 0 10 20 m
2 0 2 4 m

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

REFERENCE

Base plans provided in digital format by WSP Canada Group Limited, drawing file no. S3416024–307–001GA.dwg, received MAY. 7, 2019.

NO.	DATE	BY	REVISION

Geocres No. 31G5–306

HWY. 417		PROJECT NO. 1655214–1130	DIST. EASTERN
SUBM'D. KP	CHKD. KP	DATE: 2/28/2019	SITE: 3–60/1&2
DRAWN: JM	CHKD. FJH	APPD. FJH	DWG. 5

PLOT DATE: June 4, 2019
FILENAME: N:\Active\Spatial_IM\MTO\Hwy417Rehab&Widening\99_PROJ\1655214_MTO_Hwy417BridgeReplacement\40_PROD\Phase1130_Bronson\1655214-1130-BG-0005.dwg

APPENDIX A

Record of Boreholes, Current Investigation
Lists of Abbreviations and Symbols
Lithological and Geotechnical Rock Description Terminology
Record of Coreholes/Drillholes 17-C01 to 17-C24
Records of Boreholes 17-131 to 17-134
Records of Boreholes 18-1301 to 18-1311
Bedrock Core Photographs, Figures A1 to A32
Table A1 - Concrete Core Condition Assessment

LIST OF SYMBOLS

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

I. GENERAL

π	3.1416
$\ln x$,	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson’s ratio
	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_3	principal stress (major, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

C	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

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

Notes: 1 $\tau = c' + \sigma' \tan\phi'$
2 shear strength = (compressive strength)/2

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

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d:

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60º cone attached to “A” size drill rods for a distance of 300 mm (12 in.).

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

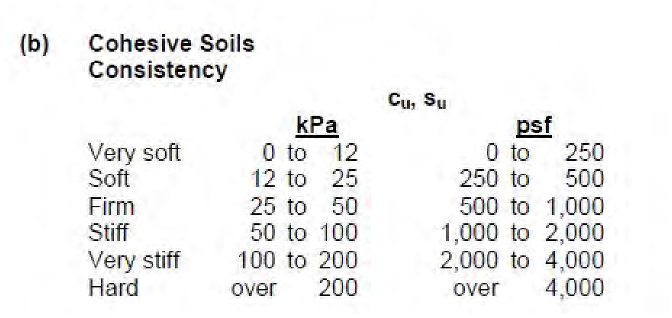
Piezo-Cone Penetration Test (CPT)

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

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Compactness Condition	N Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50



(b) Cohesive Soils

Consistency

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

IV. SOIL TESTS

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

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

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of weathering

Faintly weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 m to 2 m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	Less than 6 mm

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: * Grains greater than 60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, as measured along the centerline axis of the core, relative to the length of the total core run. RQD varies from 0% for completely broken core to 100% for core in solid segments.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

JN	Joint	PL	Planar
FLT	Fault	CU	Curved
SH	Shear	UN	Undulating
VN	Vein	IR	Irregular
FR	Fracture	K	Slickensided
SY	Stylolite	PO	Polished
BD	Bedding	SM	Smooth
FO	Foliation	SR	Slightly Rough
CO	Contact	RO	Rough
AXJ	Axial Joint	VR	Very Rough
KV	Karstic Void		
MB	Mechanical Break		

RECORD OF COREHOLE No 17-C01

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130
G.W.P. 4173-15-00
LOCATION N 5029769.3; E 367278.0 NAD 83 MTM ZONE 9 (LAT. 45.405082; LONG. -75.701882)
ORIGINATED BY PAH
DIST Eastern HWY 417
BOREHOLE TYPE Portable Drill/Hydro-excavation
COMPILED BY ZS
DATUM Geodetic
DATE July 31 to August 1, 2017
CHECKED BY KCP

SOIL PROFILE			SAMPLES											
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 + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
69.5	GROUND SURFACE													
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)													
69.4														
69.3 0.2	(SP/GP) Sand and gravel, trace silt (FILL) Grey Moist		1	GRAB	-				○		35	55	8	2
	(SP) Sand, some gravel (FILL) Brown Moist		2	GRAB	-		69							
68.5 1.1	END OF COREHOLE AT TOP OF FOOTING NOTES: 1. Corehole continued on Record of Drillhole 17-C01D.													

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

$\circ^{3\%}$ STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL_IM\MTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 6/6/19 JM

PROJECT: 1655214-1130

RECORD OF DRILLHOLE: 17-C01D

SHEET 1 OF 1

LOCATION: N 5029769.3 ;E 367278.0

DRILLING DATE: July 31 to August 1, 2017

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Drill

DRILLING CONTRACTOR: CCC

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 5 10 15 20	DISCONTINUITY DATA DIP w.r.t. CORE AXIS 0 30 60 90	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-6} 10^{-5} 10^{-4} 10^{-3}	WEATHERING INDEX W1 W2 W3 W4 W5 W6	FEATURES
		TOP OF FOOTING		68.45													
2	Portable Drill BQ Core	PORTLAND CEMENT CONCRETE (FOOTING)		1.01 67.01	C1												
3		Limestone (BEDROCK) Fresh Thinly to medium grained Grey Fine grained Non-porous Strong		2.45 66.28	C2												
		END OF DRILLHOLE		3.18													
4																	
5																	
6																	

DEPTH SCALE
1 : 25

GOLDER

LOGGED: PAH
CHECKED: KCP

GOLDER

Foundation Design

RECORD OF COREHOLE No 17-C02

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130

G.W.P. 4173-15-00

DIST Eastern HWY 417

DATUM Geodetic

LOCATION N 5029766.5; E 367279.1 NAD 83 MTM ZONE 9 (LAT. 45.405056; LONG. -75.701868)

BOREHOLE TYPE Portable Drill/Hydro-excavation

DATE July 28, 2017

ORIGINATED BY DG

COMPILED BY ZS

CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
69.4	GROUND SURFACE										
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)	▨									
69.3 0.1	(SP) Sand (FILL) Brown Moist	▨					69				
68.9 0.5	(SP) Sand, contains concrete fragments (FILL) Brown Moist	▨									
68.4 1.0	END OF COREHOLE AT TOP OF FOOTING										

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

○$^{3\%}$ STRAIN AT FAILURE

RECORD OF COREHOLE No 17-C03

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130
G.W.P. 4173-15-00
LOCATION N 5029763.6; E 367280.3 NAD 83 MTM ZONE 9 (LAT. 45.405030; LONG. -75.701853)
ORIGINATED BY DG
DIST Eastern HWY 417
BOREHOLE TYPE Portable Drill/Hydro-excavation
COMPILED BY ZS
DATUM Geodetic
DATE July 28, 2017
CHECKED BY KCP

SOIL PROFILE			SAMPLES								
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 + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
69.4	GROUND SURFACE										
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)										
0.1	(SP) Sand, some gravel (FILL) Grey Moist		1	GRAB	-						
69.1 0.3	(SP) Sand (FILL) Brown Moist						69				
			2	GRAB	-						
68.4 1.0	END OF COREHOLE AT TOP OF FOOTING										

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

RECORD OF COREHOLE No 17-C04

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130
G.W.P. 4173-15-00
DIST Eastern HWY 417
DATUM Geodetic
LOCATION N 5029761.0; E 367281.5 NAD 83 MTM ZONE 9 (LAT. 45.405007; LONG. -75.701838)
BOREHOLE TYPE Portable Drill/Hydro-excavation
DATE July 28, 2017
ORIGINATED BY PAH
COMPILED BY ZS
CHECKED BY KCP

SOIL PROFILE			SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L / WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				
69.5	GROUND SURFACE										
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)										
69.4 0.1	(SP) Gravelly sand (FILL) Grey Moist		1	GRAB	-						
69.3 0.3	(SP) Sand, some gravel (FILL) Brown Moist		2	GRAB	-		69				
68.4 1.1	END OF COREHOLE AT TOP OF FOOTING NOTES: 1. Corehole continued on Record of Drillhole 17-C04D.										

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

PROJECT: 1655214-1130

RECORD OF DRILLHOLE: 17-C04D

SHEET 1 OF 1

LOCATION: N 5029761.0 ;E 367281.5

DRILLING DATE: July 31, 2017

DATUM: Geodetic

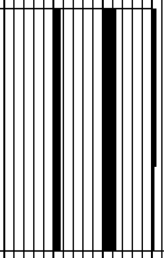
INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Drill

DRILLING CONTRACTOR: CCC

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 5 10 15 20	DISCONTINUITY DATA DIP w.r.t. CORE AXIS 0 30 60 90	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-6} 10^{-5} 10^{-4} 10^{-3}	WEATHERING INDEX W1 W2 W3 W4 W5 W6	FEATURES
		TOP OF FOOTING		68.43													
	Portable Drill BQ Core	PORTLAND CEMENT CONCRETE (FOOTING)		1.08 67.53	C1												
2		Limestone (BEDROCK) Fresh Thinly to medium bedded Grey Fine grained Non-porous Strong		1.98 66.73	C2												
		END OF DRILLHOLE		2.78													
3																	
4																	
5																	
6																	



DEPTH SCALE
1 : 25

GOLDER

LOGGED: PAH
CHECKED: KCP

RECORD OF COREHOLE No 17-C05

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130

G.W.P. 4173-15-00

LOCATION N 5029757.8; E 367282.8 NAD 83 MTM ZONE 9 (LAT. 45.404978; LONG. -75.701822)

ORIGINATED BY DG

DIST Eastern HWY 417

BOREHOLE TYPE Portable Drill/Hydro-excavation

COMPILED BY ZS

DATUM Geodetic

DATE July 28, 2017

CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
69.5	GROUND SURFACE										
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)										
69.4 0.1	(SP) Gravelly sand (FILL) Grey Moist										
69.2 0.3	(SP) Sand (FILL) Brown Moist										
69.0 0.5	END OF COREHOLE NOTES: 1. Refusal to hydro-excavation on conduit at 0.5 m below ground surface.										

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

$\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF COREHOLE No 17-C06

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130

G.W.P. 4173-15-00

DIST Eastern HWY 417

DATUM Geodetic

LOCATION N 5029754.8; E 367284.0 NAD 83 MTM ZONE 9 (LAT. 45.404951; LONG. -75.701807)

BOREHOLE TYPE Portable Drill/Hydro-excavation

DATE July 28, 2017

ORIGINATED BY DG

COMPILED BY ZS

CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
69.6	GROUND SURFACE										
0.0 69.5	PORTLAND CEMENT CONCRETE (SIDEWALK)										
69.4 0.2	(SP) Gravelly sand (FILL) Grey Moist										
	(SP) Sand (FILL) Brown Moist										
69.0 0.6	END OF COREHOLE NOTES: 1. Refusal to hydro-excavation on conduit at 0.6 m below ground surface.						69				

GTA-MTO 001 N:\ACTIVE\SPATIAL_IM\MTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 6/6/19 JM

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

$\bigcirc^{3\%}$ STRAIN AT FAILURE

RECORD OF COREHOLE No 17-C07

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130

G.W.P. 4173-15-00

LOCATION N 5029751.7; E 367285.3 NAD 83 MTM ZONE 9 (LAT. 45.404923; LONG. -75.701791)

ORIGINATED BY DG

DIST Eastern HWY 417

BOREHOLE TYPE Portable Drill/Hydro-excavation

COMPILED BY ZS

DATUM Geodetic

DATE July 28, 2017

CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
69.7	GROUND SURFACE										
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)	▒									
69.6 0.1	(SP) Gravelly sand (FILL) Grey Moist	▨	1	GRAB	-						
69.4 0.3	(SP) Sand (FILL) Brown Moist	▨									
69.2 0.5	END OF COREHOLE NOTES: 1. Refusal to hydro-excavation on conduit at 0.5 m below ground surface.										

GTA-MTO 001 N:\ACTIVE\SPATIAL_IM\MTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 6/6/19 JM

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

○ $^{3\%}$ STRAIN AT FAILURE

RECORD OF COREHOLE No 17-C08

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130

G.W.P. 4173-15-00

LOCATION N 5029748.6; E 367286.6 NAD 83 MTM ZONE 9 (LAT. 45.404895; LONG. -75.701775)

ORIGINATED BY DG

DIST Eastern HWY 417

BOREHOLE TYPE Portable Drill/Hydro-excavation

COMPILED BY ZS

DATUM Geodetic

DATE July 28, 2017

CHECKED BY KCP

SOIL PROFILE			SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				
69.7	GROUND SURFACE										
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)	░									
69.6 0.1	(SP) Gravelly sand (FILL) Grey Moist	▨									
69.5 0.3	(SP) Sand (FILL) Brown Moist	▨					69				
68.9 0.8	END OF COREHOLE NOTES: 1. Refusal to hydro-excavation on conduit at 0.8 m below ground surface.										

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

$\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF COREHOLE No 17-C09

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130
G.W.P. 4173-15-00
DIST Eastern HWY 417
DATUM Geodetic
LOCATION N 5029745.6; E 367287.8 NAD 83 MTM ZONE 9 (LAT. 45.404868; LONG. -75.701760)
BOREHOLE TYPE Portable Drill/Hydro-excavation
DATE July 27, 2017
ORIGINATED BY DG
COMPILED BY ZS
CHECKED BY KCP

SOIL PROFILE: ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED) 20 40 60 80 100	PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
69.8	GROUND SURFACE													
0.0 69.7	PORTLAND CEMENT CONCRETE (SIDEWALK)	▨												
69.6 0.2	(SP) Sand, some gravel (FILL) Grey Moist	▨	1	GRAB	-				○		14	81	4	1
	(SP) Sand, some gravel, trace silt (FILL) Brown Moist	▨	2	GRAB	-		69							
68.7 1.1	END OF COREHOLE AT TOP OF FOOTING NOTES: 1. Corehole continued on Record of Drillhole 17-C09D.													

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

○ $^{3\%}$ STRAIN AT FAILURE

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PROJECT: 1655214-1130

RECORD OF DRILLHOLE: 17-C09D

SHEET 1 OF 1

LOCATION: N 5029745.6 ;E 367287.8

DRILLING DATE: July 30 to 31, 2017

DATUM: Geodetic

INCLINATION: -78° AZIMUTH:

DRILL RIG: Portable Drill

DRILLING CONTRACTOR: CCC

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 5 10 15 20	DIP w.r.t. CORE AXIS 0 30 60 90	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-6} 10^{-5} 10^{-4} 10^{-3}	WEATHERING INDEX W1 W2 W3 W4 W5 W6	FEATURES
		TOP OF FOOTING	68.72 1.08													
2 3 4 5	Wash Boring NW Casing	REINFORCED PORTLAND CEMENT CONCRETE (FOOTING)		C1 C2 C3 C4 C5												
		Limestone (BEDROCK), with shale interbeds Thinly bedded Grey Medium strong	64.77 5.11	C5 C6	85 75											
6		END OF DRILLHOLE	64.22 5.68													

DEPTH SCALE

1 : 25

GOLDER

LOGGED: KM

CHECKED: KCP

RECORD OF COREHOLE No 17-C10

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130
G.W.P. 4173-15-00
DIST Eastern HWY 417
DATUM Geodetic

LOCATION N 5029742.5; E 367289.2 NAD 83 MTM ZONE 9 (LAT. 45.404840; LONG. -75.701742)
BOREHOLE TYPE Portable Drill/Hydro-excavation
DATE July 27, 2017

ORIGINATED BY DG
COMPILED BY ZS
CHECKED BY KCP

SOIL PROFILE			SAMPLES								
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 + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
69.8	GROUND SURFACE										
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)										
69.7 0.1	(SP) Gravelly sand (FILL) Grey Moist		1	GRAB	-						
69.5 0.3	(SP) Sand, trace gravel (FILL) Brown Moist										
			2	GRAB	-		69				
68.6 1.2	END OF COREHOLE AT TOP OF FOOTING										

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

$\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF COREHOLE No 17-C11

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130

G.W.P. 4173-15-00

LOCATION N 5029739.3; E 367290.6 NAD 83 MTM ZONE 9 (LAT. 45.404811; LONG. -75.701725)

ORIGINATED BY DG

DIST Eastern HWY 417

BOREHOLE TYPE Portable Drill/Hydro-excavation

COMPILED BY ZS

DATUM Geodetic

DATE July 27, 2017

CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
69.9	GROUND SURFACE										
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)										
69.8 0.1	(SP) Gravelly sand (FILL) Grey Moist	▨									
69.6 0.3	(SP) Sand (FILL) Brown Moist	▨					69				
68.9 1.0	END OF COREHOLE AT TOP OF FOOTING NOTES: 1. Corehole continued on Record of Drillhole 17-C11D.										

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

$\bigcirc^{3\%}$ STRAIN AT FAILURE

PROJECT: 1655214-1130

RECORD OF DRILLHOLE: 17-C11D

SHEET 1 OF 1

LOCATION: N 5029739.3 ;E 367290.6

DRILLING DATE: July 28, 2017

DATUM: Geodetic

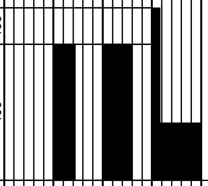
DRILL RIG: Portable Drill

INCLINATION: -90° AZIMUTH: ---

DRILLING CONTRACTOR: CCC

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA DIP w.r.t. CORE AXIS	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec	WEATH-ERING INDEX	FEATURES
		TOP OF FOOTING		68.86													
	Portable Drill NW Casing	PORTLAND CEMENT CONCRETE (FOOTING)		1.04	C1												
2					C2												
3				66.78													
		Limestone (BEDROCK), with black shale interbeds Slightly weathered Thinly to medium bedded Grey Fine grained Porous Strong		3.12	2	100											
					3	100											
		END OF DRILLHOLE		66.21 3.69													
4																	
5																	
6																	



DEPTH SCALE
1 : 25

GOLDER

LOGGED: DG
CHECKED: KCP

GOLDER

PROJECT 1655214-1130

RECORD OF COREHOLE No 17-C12

SHEET 1 OF 1

METRIC

G.W.P. 4173-15-00

LOCATION N 5029736.4; E 367291.7 NAD 83 MTM ZONE 9 (LAT. 45.404784; LONG. -75.701711)

ORIGINATED BY DG

DIST Eastern HWY 417

BOREHOLE TYPE Portable Drill/Hydro-excavation

COMPILED BY ZS

DATUM Geodetic

DATE July 27, 2017

CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT w LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR	SA	SI	CL
70.0	GROUND SURFACE													
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)	░												
69.9 0.1	(SP) Gravelly sand (FILL) Grey Moist	▨	1	GRAB	-									
69.8 0.3	(SP) Sand, trace gravel (FILL) Brown Moist	▨	2	GRAB	-									
69.0 1.0	END OF COREHOLE AT TOP OF FOOTING						69							

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

RECORD OF COREHOLE No 17-C13

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130

G.W.P. 4173-15-00

DIST Eastern HWY 417

DATUM Geodetic

LOCATION N 5029728.0; E 367270.1 NAD 83 MTM ZONE 9 (LAT. 45.404711; LONG. -75.701988)

BOREHOLE TYPE Portable Drill/Hydro-excavation

DATE July 20, 2017

ORIGINATED BY DG

COMPILED BY ZS

CHECKED BY KCP

ELEV DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
70.0	GROUND SURFACE													
0.0 69.9	PORTLAND CEMENT CONCRETE (SIDEWALK)													
0.1 69.6	(SP) Gravelly sand, trace silt (FILL) Grey Moist		1	GRAB	-				○		57	34	8	1
0.4 68.8	(SM/GM) Sand and gravel, some silt (FILL) Brown Moist		2	GRAB	-		69							
1.2	END OF COREHOLE AT TOP OF FOOTING NOTES: 1. Corehole continued on Record of Drillhole 17-C13D.													

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

PROJECT: 1655214-1130

RECORD OF DRILLHOLE: 17-C13D

SHEET 1 OF 1

LOCATION: N 5029728.0 ;E 367270.1

DRILLING DATE: July 24, 2017

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Drill

DRILLING CONTRACTOR: CCC

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 5 10 15 20	DISCONTINUITY DATA DIP w.r.t. CORE AXIS 0 30 60 90	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-6} 10^{-5} 10^{-4} 10^{-3}	WEATHERING INDEX W1 W2 W3 W4 W5 W6	FEATURES
		TOP OF FOOTING		68.81													
	Portable Drill NW Casing	PORTLAND CEMENT CONCRETE (FOOTING)		1.16	C1												
2				67.67													
		Limestone (BEDROCK), with black shale interbeds Thinly to thickly bedded Grey Fine grained Porous Strong		2.30	C2	100											
3				66.85													
		END OF DRILLHOLE		3.12													
4																	
5																	
6																	

GTA-RCK 031 N:\ACTIVE\SPATIAL_IM\MTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 6/6/19 JM

DEPTH SCALE
1 : 25

GOLDER

LOGGED: DG
CHECKED: KCP

RECORD OF COREHOLE No 17-C14

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130

G.W.P. 4173-15-00

LOCATION N 5029730.7; E 367268.9 NAD 83 MTM ZONE 9 (LAT. 45.404735; LONG. -75.702003)

ORIGINATED BY DG

DIST Eastern HWY 417

BOREHOLE TYPE Portable Drill/Hydro-excavation

COMPILED BY ZS

DATUM Geodetic

DATE July 20, 2017

CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
69.9	GROUND SURFACE										
0.0 69.8	PORTLAND CEMENT CONCRETE (SIDEWALK)										
0.1 69.5	(SP) Gravelly sand (FILL) Grey Moist										
0.4	END OF COREHOLE NOTES: 1. Refusal to hydro-excavation on conduit at 0.4 m below ground surface.										

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

$\bigcirc^{3\%}$ STRAIN AT FAILURE

RECORD OF COREHOLE No 17-C15

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130

G.W.P. 4173-15-00

LOCATION N 5029733.8; E 367267.7 NAD 83 MTM ZONE 9 (LAT. 45.404763; LONG. -75.702018)

ORIGINATED BY DG

DIST Eastern HWY 417

BOREHOLE TYPE Portable Drill/Hydro-excavation

COMPILED BY ZS

DATUM Geodetic

DATE July 20, 2017

CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR	SA	SI	CL
69.8	GROUND SURFACE													
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)	▨												
69.7 0.1	(SP) Sand, some gravel (FILL) Grey Moist	▨	1	GRAB	-									
69.4 0.4	END OF COREHOLE AT NOTES: 1. Refusal to hydro-excavation on conduit at 0.4 m below ground surface.													

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

$\circ^{3\%}$ STRAIN AT FAILURE

PROJECT 1655214-1130	**RECORD OF COREHOLE No 17-C16** SHEET 1 OF 1		**METRIC**
G.W.P. 4173-15-00	LOCATION N 5029736.4; E 367266.5 NAD 83 MTM ZONE 9 (LAT. 45.404787; LONG. -75.702033)		ORIGINATED BY DG
DIST Eastern HWY 417	BOREHOLE TYPE Portable Drill/Hydro-excavation		COMPILED BY ZS
DATUM Geodetic	DATE July 20, 2017		CHECKED BY KCP

SOIL PROFILE			SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				
69.8	GROUND SURFACE										
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)										
69.7 0.1	(SP) Gravelly sand (FILL) Grey Moist	▨									
69.4 0.4	END OF COREHOLE NOTES: 1. Refusal to hydro-excavation on conduit at 0.4 m below ground surface.										

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

GTA-MTO 001 N:\ACTIVE\SPATIAL_IM\MTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 6/6/19 JM

RECORD OF COREHOLE No 17-C17

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130

G.W.P. 4173-15-00

DIST Eastern HWY 417

DATUM Geodetic

LOCATION N 5029739.4; E 367265.3 NAD 83 MTM ZONE 9 (LAT. 45.404814; LONG. -75.702048)

BOREHOLE TYPE Portable Drill/Hydro-excavation

DATE July 20, 2017

ORIGINATED BY DG

COMPILED BY ZS

CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
69.7	GROUND SURFACE										
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)										
69.6 0.1	(SP) Gravelly sand (FILL) Grey Moist		1	GRAB	-						
69.3 0.4	(SP) Sand (FILL) Brown Moist		2	GRAB	-						
							69				
68.6 1.1	END OF COREHOLE AT TOP OF FOOTING NOTES: 1. Corehole continued on Record of Drillhole 17-C17D.										

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

$\circ^{3\%}$ STRAIN AT FAILURE

PROJECT: 1655214-1130

RECORD OF DRILLHOLE: 17-C17D

SHEET 1 OF 1

LOCATION: N 5029739.4 ;E 367265.3

DRILLING DATE: July 23, 2017

DATUM: Geodetic

DRILL RIG: Portable Drill

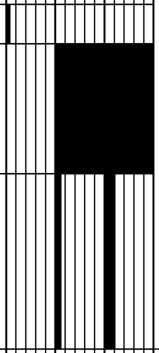
INCLINATION: -90° AZIMUTH: ---

DRILLING CONTRACTOR: CCC

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN
		TOP OF FOOTING		68.60		
	Portable Drill NW Casing	PORTLAND CEMENT CONCRETE (FOOTING)	▨	1.09	C1	
				67.82		
2		Limestone (BEDROCK), with black shale interbeds Slightly weathered to fresh Thinly to thickly bedded Grey Fine grained Strong	▨	1.87	C1 C2 C3	
3				66.68		
		END OF DRILLHOLE		3.01		
4						
5						
6						

RECOVERY: TOTAL CORE % (80 60 40 20), SOLID CORE % (80 60 40 20) | R.Q.D. % (80 60 40 20) | FRACT. INDEX PER (5 10 15 20) | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS (0 30 60 90), TYPE AND SURFACE DESCRIPTION, Jr, Ja | HYDRAULIC CONDUCTIVITY K, cm/sec (10^{-6} 10^{-5} 10^{-4} 10^{-3}) | WEATH-ERING INDEX (W1 W2 W3 W4 W5 W6) | FEATURES



GTA-RCK 031 N:\ACTIVE\SPATIAL_IM\MTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 6/6/19 JM

DEPTH SCALE
1 : 25

GOLDER

LOGGED: DG
CHECKED: KCP

RECORD OF COREHOLE No 17-C18

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130

G.W.P. 4173-15-00

LOCATION N 5029742.5; E 367264.0 NAD 83 MTM ZONE 9 (LAT. 45.404842; LONG. -75.702064)

ORIGINATED BY DG

DIST Eastern HWY 417

BOREHOLE TYPE Portable Drill/Hydro-excavation

COMPILED BY ZS

DATUM Geodetic

DATE July 20, 2017

CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
69.6	GROUND SURFACE										
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)										
69.4 0.2	(SP) Gravelly sand (FILL) Grey Moist	▨	1	GRAB	-						
69.2 0.4	(SP) Sand (FILL) Brown Moist	▨					69				
68.4 1.2	END OF COREHOLE AT TOP OF FOOTING										

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

○ $^{3\%}$ STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL_IM\MTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 6/6/19 JM

RECORD OF COREHOLE No 17-C19

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130

G.W.P. 4173-15-00

LOCATION N 5029745.3; E 367262.7 NAD 83 MTM ZONE 9 (LAT. 45.404867; LONG. -75.702081)

ORIGINATED BY DG

DIST Eastern HWY 417

BOREHOLE TYPE Portable Drill/Hydro-excavation

COMPILED BY ZS

DATUM Geodetic

DATE July 20, 2017

CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR	SA	SI	CL
69.6	GROUND SURFACE													
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)	▨												
69.4 0.2	(SP) Gravelly sand (FILL) Grey Moist	▨	1	GRAB	-									
69.2 0.4	(SP-SM) Sand, trace silt (FILL) Brown Moist	▨					69							
		▨	2	GRAB	-				○		1	91	6	2
68.4 1.2	END OF COREHOLE AT TOP OF FOOTING NOTES: 1. Probable wood formwork encountered at 1.1 m below ground surface. 2. Corehole continued on Record of Drillhole 17-C19D.													

GTA-MTO 001 N:\ACTIVE\SPATIAL_IM\MTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 6/6/19 JM

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

$\circ^{3\%}$ STRAIN AT FAILURE

PROJECT: 1655214-1130

RECORD OF DRILLHOLE: 17-C19D

SHEET 1 OF 1

LOCATION: N 5029745.3 ;E 367262.7

DRILLING DATE: July 20 to 21, 2017

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Drill

DRILLING CONTRACTOR: CCC

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE % (80 60 40 20)	RECOVERY SOLID CORE % (80 60 40 20)	R.Q.D. % (80 60 40 20)	FRACT. INDEX PER (5 10 15 20)	DIP w.r.t. CORE AXIS (0 30 60 90)	TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WEATHERING INDEX (W1 W2 W3 W4 W5 W6)	FEATURES
		TOP OF FOOTING	68.42													
	Portable Drill NQ Core	PORTLAND CEMENT CONCRETE (FOOTING)	1.20 67.81	C1												
2		Limestone (BEDROCK) Slightly weathered to fresh Thinly to medium bedded Grey Fine grained Non-porous Strong	1.81	C2	100											
			67.09	C3	100											
		END OF DRILLHOLE	2.53													
3																
4																
5																
6																

DEPTH SCALE
1 : 25

GOLDER

LOGGED: DG
CHECKED: KCP

RECORD OF COREHOLE No 17-C20

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130
G.W.P. 4173-15-00
LOCATION N 5029748.4; E 367261.6 NAD 83 MTM ZONE 9 (LAT. 45.404895; LONG. -75.702094)
ORIGINATED BY DG
DIST Eastern HWY 417
BOREHOLE TYPE Portable Drill/Hydro-excavation
COMPILED BY ZS
DATUM Geodetic
DATE July 19, 2017
CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
69.6	GROUND SURFACE										
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)										
69.5 0.1	(SP) Gravelly Sand (FILL) Brown Moist		1	GRAB	-						
69.2 0.4	(SP) Sand (FILL) Brown Moist		2	GRAB	-		69				
68.5 1.1	END OF COREHOLE NOTES: 1. Refusal to hydro-excavation on probable wood formwork encountered at 1.1 m below ground surface.										

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

$\circ^{3\%}$ STRAIN AT FAILURE

PROJECT 1655214-1130

RECORD OF COREHOLE No 17-C21

SHEET 1 OF 1

METRIC

G.W.P. 4173-15-00

LOCATION N 5029751.0; E 367260.5 NAD 83 MTM ZONE 9 (LAT. 45.404919; LONG. -75.702108)

ORIGINATED BY DG

DIST Eastern HWY 417

BOREHOLE TYPE Portable Drill/Hydro-excavation

COMPILED BY ZS

DATUM Geodetic

DATE July 19, 2017

CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
69.5	GROUND SURFACE										
0.0 69.4	PORTLAND CEMENT CONCRETE (SIDEWALK)	⁘									
0.1 69.1	(SP) Sand (FILL) Brown Moist	▨									
0.4	END OF COREHOLE NOTES: 1. Refusal to hydro-excavation on conduit at 0.4 m below ground surface.										

