Victoria Square Boulevard Class Environmental Assessment

Woodbine Avenue (north connection) to Woodbine Avenue (south connection)

Environmental Study Report

Appendix

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Geotechnical and Pavement Report

June 5, 2018

GEOTECHNICAL AND PAVEMENT INVESTIGATION AND DESIGN REPORT

Victoria Square Boulevard
Class Environmental Assessment
Between North and South Connections to Woodbine Avenue
City of Markham, Ontario

Submitted to:
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FINAL REPORT

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1 E-Copy - HDR Inc.
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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) is pleased to present this report to HDR Inc. (HDR) with the findings of the investigation and design for the rehabilitation and widening of the existing pavement on Victoria Square Boulevard from Woodbine Avenue north connection to Woodbine Avenue south connection, as well as recommendations for the replacement of the Carlton Creek Culvert. The approximate length of roadway included within the project limits is 2.7 centreline kilometres.

2.0 FIELD INVESTIGATION

The first stage of this assignment included developing a field investigation program and executing the program. A field investigation was completed to obtain information regarding the condition and type of the existing pavement on Victoria Square Boulevard. Our field investigation program included the following:

- Pavement visual condition inspection; and
- Borehole investigation.

The following sections of this report detail the investigation methods and findings.

2.1 Pavement Visual Condition Inspection

A pavement visual condition inspection was completed in December 2017 by a Pavement and Materials Engineer. The section of Victoria Square Boulevard south of Elgin Mills Road mainly has a rural cross section with ditches for drainage. The section north of Elgin Mills Road has a combination of rural and urban cross sections. Along the rural sections ditches are used for drainage and in the urban sections a curb and gutter and storm sewer/ditches system is used for drainage. The existing ditches are often very shallow and filled with overgrown vegetation.

The pavement on a short section of Victoria Square Boulevard from Vetmar Road to Woodbine Avenue (north connection) appears to have been recently rehabilitated and is in good condition with few, slight transverse cracks. Photo 1 shows an example of the pavement condition north of Vetmar Road.

Photo 1: Pavement in good condition on Victoria Square Boulevard north of Vetmar Road

Victoria Square Boulevard south of Vetmar Road is generally in fair condition. The following distresses were identified:

- Intermittent, slight to moderate fatigue cracking;
- Throughout, slight to moderate transverse cracking;
- Throughout, slight to severe opening and deterioration of the longitudinal construction joint; and
- Frequent, slight ravelling.

Localized and lane width patching has been carried out; however, the reasons for the patching were unclear at the time of our visual condition inspection. The lane width patching was noted to be in good condition, but the age of the patches was not evident. Crack sealing has been carried out but is no longer effective. Photo 2 to Photo 4 show examples of the pavement condition on Victoria Square Boulevard.

Photo 2: Patching and longitudinal joint deterioration on Victoria Square Boulevard

Photo 3: Transverse and fatigue cracking on Victoria Square Boulevard

Photo 4: Crack sealing, transverse cracking and longitudinal joint deterioration on Victoria Square Boulevard

2.2 Borehole Investigation

The borehole investigation program was carried out from December 11 to 14, 2017, and included advancing a total of 20 boreholes through the existing pavement structure on Victoria Square Boulevard, within the project limits. Prior to advancing the boreholes, Golder exercised reasonable due diligence to clear the proposed borehole locations of all underground utilities. The borehole locations along the length of Victoria Square Boulevard are shown in Appendix A.

The drilling was carried out by Tri-Phase Group, a drilling subcontractor, using a truck-mounted CME55 drill rig with 108 mm diameter solid stem augers. Additionally, Standard Penetration Tests (SPTs) using a split-spoon sampler and an automatic hammer were carried out at selected depths in accordance with SPT procedures (ASTM D1586-08). Fifteen boreholes were advanced to a depth of approximately 2 m below the ground surface, four boreholes were advanced to a depth of approximately 5 m below ground surface, and one borehole was advanced to a depth of approximately 10 m below ground surface at the Carlton Creek culvert location. A standpipe piezometer was installed at three of the borehole locations to permit the measurement of the stabilized groundwater levels. A Golder representative was present on site during the drilling to supervise the operation, and to log the observations at each of the borehole locations. The borehole records are attached in Appendix B.