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

○$^{3\%}$ STRAIN AT FAILURE

GOLDER

Foundation Design

RECORD OF COREHOLE No 17-C22

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130

G.W.P. 4173-15-00

LOCATION N 5029753.9; E 367259.2 NAD 83 MTM ZONE 9 (LAT. 45.404945; LONG. -75.702124)

ORIGINATED BY DG

DIST Eastern HWY 417

BOREHOLE TYPE Portable Drill/Hydro-excavation

COMPILED BY ZS

DATUM Geodetic

DATE July 19, 2017

CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
69.5	GROUND SURFACE										
0.0 69.4	PORTLAND CEMENT CONCRETE (SIDEWALK)										
0.1	(SP) Sand (FILL) Brown Moist		1	GRAB	-						
							69				
68.5 1.0	END OF COREHOLE AT TOP OF FOOTING										

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

$\circ^{3\%}$ STRAIN AT FAILURE

GOLDER

Foundation Design

RECORD OF COREHOLE No 17-C23

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130

G.W.P. 4173-15-00

LOCATION N 5029756.8; E 367258.0 NAD 83 MTM ZONE 9 (LAT. 45.404971; LONG. -75.702139)

ORIGINATED BY DG

DIST Eastern HWY 417

BOREHOLE TYPE Portable Drill/Hydro-excavation

COMPILED BY ZS

DATUM Geodetic

DATE July 19, 2017

CHECKED BY KCP

SOIL PROFILE			SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				
69.5	GROUND SURFACE										
0.0 69.4	PORTLAND CEMENT CONCRETE (SIDEWALK)										
0.1	(SP) Gravelly sand (FILL) Grey Moist		1	GRAB	-						
69.1 0.4	(SP) Sand (FILL) Brown Moist						69				
68.5 1.0	END OF COREHOLE NOTES: 1. Refusal to hydro-excavation on probable wood formwork encountered at 1.0 m below ground surface.										

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

$○^{3\%}$ STRAIN AT FAILURE

PROJECT 1655214-1130

RECORD OF COREHOLE No 17-C24

SHEET 1 OF 1

METRIC

G.W.P. 4173-15-00

LOCATION N 5029759.8; E 367256.8 NAD 83 MTM ZONE 9 (LAT. 45.404998; LONG. -75.702154)

ORIGINATED BY DG

DIST Eastern HWY 417

BOREHOLE TYPE Portable Drill/Hydro-excavation

COMPILED BY ZS

DATUM Geodetic

DATE July 19, 2017

CHECKED BY KCP

SOIL PROFILE			SAMPLES								
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 + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
69.5	GROUND SURFACE										
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)										
69.4 0.1	(SP) Gravelly Sand (FILL) Grey Moist	▨	1	GRAB	-						
69.1 0.5	(SP) Sand (FILL) Brown Moist	▨	2	GRAB	-		69				
68.5 1.0	END OF COREHOLE AT TOP OF FOOTING NOTES: 1. Probable wood formwork encountered at 1.0 m below ground surface. 2. Corehole continued on Record of Drillhole 17-C24D.										

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

$\circ^{3\%}$ STRAIN AT FAILURE

PROJECT: 1655214-1130

RECORD OF DRILLHOLE: 17-C24D

SHEET 1 OF 1

LOCATION: N 5029759.8 ;E 367256.8

DRILLING DATE: July 20, 2017

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Drill

DRILLING CONTRACTOR: CCC

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec	WEATH-ERING INDEX	FEATURES
		TOP OF FOOTING	68.42													
	Portable Drill NQ Core	PORTLAND CEMENT CONCRETE (FOOTING)	1.04	C1												
			67.69	C2												
2		Limestone (BEDROCK) Fresh Thinly to medium bedded Grey Fine grained Non-porous Strong	1.77 66.94	C2	100											
3 4 5 6		END OF DRILLHOLE	2.52													

DEPTH SCALE
1 : 25

GOLDER

LOGGED: DG
CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IM\MTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 6/6/19 JM

RECORD OF BOREHOLE No 17-131

SHEET 1 OF 2

METRIC

PROJECT 1655214-1130

G.W.P. 4173-15-00

LOCATION N 5029723.5; E 367276.0 NAD 83 MTM ZONE 9 (LAT. 45.404670; LONG. -75.701913)

ORIGINATED BY PAH

DIST Eastern HWY 417

BOREHOLE TYPE Hydro-excavation/NQ Core

COMPILED BY ZS

DATUM Geodetic

DATE August 7, 2017

CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
70.0	GROUND SURFACE										
0.0	ASPHALTIC CONCRETE										
69.6 0.5	PORTLAND CEMENT CONCRETE										
	(SP-SM) Gravelly sand (FILL) Grey										
69.1 0.9	(SP-SM) Sand, trace silt (FILL) Brown		1	GRAB	-				○		1 91 6 2
68.2 1.8	(SM/GMP) Sand and gravel, some silt, contains limestone fragments, cobbles and boulders Brown Moist						69				
	Limestone (BEDROCK) Bedrock cored from depths 1.8 m to 4.9 m For bedrock coring details refer to Record of Drillhole 17-131		C1	RC	REC 98%		68				RQD = 56%
			C2	RC	REC 100%		67 66				RQD = 100%
65.1 4.9			C3	RC	REC 100%					UCS = 54 MPa	RQD = 100%
	END OF BOREHOLE										

GTA-MTO 001 N:\ACTIVE\SPATIAL_IM\MTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 6/6/19 JM

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

$○^{3\%}$ STRAIN AT FAILURE

PROJECT: 1655214-1130

RECORD OF DRILLHOLE: 17-131

SHEET 2 OF 2

LOCATION: N 5029723.5 ;E 367276.0

DRILLING DATE: August 7, 2017

DATUM: Geodetic

DRILL RIG: CME 75

INCLINATION: -90° AZIMUTH: ---

DRILLING CONTRACTOR: CCC

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 5 10 15 20	DISCONTINUITY DATA DIP w.r.t. CORE AXIS 0 30 60 90	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-6} 10^{-5} 10^{-4} 10^{-3}	WEATH-ERING INDEX W1 W2 W3 W4 W5 W6	FEATURES
		Continued from Record of Borehole 17-131		68.20													
2	Rotary Drill NQ Core	Limestone (BEDROCK), with black shale partings Slightly weathered to fresh Thinly to medium bedded Grey Fine grained Non-porous Strong		1.80	C1	100											
3					C2	100											
4				65.06	C3	100											
5		END OF DRILLHOLE		4.94													
6																	
7																	
8																	
9																	
10																	
11																	

GTA-RCK 031 N:\ACTIVE\SPATIAL_IM\MTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 6/6/19 JM

DEPTH SCALE
1 : 50

GOLDER

LOGGED: PAH
CHECKED: KCP

RECORD OF BOREHOLE No 17-132

SHEET 1 OF 2

METRIC

PROJECT 1655214-1130

G.W.P. 4173-15-00

LOCATION N 5029729.5; E 367290.4 NAD 83 MTM ZONE 9 (LAT. 45.404722; LONG. -75.701729)

ORIGINATED BY PAH

DIST Eastern HWY 417

BOREHOLE TYPE Wash Boring, NW Casing/NQ Core

COMPILED BY ZS

DATUM Geodetic

DATE August 3 to 4, 2017

CHECKED BY KCP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES						
70.1	GROUND SURFACE					70				
0.0	ASPHALTIC CONCRETE									
69.8	PORTLAND CEMENT CONCRETE									
69.6 0.5	(SP) Gravelly sand (FILL) Grey Moist	1	SS	55						
69.1 1.0	(SP) Sand, trace gravel (FILL) Dense Brown Moist	2	SS	93		69				
	(SM) Gravelly Silty SAND, contains cobbles (TILL) Very dense Brown Moist to wet	3	SS	50/0.08						
68.2 1.9	Limestone (BEDROCK) Bedrock cored from depths 1.9 m to 5.3 m For bedrock coring details refer to Record of Drillhole 17-132	C1	RC	REC 100%		68				RQD = 100%
		C2	RC	REC 100%		67 66				RQD = 96%
		C3	RC	REC 100%		65				RQD = 97%
64.8 5.3	END OF BOREHOLE									

GTA-MTO 001 N:\ACTIVE\SPATIAL_IM\MTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 6/6/19 JM

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

$\bigcirc^{3\%}$ STRAIN AT FAILURE

PROJECT: 1655214-1130

RECORD OF DRILLHOLE: 17-132

SHEET 2 OF 2

LOCATION: N 5029729.5 ;E 367290.4

DRILLING DATE: August 3 to 4, 2017

DATUM: Geodetic

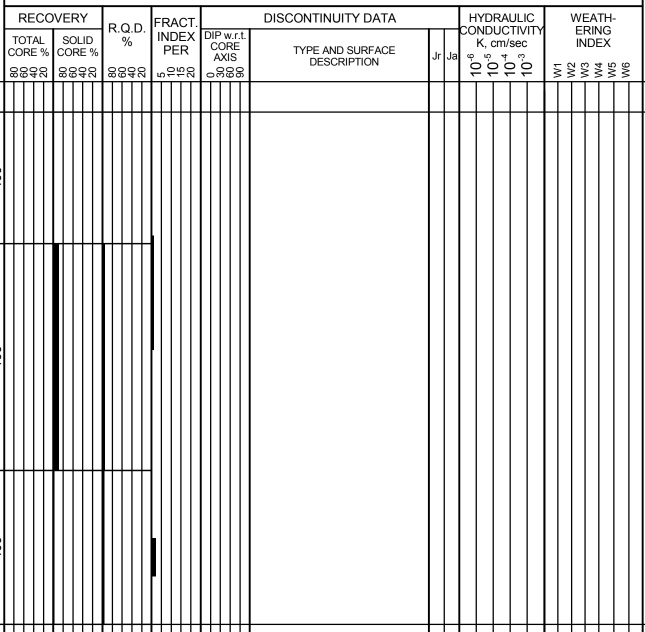
DRILL RIG: CME 75

INCLINATION: -90° AZIMUTH: ---

DRILLING CONTRACTOR: CCC

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN
		Continued from Record of Borehole 17-132		68.17		
2	Rotary Drill NQ Core	Limestone (BEDROCK), with black shale partings Fresh Thinly to medium bedded Grey Fine grained Non-porous Strong		1.93	C1	100
3						
					C2	100
4						
5					C3	100
				64.78		
		END OF DRILLHOLE		5.32		
6						
7						
8						
9						
10						
11						



FEATURES

DEPTH SCALE
1 : 50

GOLDER

LOGGED: PAH
CHECKED: KCP

RECORD OF BOREHOLE No 17-133

SHEET 1 OF 2

METRIC

PROJECT 1655214-1130
G.W.P. 4173-15-00
LOCATION N 5029764.9; E 367258.1 NAD 83 MTM ZONE 9 (LAT. 45.405044; LONG. -75.702136)
ORIGINATED BY PAH
DIST Eastern HWY 417
BOREHOLE TYPE Wash Boring, NW Casing/NQ Core
COMPILED BY ZS
DATUM Geodetic
DATE August 7 to 8 2017
CHECKED BY KCP

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED: 20 40 60 80 100
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%): 25 50 75

SOIL PROFILE: ELEV DEPTH	SOIL PROFILE: DESCRIPTION	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
69.4	GROUND SURFACE								
0.0	ASPHALTIC CONCRETE								
69.0 0.5	PORTLAND CEMENT CONCRETE					69			
	(SP) Gravelly sand (FILL) Grey (SM) Sand, some gravel and silt (FILL) Dense Brown Moist	1	SS	33			○		9 76 12 3
68.5 1.1	(SP/GP) Sand and gravel (FILL) Grey brown Wet	2	SS	50/0.15					
	Limestone (BEDROCK) Bedrock cored from depths 1.1 m to 4.1 m For bedrock coring details refer to Record of Drillhole 17-133	C1	RC	REC 100%		68 67			RQD = 84%
		C2	RC	REC 100%		66			RQD = 100%
65.3 4.1	END OF BOREHOLE								

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

PROJECT: 1655214-1130

RECORD OF DRILLHOLE: 17-133

SHEET 2 OF 2

LOCATION: N 5029764.9 ;E 367258.1

DRILLING DATE: August 7 to 8 2017

DATUM: Geodetic

DRILL RIG: CME 75

INCLINATION: -90° AZIMUTH: ---

DRILLING CONTRACTOR: CCC

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 5 10 15 20	DISCONTINUITY DATA DIP w.r.t. CORE AXIS 0 30 60 90	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-6} 10^{-5} 10^{-4} 10^{-3}	WEATHERING INDEX W1 W2 W3 W4 W5 W6	FEATURES
		Continued from Record of Borehole 17-133		68.36													
	Rotary Drill NQ Core	Limestone (BEDROCK), with black shale partings Fresh Grey Thinly to medium bedded Fine grained Non-porous Strong		1.06	C1	100											
					C2	100											
				65.30 4.12													
		END OF DRILLHOLE															

DEPTH SCALE

1 : 50

GOLDER

LOGGED: PAH

CHECKED: KCP

RECORD OF BOREHOLE No 17-134

SHEET 1 OF 2

METRIC

PROJECT 1655214-1130

G.W.P. 4173-15-00

LOCATION N 5029772.1; E 367272.0 NAD 83 MTM ZONE 9 (LAT. 45.405108; LONG. -75.701958)

ORIGINATED BY PAH

DIST Eastern HWY 417

BOREHOLE TYPE Portable Drill/NQ Core

COMPILED BY ZS

DATUM Geodetic

DATE August 1 and 3, 2017

CHECKED BY KCP

ELEV DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLES – NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
69.3	GROUND SURFACE						
0.0	ASPHALTIC CONCRETE						
69.0	PORTLAND CEMENT CONCRETE				69		
68.8	(SP) Gravelly sand (FILL) Grey						
0.5	(SP) Sand, trace gravel (FILL) Very dense to compact Brown Moist	1	SS	51			
		2	SS	15	68		
		3	SS	150/0.15			
67.6 1.9	(GM) Sandy gravel, some silt (FILL) Grey brown						
	Limestone (BEDROCK) Bedrock cored from depths 1.9 m to 5.8 m For bedrock coring details refer to Record of Drillhole 17-134	C1	RC	REC 100%	67		RQD = 68%
		C2	RC	REC 100%	66 65	UCS = 63 MPa	RQD = 100%
		C3	RC	REC 100%	64		RQD = 100%
63.5 5.8	END OF BOREHOLE						

NOTES:

1. Water level in well screen at a depth of 1.5 m below ground surface (Elev. 67.8 m), measured on August 23, 2017.

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

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

PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L

WATER CONTENT (%) 25 50 75

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

$\bigcirc^{3\%}$ STRAIN AT FAILURE

PROJECT: 1655214-1130

RECORD OF DRILLHOLE: 17-134

SHEET 2 OF 2

LOCATION: N 5029772.1 ;E 367272.0

DRILLING DATE: August 1 and 3, 2017

DATUM: Geodetic

DRILL RIG: Portable Drill

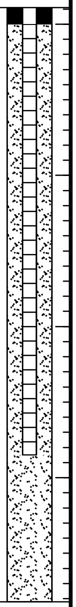
INCLINATION: -90° AZIMUTH: ---

DRILLING CONTRACTOR: CCC

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN
		Continued from Record of Borehole 17-134			
2	Rotary Drill NQ Core	Limestone (BEDROCK), with black shale partings Fresh Thinly to medium bedded Grey Fine grained Non-porous Strong	67.45 1.89	C1	100
3				C2	100
4					
5			63.52 5.82	C3	100
6		END OF DRILLHOLE			
7					
8					
9					
10					
11					

RECOVERY: TOTAL CORE % / SOLID CORE %; R.Q.D. %; FRACT. INDEX PER; DISCONTINUITY DATA: DIP w.r.t. CORE AXIS, TYPE AND SURFACE DESCRIPTION, Jr, Ja; HYDRAULIC CONDUCTIVITY K, cm/sec; WEATHERING INDEX W1–W6; FEATURES



DEPTH SCALE
1 : 50

GOLDER

LOGGED: PAH
CHECKED: KCP

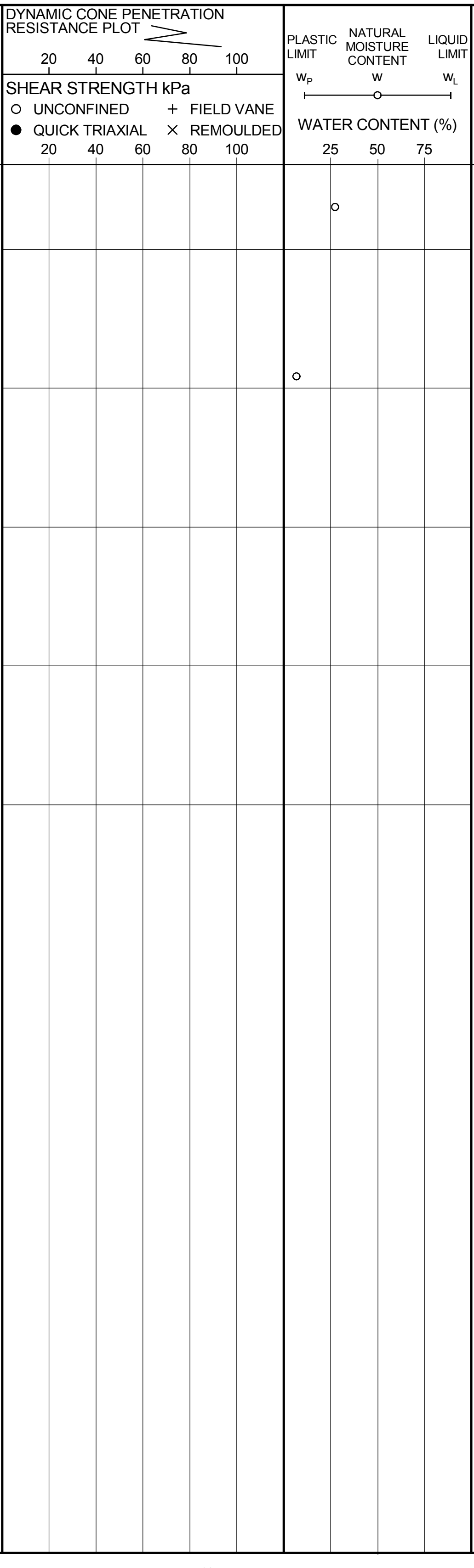
RECORD OF BOREHOLE No 18-1301

SHEET 1 OF 2

METRIC

PROJECT 1655214-1130
G.W.P. 4173-15-00
DIST Eastern HWY 417
DATUM Geodetic
LOCATION N 5029759.9; E 367250.0 NAD 83 MTM ZONE 9 (LAT. 45.404990; LONG. -75.702240)
BOREHOLE TYPE Portable Rotary Drill, BW Casing/AW Rod
DATE November 20 to 21, 2018
ORIGINATED BY RI
COMPILED BY ZS
CHECKED BY KCP

SOIL PROFILE			SAMPLES						REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
71.6	GROUND SURFACE											
0.0	(SM) Silty sand, contains organic matter (rootlets) (TOPSOIL) Very loose Brown Moist		1	SS	4							
71.2 0.4	(SP-SM) Sand, trace gravel, contains thin seams of silty sand (FILL) Brown Moist		2	SS	7		71					
			3	SS	7		70		5	84	(11)	
			4	SS	3							
69.3 2.4	CONCRETE (FOOTING)		1A	RC	-		69 68					
67.9 3.7	Limestone (BEDROCK) Bedrock cored from depths 3.7 m to 5.5 m For bedrock coring details refer to Record of Drillhole 18-1301		1B	RC	REC 95%				RQD = 76%			
			2	RC	REC 100%		67		RQD = 97%			
66.1 5.5	END OF BOREHOLE NOTES: 1. Manual third weight hammer used for all split spoon samples. "N" values are not representative of ASTM D1586 SPT N values and should be interpreted in consideration of their reduced energy.											



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

○$^{3\%}$ STRAIN AT FAILURE

PROJECT: 1655214-1130

RECORD OF DRILLHOLE: 18-1301

SHEET 2 OF 2

LOCATION: N 5029759.9 ;E 367250.0

DRILLING DATE: November 20 to 21, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable

DRILLING CONTRACTOR: CCC Drilling

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 5 10 15 20	DISCONTINUITY DATA DIP w.r.t. CORE AXIS 0 30 60 90	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-6} 10^{-5} 10^{-4} 10^{-3}	WEATH-ERING INDEX W1 W2 W3 W4 W5 W6	FEATURES
		Continued from Record of Borehole 18-1301	69.26													
3	Rotary Drill AW Rod	CONCRETE (FOOTING)	2.35 67.92	1A												
4 5		Shaley nodular Limestone (BEDROCK) Fresh Thinly to medium bedded Grey to dark grey Fine to medium grained Non-porous Slightly to moderately fossiliferous Medium strong	3.69 66.15	1B 2	100-0 0											
6 7 8 9 10 11 12		END OF DRILLHOLE	5.46													

DEPTH SCALE

1 : 50

GOLDER

LOGGED: RI

CHECKED: KCP

RECORD OF BOREHOLE No 18-1302

SHEET 1 OF 2

METRIC

PROJECT 1655214-1130
G.W.P. 4173-15-00
DIST Eastern HWY 417
DATUM Geodetic
LOCATION N 5029724.1; E 367265.0 NAD 83 MTM ZONE 9 (LAT. 45.404670; LONG. -75.702050)
BOREHOLE TYPE Portable Rotary Drill, BW Casing
DATE November 21 and 22, 2018
ORIGINATED BY RI
COMPILED BY ZS
CHECKED BY KCP

SOIL PROFILE ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W$_P$ NATURAL MOISTURE CONTENT W LIQUID LIMIT W$_L$ WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
72.3	GROUND SURFACE										
0.0	(SM) SILTY SAND, contains organic matter (rootlets) (TOPSOIL) Dark brown Moist		1	SS	4		72				
71.9 0.4	(SP) SAND (FILL) Brown Moist		2	SS	6						
71.2 1.1	(SM) Silty sand, some gravel, contains brick, mortar and concrete (FILL) Dark brown Moist		3	SS	33		71		○		18 58 (24)
			4	SS	37		70				
			5	SS	17						
69.5 2.8	Weathered CONCRETE		1	RC	-						
69.1 3.2	PORTLAND CEMENT CONCRETE (FOOTING)		2	RC	-		69 68				
67.9 4.4	Limestone (BEDROCK) Bedrock cored from depths 4.4 m to 6.5 m For bedrock coring details refer to Record of Drillhole 18-1302		3	RC	REC 100%		67				RQD = 100%
			4	RC	REC 100%		66				RQD = 97%
65.8 6.5	END OF BOREHOLE NOTES: 1. Manual third weight hammer used for all split spoon samples. "N" values are not representative of ASTM D1586 SPT N values and should be interpreted in consideration of their reduced energy.										

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

○ $^{3\%}$ STRAIN AT FAILURE

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PROJECT: 1655214-1130

RECORD OF DRILLHOLE: 18-1302

SHEET 2 OF 2

LOCATION: N 5029724.1 ;E 367265.0

DRILLING DATE: November 21 and 22, 2018

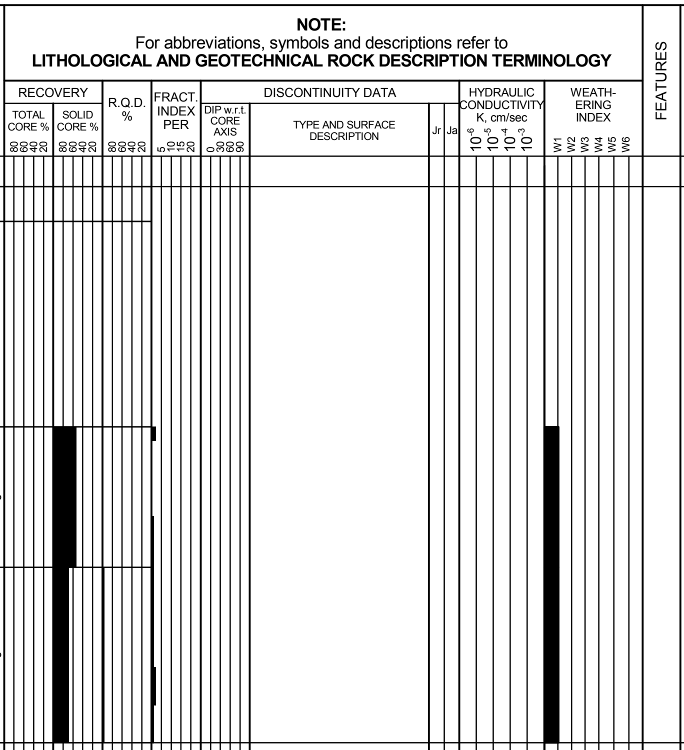
DATUM: Geodetic

DRILL RIG: Portable

INCLINATION: -90° AZIMUTH: ---

DRILLING CONTRACTOR: CCC Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN
		Continued from Record of Borehole 18-1302		69.45		
	Rotary Drill BW Casing	Weathered CONCRETE		2.82	1	
3 4		PORTLAND CEMENT CONCRETE (FOOTING)		2.91	1 2	
5 6		Limestone (BEDROCK) Fresh Thinly to medium bedded Grey to dark gery Fine to medium grained Non-porous Medium strong		67.88 4.39	3 4	0 0
7 8 9 10 11 12		END OF DRILLHOLE		65.77 6.50		



DEPTH SCALE

1 : 50

GOLDER

LOGGED: RI

CHECKED: KCP

RECORD OF BOREHOLE No 18-1303

SHEET 1 OF 2

METRIC

PROJECT 1655214-1130

G.W.P. 4173-15-00

LOCATION N 5029772.9; E 367281.5 NAD 83 MTM ZONE 9 (LAT. 45.405100; LONG. -75.701830)

ORIGINATED BY RI

DIST Eastern HWY 417

BOREHOLE TYPE Portable Rotary Drill, BW Casing

COMPILED BY ZS

DATUM Geodetic

DATE November 18 and 19, 2018

CHECKED BY KCP

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
69.5	GROUND SURFACE
0.0	ASPHALTIC CONCRETE
69.3 0.3	(SW) Gravelly sand, angular (FILL) Grey
	(SW) Sand, fine to coarse, trace gravel (FILL) Loose to compact Brown Moist
68.4 1.1	CONCRETE (FOOTING)
67.0 2.5	Limestone (BEDROCK) Bedrock cored from depths 2.5 m to 4.5 m For bedrock coring details refer to Record of Drillhole 18-1303
65.0 4.5	END OF BOREHOLE

NOTES:

1. Manual third weight hammer used for all split spoon samples. "N" values are not representative of ASTM D1586 SPT N values and should be interpreted in consideration of their reduced energy.

2. Water level in open borehole at 1.7 m depth below ground surface (Elev. 67.8 m), upon completion of drilling.

SAMPLES

NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%)
1	SS	25		69		
2	SS	167/0.28			○	
1	RC	-	∇	68		
2A	RC	-				
2B	RC	-		67		
3	RC	REC 100%		66		RQD = 93%
4	RC	REC 100%				RQD = 100%

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L

WATER CONTENT (%): 25 50 75

UNIT WEIGHT γ kN/m³

GR SA SI CL

+³, ×³: Numbers refer to Sensitivity

○³% STRAIN AT FAILURE

PROJECT: 1655214-1130

RECORD OF DRILLHOLE: 18-1303

SHEET 2 OF 2

LOCATION: N 5029772.9 ;E 367281.5

DRILLING DATE: November 18 and 19, 2018

DATUM: Geodetic

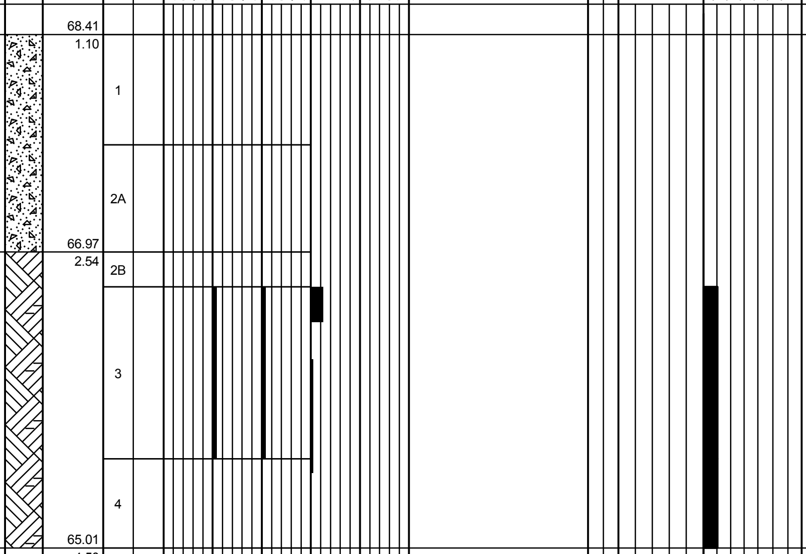
INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable

DRILLING CONTRACTOR: CCC Drilling

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	RUN No.
		Continued from Record of Borehole 18-1303	68.41	
		CONCRETE (FOOTING)	1.10	1
2				2A
	Rotary Drill BW Casing	Limestone (BEDROCK) Fresh Thinly to medium bedded Greyto dark grey Fine to medium grey Non-porous Slightly to moderately fossiliferous Medium strong	66.97 2.54	2B
3				3
4				4
		END OF DRILLHOLE	65.01 4.50	
5				
6				
7				
8				
9				
10				
11				



DEPTH SCALE
1 : 50

GOLDER

LOGGED: RI
CHECKED: KCP

RECORD OF BOREHOLE No 18-1304

SHEET 1 OF 2

METRIC

PROJECT 1655214-1130

G.W.P. 4173-15-00

DIST Eastern HWY 417

DATUM Geodetic

LOCATION N 5029737.0; E 367296.7 NAD 83 MTM ZONE 9 (LAT. 45.404780; LONG. -75.701640)

BOREHOLE TYPE Portable Rotary Drill, BW Casing

DATE November 18 and 19, 2018

ORIGINATED BY RI

COMPILED BY ZS

CHECKED BY KCP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES						
69.7	GROUND SURFACE									
0.0 0.1	(SM) Silty sand, contains organic matter (rootlets) (TOPSOIL) Dark brown Moist	1	SS	25						
	(SW) Sand, trace gravel (FILL) Loose Brown Moist	2	SS	50/0.10		69		○		
69.0 0.7	PORTLAND CEMENT CONCRETE (FOOTING)	1	RC	-						
		2A	RC	-		68				
67.9 1.8	Limestone (BEDROCK) Bedrock cored from depths 1.8 m to 3.8 m For bedrock coring details refer to Record of Drillhole 18-1304	2B	RC	REC 100%		67				RQD = 51%
		3	RC	REC 100%		66				RQD = 82%
65.9 3.8	END OF BOREHOLE NOTES: 1. Manual third weight hammer used for all split spoon samples. "N" values are not representative of ASTM D1586 SPT N values and should be interpreted in consideration of their reduced energy.									

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

○ $^{3\%}$ STRAIN AT FAILURE

PROJECT: 1655214-1130

RECORD OF DRILLHOLE: 18-1304

SHEET 2 OF 2

LOCATION: N 5029737.0 ;E 367296.7

DRILLING DATE: November 18 and 19, 2018

DATUM: Geodetic

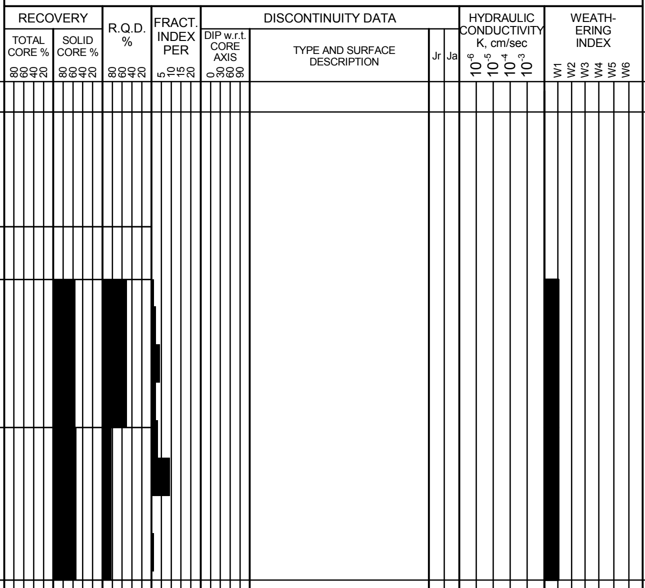
INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable

DRILLING CONTRACTOR: CCC Drilling

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA DIP w.r.t. CORE AXIS	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec	WEATHERING INDEX	FEATURES
		Continued from Record of Borehole 18-1304		68.95													
1	Rotary Drill BW Casing	PORTLAND CEMENT CONCRETE (FOOTING)		0.71	1 2A												
2 3		Limestone (BEDROCK) Fresh Thinly to medium bedded Grey to dark grey Fine to medium grained Non-porous Slightly to moderately Fossiliferous Medium strong		67.84 1.82	2B 3											W1	
4		END OF DRILLHOLE		65.85 3.81													



DEPTH SCALE
1 : 50

LOGGED: RI
CHECKED: KCP

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RECORD OF BOREHOLE No 18-1305

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130

G.W.P. 4173-15-00

LOCATION N 5029743.1; E 367253.1 NAD 83 MTM ZONE 9 (LAT. 45.404840; LONG. -75.702200)

ORIGINATED BY DJG

DIST Eastern HWY 417

BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)

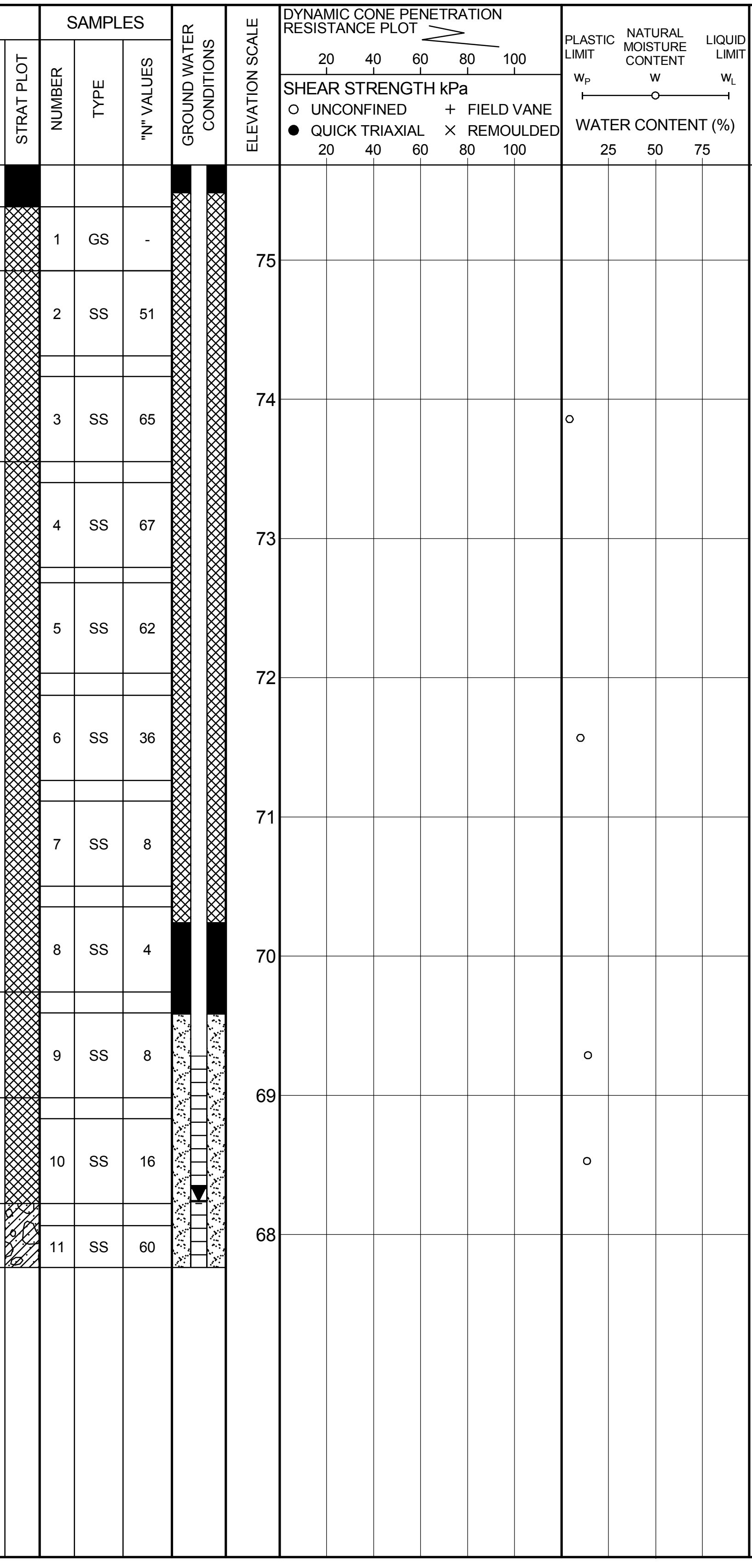
COMPILED BY ZS

DATUM Geodetic

DATE October 10, 2018

CHECKED BY KCP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
75.7	GROUND SURFACE								
0.0	ASPHALTIC CONCRETE								
75.4 0.3	(GW/SW) Sand and gravel, angular (FILL) Grey Moist	1	GS	-	75				
74.9 0.8	(SW) Gravelly sand, trace silt (FILL) Very dense Brown Moist	2	SS	51					
		3	SS	65	74				
73.6 2.1	(SP/SM) Sand, some silt (FILL) Very dense to loose Brown Moist	4	SS	67	73				
		5	SS	62	72				
		6	SS	36		0	87	(13)	
		7	SS	8	71				
		8	SS	4	70				
69.8 5.9	(SM/ML) Gravelly silty sand, some clay (FILL) Loose Brown, mottled Moist	9	SS	8		24	36	30	10
69.0 6.7	(SP) Sand (FILL) Compact Brown Moist	10	SS	16	69				
68.2 7.5	(SM) Gravelly Silty SAND, contains organic matter (rootlets/shells) (TILL) Very dense Dark grey brown Moist	11	SS	60	68				
67.8 7.9	END OF BOREHOLE AUGER REFUSAL								



NOTES:

1. Water level in well screen at a depth of 7.4 m below ground surface (Elev. 68.3 m), measured on Dec. 6, 2018.

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

$\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No 18-1306

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130

G.W.P. 4173-15-00

LOCATION N 5029727.0; E 367259.4 NAD 83 MTM ZONE 9 (LAT. 45.404690; LONG. -75.702120)

ORIGINATED BY RI

DIST Eastern HWY 417

BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)

COMPILED BY ZS

DATUM Geodetic

DATE October 16-17, 2018

CHECKED BY KCP

SOIL PROFILE ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
76.0	GROUND SURFACE											
0.0	ASPHALTIC CONCRETE											
	CONCRETE											
75.6 0.4	(SW) Sand and gravel, angular (FILL) Grey Moist	1	GS	-								
75.3 0.7	(SW/SP) Gravelly sand, angular (FILL) Dense to very dense Grey brown Moist	2	GS	-								
		3	SS	39		75						
		4	SS	75		74	○					
73.9 2.1	(SP) Sand, trace silt and gravel (FILL) Dense to compact Brown Moist	5	SS	38		73						
		6	SS	46								
		7	SS	29		72	○		3	90	(7)	
		8	SS	19		71						
70.7 5.3	(SM) Gravelly SAND, some silt and clay, contains organic matter (TILL) Loose Brown to dark brown Moist to wet	9	SS	6			○		10	78	(12)	
		10	SS	50/0.28								
69.5 6.6	END OF BOREHOLE AUGER REFUSAL on inferred bedrock NOTES: 1. Borehole dry upon completion of drilling.											

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%): 25 50 75

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

$\bigcirc^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No 18-1307

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130

G.W.P. 4173-15-00

DIST Eastern HWY 417

DATUM Geodetic

LOCATION N 5029771.2; E 367290.2 NAD 83 MTM ZONE 9 (LAT. 45.405090; LONG. -75.701720)

BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)

DATE October 15-16, 2018

ORIGINATED BY RI

COMPILED BY ZS

CHECKED BY KCP

SOIL PROFILE

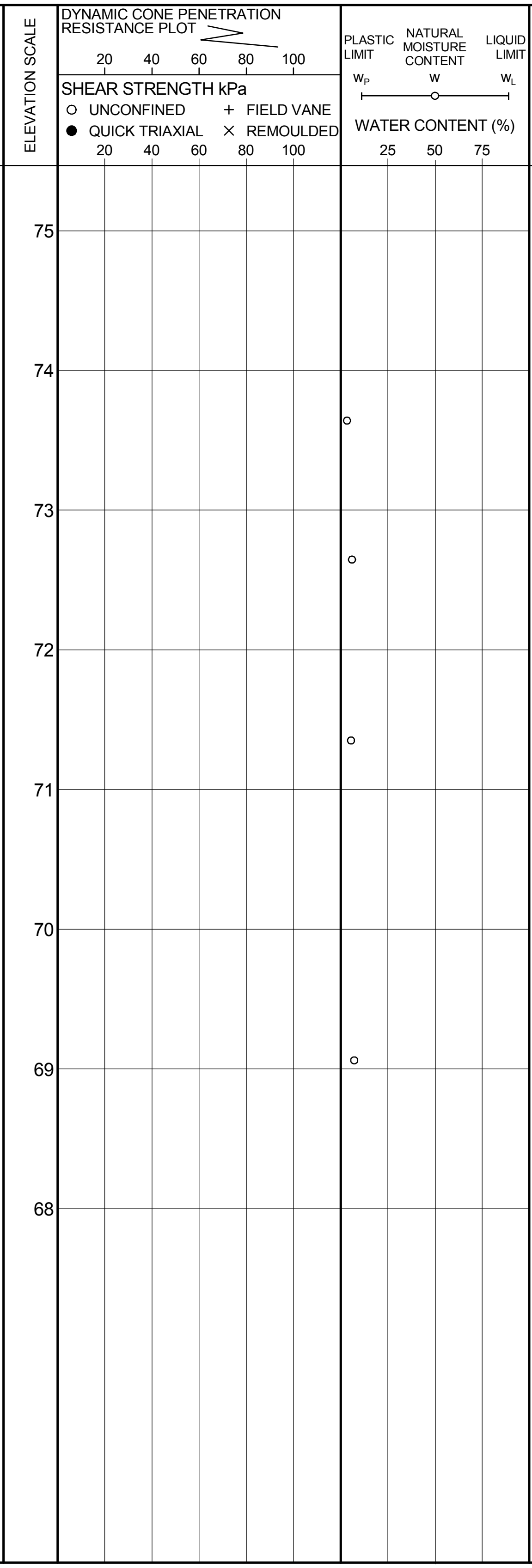
ELEV DEPTH	DESCRIPTION
75.5	GROUND SURFACE
0.0	ASPHALTIC CONCRETE
0.1	CONCRETE
74.9 0.6	(SM) Sand, some silt, some gravel (FILL) Very dense Grey Moist
72.9 2.6	(SP-SM) Sand, some silt (FILL) Very dense to compact Brown
68.8 6.7	(SM) Silty sand, contains organic matter and ash (FILL) Compact Dark brown to black Moist
68.2 7.3	(SM) Gravelly Silty SAND (TILL) Compact Grey Moist to wet
67.8 7.7	END OF BOREHOLE SAMPLER REFUSAL

NOTES:

1. Borehole dry upon completion of drilling.

SAMPLES

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	GS	-				
2	SS	59				
3	SS	52	7	76	(17)	
4	SS	85				
5	SS	59				
6	SS	42	0	88	(12)	
7	SS	61				
8	SS	36				
9	SS	15				
10	SS	13				



GROUND WATER CONDITIONS

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL_IM\MTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 6/6/19 JM

RECORD OF BOREHOLE No 18-1308

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130

G.W.P. 4173-15-00

LOCATION N 5029754.4; E 367294.6 NAD 83 MTM ZONE 9 (LAT. 45.404940; LONG. -75.701670)

ORIGINATED BY DJG

DIST Eastern HWY 417

BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)

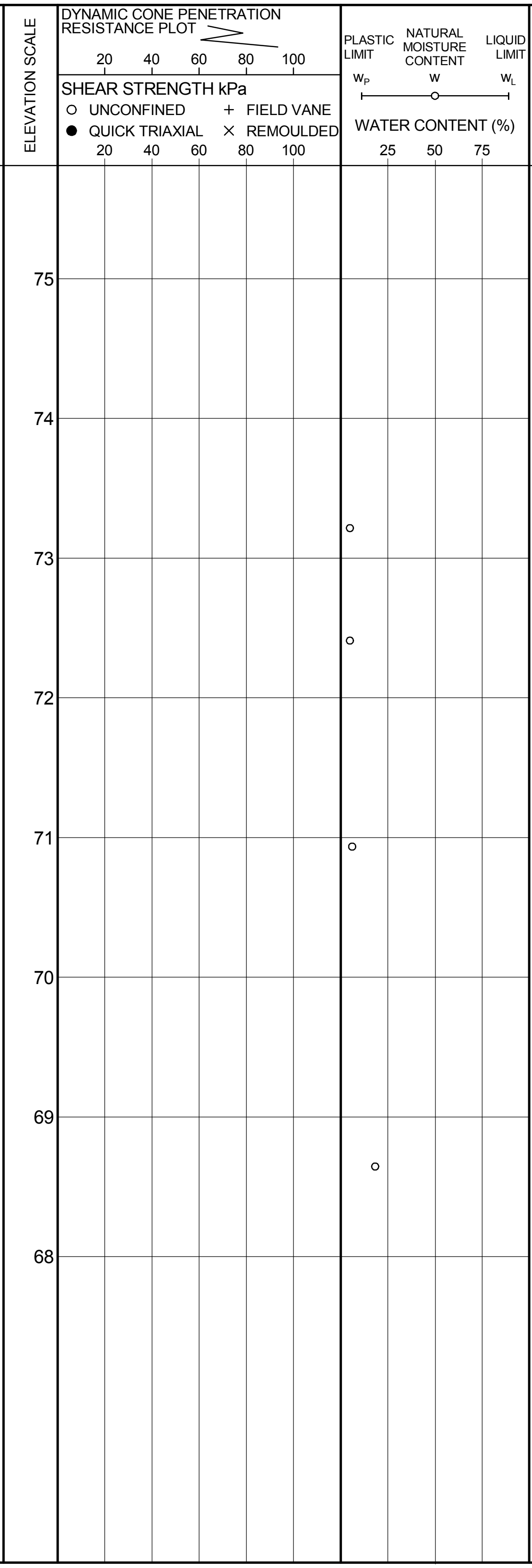
COMPILED BY ZS

DATUM Geodetic

DATE October 3, 2018

CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			GR	SA	SI	CL
75.8	GROUND SURFACE										
0.0	ASPHALTIC CONCRETE	■									
75.5 0.3	(SP) Sand and gravel, angular (FILL) Grey	▨	1	GS	-						
75.0 0.8	(SP) Gravelly sand (FILL) Dense to very dense Grey Moist	▨	2	SS	35						
		▨	3	SS	81						
		▨	4	SS	64						
72.7 3.1	(SP-SM) Sand, trace silt, trace gravel (FILL) Dense to very dense Brown Moist	▨	5	SS	58						
		▨	6	SS	48						
		▨	7	SS	58			1	91	(8)	
70.5 5.3	(SP-SM) Sand, some silt and gravel (FILL) Dense Grey brown to black Moist	▨	8	SS	44						
		▨	9	SS	41						
68.9 6.9	(SM) SILTY SAND, some gravel and clay (TILL) Compact Grey brown Moist		10	SS	15			17	62	(21)	
			11	SS	27						
67.5 8.3	END OF BOREHOLE AUGER REFUSAL NOTES: 1. Borehole dry upon completion of drilling.										



+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 18-1309

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130

G.W.P. 4173-15-00

DIST Eastern HWY 417

DATUM Geodetic

LOCATION N 5029734.2; E 367312.9 NAD 83 MTM ZONE 9 (LAT. 45.404750; LONG. -75.701440)

BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)

DATE November 7, 2018

ORIGINATED BY KM

COMPILED BY ZS

CHECKED BY KCP

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 + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L / WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
70.1	GROUND SURFACE													
0.0	(SM) Gravelly silty sand (FILL) Compact Brown Moist	▨	1	SS	10		70							
69.8 0.3	(SM) Silty sand, contains cobbles (FILL) Compact Brown Moist	▨												
69.3 0.8	(SP) Gravelly sand, contains cobbles (FILL) Compact Brown Moist	▨	2	SS	27		69							
68.6 1.5	(SM/ML) Sand and silt, some gravel (FILL) Very loose Brown Moist	▨	3	SS	2				○		14	42	(44)	
		▨	4	SS	3		68		○					
67.4 2.7	(SM) Silty SAND, some gravel (TILL) Very loose to very dense Grey Moist		5	SS	50/0.03	▽	67							
66.9 3.2	END OF BOREHOLE AUGER REFUSAL													

NOTES:

1. Water level in open borehole at 3.1 m depth below ground surface (Elev. 67.1 m), upon completion of drilling.

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

$\bigcirc^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No 18-1310

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130

G.W.P. 4173-15-00

LOCATION N 5029707.8; E 367353.0 NAD 83 MTM ZONE 9 (LAT. 45.404510; LONG. -75.700930)

ORIGINATED BY KM

DIST Eastern HWY 417

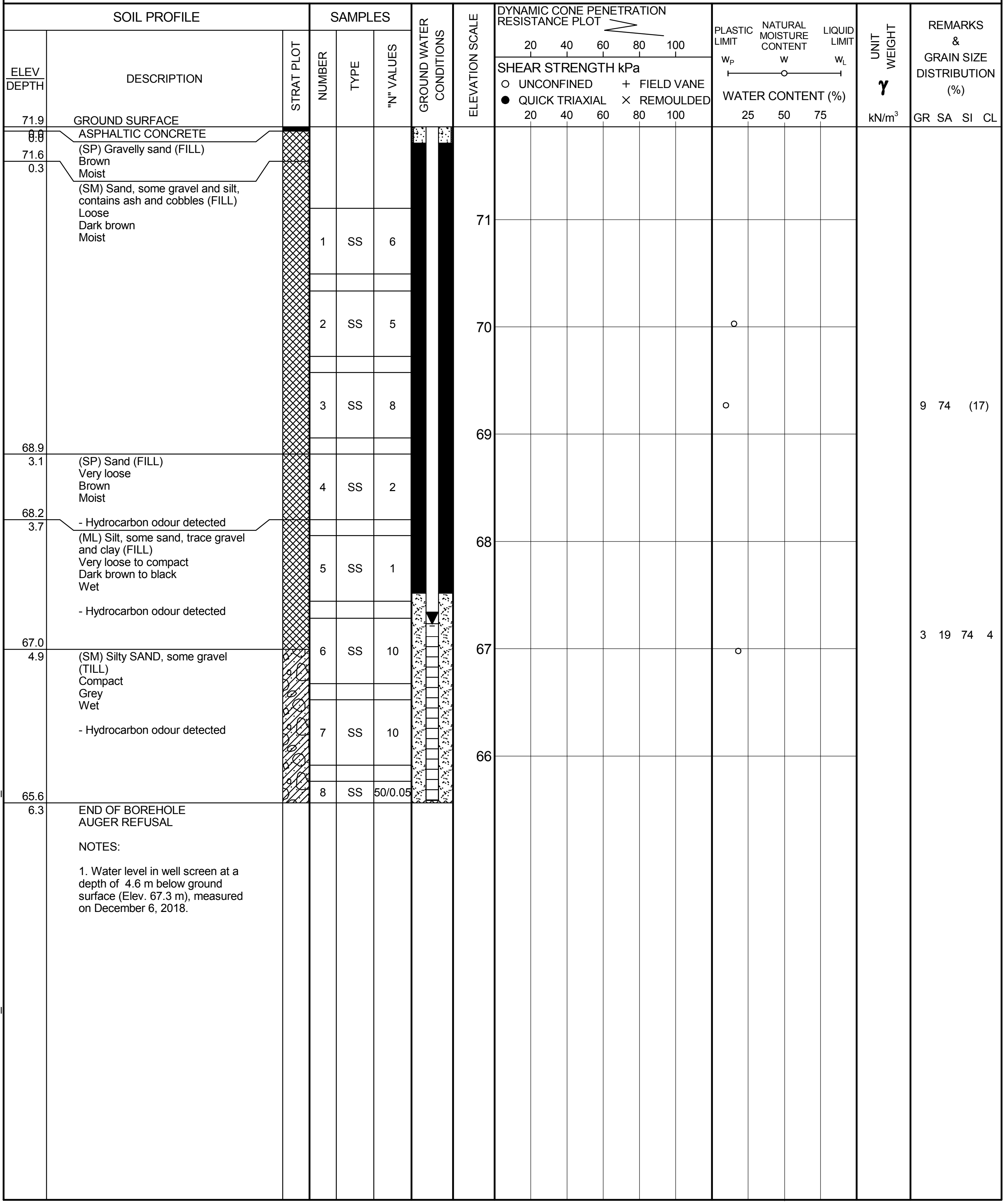
BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)

COMPILED BY ZS

DATUM Geodetic

DATE November 8, 2018

CHECKED BY KCP



ELEV DEPTH	DESCRIPTION
71.9	GROUND SURFACE
0.0	ASPHALTIC CONCRETE
	(SP) Gravelly sand (FILL) Brown Moist
71.6 0.3	(SM) Sand, some gravel and silt, contains ash and cobbles (FILL) Loose Dark brown Moist
68.9 3.1	(SP) Sand (FILL) Very loose Brown Moist - Hydrocarbon odour detected
68.2 3.7	(ML) Silt, some sand, trace gravel and clay (FILL) Very loose to compact Dark brown to black Wet - Hydrocarbon odour detected
67.0 4.9	(SM) Silty SAND, some gravel (TILL) Compact Grey Wet - Hydrocarbon odour detected
65.6 6.3	END OF BOREHOLE AUGER REFUSAL

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	SS	6				
2	SS	5				
3	SS	8	9	74	(17)	
4	SS	2				
5	SS	1				
6	SS	10	3	19	74	4
7	SS	10				
8	SS	50/0.05				

REMARKS & GRAIN SIZE DISTRIBUTION (%)

NOTES:

1. Water level in well screen at a depth of 4.6 m below ground surface (Elev. 67.3 m), measured on December 6, 2018.

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

$\bigcirc^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No 18-1311

SHEET 1 OF 1

METRIC

PROJECT 1655214-1130

G.W.P. 4173-15-00

LOCATION N 5029774.9; E 367417.2 NAD 83 MTM ZONE 9 (LAT. 45.405110; LONG. -75.700100)

ORIGINATED BY KM

DIST Eastern HWY 417

BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)

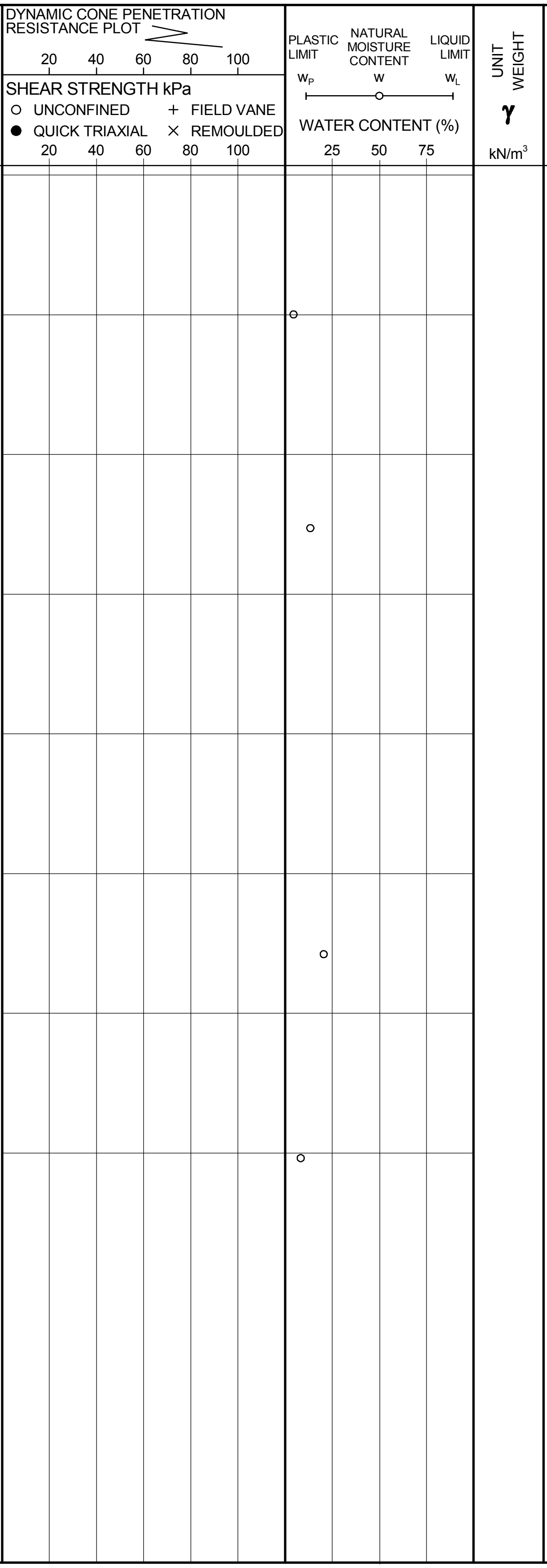
COMPILED BY ZS

DATUM Geodetic

DATE November 7-8, 2018

CHECKED BY KCP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			GR	SA	SI	CL
70.1	GROUND SURFACE									
0.0	ASPHALTIC CONCRETE					70				
0.2	(SP) Gravelly SAND (FILL) Brown Moist	1	SS	14						
	(SP) SAND, trace to some gravel (FILL) Compact Brown Moist	2	SS	33		69				
68.6 1.5	(SM) Silty SAND Compact to loose Brown to grey Moist to wet	3	SS	11		68				
		4	SS	4			1	71	(28)	
		5	SS	8		67				
		6	SS	8	∇	66				
		7	SS	15		65				
64.8 5.3	(ML) SILT, some sand Compact Grey Wet	8	SS	11		64	2	15	79	4
63.9 6.3	(SM/GM) Silty SAND and GRAVEL (TILL) Compact to dense Grey Wet	9	SS	30						
		10	SS	34		63	31	39	21	9
62.8 7.3	END OF BOREHOLE AUGER REFUSAL NOTES: 1. Water level in open borehole at 4.3 m depth below ground surface (Elev. 65.8 m), upon completion of drilling.									