3.0 SUBSURFACE CONDITIONS

3.1 Pavement Layer Thicknesses and Subgrade Soils

Table 1 shows a summary of the pavement structure that was identified at each of the borehole locations. In 19 of 20 boreholes, a layer of asphalt was encountered at the surface. Borehole 17-10 was advanced on the unpaved shoulder. The average thickness of the asphalt in the boreholes was determined to be 129 mm, and ranged from 80 mm to 150 mm. The average depth of the pavement granular materials was 720 mm, and ranged from 540 mm to 1,290 mm.

Table 1: Summary of Pavement Structure Thickness from Borehole Investigation

Borehole No.	Asphalt Thickness (mm)	Granular Thickness (mm)
17-01	130	560
17-02	130	560
17-03	150	1,220
17-04	130	560
17-05	140	550
17-06	110	1,260
17-07	130	560
17-08	140	550
17-09	150	540
17-10	N/A	690
17-11	140	770
17-12	80	610
17-13	140	550
17-14	150	650
17-15	150	540
17-16	130	560
17-17	110	580
17-18	130	1,240
17-19	80	1,290
17-20	130	560

In 17 of the boreholes, the pavement granular layers were underlain by a sandy silty clay to clayey silt deposit. In 9 of those boreholes the sandy silty clay to clayey silt subgrade soils extended to the borehole termination depth. In 7 of the boreholes, the sandy silty clay to clayey silt was underlain by a sandy silt to silty sand to sand layer, in which all 7 boreholes were terminated. In BH17-02, the silty clay layer extended to 2.9 m below surface and was underlain by a clayey silty sand and gravel. BH17-02 was terminated in the clayey silty sand and gravel layer.

In BH17-04 and BH17-07, the pavement granular layers were underlain by a silty sand to sandy silt layer. BH17-07 terminated in this layer, while the silty sand was underlain by a clayey silt layer in BH17-04. BH17-04 was terminated in the clayey silt layer.

3.2 Carlton Creek Culvert Borehole (Borehole 17-06)

Borehole 17-06 was advanced adjacent to Carlton Creek Culvert to a depth of 10.1 m below road surface. The subsurface conditions at this site are consistent with the subsurface conditions within the project limits described above and consist of the following:

- An approximately 110 mm thick layer of asphalt underlain by an approximately 1.3 m thick sand and gravel fill layer, extending to Elevation 215.1 m. The Standard Penetration Test (SPT) ‘N’-values measured within the fill layer were greater than 100 blows per 0.3 m of penetration, indicating a very dense state of compactness.
- A silty clay deposit was encountered underlying the fill and extends to a depth of about 5.5 m, corresponding to approximately Elevation 211.0 m. The SPT ‘N’-values measured within the silty clay deposit are 11 to 16 blows per 0.3 m or penetration, suggesting a stiff to very stiff consistency. Atterberg limits testing was carried out one sample of the silty clay deposit and measured a liquid limit of 28.5 per cent, a plastic limit of 13.7 per cent, and a corresponding plasticity index of 14.8 per cent. These results indicate that the deposit consist of silty clay of low plasticity.
- A sand deposit was encountered underlying the silty clay deposit, extending to a depth of about 7.1 m, corresponding to Elevation 209.4 m. One SPT ‘N’-value of 1 blow per 0.3 m of penetration was measured within the sand deposit; however, this low SPT ‘N’-value is likely due to disturbance from the groundwater table and is not considered representative of the actual relative density of the sand.
- A sand and gravel deposit was encountered below the sand deposit. The borehole was terminated in this deposit, penetrating it for a thickness of about 3.0 m to a depth of about 10.1 m. The SPT ‘N’-values within the sand and gravel deposit are 20 to 49 blows per 0.3 m of penetration, indicating a compact to dense state of compactness.

3.3 Groundwater Conditions

Standpipe piezometers were installed in BH17-02, BH17-06 and BH17-15 to monitoring the groundwater level at the site. The groundwater level measurements in the monitoring wells installed as part of this investigation are shown in the following Table 2.

Table 2: Water Level Measurements

Borehole No.	Depth to Groundwater Level below Existing Ground Surface (m)	Groundwater Elevation (m)	Date
17-02	Dry at 4.6 m	-	December 14, 2017
17-06	5.8	210.7	December 11, 2017
17-15	Dry at 4.5 m	-	December 13, 2017

The water level at the site is expected to fluctuate seasonally in response to changes in precipitation and snow melt, and is expected to be higher during the spring season and following periods of precipitation.