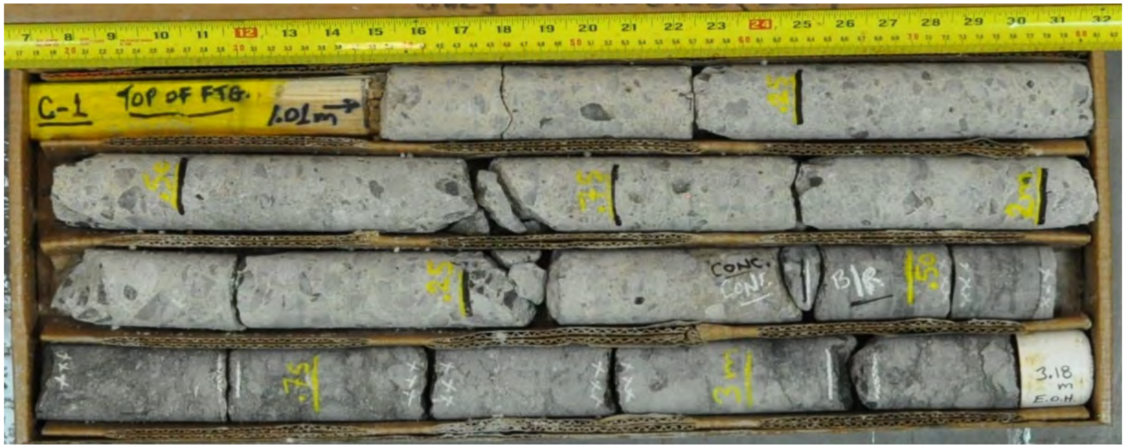
+3, ×3: Numbers refer to Sensitivity

○3% STRAIN AT FAILURE

CH 17-C01 (Dry)

Core Box 1 of 1

Elevation 68.45 m Top of Footing



Elevation 66.28 m EOH

GOLDER

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

Ottawa, Ontario

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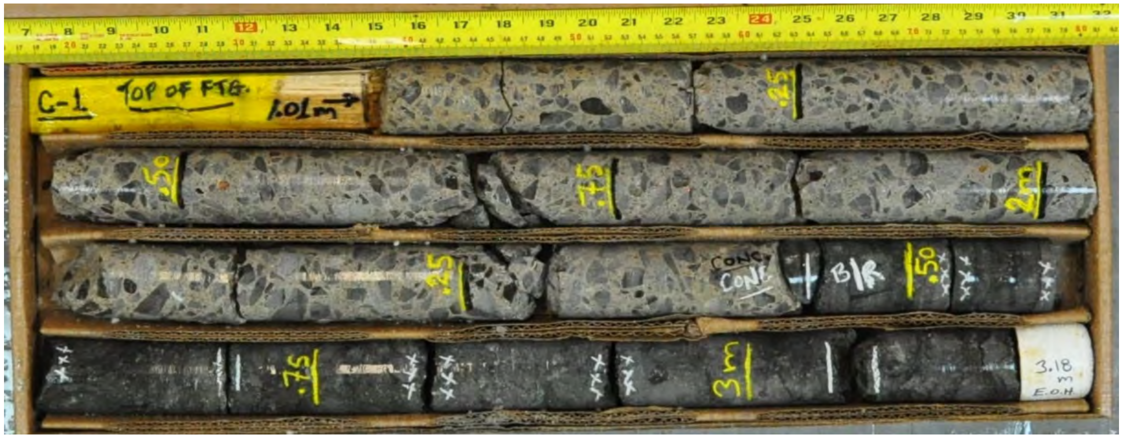
Figure A1

CH 17-C01 (Wet)

Core Box 1 of 1

Elevation 68.45 m Top of Footing



Elevation 66.28 m EOH

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

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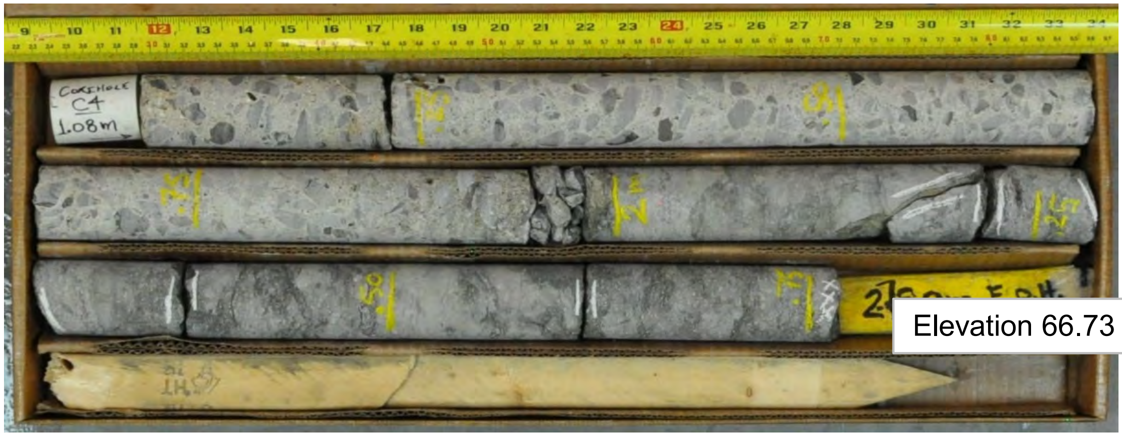
Figure A2

CH 17-C04 (Dry)
Core Box 1 of 1

Elevation 68.43 m Top of Footing



Elevation 66.73 m EOH

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

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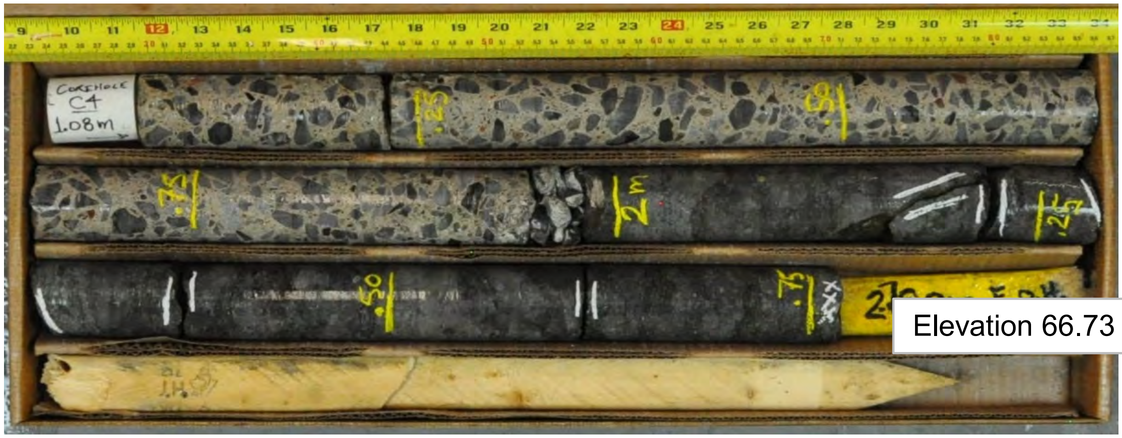
Figure A3

CH 17-C04 (Wet)
Core Box 1 of 1

Elevation 68.43 m Top of Footing



Elevation 66.73 m EOH

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

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Figure A4

CH 17-C09 (Dry)
Core Box 1 to 3 of 3

Elevation 68.72 m Top of Footing

Elevation 64.22 m EOH

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

Ottawa, Ontario

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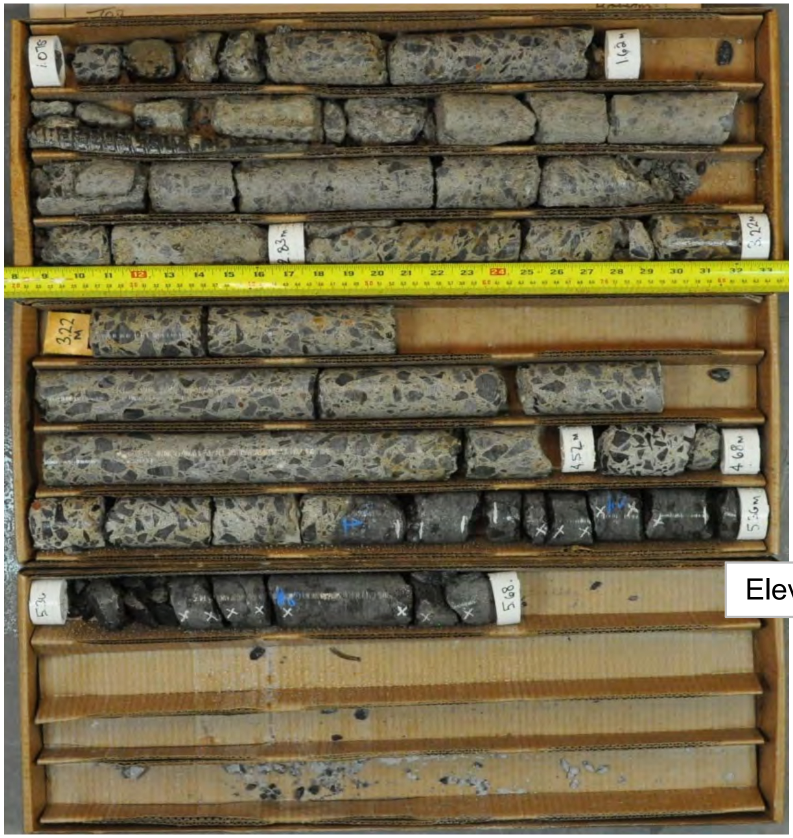
Figure A5

CH 17-C09 (Wet)
Core Box 1 of 3 of 3

Elevation 68.72 m Top of Footing



Elevation 64.22 m EOH

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

Ottawa, Ontario

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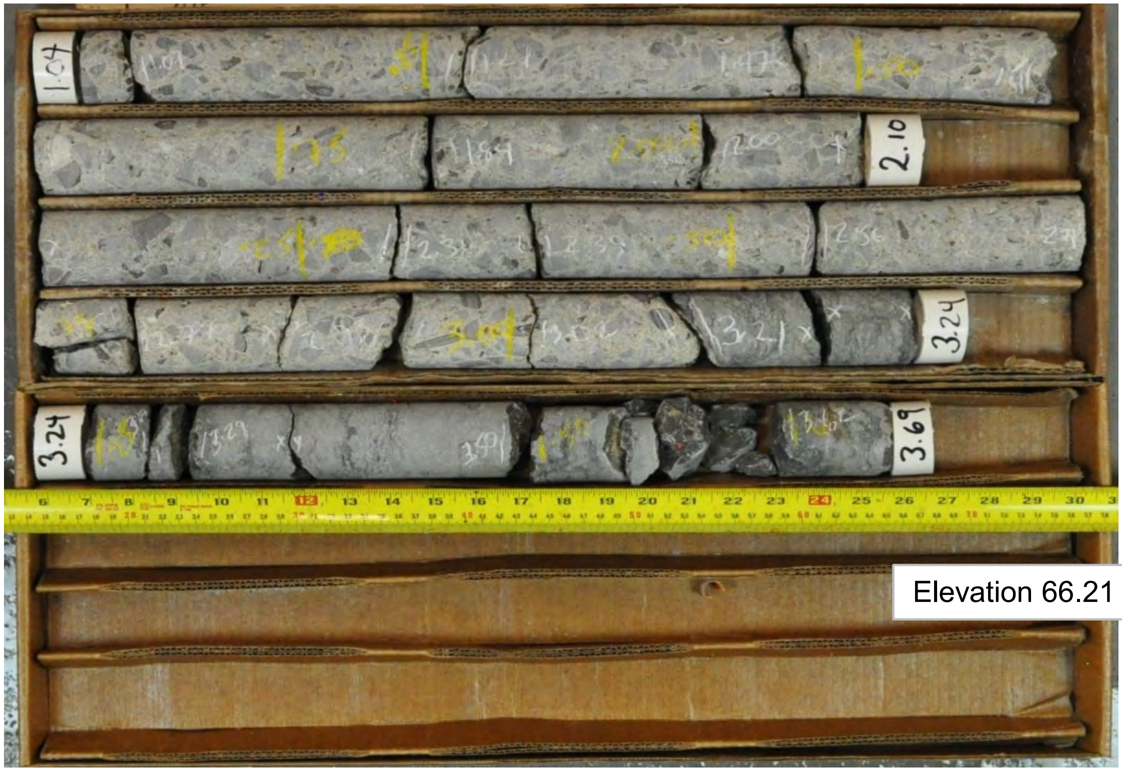
Figure A6

CH 17-C11 (Dry)
Core Box 1 and 2 of 2

Elevation 68.86 m Top of Footing



Elevation 66.21 m EOH

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

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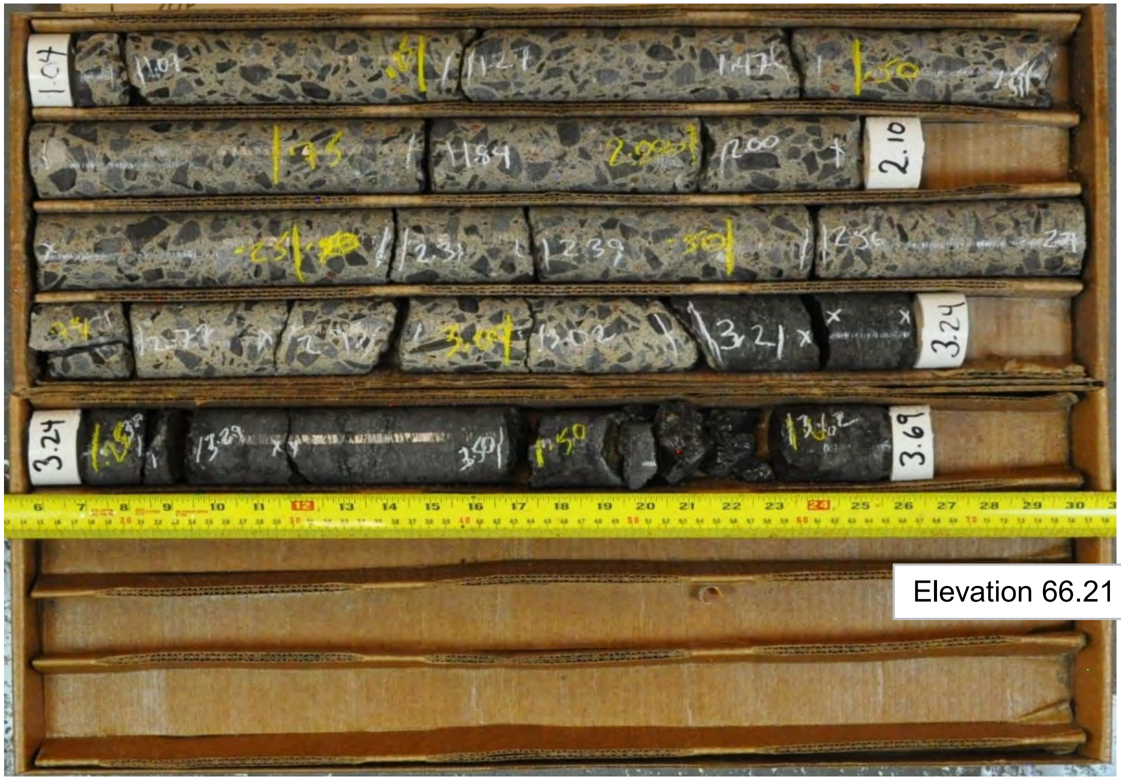
Figure A7

CH 17-C11 (Wet)
Core Box 1 and 2 of 2

Elevation 68.86 m Top of Footing



Elevation 66.21 m EOH

GOLDER

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

Ottawa, Ontario

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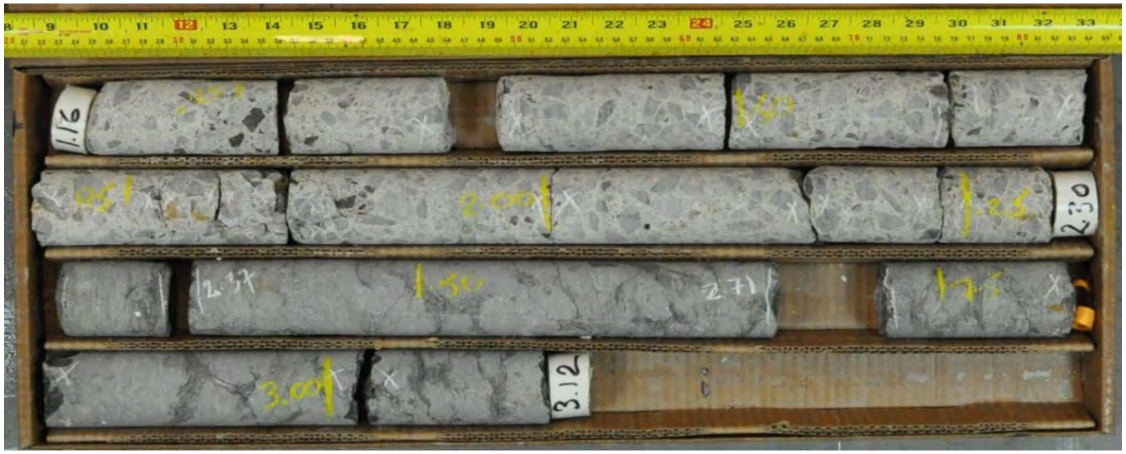
Figure A8

CH 17-C13 (Dry)

Core Box 1 of 1

Elevation 68.81 m Top of Footing



Elevation 66.85 m EOH

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

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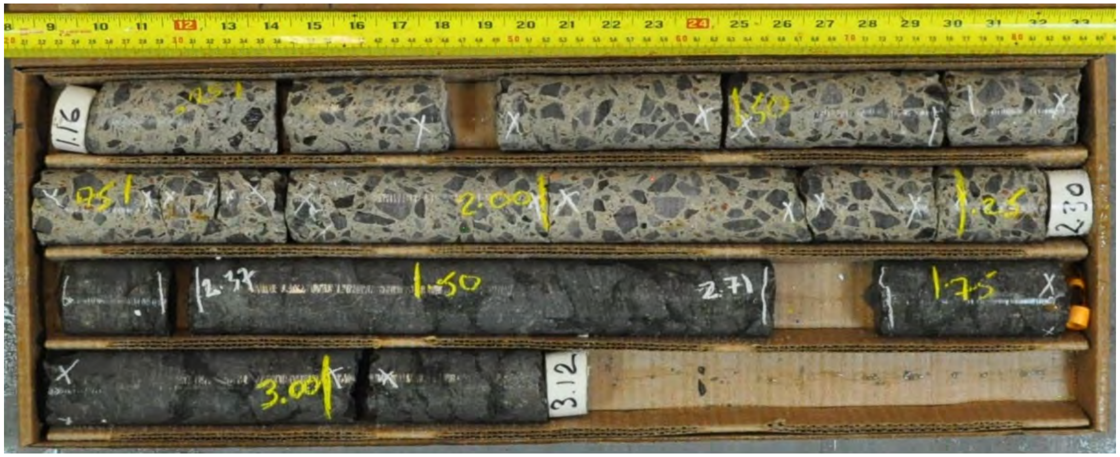
Figure A9

GOLDER

CH 17-C13 (Wet)
Core Box 1 of 1

Elevation 68.81 m Top of Footing



Elevation 66.85 m EOH

Foundation Investigation **Highway 417 Overpass Structures at Bronson Avenue** **Ottawa, Ontario**	
Project No.	1655214 / 1130
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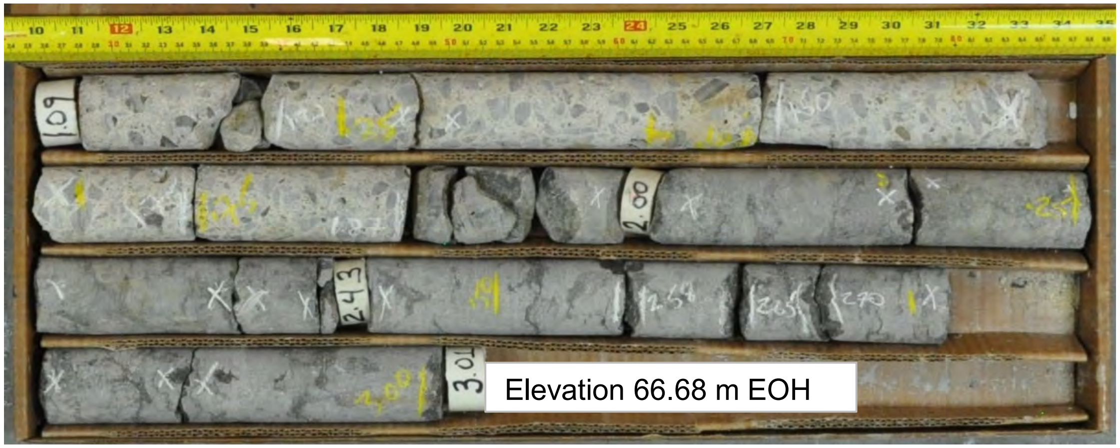
Figure A10

CH 17-C17 (Dry)
Core Box 1 of 1

Elevation 68.60 m Top of Footing



Elevation 66.68 m EOH

GOLDER

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

Ottawa, Ontario

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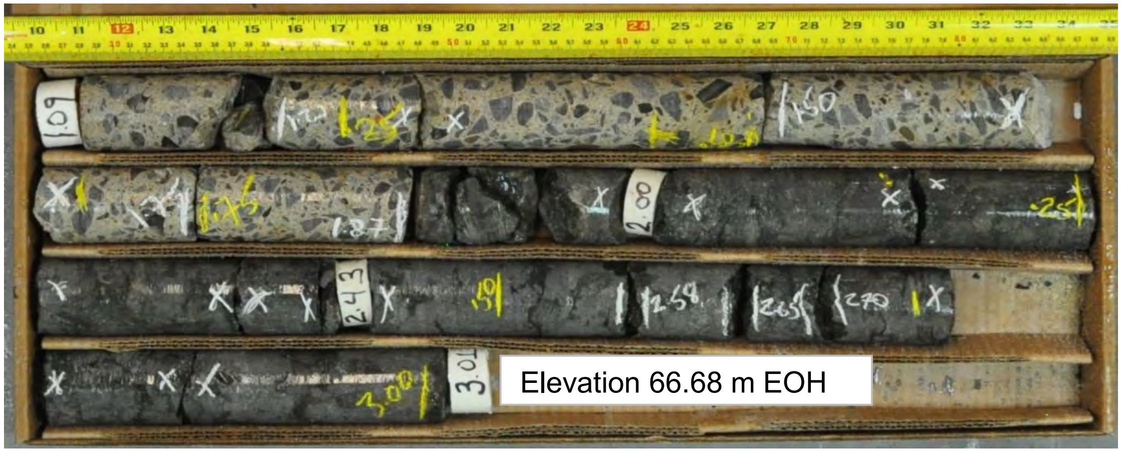
Figure A11

CH 17-C17 (Wet)
Core Box 1 of 1

Elevation 68.60 m Top of Footing



Elevation 66.68 m EOH

GOLDER

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

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Figure A12

CH 17-C19 (Dry)

Core Box 1 of 1

Elevation 68.42 m Top of Footing

Elevation 67.09 m EOH

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

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Figure A13

CH 17-C19 (Wet)
Core Box 1 of 1

Elevation 68.42 m Top of Footing

Elevation 67.09 m EOH

GOLDER

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

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Review:	KCP

Figure A14

CH 17-C24 (Dry)
Core Box 1 of 1

Elevation 68.42 m Top of Footing

Elevation 66.94 m EOH

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

Ottawa, Ontario

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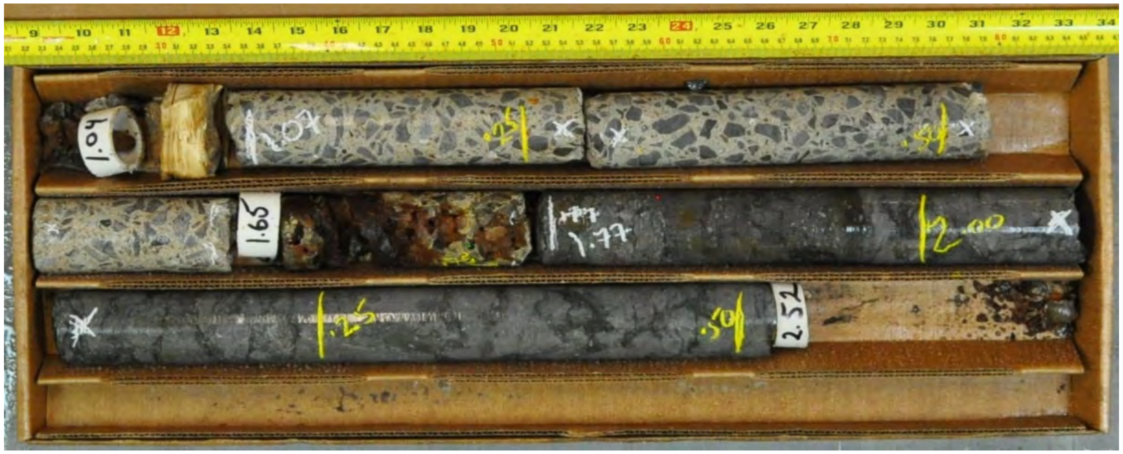
Figure A15

CH 17-C24 (Wet)

Core Box 1 of 1

Elevation 68.42 m Top of Footing



Elevation 66.94 m EOH

GOLDER

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

Ottawa, Ontario

Project No.	1655214 / 1130
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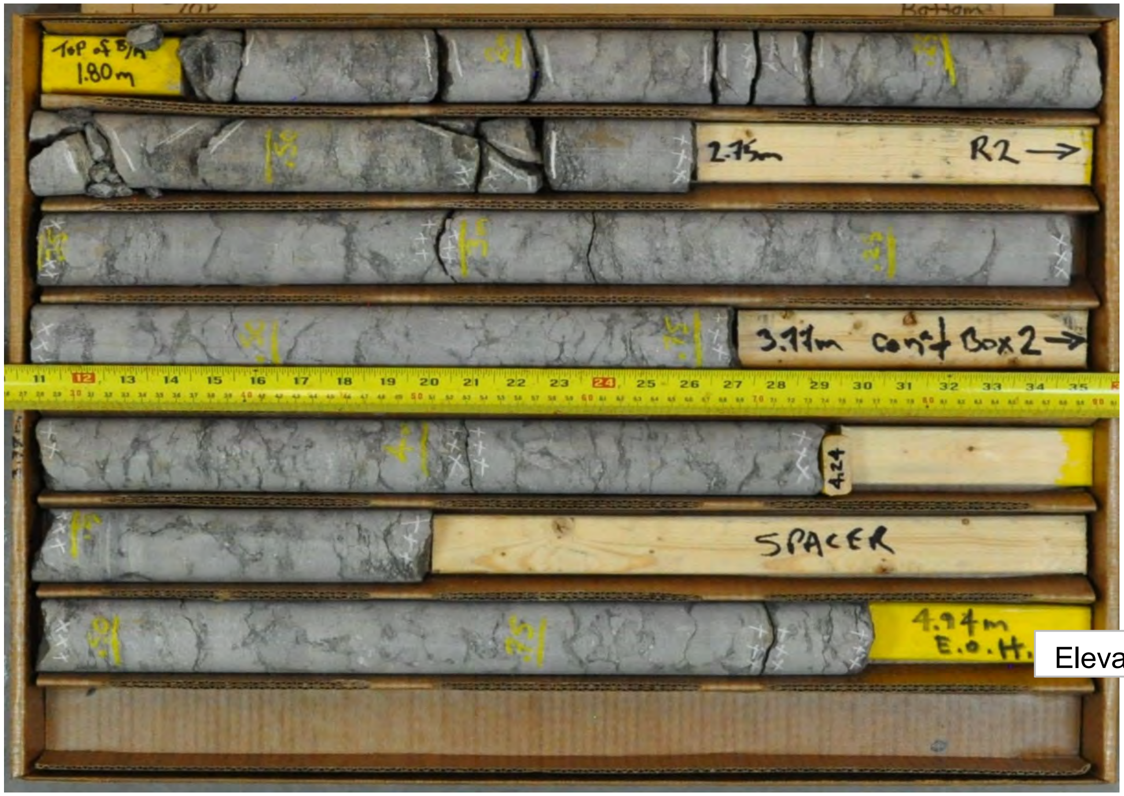
Figure A16

BH 17-131 (Dry)

Core Box 1 of 2 and 2

Elevation 68.24 m Top of Bedrock



Elevation 65.10 m EOH

GOLDER

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

Ottawa, Ontario

Project No.	1655214 / 1130
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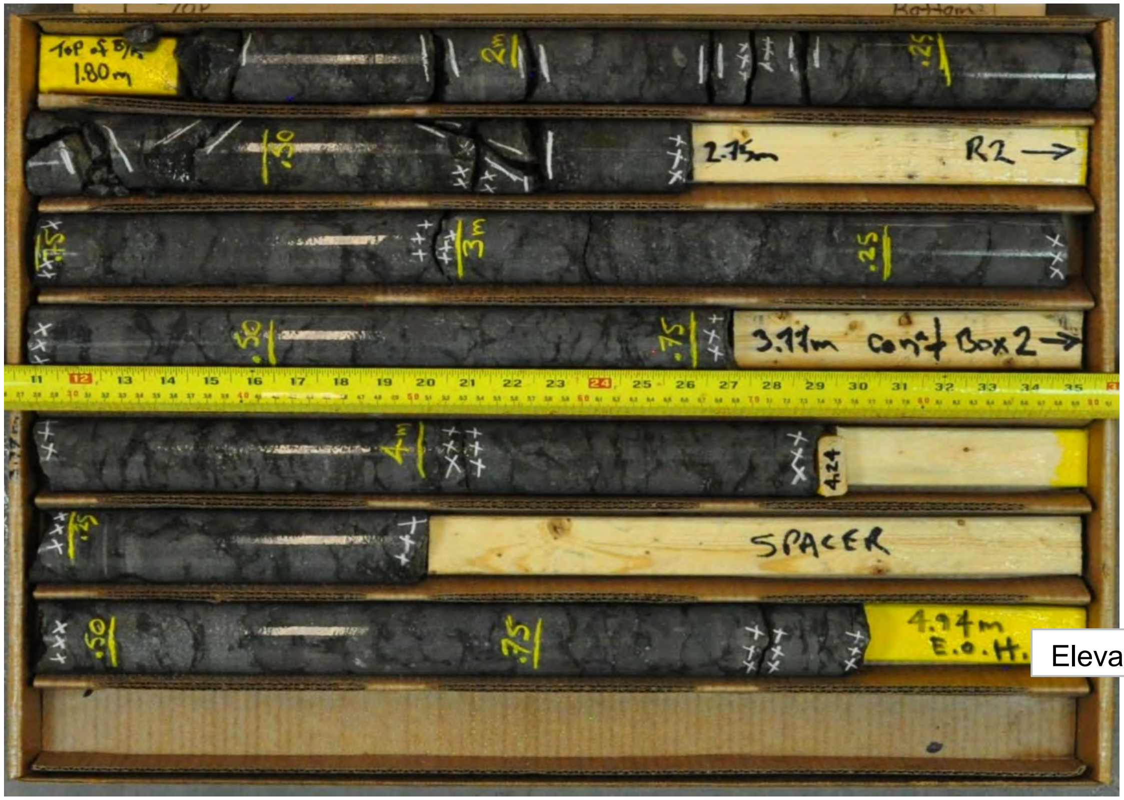
Figure A17

BH 17-131 (Wet)
Core Box 1 and 2 of 2

Elevation 68.24 m Top of Bedrock



Elevation 65.10 m EOH

GOLDER

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

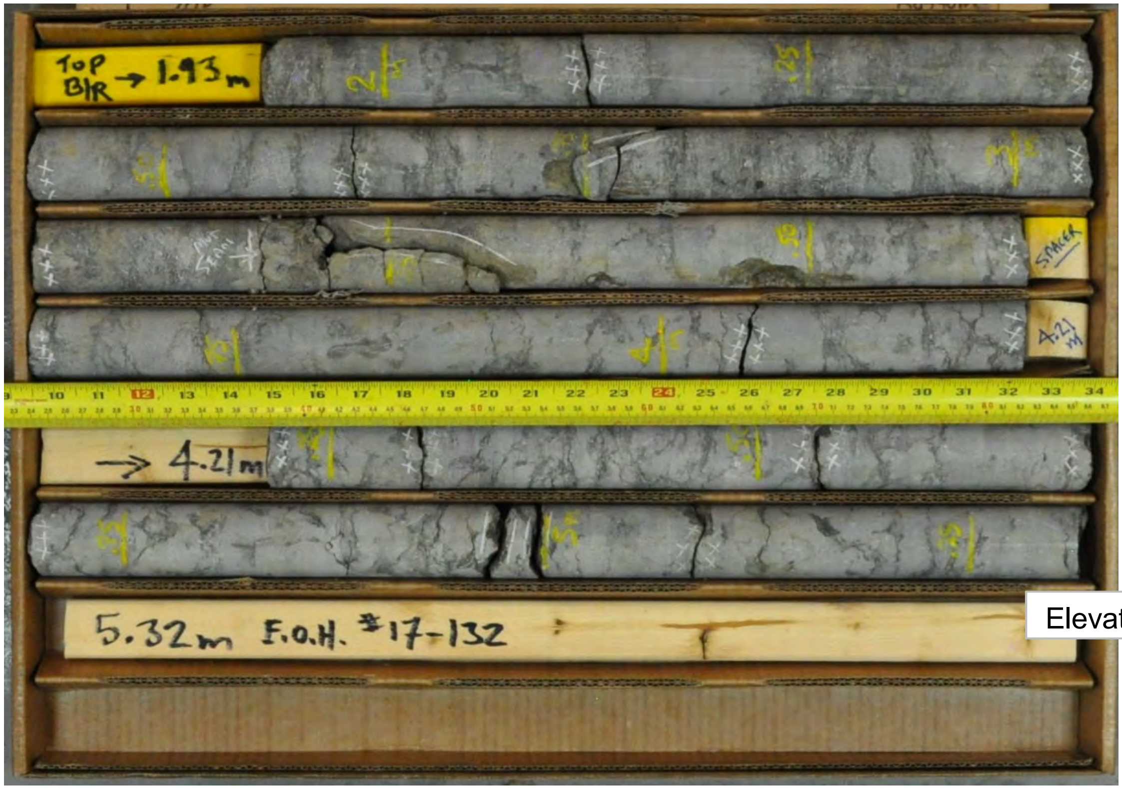
Ottawa, Ontario

Project No.	1655214 / 1130
Drawn:	KS
Date:	2017-09-08
Review:	KCP

Figure A18

BH 17-132 (Dry)
Core Box 1 and 2 of 2

Elevation 68.12 m Top of Bedrock



Elevation 64.73 m EOH

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

Ottawa, Ontario

Project No.	1655214 / 1130
Drawn:	KS
Date:	2017-09-08
Review:	KCP

Figure A19

BH 17-132 (Wet)
Core Box 1 and 2 of 2

Elevation 68.12 m Top of Bedrock

Elevation 64.73 m EOH

GOLDER

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

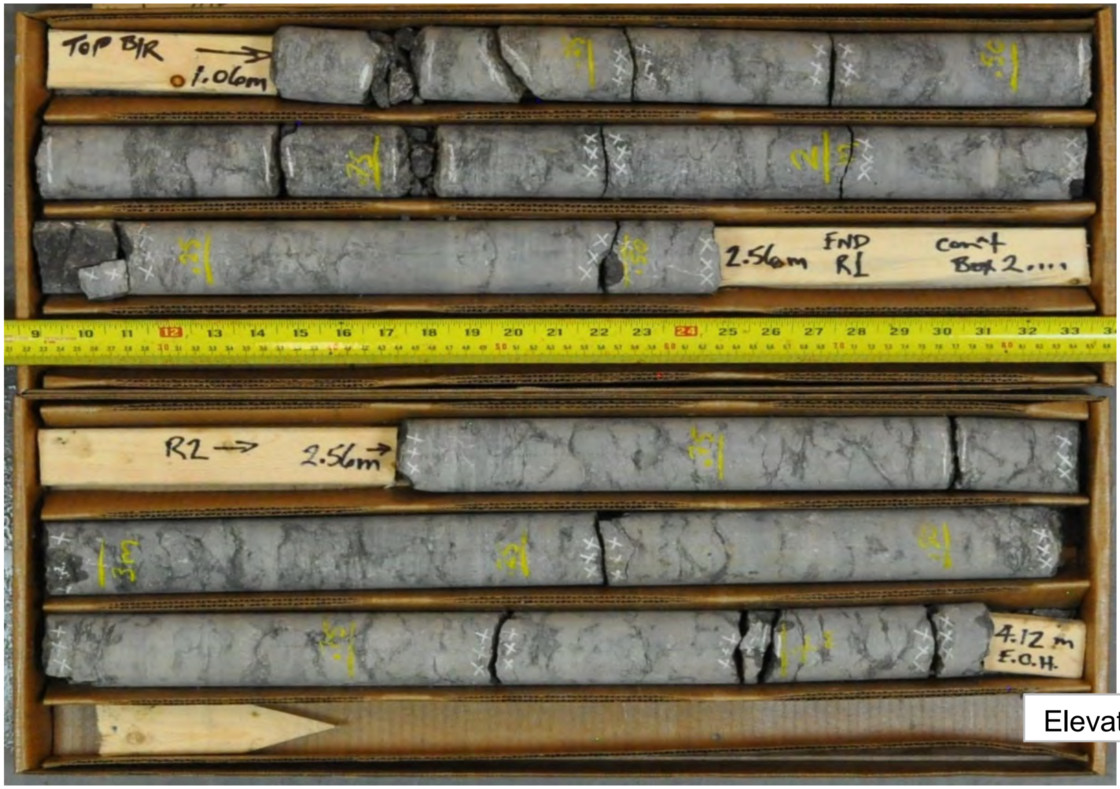
Ottawa, Ontario

Project No.	1655214 / 1130
Drawn:	KS
Date:	2017-09-08
Review:	KCP

Figure A20

BH 17-133 (Dry)
Core Box 1 and 2 of 2

Elevation 68.36 m Top of Bedrock



Elevation 65.30 m EOH

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

Ottawa, Ontario

Project No.	1655214 / 1130
Drawn:	KS
Date:	2017-09-08
Review:	KCP

Figure A21

BH 17-133 (Wet)
Core Box 1 and 2 of 2

Elevation 68.36 m Top of Bedrock

Elevation 65.30 m EOH

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

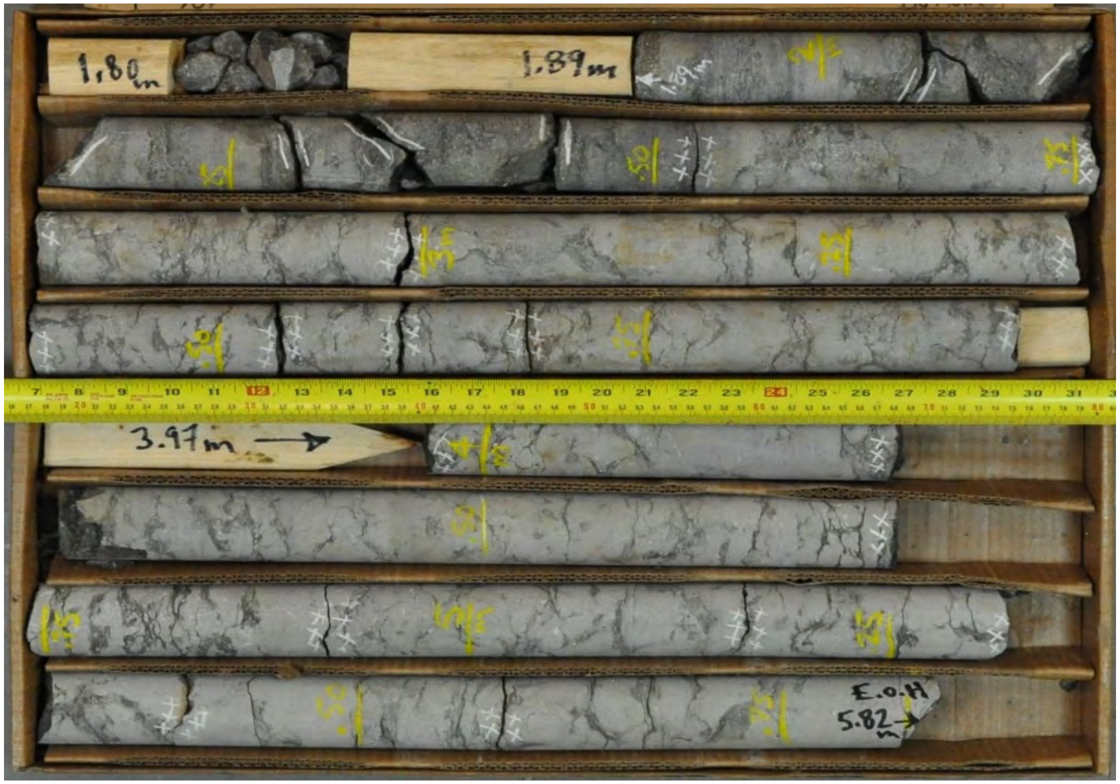
Ottawa, Ontario

Project No.	1655214 / 1130
Drawn:	KS
Date:	2017-09-08
Review:	KCP

Figure A22

BH 17-134 (Dry)
Core Box 1 and 2 of 2

Elevation 67.45 m Top of Bedrock



Elevation 63.52 m EOH

GOLDER

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

Ottawa, Ontario

Project No.	1655214 / 1130
Drawn:	KS
Date:	2017-09-08
Review:	KCP

Figure A23

BH 17-134 (Wet)
Core Box 1 and 2 of 2

Elevation 67.45 m Top of Bedrock

Elevation 63.52 m EOH

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

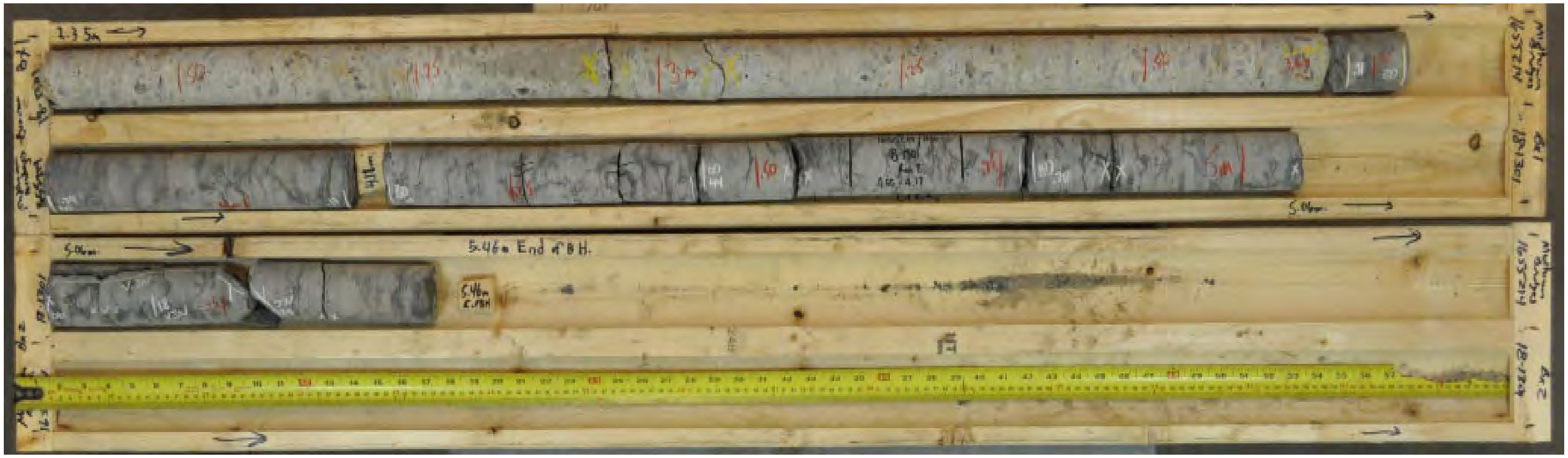
Ottawa, Ontario

Project No.	1655214 / 1130
Drawn:	KS
Date:	2017-09-08
Review:	KCP

Figure A24

BH 18-1301 (Dry)
Core Box 1 and 2 of 2

Elevation 69.26 m Top of Footing



Elevation 66.15 m EOH

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

Ottawa, Ontario

Project No.	1655214 / 1130
Drawn:	KS
Date:	2019-03-19
Review:	KCP

Figure A25

BH 18-1301 (Wet)
Core Box 1 and 2 of 2

Elevation 69.26 m Top of Footing

Elevation 66.15 m EOH

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

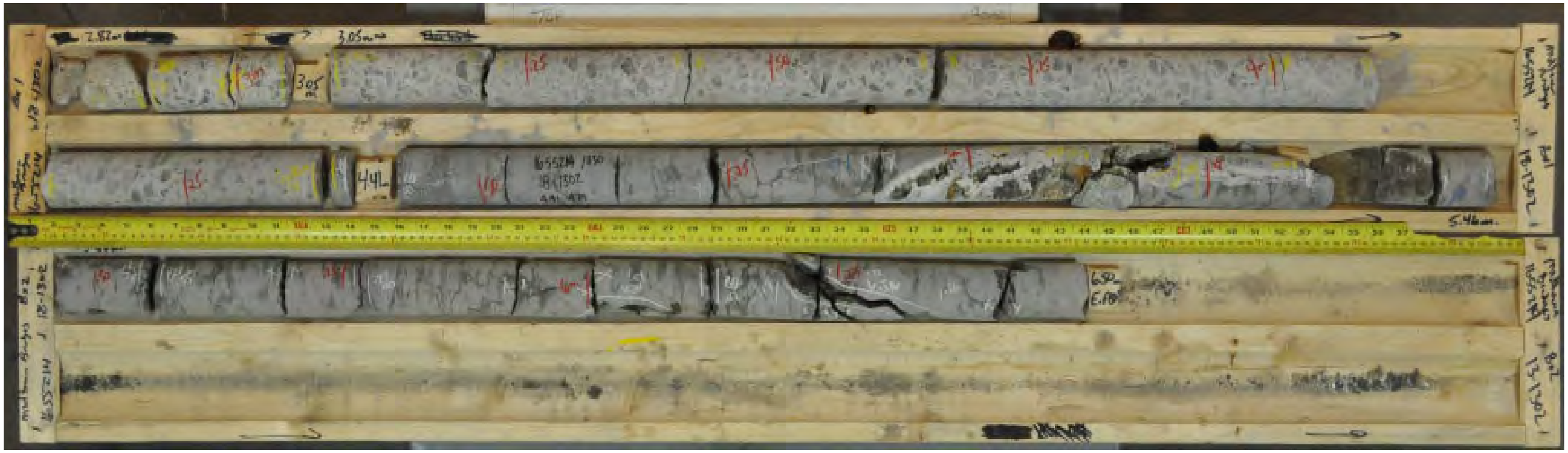
Ottawa, Ontario

Project No.	1655214 / 1130
Drawn:	KS
Date:	2019-03-19
Review:	KCP

Figure A26

BH 18-1302 (Dry)
Core Box 1 and 2 of 2

Elevation 69.45 m Top of Footing



Elevation 65.77 m EOH

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

Ottawa, Ontario

Project No.	1655214 / 1130
Drawn:	KS
Date:	2019-03-19
Review:	KCP

Figure A27

BH 18-1302 (Wet)
Core Box 1 and 2 of 2

Project No.	1655214 / 1130
Drawn:	KS
Date:	2019-03-19
Review:	KCP

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

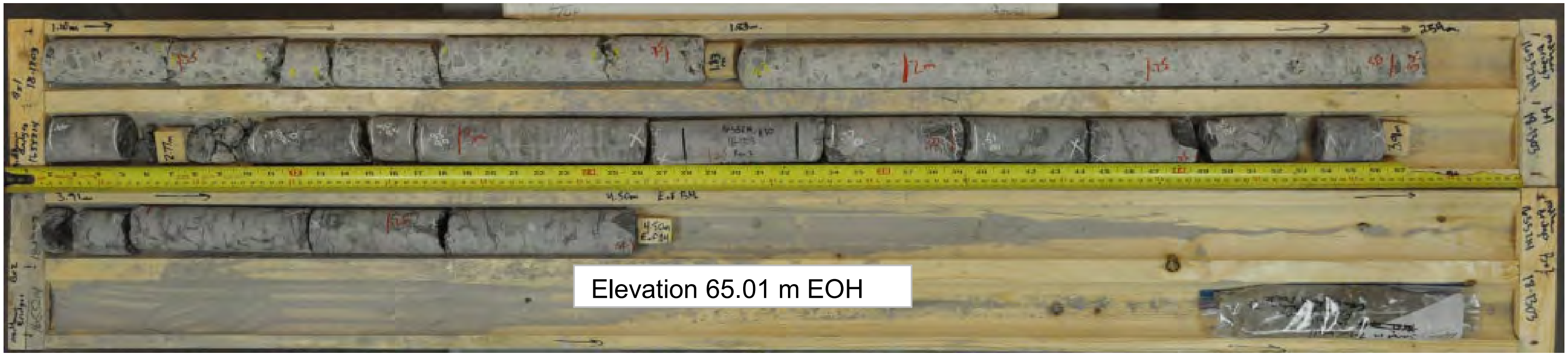
Ottawa, Ontario

Figure A28

GOLDER

BH 18-1303 (Dry)
Core Box 1 and 2 of 2

Elevation 68.41 m Top of Footing



Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

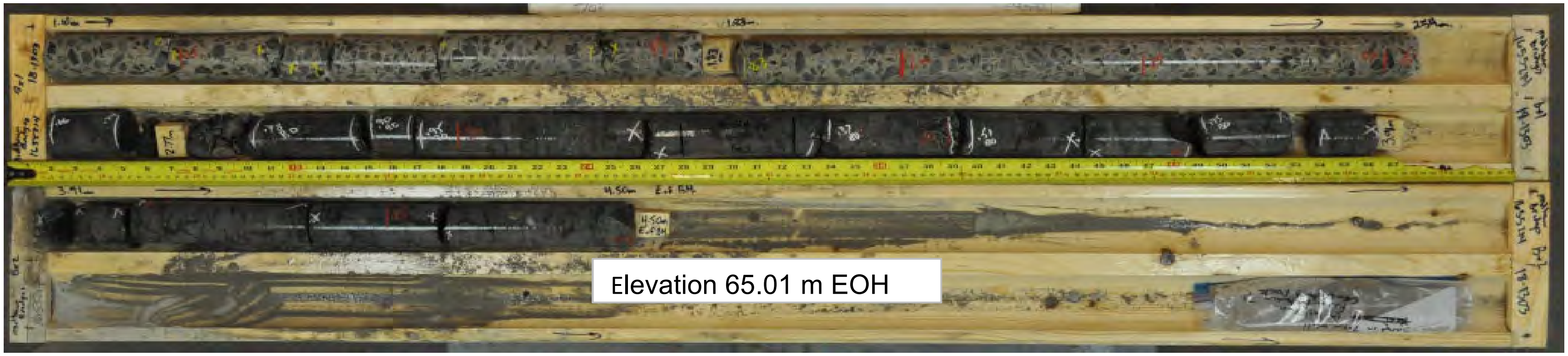
Ottawa, Ontario

Project No.	1655214 / 1130
Drawn:	KS
Date:	2019-03-19
Review:	KCP

Figure A29

BH 18-1303 (Wet)
Core Box 1 and 2 of 2

Elevation 68.41 m Top of Footing



Elevation 65.01 m EOH

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

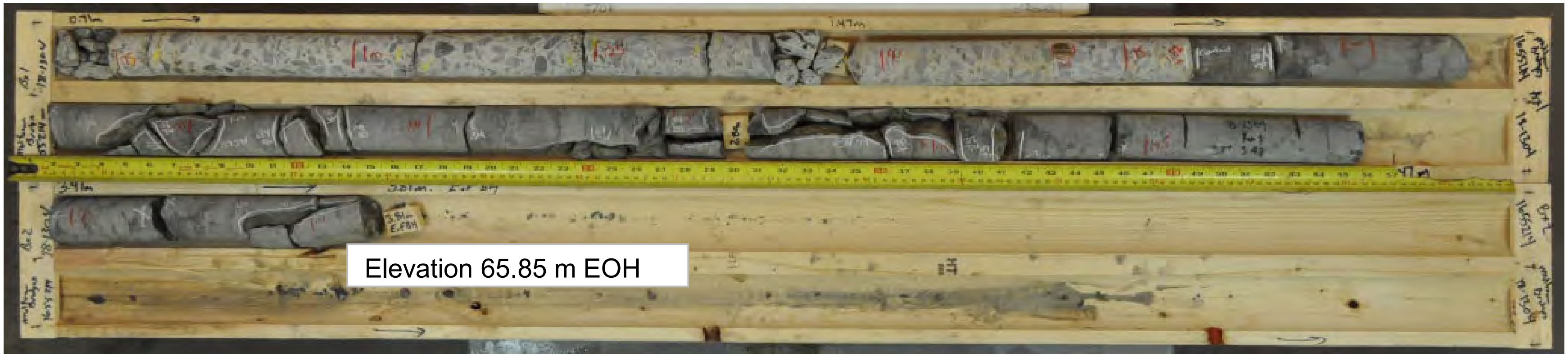
Ottawa, Ontario

Project No.	1655214 / 1130
Drawn:	KS
Date:	2019-03-19
Review:	KCP

Figure A30

BH 18-1304 (Dry)
Core Box 1 and 2 of 2

Elevation 68.95 m Top of Footing



Elevation 65.85 m EOH

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

Ottawa, Ontario

Project No.	1655214 / 1130
Drawn:	KS
Date:	2019-03-19
Review:	KCP

Figure A31

BH 18-1304 (Wet)
Core Box 1 and 2 of 2

Elevation 68.95 m Top of Footing

Elevation 65.85 m EOH

Foundation Investigation

Highway 417 Overpass Structures at Bronson Avenue

Ottawa, Ontario

Project No.	1655214 / 1130
Drawn:	KS
Date:	2019-03-19
Review:	KCP

Figure A32

TABLE A1: Concrete Core Condition Assessment
Existing Concrete Footing - Bronson Avenue

Project No. 1655214 - 1130 **20-Oct-17 CNM**

Bronson Avenue

17-C01 : - 1.01 - 2.45
- Top surface broken up.
- Good condition, with only mechanical breaks.
- Well formed but unbonded joint to rock.

17-C04 : - 1.08 - 1.99
- Slightly degraded top surface.
- Voids and mechanical break at 1.24.
- Good condition to 1.95.
- 1.95-1.99 : Broken up and poor bond to rock.

17-C09 : - 1.08 - 5.00
- Top surface intact but core broken at shallow depth … may be pre-existing crack.
- 1.62-2.20 : Damaged section likely due to coring longitudinally through re-bar.
- 2.60-3.15 : Coring damage due to apparent cold joint, plus broken pieces with flat formed surfaces, but no wood or debris recovered.
- 3.15-4.45 : Good condition.
- 4.45 : Horizontal joint, appearance of pouring in water.
- 4.52-5.00 : Much poorer quality concrete; likely mud-slab.
- Excellent bond to rock.

17-C11 : - 1.04 - 3.21
- Good condition, with only mechanical breaks.
- Good bond to rock.

17-C13 : - 1.16 - 2.30
- Good condition, with only mechanical breaks.
- Poor bond to rock.

17-C17 : - 1.09 - 1.87
- Good condition, with only mechanical breaks.
- No bond to rock. Mud in joint.

17-C19 : - 1.20 - 1.81
- Good to fair condition; mechanical breaks have coring damage (spun), and areas of abraded paste.
- Poor bond to rock.

17-C24 : - 1.07 - 1.77
- Wood at surface, but no intact formed surface.
- 1.07-1.53 : Good condition; mechanical breaks only.
- 1.53 : Flat cold joint, likely to mud-slab, no bond.
- 1.53-1.65 : Lesser quality concrete; some paste abraded.
- 1.65-1.77 : Heavily corroded re-bar splice in heavily voided concrete (likely poured in water).
    - Voids heavily infilled with rust.
- No bond to rock.

APPENDIX B

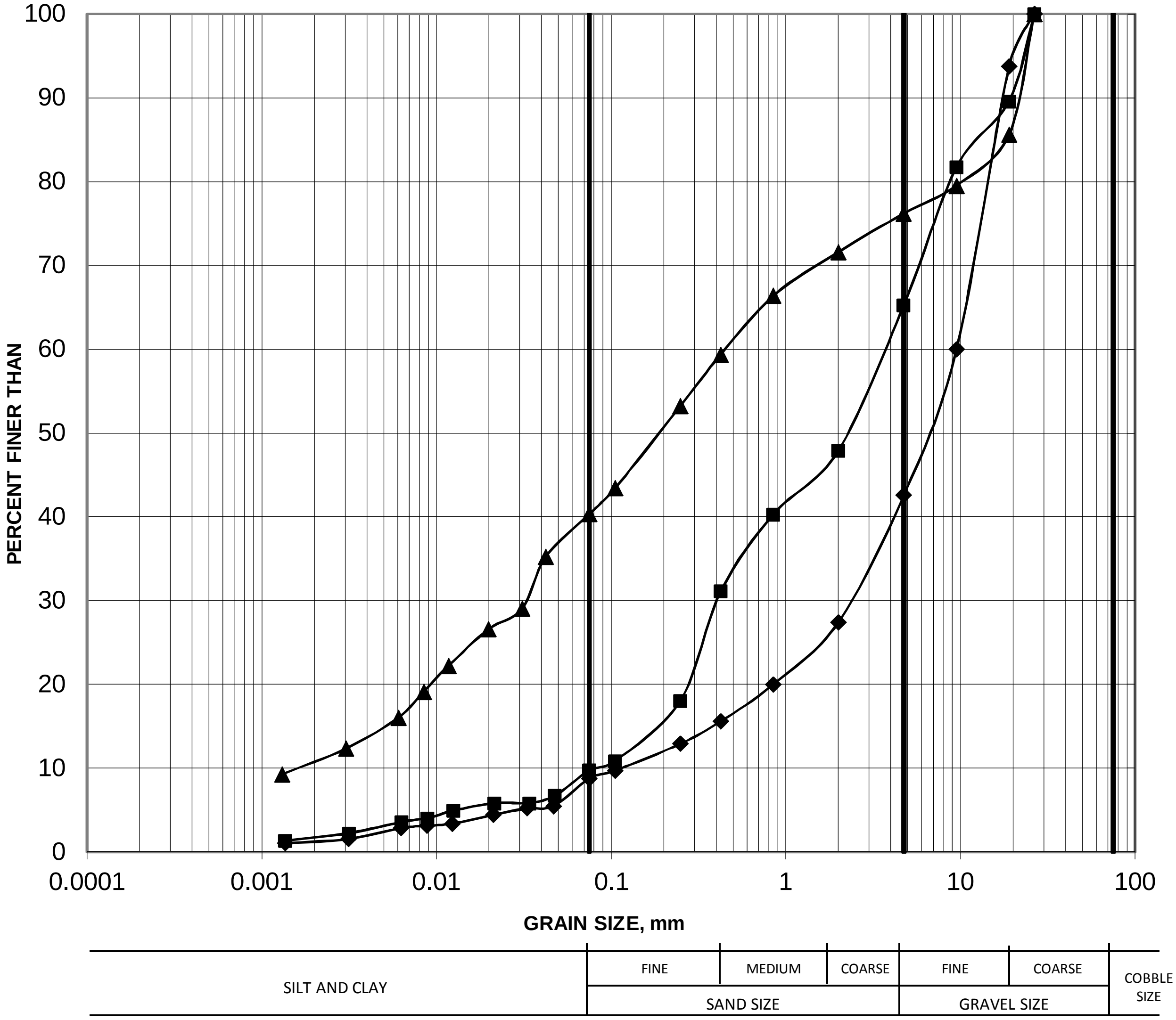
Laboratory Test Results, Current Investigation

Figure B1 – Grain Size Distribution Test Results – Sand and Gravel (Fill)
Figure B2 – Grain Size Distribution Test Results – Sand (Fill)
Figure B3 – Grain Size Distribution Test Results – Sand (Fill)
Figure B4 – Grain Size Distribution Test Results – Silt (Fill)
Figure B5 – Grain Size Distribution Test Results – Sand (Fill)
Figure B6 – Grain Size Distribution Test Results – Silty Sand
Figure B7 – Grain Size Distribution Test Results – Silt
Figure B8 – Grain Size Distribution Test Results – Glacial Till
Figure B9 – Summary of Laboratory Compressive Strength Unconfined Compression Tests

GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND AND GRAVEL (FILL)



Borehole	Sample	Depth (m)
■ 17-C01	1	0.10-0.20
◆ 17-C13	1	0.30-0.40
▲ 18-1305	9	6.10-6.71

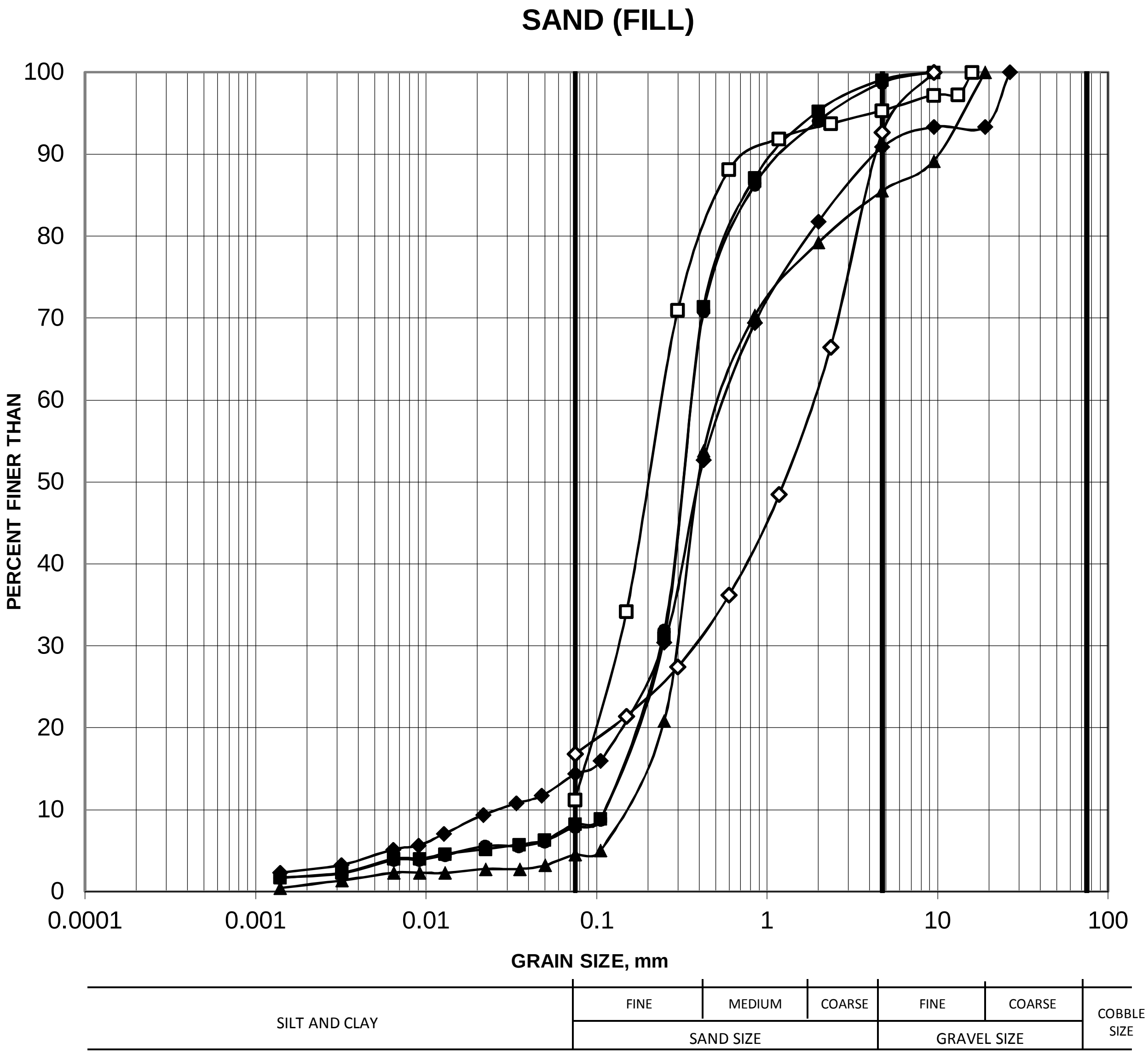
Project: 1655214 /1130

Golder Associates

Created by: CW
Checked by: MI

GRAIN SIZE DISTRIBUTION

FIGURE B2



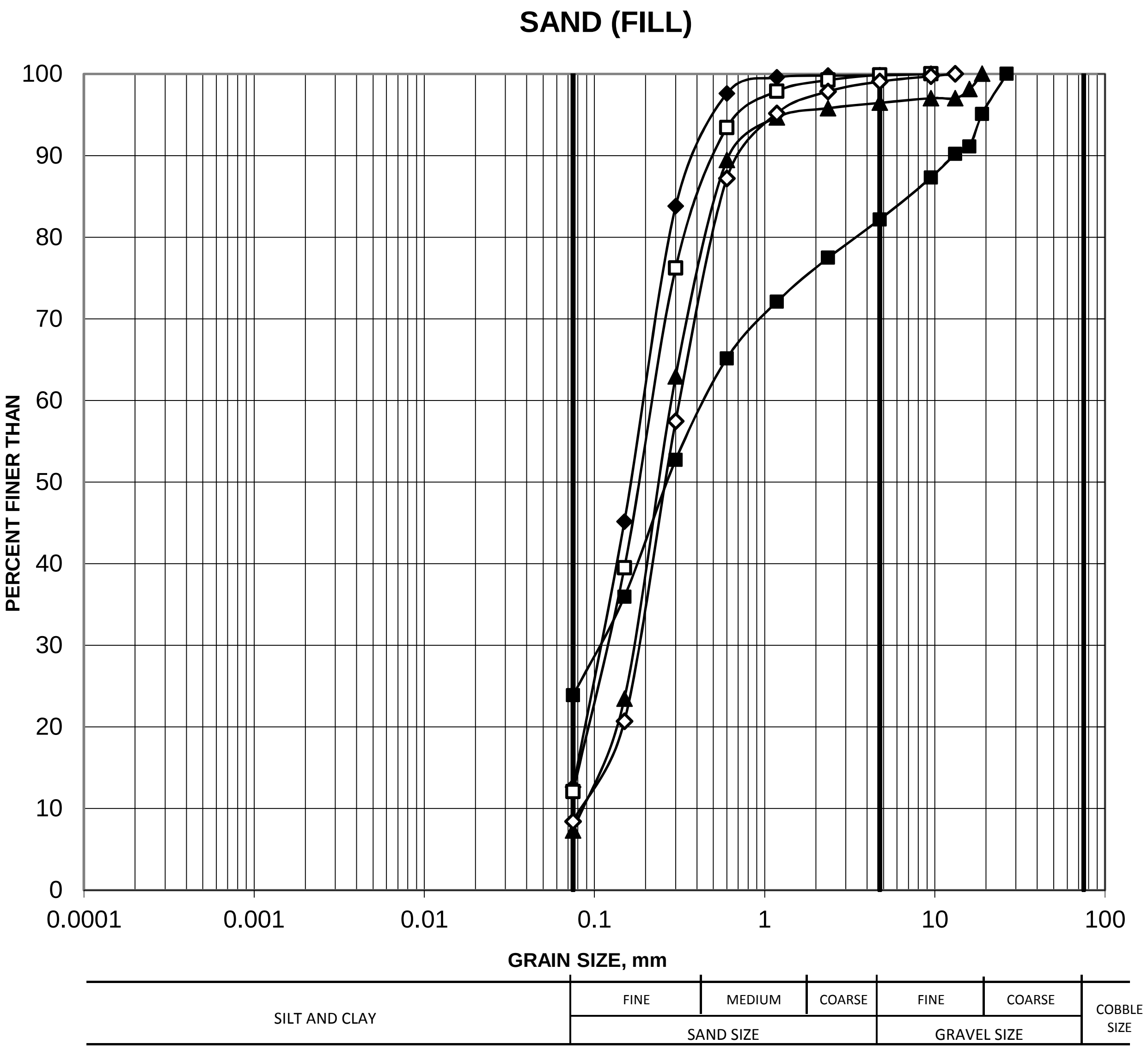
Borehole	Sample	Depth (m)
■ 17-131	1	1.50-2.80
◆ 17-133	1	1.20-3.00
▲ 17-C09	2	0.75-0.90
● 17-C19	2	0.60-0.90
□ 18-1301	3	1.22-1.83
◇ 18-1307	3	1.52-2.13