4.0 GEOTECHNICAL LABORATORY TESTING

The pavement granular materials and subgrade soil samples that were obtained during the borehole investigation were brought to Golder’s Cambridge laboratory for further visual examination and testing. The testing of the samples included carrying out grain size distribution analysis, Atterberg limit determination, and moisture content testing for select, representative samples. The detailed laboratory test reports for this assignment are included in Appendix C.

Table 3 shows a summary of the grain size distribution analysis results for each of the tested samples. From the table below it can be seen that the proportion of silt and clay (i.e. passing 75 µm sieve) in the pavement granular material samples was quite high and well above the maximum allowable of 8 percent for Ontario Provincial Standard Specification (OPSS) Granular B, Type I. As can be seen from Figure C1 in Appendix C, of the eight samples of pavement granular materials that were tested for their grain size distribution, when compared to the requirements for OPSS Granular B, Type I, they exceeded the percent passing the 75 µm sieve. The overall quality of the existing granular material is considered to be relatively poor.

Table 3: Summary of Grain Size Distribution Analysis Results

Borehole ID	Sample ID	Sample Type	Percent Gravel	Percent Sand	Percent Silt	Percent Clay
17-01	3	Clayey Silty Sand	9	46	32	13
17-02	1	Pavement Granular Material	17	66	17	
17-02	2	Gravelly Sandy Silty Clay	16	32	32	20
17-03	1	Pavement Granular Material	28	60	12	
17-04	3	Sandy Silty Clay	3	25	37	35
17-06	5	Sandy Silty Clay	1	15	51	33
17-06	9	Sand and Gravel	37	57	6	
17-07	3	Sandy Silt	4	23	61	12
17-08	3	Sandy Silty Clay	2	40	37	21
17-09	1	Pavement Granular Material	27	60	13	
17-11	5	Sand	0	90	6	4
17-13	1	Pavement Granular Material	21	58	11	
17-14	1	Pavement Granular Material	23	37	29	11
17-15	1	Pavement Granular Material	18	60	12	
17-15	5	Silt	0	9	86	5
17-16	2	Sandy Silty Clay	3	27	33	37
17-17	3	Silty Sand	3	63	29	5
17-18	2	Pavement Granular Material	22	60	18	

Borehole ID	Sample ID	Sample Type	Percent Gravel	Percent Sand	Percent Silt	Percent Clay
17-19	2	Pavement Granular Material	45	45	10	
17-19	5	Sandy Silty Clay	5	31	51	14

From the grain size distribution analysis, it was determined that the silt, sandy silt and the sandy silty clay subgrade soils would be considered to have moderate to high frost susceptibility. In the 20 boreholes that were advanced and in those that the subgrade soils were encountered, the frost susceptible soils were found at an average depth of 1,330 mm below the ground surface, ranging from 690 mm to 2,130 mm. The frost penetration depth in the area of Victoria Square Boulevard is estimated to be 1.2 m as per Ontario Provincial Standard Drawing (OPSD) 3090.101.

Six samples of the sandy silty clay/sandy clayey silt soils were tested for their Atterberg limits. The testing results indicated that the soils were low plasticity clays (CL). Table 4 summarizes the moisture content testing results for the pavement granular materials, and subgrade soils. The average moisture content for the pavement granular material is close to the optimum moisture content for typical pavement granular materials; however, it is critical to note that this value can vary for different granular materials.

Table 4: Summary of Moisture Content Testing Results

Soil Type	Average Moisture Content	Moisture Content Range
Pavement Granular Materials	4.1%	2.8% - 8.0%
Sandy Silty Clay	14.7%	10.4% - 19.9%
Sandy Silt/Silty Sand	13.9%	8.4% - 24.1%
Sand and Gravel	14.5%	14.5%
Sand	7.0%	7.0%
Silt	10.9%	10.9%

5.0 CARLTON CREEK CULVERT REPLACEMENT

This section of the report provides preliminary geotechnical/foundation design recommendations for the proposed culvert replacement associated with the proposed roadway improvements and pavement rehabilitation of Victoria Square Boulevard between Woodbine Avenue (north connection) and Woodbine Avenue (south connection). These preliminary recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the subsurface investigation. The discussion and recommendations presented are intended to provide the designer with sufficient information to assess the feasibility and carry out the design of the proposed culvert replacement.

The investigation report, discussion and recommendations are intended for the use of HDR and the City of Markham and shall not be used or relied upon for any other purpose or by any other parties, including the construction or design-build contractor. The contractor must make their own interpretation based on the factual data provided in Section 3.0 of the report. Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project and for which special provisions may be required in the Contract Documents. 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.

Based on the information provided by HDR on January 9, 2018, the existing 1250 mm wide by 1250 mm high box culvert is to be replaced by an 8500 mm wide by 1500 mm high concrete open footing culvert for the section crossing beneath Victoria Square Boulevard. The new culvert will be constructed to match the existing culvert invert at Elevation 213.6 m. The proposed culvert is to be constructed on the same alignment as the existing culvert.

5.1 Founding Elevations

Strip footings for the open footing culvert replacement should be founded at a minimum depth of 1.2 m below the lowest surrounding grade to provide adequate protection against frost penetration, as per Ontario Provincial Standard Drawing (OPSD) 3090.101 *(Foundation Frost Depths for Southern Ontario)*. In addition, the footings should extend below any existing fill, surficial organic materials, or loose/firm soils, where present. Based on the subsurface conditions encountered in Borehole 17-06, the footings should be founded on the stiff to very stiff silty clay deposit at or below Elevation 212.4 m.

The silty clay subgrade will be susceptible to disturbance and degradation on exposure to water and construction traffic. It is recommended that a 100 mm thick, 20 MPa concrete working slab be placed within four hours following inspection and approval of the subgrade, to protect the subgrade from softening.

Groundwater and/or surface water control will be required for excavation and construction of an open footing culvert. It is assumed that the existing culvert will remain in place until the new culvert footings have been constructed outside of the existing, or that surface water conveyed by the existing culvert will bypass the new construction by means of pumping.

The footing subgrade should be inspected by qualified geotechnical personnel following excavation, in accordance with OPSS 902 (*Excavating and Backfilling Structures*) to check that all existing fill or other unsuitable material have been removed. Where subexcavation is required, the sub-excavated area should be backfilled with granular material meeting OPSS.MUNI 1010 (*Aggregates*) Granular ‘A’ or Granular ‘B’ Type II that is placed and compacted in accordance with OPSS.MUNI 501 (*Compacting*), or the thickness of the footing increased to the full excavation depth.

5.2 Factored Geotechnical Resistance

Strip footings placed on the properly prepared silty clay subgrade should be designed based on the following factored geotechnical resistances:

Footing Width (m)	**Founding Material**	**Factored Ultimate Geotechnical Resistance(kPa)**	**Factored Serviceability Geotechnical Resistance (kPa)** **(for 25 mm of Settlement)**
0.6 to 1.2	Silty Clay	225	175

The factored ultimate and factored serviceability geotechnical resistances are dependent on the culvert footing and founding elevation and as such, the geotechnical resistances should be reviewed if the footing width is greater than the width specified above or the founding elevation differs from that given in Section 5.1.

The factored ultimate geotechnical resistance provided is based on loading applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the surface of the footings, inclination of the load should be taken into account in accordance with Section 6.10.4 of the CHBDC (2014) and its Commentary.

5.3 Settlement

It is understood that Victoria Square Boulevard will be widened by up to 4 m; in the vicinity of the proposed culvert replacement the extent of the widening has been assumed to be a maximum of 4 m.

Settlement analysis was carried out using the commercially available program *Settle3D* (version 4.0), developed by Rocscience Inc. The settlement of the foundation soils under the approximately 2 m of additional fill placed on the existing slope is estimated to be less than 25 mm. For these predicted settlements, settlement mitigation measures are not required; however, this should be reassessed at the detail design stage following completion of additional borehole investigation at that time.

5.4 Culvert Bedding, Backfill and Erosion Protection

Backfill and cover for the concrete culvert should be completed similar to OPSD 803.010 *(Backfill and Cover for Concrete Culverts)*. Backfill to culvert walls should consist of granular fill meeting the requirements of OPSS.MUNI 1010 Granular A or Granular B Type II. The backfill and bedding should be placed and compacted in accordance with OPSS.MUNI 501 (*Compacting*). The culvert replacement should be designed for the full overburden pressure and live load, assuming that the embankment fill has a unit weight of 22 kN/m^3 for Granular A, and 21 kN/m^3 for Granular B Type II or select earth fill above and/or surrounding the culvert.