Created by: CW
Checked by: MI

Project: 1655214 /1130

Golder Associates

GRAIN SIZE DISTRIBUTION	FIGURE B3



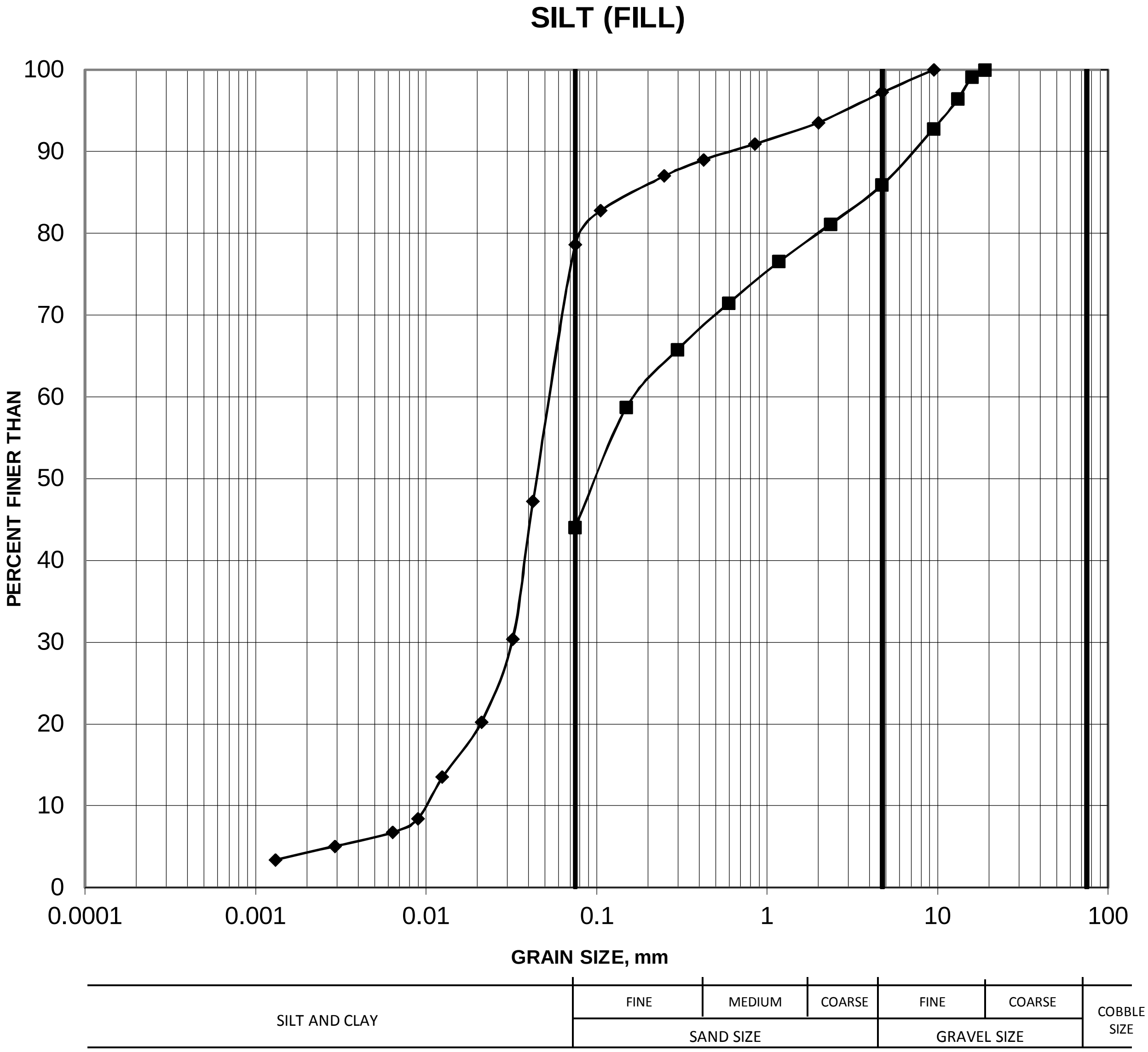
Borehole	Sample	Depth (m)
■ 18-1302	3	1.22-1.83
◆ 18-1305	6	3.81-4.42
▲ 18-1306	7	3.81-4.42
□ 18-1307	6	3.81-4.42
◇ 18-1308	7	4.57-5.18

Project: 1655214/1130

Golder Associates

Created by: MI
Checked by: AC

GRAIN SIZE DISTRIBUTION	FIGURE B4



Borehole	Sample	Depth (m)
■ 18-1309	3	1.52-2.13
◆ 18-1310	6A	4.57-5.18

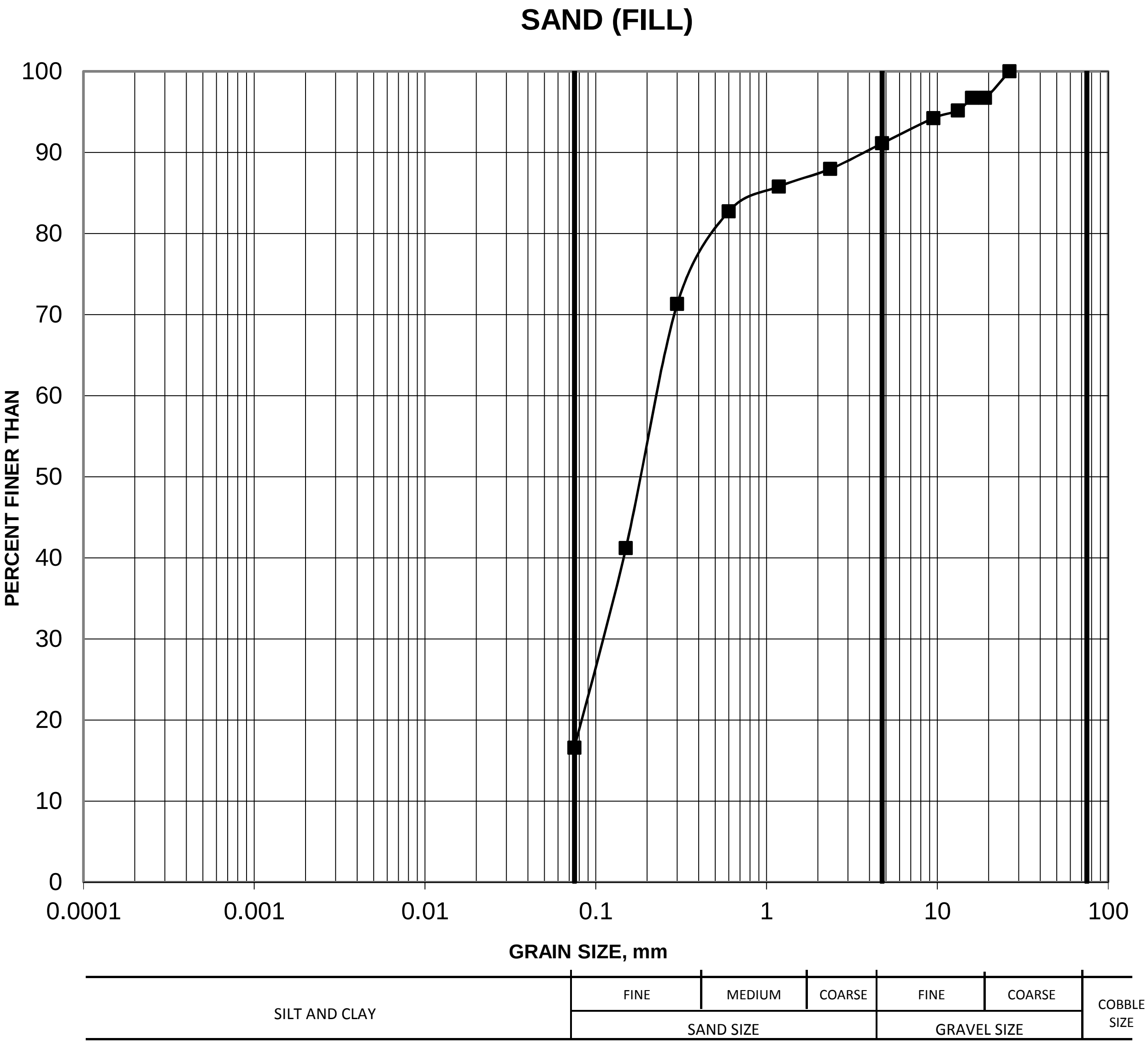
Project: 1655214/1130

Golder Associates

Created by: MI
Checked by: AC

GRAIN SIZE DISTRIBUTION

FIGURE B5



Borehole	Sample	Depth (m)
■ 18-1310	3	2.29-2.90

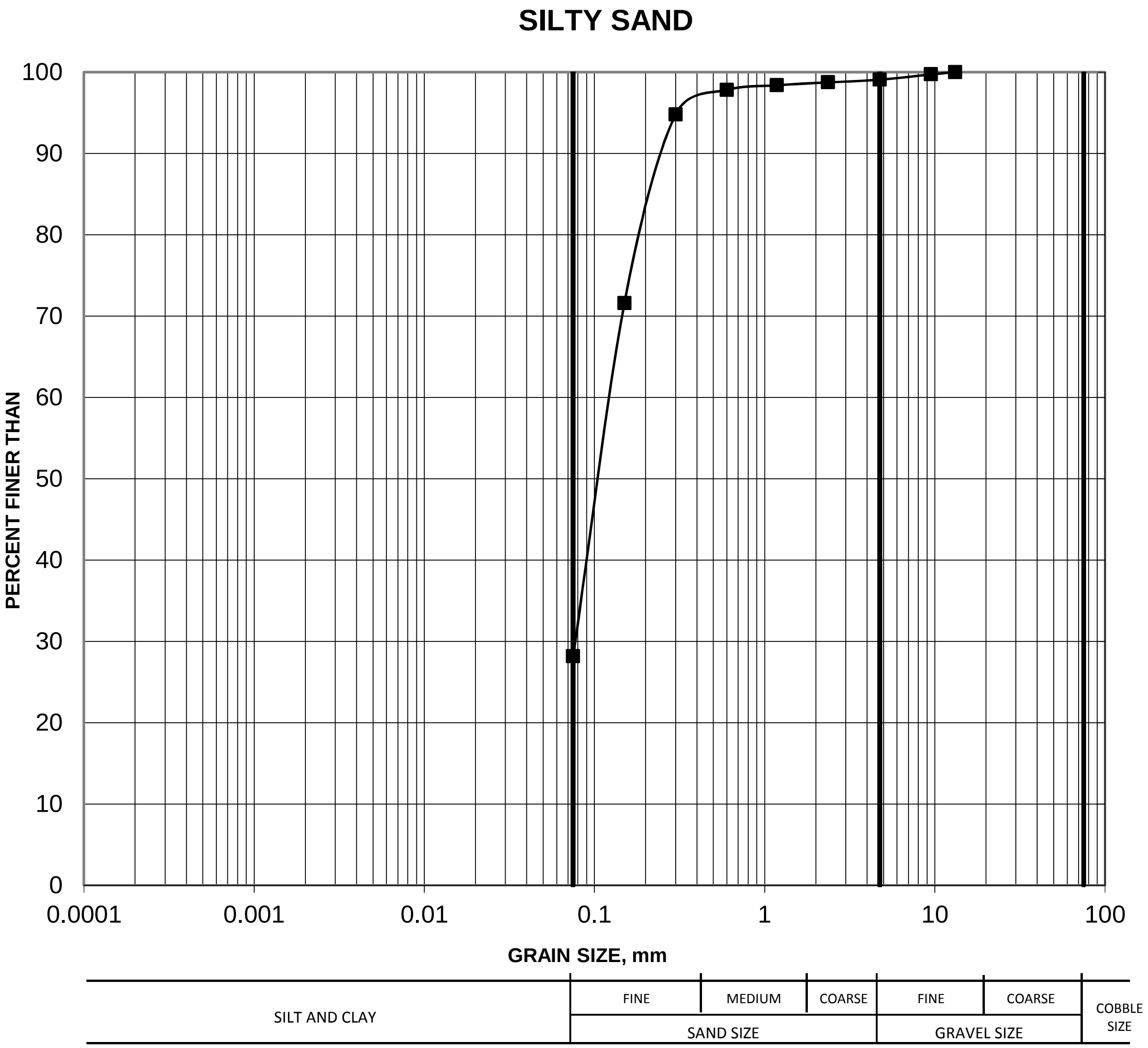
Project: 1655214/1130

Golder Associates

Created by: MI
Checked by: AC

GRAIN SIZE DISTRIBUTION

FIGURE B6



Borehole	Sample	Depth (m)
■ 18-1311	4	2.29-2.90

Project: 1655214/1130

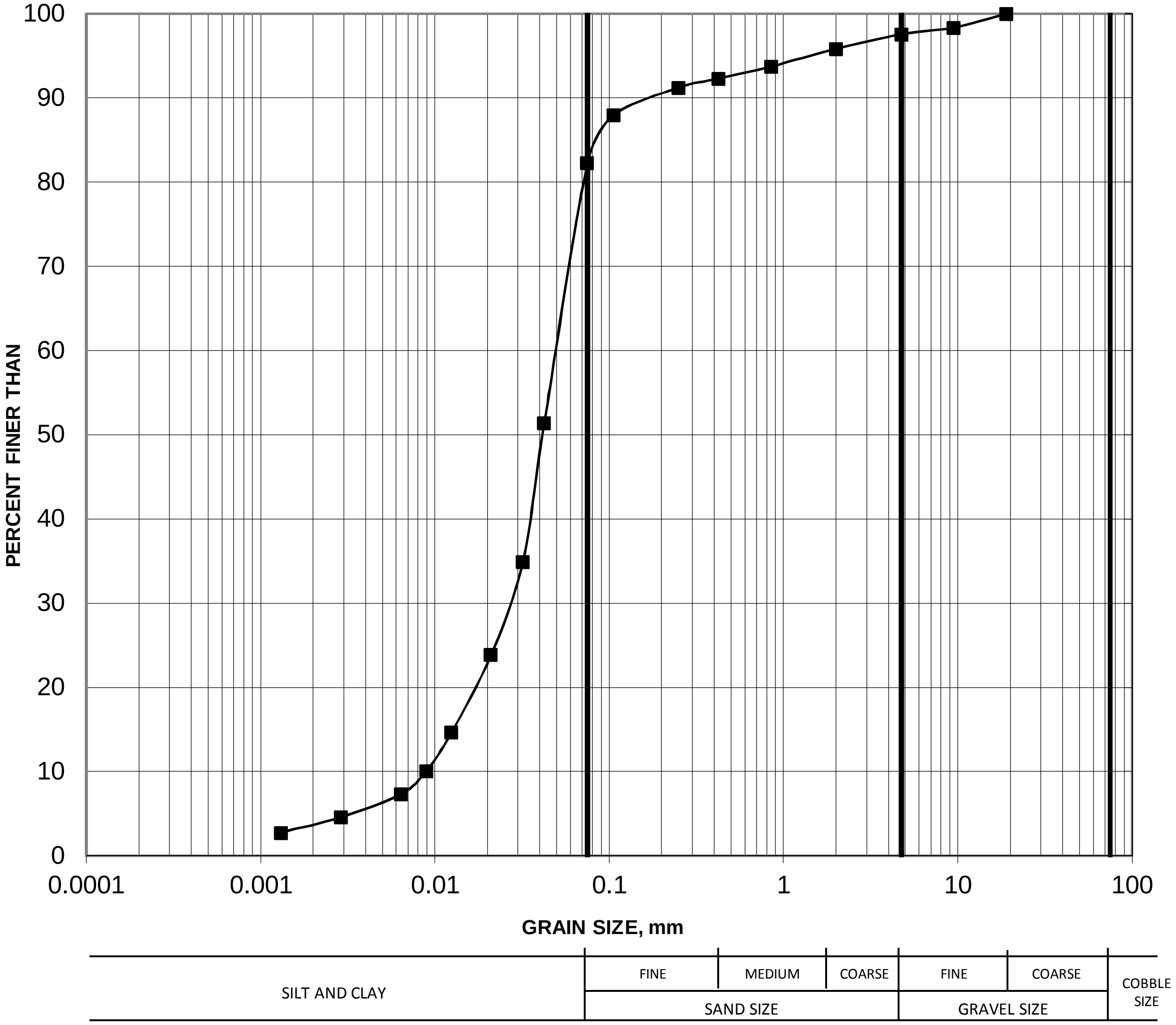
Golder Associates

Created by: MI
Checked by: AC

GRAIN SIZE DISTRIBUTION

FIGURE B7

SILT



Borehole	Sample	Depth (m)
—■— 18-1311	8	5.33-5.94

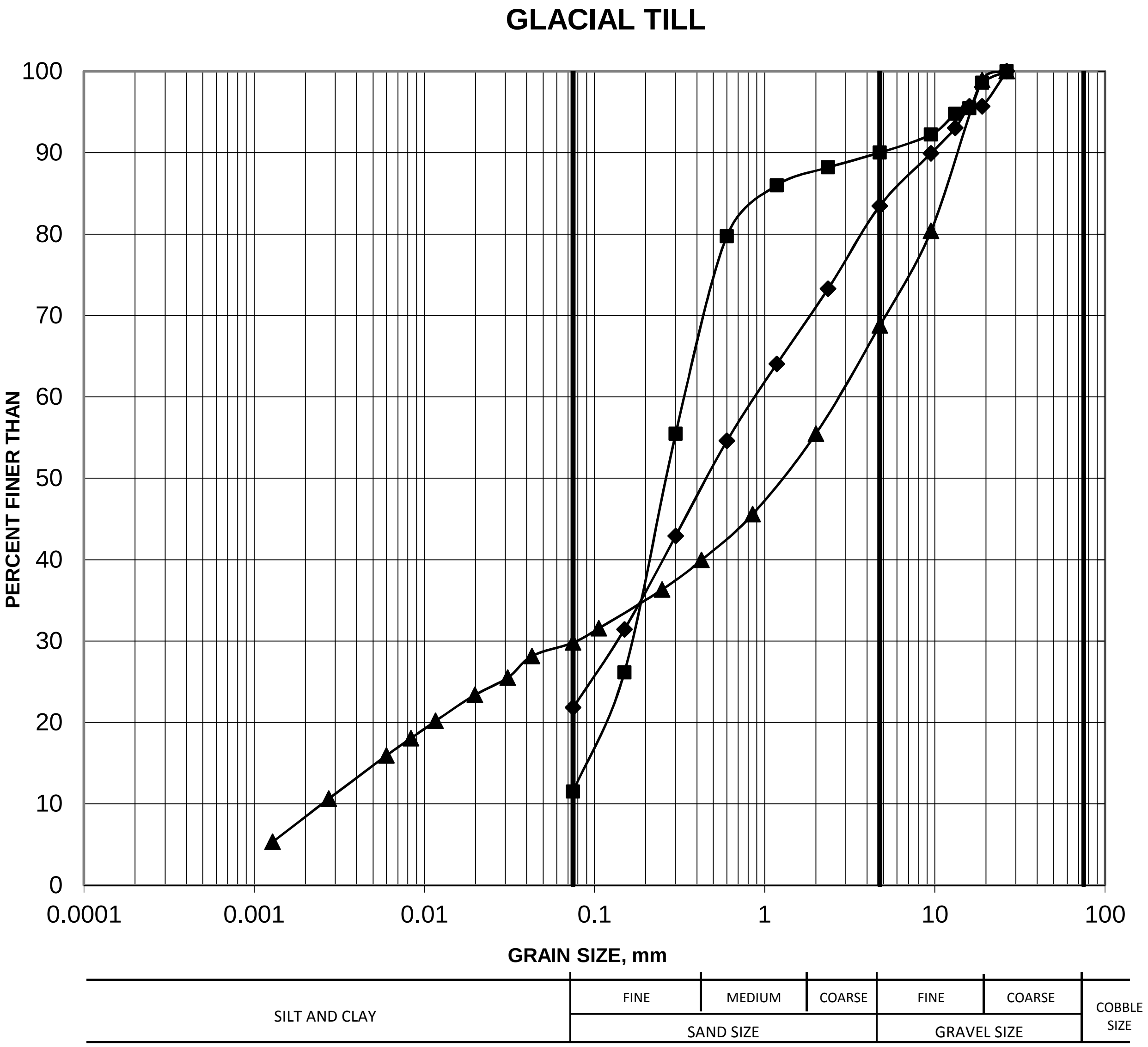
Project: 1655214/1130

Golder Associates

Created by: MI
Checked by: AC

GRAIN SIZE DISTRIBUTION

FIGURE B8



Borehole	Sample	Depth (m)
■ 18-1306	9	5.33-5.94
◆ 18-1308	10	6.86-7.47
▲ 18-1311	10	6.86-7.35

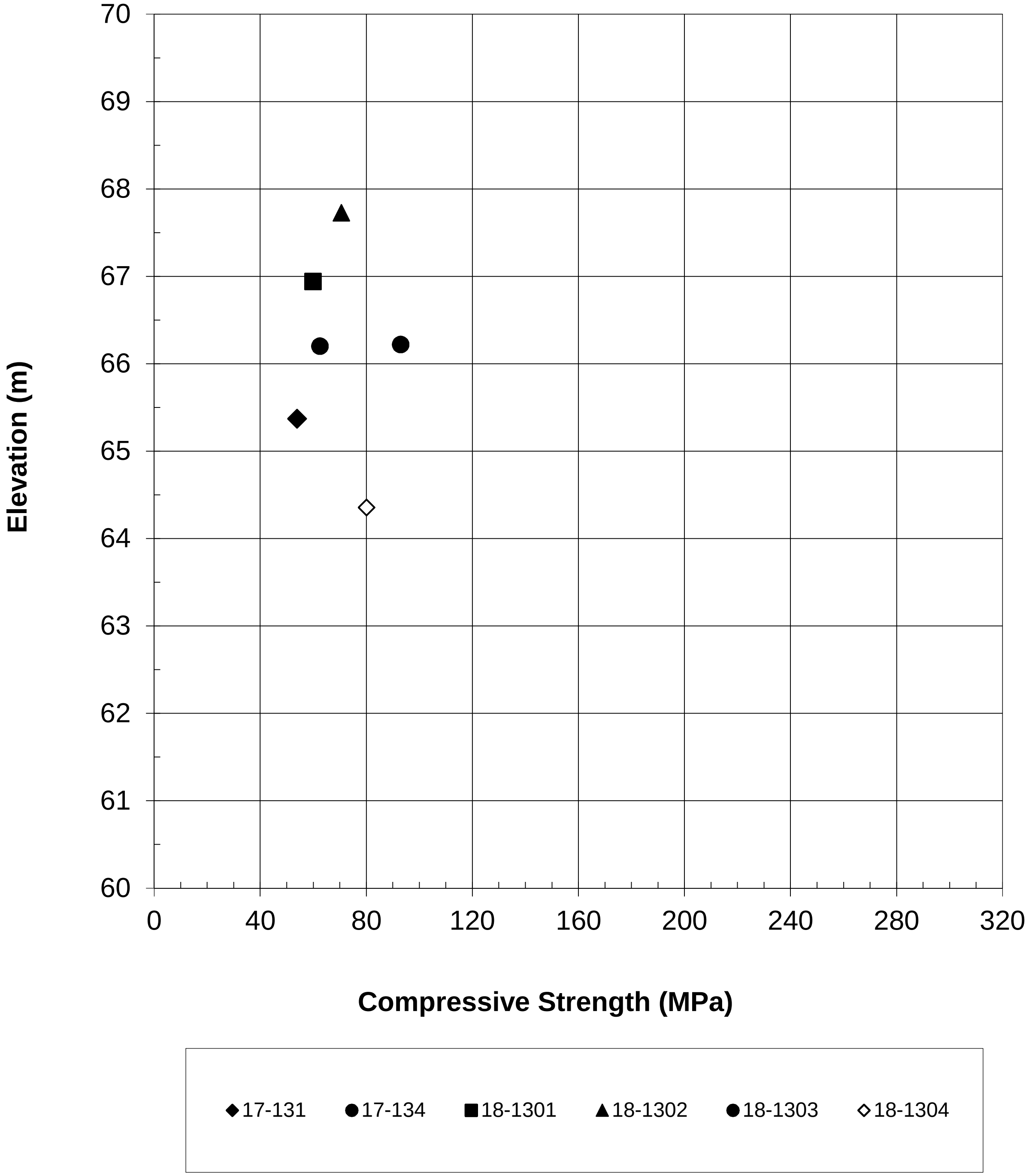
Created by: MI
Checked by: AC

Project: 1655214/1130

Golder Associates

SUMMARY OF LABORATORY COMPRESSIVE STRENGTH UNCONFINED COMPRESSION TESTS

FIGURE B9



Project: 1655214 /1130

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Created by: MI
Checked by: AC

APPENDIX C

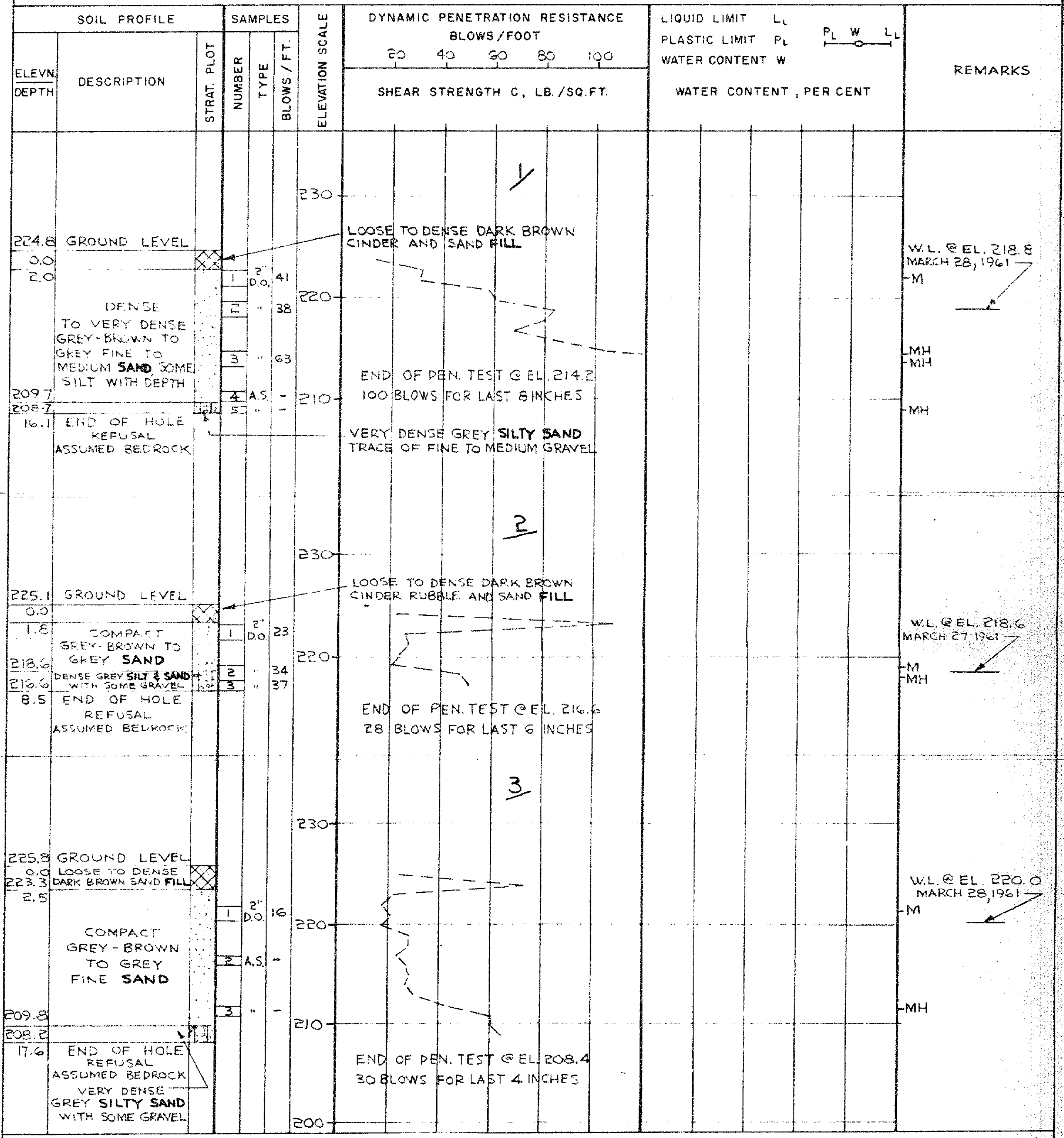
Previous Investigations, GEOCRES 31G05-043 (1961)
Record of Boreholes 1 to 6
Boring Plan and Soil Stratigraphy
Laboratory Test Results

RECORD OF BOREHOLES 1, 2, 3

LOCATION SEE FIGURE 1 BORING DATE MARCH 27, 28, 1961 DATUM GEODETIC

BOREHOLE TYPE POWER AUGER & WASH BORINGS BOREHOLE DIAMETER 4" & BX CASING

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES



VERTICAL SCALE

1 INCH TO 10 FEET

GOLDER & ASSOCIATES

DRAWN J.A.