To prevent surface water from flowing either beneath the culvert (potentially causing undermining and scouring) or around the culvert (creating seepage through the embankment fill, and potentially causing erosion and loss of fine soil particles), a clay seal should be provided at the upstream end of the open footing culvert. Clay seals should also be placed adjacent to the culvert inlet opening. The clay material should meet the requirements of OPSS 1205 *(Material Specification for Clay Seal)*. The clay seal should have a thickness of 1 m, and the seal should extend from a depth of 1 m below the scour level to a minimum horizontal distance of 2 m on either side of the culvert inlet opening, and a minimum vertical height equivalent to the high water level including treatment of the adjacent side slopes. Alternatively, a clay blanket may be constructed, extending upstream to a distance equal to three times the culvert height, and extending along the adjacent side slopes to a height of two times the culvert height or the high water level, whichever is higher.

If the creek flow velocities are sufficiently high under the base or design storm condition(s), provision should be made for scour and erosion protection (suitable non-woven geotextiles and/or rip-rap) at the culvert inlet and outlet, including in front of any wing walls/retaining walls adjacent to the creek channel. The requirements for and design of erosion protection measures for the culvert inlet should be assessed by the hydraulic design engineer. As a minimum, natural stone treatment for the culvert outlet should be provided, with the natural stone placed up to the toe of slope level, in combination with the cut-off measures noted above. Similarly, natural stone should be provided over the full extent of the clay blanket if adopted, including the creek side slopes and embankment fill slope adjacent to the culvert.

5.5 Construction Considerations

5.5.1 Surface Water and Groundwater Control

Excavation at the site will be advanced through existing non-cohesive fill and terminate in cohesive native soils. The non-cohesive soils were noted to be moist and the boreholes were generally dry through these deposits. Some groundwater pumping, from properly filtered sumps, may be required to address shallow groundwater perched within the near-surface sand and gravel above the cohesive soil deposits. However, dewatering of the sand deposit (encountered at about Elevation 211.0 m) is not anticipated to be required based on the depth of excavation for the culvert replacement.

Control of the surface water will be necessary for the construction of the culvert replacement, to allow excavation and foundation construction to be carried out in dry conditions. Depending on the creek flow at the time of construction, the surface water being conveyed by the existing culvert could bypass culvert construction area by means of a temporary pipe, or be diverted by pumping from behind a temporary barrier (cofferdam) placed/constructed inside the existing culvert. Precipitation runoff in the construction area should be directed away from the excavation areas, to prevent ponding of water that could result in disturbance and weakening of the shale bedrock subgrade or granular backfill/bedding material.

5.5.2 Excavation and Temporary Protection Systems

Temporary excavations for the culvert replacement will be made through the existing fill, clayey silt deposit, and will terminate within the silty clay deposit. Excavation works must be carried out in accordance with the guidelines outlined in the Occupational Health and Safety Act (OHSA) and Regulations for Construction Projects. The existing fill would be classified as Type 3 soil, while the native materials would be classified as a Type 2 soil, according to the OHSA. Temporary excavations (i.e. those that are open for a relatively short time period) should be made with side slopes no steeper than 1 horizontal to 1 vertical (1H:1V).

It is expected that temporary protection systems will be required for the culvert replacement works, installed parallel to the culvert alignment to facilitate foundation excavation. The temporary excavation support systems for the culvert replacement works should be designed and constructed in accordance with OPSS.MUNI 539 *(Construction Specification for Temporary Protection Systems).* The lateral movement of the temporary shoring system should meet Performance Level 2 as specified in OPSS.MUNI 539, provided that any adjacent utilities can tolerate this magnitude of deformation.

Although the selection and design of the protection system will be the responsibility of the Contractor, it is considered that either a driven, interlocking sheetpile system or a soldier pile and timber lagging system would be suitable for the roadway protection, based on the subsurface soil and groundwater conditions. An interlocking sheetpile system would contribute to both ground and groundwater/surface water control, which is considered to be advantageous for this site but cannot be keyed into the bedrock.

5.5.3 Subgrade Inspection and Protection

The silty clay deposit that will be exposed at the foundation subgrade level will be susceptible to disturbance from water and construction traffic. To limit this degradation, it is recommended that a minimum 100 mm thick concrete working slab, with a minimum unconfined compressive strength of 20 MPa, be placed on the subgrade within four hours after preparation, inspection and approval of the footing subgrade.