CHECKED

PROJECT No. 6105

RECORD OF BOREHOLES 4,5

LOCATION SEE FIGURE 1 BORING DATE MARCH 25-27, 1961 DATUM GEODETIC

BOREHOLE TYPE WASH BORINGS BOREHOLE DIAMETER BX CASING

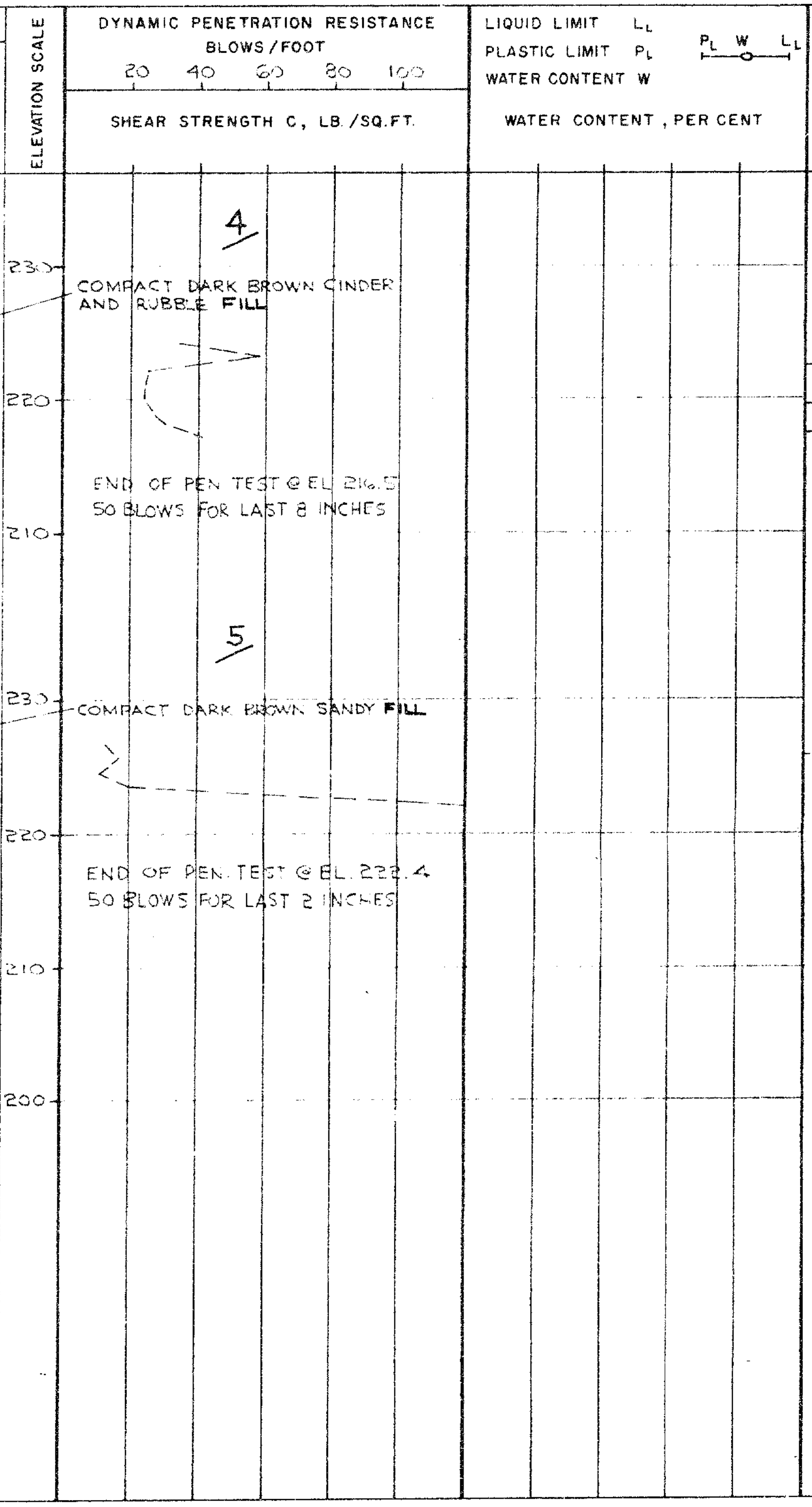
SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

4

ELEVN. DEPTH	SOIL PROFILE DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS / FT
225.2	GROUND LEVEL				
0.0					
1.2	COMPACT GREY-BROWN TO GREY FINE TO MEDIUM **SAND** WITH SOME GRAVEL SILTY WITH DEPTH		1	2" D.O.	20
			2	"	28
217.7			3	"	
8.3	END OF HOLE REFUSAL ASSUMED BEDROCK				
	VERY DENSE GREY **SAND AND GRAVEL**				

5

ELEVN. DEPTH	SOIL PROFILE DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS / FT
227.6	GROUND LEVEL				
0.0	-		1	C.S.	-
1.5					
3.2	COMPACT TO DENSE GREY-BROWN FINE TO MEDIUM **SAND**		2	E.X. R.C.	—
	SOUND DARK GREY LIMESTONE **BEDROCK**		3	"	—
			4	"	—
			5	"	—
204.3					
23.3	END OF HOLE				



REMARKS

W.L. @ EL. 220.0
MARCH 27, 1961

BOREHOLE DRY
MARCH 27, 1961
NO WATER LOSS
DURING DRILLING
OF BEDROCK

VERTICAL SCALE
1 INCH TO 10 FEET

GOLDER & ASSOCIATES

DRAWN J.A.
CHECKED

PROJECT No.

RECORD OF BOREHOLE 6 & P.T. 7

LOCATION SEE FIGURE 1 BORING DATE MARCH 24, 25, 1961 DATUM GEODETIC

BOREHOLE TYPE WASH BORING & PEN. TEST BOREHOLE DIAMETER BX CASING

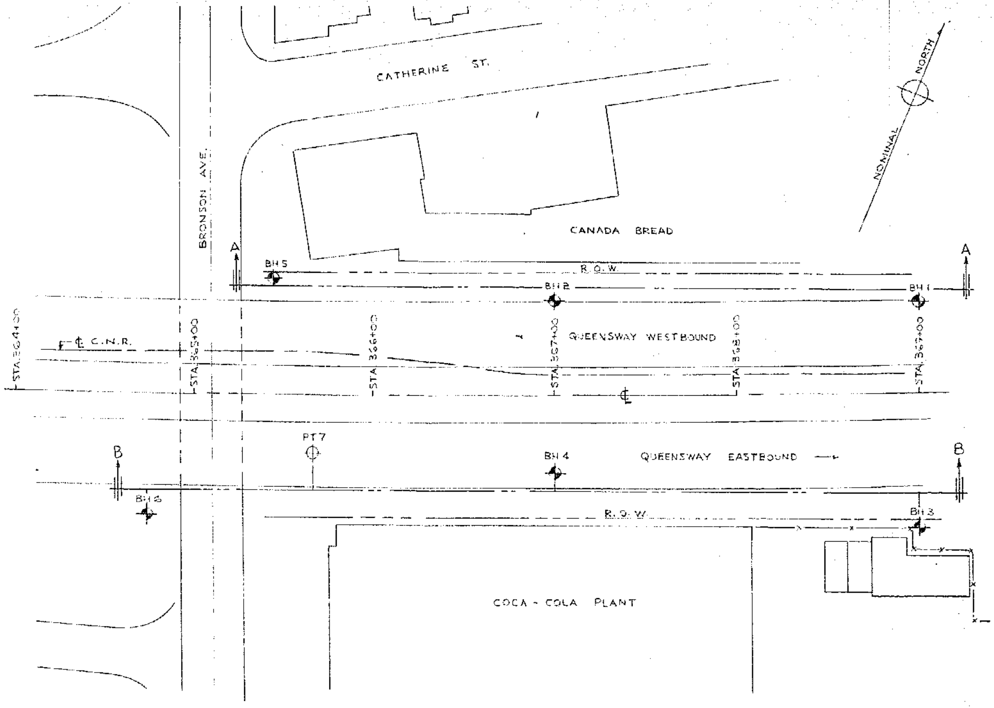
SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

SOIL PROFILE		SAMPLES			ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 20 40 60 80 100 SHEAR STRENGTH C, LB./SQ.FT.	LIQUID LIMIT L_L PLASTIC LIMIT P_L WATER CONTENT W (P_L W L_L) WATER CONTENT, PER CENT	REMARKS
ELEVN. DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FT.				
					240	6		
233.2	GROUND LEVEL							W.L. @ EL. 229.5 MAY 10, 1961
0.0						COMPACT DARK BROWN SAND AND RUBBLE **FILL**		
1.5						COMPACT TO DENSE GREY-BROWN FINE TO MEDIUM **SAND**		
3.8		1	C.S.	–	230			
226.7 6.5	VERY DENSE GREY-BROWN **SILTY SAND** WITH SOME GRAVEL.	2	BX R.C.	–		END OF PEN. TEST @ EL. 227.3 100 BLOWS FOR LAST 11 INCHES		
		3	"	–				
	SOUND DARK GREY LIMESTONE **BEDROCK**	4	"	–	220			
		5	"	–	210			
		6	"	–				
205.4 27.8	END OF HOLE				200			
						P.T. 7		
					230			
226.3	GROUND LEVEL							
0.0								
222.4 3.9	END OF PEN. TEST REFUSAL ASSUMED BEDROCK				220	40 BLOWS FOR LAST 10½ INCHES 40 BLOWS FOR LAST ½ INCH		

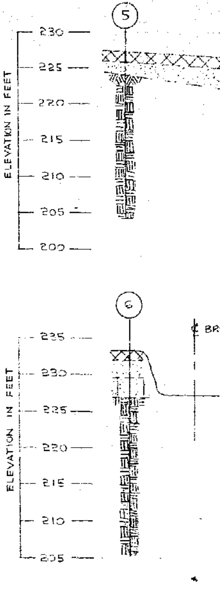
VERTICAL SCALE
1 INCH TO 10 FEET

GOLDER & ASSOCIATES

DRAWN J.A.
CHECKED



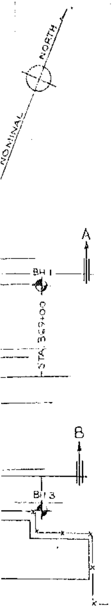
PLAN
SCALE 1" TO 40'-0"

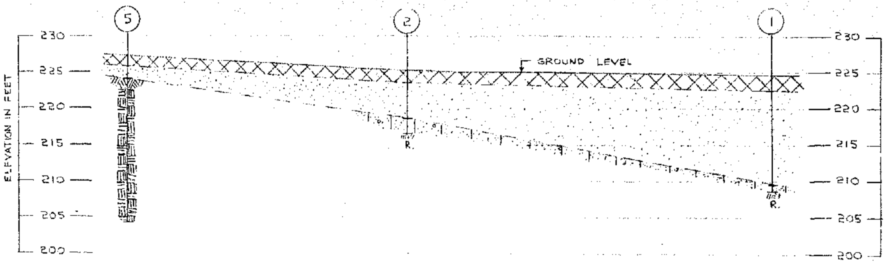


LEGEND

⯐ BOREHOLE WITH PENETRATION TEST IN PLAN

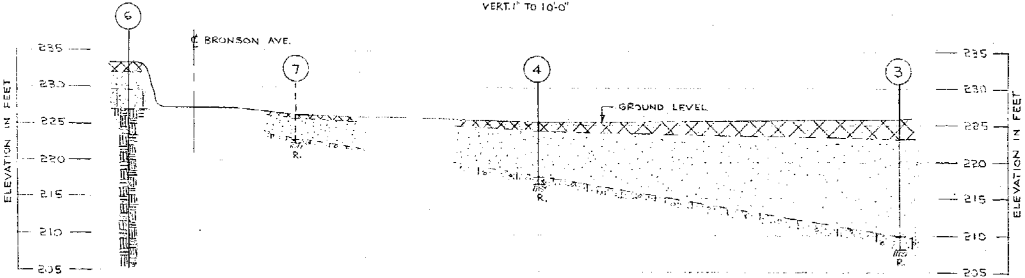
⌖ PENETRATION TEST IN PLAN, (7) IN ELEV





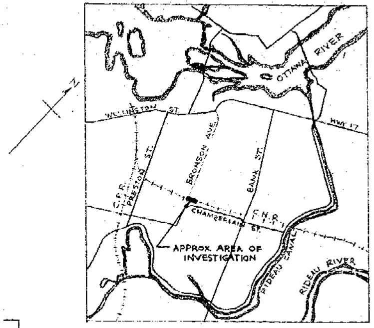
SECTION A-A

SCALE: HORIZ 1" TO 40'-0"
VERT. 1" TO 10'-0"



SECTION B-B

SCALE: HORIZ. 1" TO 40'-0"
VERT. 1" TO 10'-0"



KEY PLAN

SCALE: 1" TO 3,800' (APPROX.)

STRATIGRAPHY

- ⊠ LOOSE TO DENSE DARK BROWN HETEROGENEOUS FILL
- ▒ COMPACT TO DENSE GREY-BROWN TO GREY FINE TO MEDIUM SAND.
- ▨ DENSE TO VERY DENSE GREY SILTY SAND WITH GRAVEL
- ▦ LIMESTONE BEDROCK
- R. REFUSAL - ASSUMED BEDROCK

LEGEND

- ⊕ BOREHOLE WITH PENETRATION TEST IN PLAN, ① IN ELEVATION
- ⊕ PENETRATION TEST IN PLAN, ⑦ IN ELEVATION

SPECIAL NOTE: DATA CONCERNING THE VARIOUS STRATA HAVE BEEN OBTAINED AT BOREHOLE LOCATIONS ONLY. THE SOIL STRATIGRAPHY BETWEEN BOREHOLES HAS BEEN INFERRED FROM GEOLOGICAL EVIDENCE AND SO MAY VARY FROM THAT SHOWN.

REFERENCE

DRWG No.	DESCRIPTION
III-A-22	DE LEUW CATHER & COMPANY OF CANADA LIMITED - OTTAWA QUEENSWAY, STA. 357+00 TO STA. 369+00, R.O.W. & UTILITIES.

DE LEUW CATHER & COMPANY
OF CANADA LIMITED
OTTAWA ONTARIO
PROPOSED QUEENSWAY - BRONSON OVERPASS
OTTAWA ONTARIO
BORING PLAN AND SOIL STRATIGRAPHY

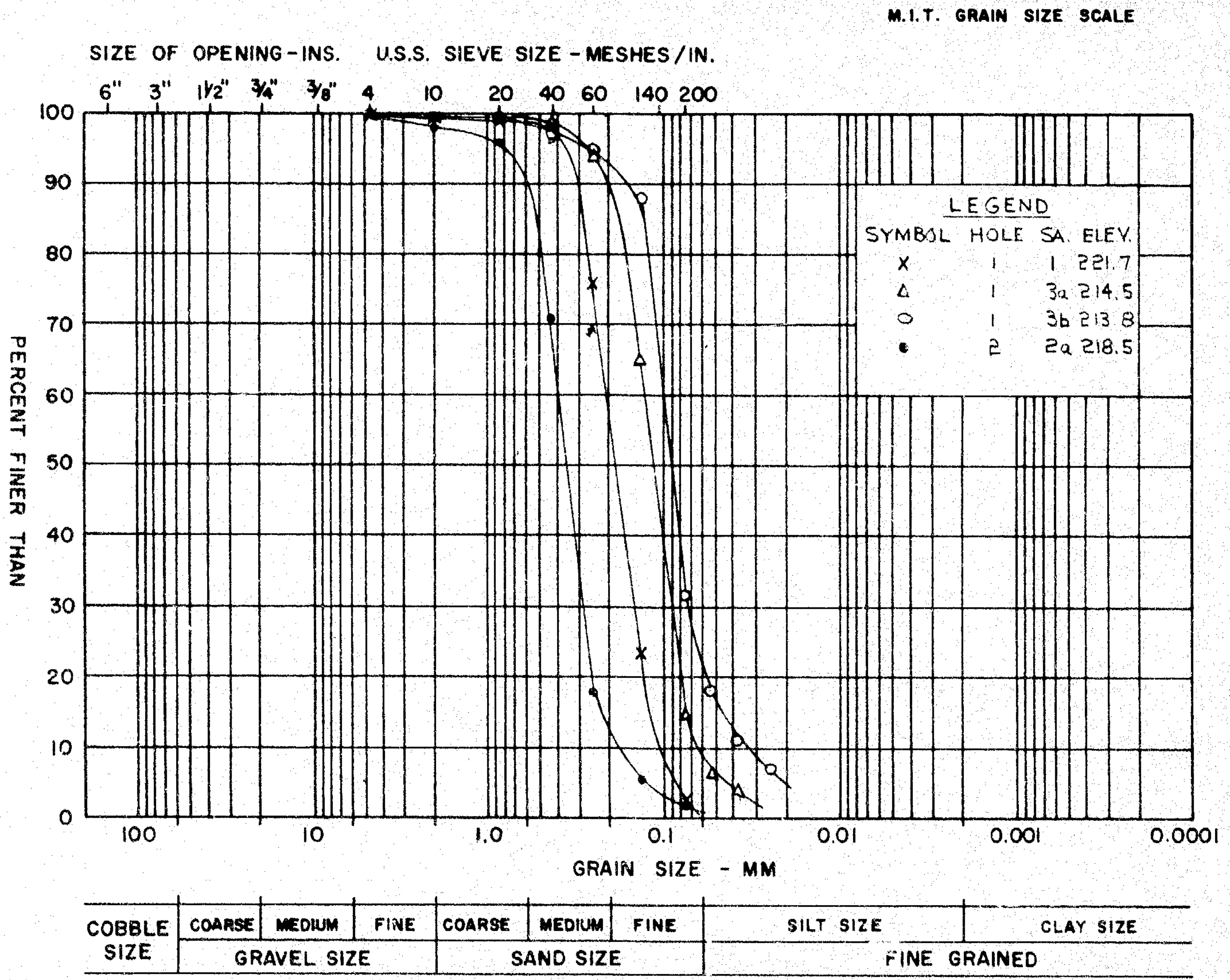
GOLDER & ASSOCIATES
CONSULTING CIVIL ENGINEERS

DATE: AUG. 15, 1961 SCALE: HORIZ. 1" TO 40'-0" VERT. 1" TO 10'-0"

MADE	CHKD.	APPD.	
I.A.	JJC	JJC	FIGURE 1

PROJECT No. 6105

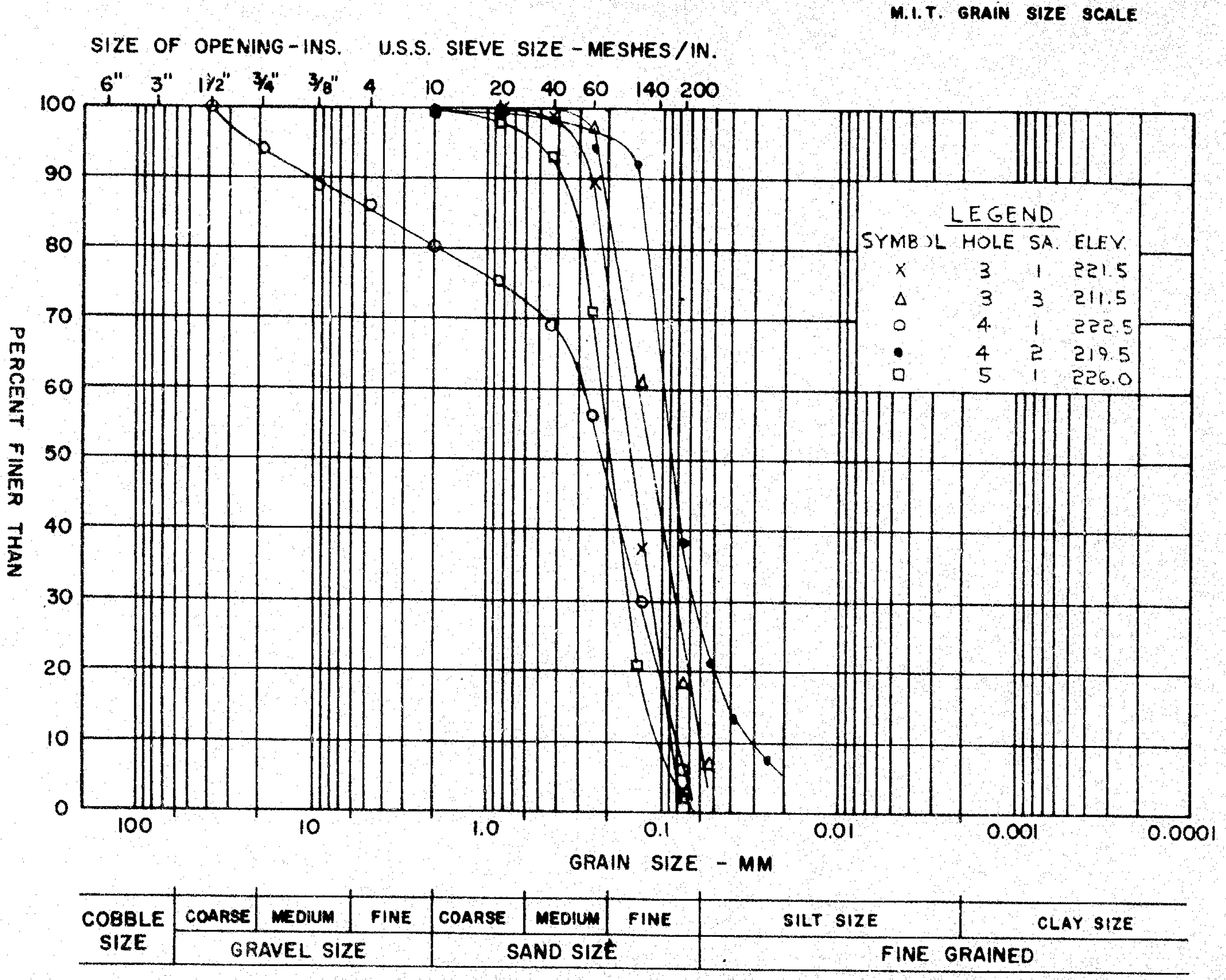
GRAIN SIZE DISTRIBUTION



GOLDER & ASSOCIATES

FIGURE 2

PROJECT No. 6105



GRAIN SIZE DISTRIBUTION

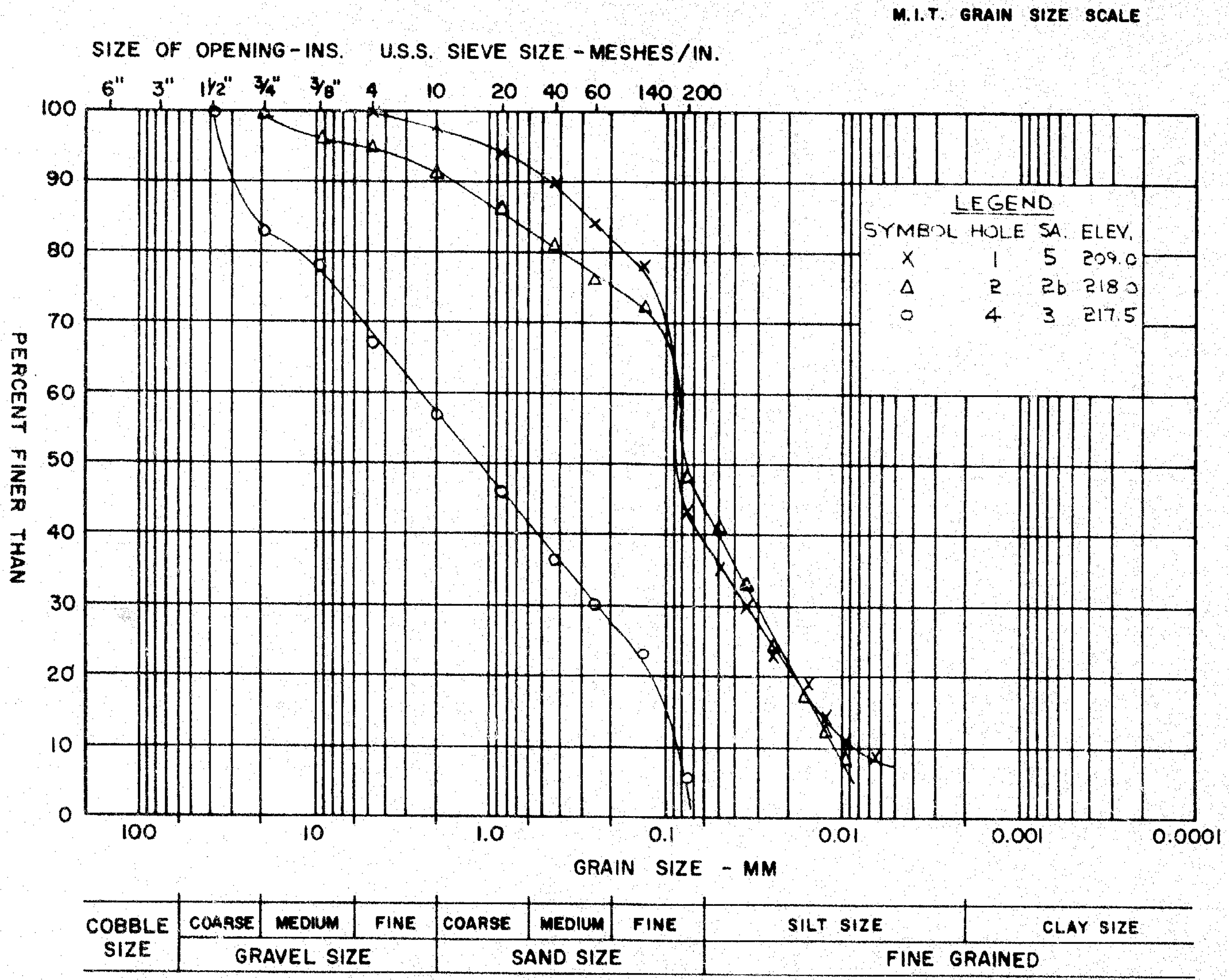
FIGURE 3

GOLDER & ASSOCIATES

PROJECT No. 6125

GRAIN SIZE DISTRIBUTION

FIGURE 4



LEGEND

SYMBOL	HOLE	SA.	ELEV.
X	1	5	209.0
Δ	2	2b	218.0
○	4	3	217.5

GOLDER & ASSOCIATES

APPENDIX D

Basic Chemical Analysis Results – Eurofins Report Numbers 1717833 and 1901731

Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Mr. Alex Meacoe
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1717833
Date Submitted: 2017-09-15
Date Reported: 2017-09-20
Project: 1655214/1130
COC #: 823503

				Lab I.D.	1320697
				Sample Matrix	Soil
				Sample Type	
				Sampling Date	2017-09-15
				Sample I.D.	17-132 sa2 3-4.5
Group	**Analyte**	**MRL**	**Units**	**Guideline**	
Agri. - Soil	pH	2.0			8.2
	SO4	0.01	%		0.06
General Chemistry	Cl	0.002	%		0.050
	Electrical Conductivity	0.05	mS/cm		1.26
	Resistivity	1	ohm-cm		794

Guideline = *** = Guideline Exceedence**

All analysis completed in Ottawa, Ontario (unless otherwise indicated by ** which indicates analysis was completed in Mississauga, Ontario).
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Certificate of Analysis

eurofins | Environment Testing

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Mr. Gabrielle Marcotte
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1901731
Date Submitted: 2019-02-05
Date Reported: 2019-02-12
Project: 1655214
COC #: 840230

Group	Analyte	MRL	Units	Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D. Guideline	1410016 Soil 2019-02-05 Phase 1220 18-2203 sa 9	1410017 Soil 2019-02-05 Phase 1220 18-2205 sa 16	1410018 Soil 2019-02-05 phase 1130 18-1301 sa 4	1410019 Soil 2019-02-05 phase 1130 18-1304 sa 2
Anions	Cl	0.002	%		0.014	0.005	0.007	<0.002
	SO4	0.01	%		0.04	0.05	0.04	0.06
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.37	0.12	0.10	<0.05
	pH	2.00			8.06	7.85	8.43	8.81
	Resistivity	1	ohm-cm		2700	8330	10000	25000

Group	Analyte	MRL	Units	Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D. Guideline	1410020 Soil 2019-02-05 phase 1130 18-1309 sa 5	1410021 Soil 2019-02-05 phase 1130 18-1311 sa 9	1410022 Soil 2019-02-05 phase 1110 18-1106 sa 5	1410023 Soil 2019-02-05 phase 1110 18-1105 sa 6
Anions	Cl	0.002	%		0.006	0.005	0.003	0.093
	SO4	0.01	%		0.06	0.03	0.04	0.10
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.32	0.12	0.05	1.02
	pH	2.00			7.98	7.78	8.96	9.95
	Resistivity	1	ohm-cm		3120	8330	20000	980

Guideline = *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

APPENDIX E

MASW Test Results and Report – Sites 3-56/1 and 3-56/2 Highway 417 Overpass at Rochester Street

TECHNICAL MEMORANDUM

DATE December 8, 2017 **PROJECT No.** 1655214/1500

TO Susan Trickey
Golder Associates Ltd.

FROM Stephane Sol
Christopher Phillips

EMAIL ssol@golder.com
cphillips@golder.com

CHBDC SEISMIC SITE CLASS TESTING RESULTS – HWY417 (ROCHESTER ST EXIT) OTTAWA, ONTARIO

This technical memorandum presents the results of one Multichannel Analysis of Surface Waves (MASW) test performed for the purpose of the Canadian Highway Bridge Design Code (CHBDC 2014) Seismic Site Classification for a site located near the HWY417 off ramp to Rochester Street just east of Preston Street in Ottawa, Ontario (Figure 1). The MASW line was located on a grassy area on north of the off ramp. The geophysical testing was performed by Golder personnel on October 18, 2017.

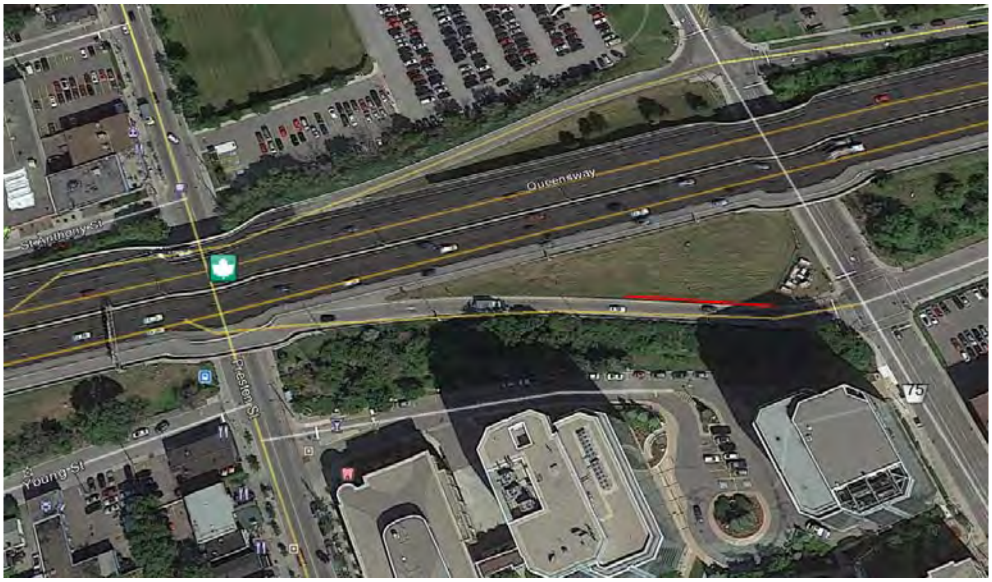


Figure 1: MASW Location Site Map (MASW Line in red)

Methodology

The MASW method measures variations in surface-wave velocity with increasing distance and wavelength and can be used to infer the rock/soil types, stratigraphy and soil conditions.

A typical MASW survey requires a seismic source, to generate surface waves, and a minimum of two geophone receivers, to measure the ground response at some distance from the source. Surface waves are a special type of seismic wave whose propagation is confined to the near surface medium.

The depth of penetration of a surface wave into a medium is directly proportional to its wavelength. In a non-homogeneous medium, surface waves are dispersive, i.e., each wavelength has a characteristic velocity owing to the subsurface heterogeneities within the depth interval that particular wavelength of surface wave propagates through. The relationship between surface-wave velocity and wavelength is used to obtain the shear-wave velocity and attenuation profile of the medium with increasing depth.

The seismic source used can be either active or passive, depending on the application and location of the survey. Examples of active sources include explosives, weight-drops, sledge hammer and vibrating pads. Examples of passive sources are road traffic, micro-tremors, and water-wave action (in near-shore environments).

The geophone receivers measure the wave-train associated with the surface wave travelling from a seismic source at different distances from the source.

The participation of surface waves with different wavelengths can be determined from the wave-train by transforming the wave-train results into the frequency domain. The surface-wave velocity profile with respect to wavelength (called the ‘dispersion curve’) is determined by the delay in wave propagation measured between the geophone receivers. The dispersion curve is then matched to a theoretical dispersion curve using an iterative forward-modelling procedure. The result is a shear-wave velocity profile of the tested medium with depth, which can be used to estimate the dynamic shear-modulus of the medium as a function of depth.

Field Work

The MASW field work was conducted on October 18, 2017, by personnel from the Golder Mississauga and Ottawa offices. For the MASW line, a series of 24 low frequency (4.5 Hz) geophones were laid out at 2 metre intervals. Both active and passive readings were recorded along the MASW line. For the active investigation, a seismic drop of 34 kg and a 9.9 kg sledge hammer were used as seismic sources. Active seismic records were collected with seismic sources located 5, 10, 15, and 20 metres from and collinear to the geophone array. An example of active seismic records collected is shown in Figure 2 below.

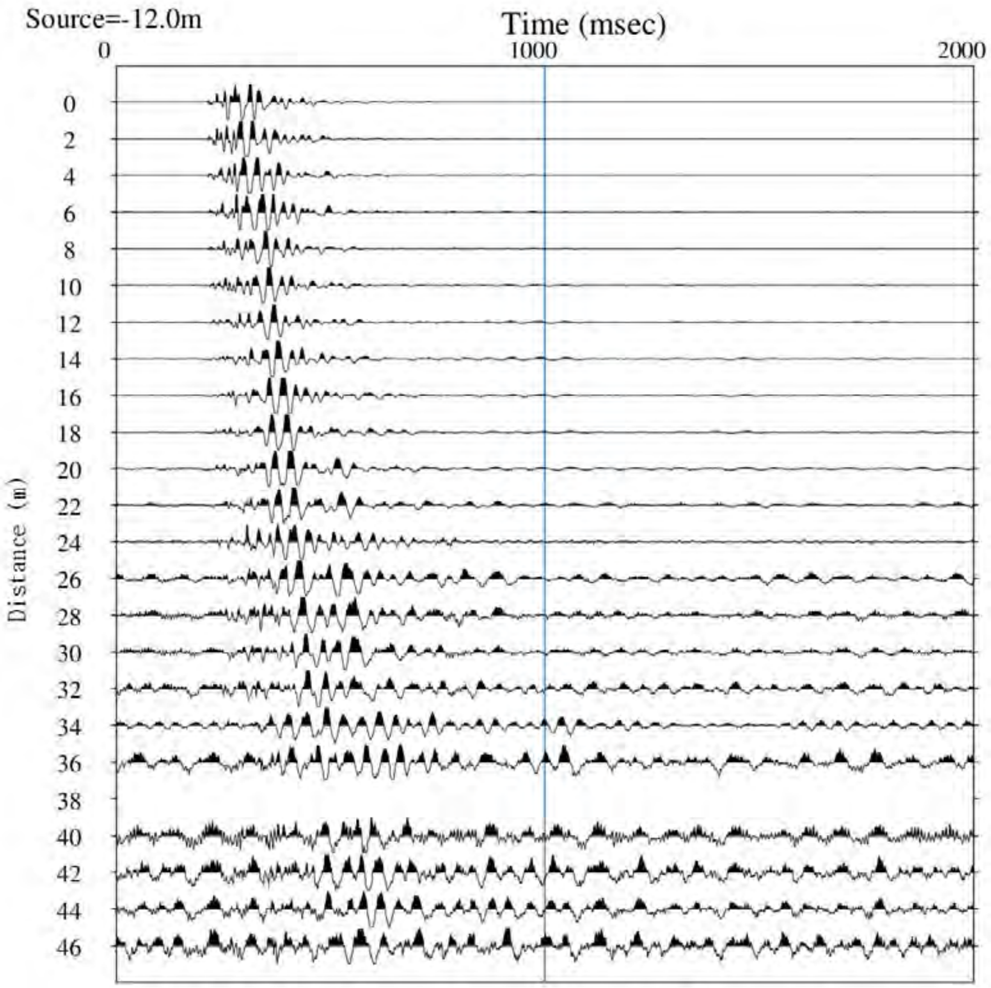


Figure 2: Typical seismic record collected along MASW Line 1

Data Processing

Processing of the MASW test results consisted of the following main steps:

1) Transformation of the time domain data into the frequency domain using a Fast-Fourier Transform (FFT) for each source location;

2) Calculation of the phase for each frequency component;

3) Linear regression to calculate phase velocity for each frequency component;

4) Filtering of the calculated phase velocities based on the Pearson correlation coefficient (r2) between the data and the linear regression best fit line used to calculate phase velocity;

5) Generation of the dispersion curve by combining calculated phase velocities for each shot location of a single MASW test; and,

6) Generation of the stiffness profile, through forward iterative modelling and matching of model data to the field collected dispersion curve.

Processing of the MASW data was completed using the SeisImager/SW software package (Geometrics Inc.). The calculated phase velocities for a seismic shot point were combined and the dispersion curve generated by choosing the minimum phase velocity calculated for each frequency component as shown on Figure 3 and 4. Shear wave velocity profiles were generated through inverse modelling to best fit the calculated dispersion curves. The active survey provided a dispersion curve with a suitable frequency range (14 -33 Hz). The minimum measured surface wave frequency with sufficient signal-to-noise ratio to accurately measure phase velocity was approximately 14 Hz.

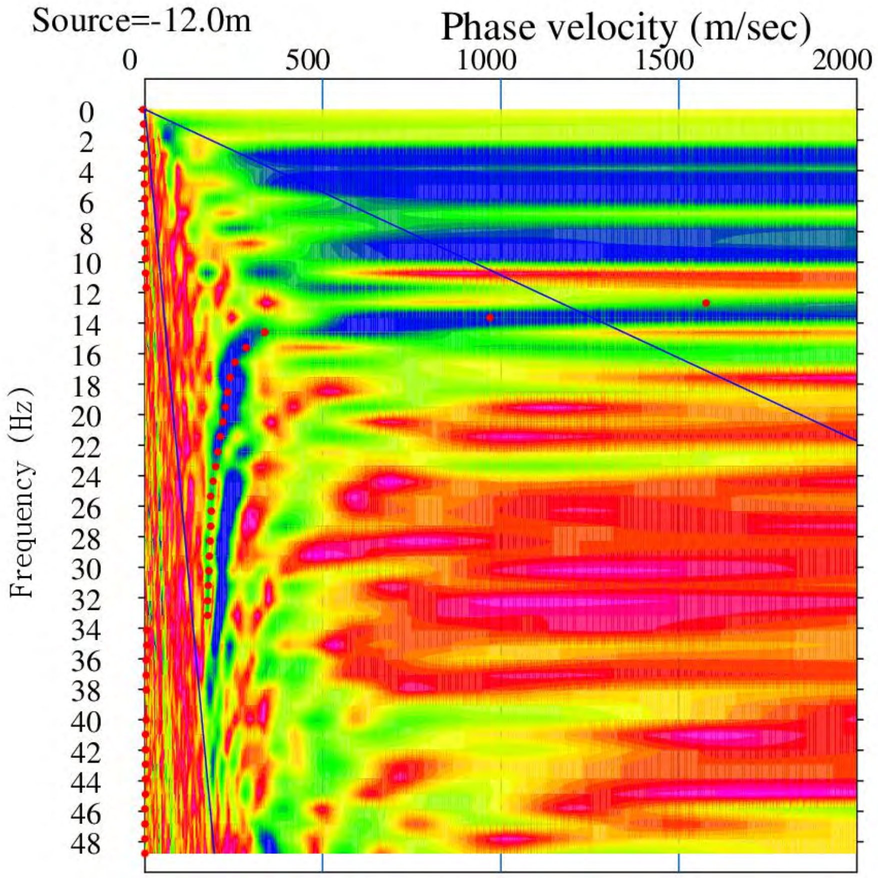


Figure 3: Active MASW Dispersion Curve Picks (red dots) along MASW Line 1

Results

The MASW test results are presented in Figure 4, which presents the calculated shear wave velocity profile derived from the field testing. The results along MASW Line 1 have been calculated using a weight-drop located at 15 m from the last geophone. The field collected dispersion curves are compared with the model generated dispersion curves on Figure 5. There is a satisfactory correlation between the field collected and model calculated dispersion curves, with a root mean squared error of less than 11%.

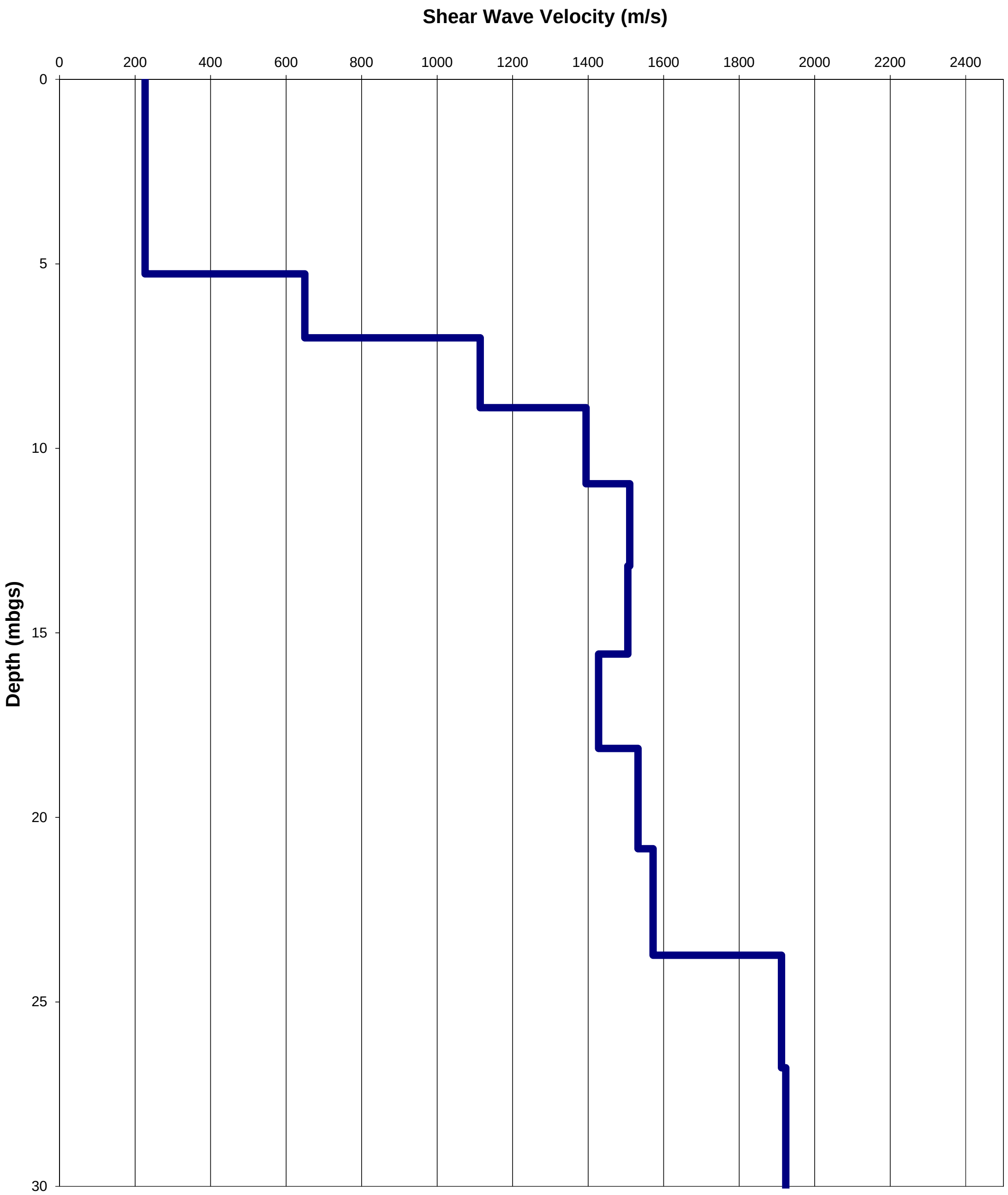


Figure 4: MASW Modelled Shear-Wave Velocity Depth profile along MASW Line 1

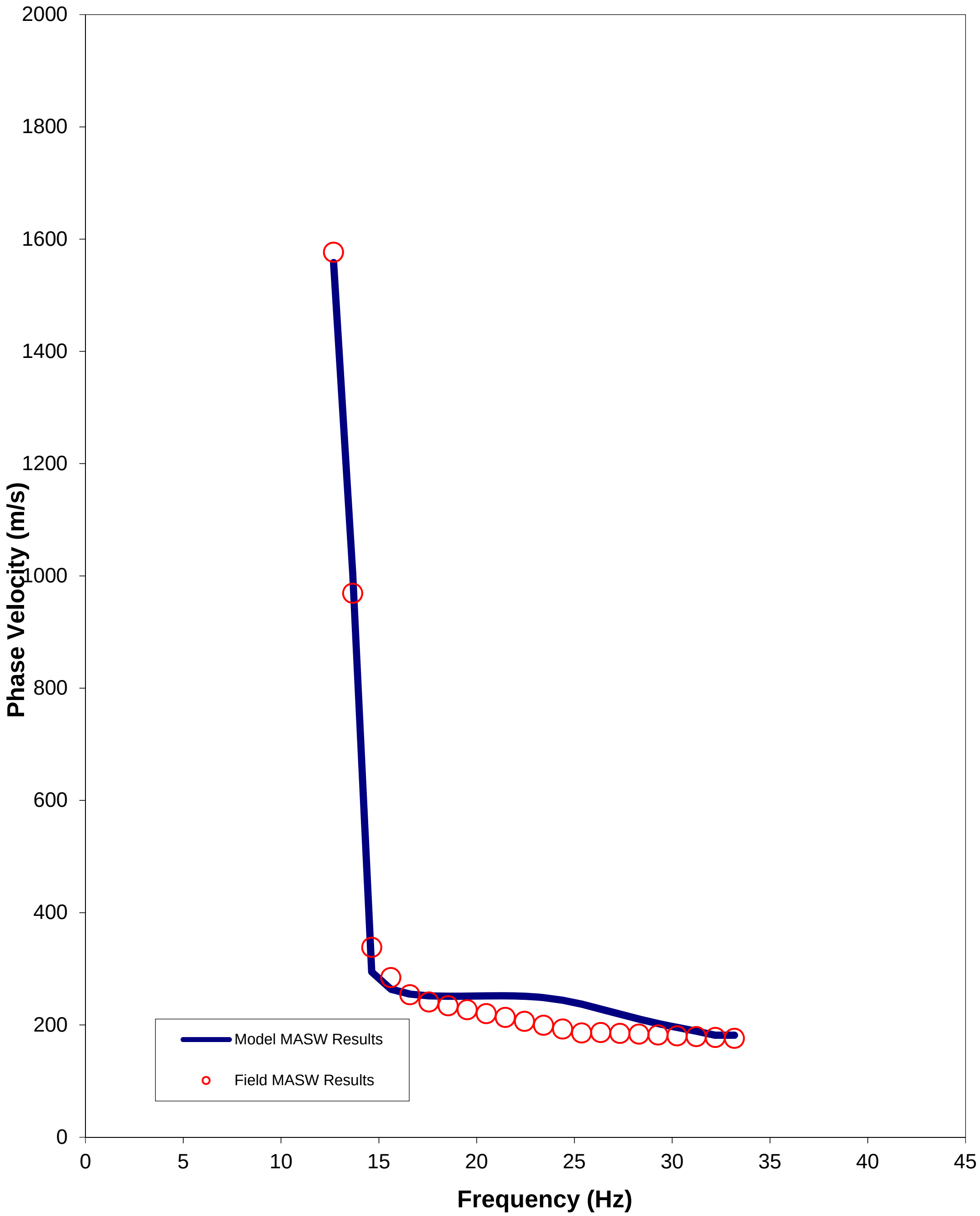


Figure 5: Comparison of Field (red dots) vs. Modelled Data (blue line) along MASW Line 1

To calculate the average shear-wave velocity as required by the Canadian Highway Bridge Design Code (CHBDC, 2014), the results were modelled to 30 metres below ground surface. The average shear-wave velocity along MASW Line 1 was found to be 734 m/s (Table 1).

The Canadian Highway Bridge Design Code (CHBDC, 2014) requires special site-specific evaluation if certain soil types are encountered on the site, so the site classification stated here should be reviewed, and modified if necessary, according to borehole stratigraphy, standard penetration resistance results, and undrained shear strength measurements, if available for this site.

Table 1: Shear-Wave Velocity Profile along MASW Line 1

Model Layer (mbgs)		Layer Thickness (m)	Shear Wave Velocity (m/s)	Shear Wave Travel Time Through Layer (s)
Top	Bottom			
0.00	1.07	1.07	226	0.004732
1.07	2.31	1.24	226	0.005460
2.31	3.71	1.40	226	0.006188
3.71	5.27	1.57	226	0.006916
5.27	7.01	1.73	650	0.002664
7.01	8.90	1.90	1114	0.001701
8.90	10.96	2.06	1395	0.001478
10.96	13.19	2.23	1510	0.001473
13.19	15.58	2.39	1505	0.001588
15.58	18.13	2.55	1428	0.001789
18.13	20.85	2.72	1532	0.001775
20.85	23.74	2.88	1572	0.001835
23.74	26.79	3.05	1912	0.001595
26.79	30.00	3.21	1924	0.001671
Vs Average to 30 mbgs (m/s)				**734**

Limitations

This technical memorandum, which specifically includes all tables, figures and attachments, is based on data and information collected by Golder Associates Ltd. and is based solely on the conditions of the properties at the time of the work, supplemented by historical information and data obtained by Golder Associates Ltd. as described in this memo.

Golder Associates Ltd. has relied in good faith on all information provided and does not accept responsibility for any deficiency, misstatements, or inaccuracies contained in the reports as a result of omissions, misinterpretation, or fraudulent acts of the persons contacted or errors or omissions in the reviewed documentation.

The services performed, as described in this memo, were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

Any use which a third party makes of this memo, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. Golder Associates Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this memo.

The findings and conclusions of this memo are valid only as of the date of this memo. If new information is discovered in future work, including excavations, borings, or other studies, Golder Associates Ltd. should be requested to re-evaluate the conclusions of this memo, and to provide amendments as required.

Closure

We trust that this technical memorandum meets your needs at the present time. If you have any questions or require clarification, please contact the undersigned at your convenience.

GOLDER ASSOCIATES LTD.

Stephane Sol, Ph.D, P. Geo.
Senior Geophysicist

Christopher Phillips, M. Sc., P. Geo.
Senior Geophysicist, Principal

SS/CRP/mvrd

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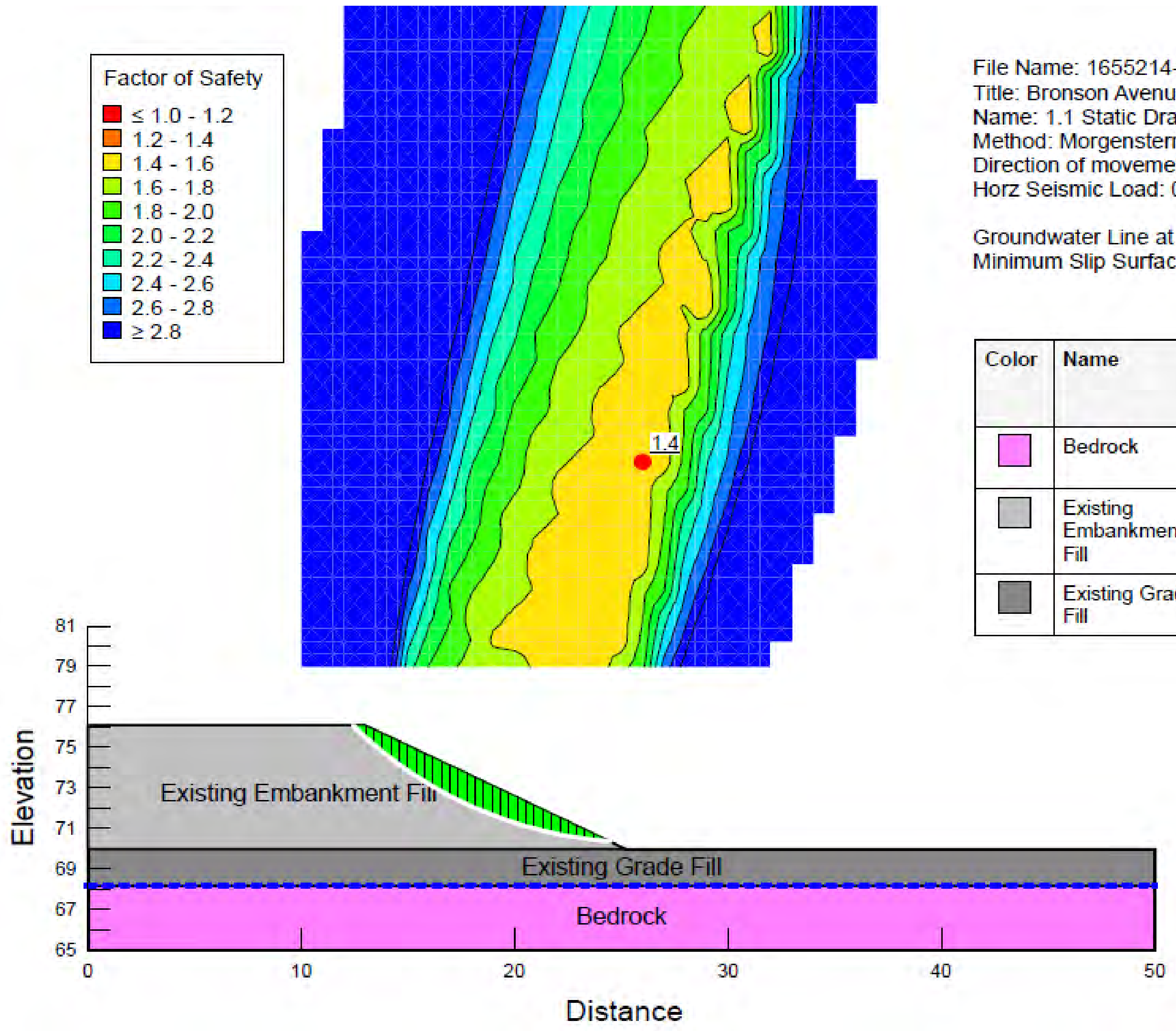
APPENDIX F

Results of Slope Stability Analysis
Figure F1 – Static Condition
Figure F2 – Seismic Condition



File Name: 1655214-1130 Bronson Avenue Overpass _ RKMarch_2019.gsz
Title: Bronson Avenue Overpass
Name: 1.1 Static Drained
Method: Morgenstern-Price
Direction of movement: Left to Right
Horz Seismic Load: 0

Groundwater Line at 68.2 Metres
Minimum Slip Surface Depth of 1.5 Metres

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
🟪	Bedrock	Bedrock (Impenetrable)			
⬜	Existing Embankment Fill	Mohr-Coulomb	20	0	33
⬛	Existing Grade Fill	Mohr-Coulomb	19	0	30

GOLDER

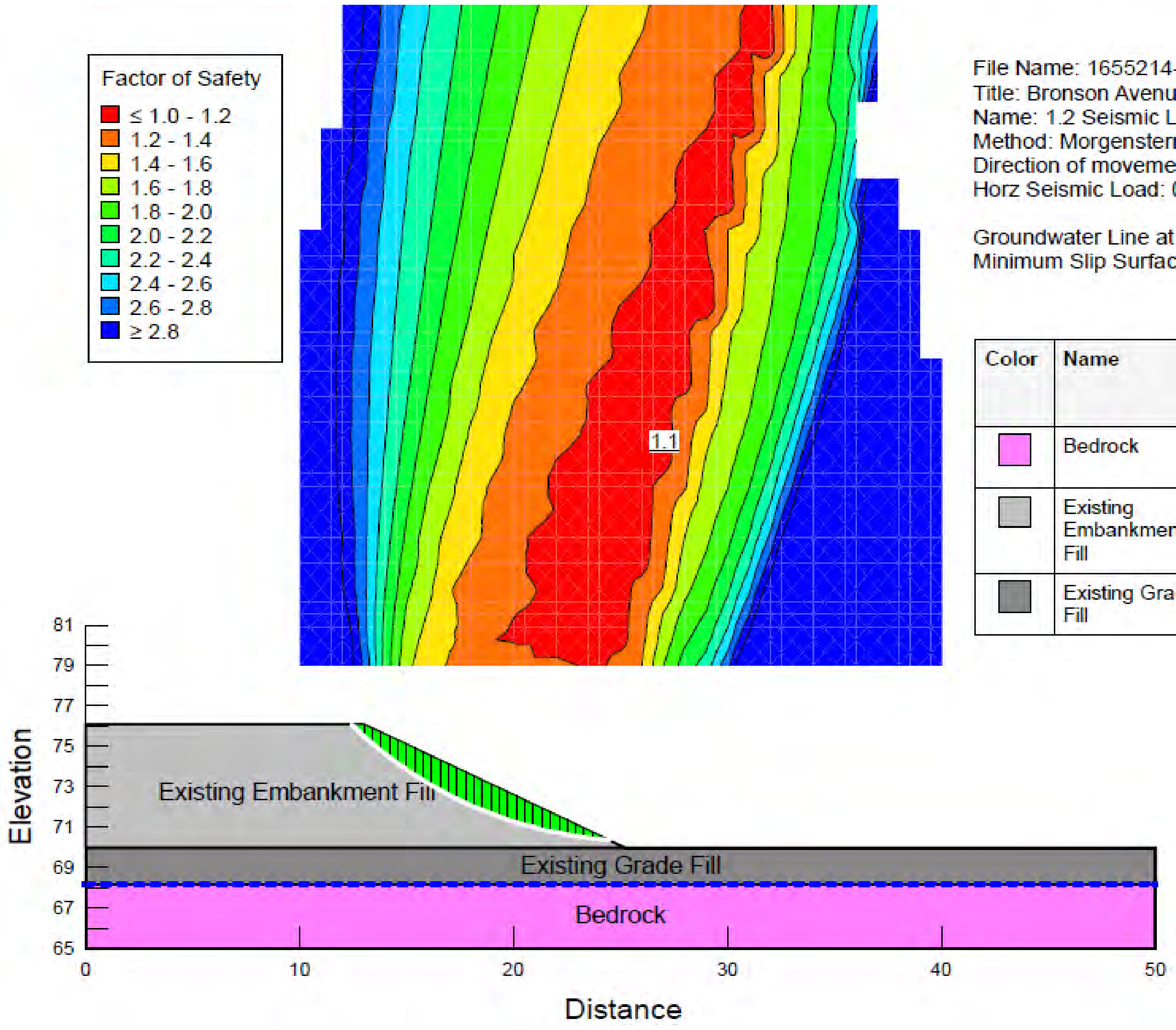
Foundation Investigation

Highway 417 Overpass at Bronson Avenue
Slope Stability - Static Analysis

Ottawa, Ontario

Project No.	1655214-1130
Drawn:	RK
Date:	2019-03-18
Checked:	KP
Review:	

Figure F1



File Name: 1655214-1130 Bronson Avenue Overpass _ RKMarch_2019.gsz
Title: Bronson Avenue Overpass
Name: 1.2 Seismic Load
Method: Morgenstern-Price
Direction of movement: Left to Right
Horz Seismic Load: 0.126

Groundwater Line at 68.2 Metres
Minimum Slip Surface Depth of 1.5 Metres

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
🟪	Bedrock	Bedrock (Impenetrable)			
⬜	Existing Embankment Fill	Mohr-Coulomb	20	0	33
⬛	Existing Grade Fill	Mohr-Coulomb	19	0	30

GOLDER

Foundation Investigation

Highway 417 Overpass at Bronson Avenue
Slope Stability - Seismic Analysis

Ottawa, Ontario

Project No.	1655214-1130
Drawn:	RK
Date:	2019-03-18
Checked:	KP
Review:	

Figure F2

APPENDIX G

Site Photographs

Photograph 1: Looking north along Bronson Avenue towards the Highway 417 Overpass at Bronson Avenue 2019-03-13

Photograph 2: Looking south towards the Highway 417 Overpass at Bronson Avenue 2019-03-13

Photograph 3: Looking southwest towards existing northeast retaining wall east of east abutment 2019-03-13

Photograph 4: Looking southwest towards existing northwest retaining wall west of west abutment 2019-03-13

Photograph 5: Looking west towards the southwest embankment 2019-03-13

Photograph 6: Looking north towards the southeast retaining wall 2019-03-13

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