6.0 UNDERGROUND INFRASTRUCTURE BEDDING AND BACKFILL

6.1 Bedding

The bedding for the underground utilities should be compatible with the type and class of pipe, the surrounding subsoil and anticipated loading conditions and should be designed in accordance with local municipal standards. If granular bedding is deemed to be acceptable, then OPSS.MUNI 1010 Granular 'A' materials should be used from at least 150 mm below invert to springline. Clear stone should not be used as bedding material. From springline to 300 mm above the obvert of the pipe, sand cover could be used. All bedding and cover material should be placed in 150 mm loose lifts and uniformly compacted to at least 95% of Standard Proctor Maximum Dry Density (SPMDD).

6.2 Trench Backfill

The excavated subsoils may be reused as backfill provided they are free of topsoil, organics or other deleterious material, are at suitable water contents and are placed and compacted as outlined below. All topsoil and organic materials including the clayey materials containing organics encountered beneath the fill materials should be wasted or used for landscaping purposes.

All trench backfill materials should be placed in maximum 300 mm loose lifts and uniformly compacted to at least 95% of SPMDD at depth in pavement areas and at least 98% of the material's SPMDD within 1 m of pavement subgrade (i.e. base of pavement structure) level.

If water contents of the site soils at the time of construction are too high, or if there is a shortage of suitable in-situ material, then an approved imported sandy material which meets the requirements for OPSS.MUNI 1010 Select Subgrade Material (SSM) could be used. It should be placed in loose lift thicknesses and compacted as indicated above. Backfilling operations during cold weather should avoid inclusions of frozen lumps of material, snow and ice.

Normal post-construction settlement of the compacted trench backfill should be anticipated, with the majority of such settlement taking place within about six months following the completion of trench backfilling operations. This settlement will be reflected at the ground surface and may be compensated for, where necessary, by placing additional granular material prior to asphalt paving. Alternatively, if the asphalt binder course is placed shortly following the completion of trench backfilling operations in these areas, any settlement that may be reflected by subsidence of the surface of the binder asphalt should be compensated for by placing an additional thickness of binder asphalt or by padding.

7.0 PAVEMENT REHABILITATION AND WIDENING DESIGN

The findings of our field investigations, laboratory testing and provided traffic data were used to carry out a design analysis for the initially proposed rehabilitation and widening of the existing pavement on Victoria Square Boulevard, within the project limits. The structural design analysis for the pavement rehabilitation and widening was carried out in accordance with the American Association of State Highway and Transportation Officials (AASHTO) 1993 "Guide for Design of Pavement Structures".

In Section 2.1 of this report it was identified that the pavement on Victoria Square Boulevard between Woodbine Avenue (north connection) and Vetmar Road appears to have recently have some pavement treatment applied to it. However, Golder is not aware whether this treatment was a full rehabilitation of this pavement, or a maintenance patch. Furthermore, this section of pavement is relatively short compared to the entire project length, and therefore its relatively good surface condition was not considered when carrying out the pavement structural design.

7.1 Traffic Analysis

For the purpose of carrying out the structural design analysis Golder was provided with anticipated traffic volumes that the rehabilitated pavement on Victoria Square Boulevard would be required to accommodate. The road was broken into two sections based on the varying AADT and growth rate as follows:

- Section 1 – Victoria Square Boulevard between Woodbine Avenue (south connection) and Elgin Mills Road; and
- Section 2 – Victoria Square Boulevard between Elgin Mills Road and Woodbine Avenue (north connection).

Table 5 shows the traffic parameters that were used to calculate the design Equivalent Single Axle Loads (ESALs) that the rehabilitated pavement would be required to accommodate for Section of Victoria Square Boulevard between Woodbine Avenue (south connection) and Elgin Mills Road.

Table 5: Summary of Traffic Volumes on Section 1 Victoria Square Boulevard

Parameter	Values
2018 Two-Way Annual Average Daily Traffic	6,232
Growth Rate	2.0 %
Percent Trucks	2.0 %
Truck Factor	1.8
Design Life	20 years

Based on the above traffic parameter the design ESALs for Section 1 Victoria Square Boulevard was calculated to be approximately 1,000,000.

Table 6 shows the traffic parameters that were used to calculate the design ESALs that the rehabilitated pavement would be required to accommodate for Section 2 of Victoria Square Boulevard.

Table 6: Summary of Traffic Volumes on Section 2 of Victoria Square Boulevard

Parameter	Values
2018 Two-Way Annual Average Daily Traffic	2,466
Growth Rate	5.3 %
Percent Trucks	2.0 %
Truck Factor	1.8
Design Life	20 years

Based on the above traffic parameter the design ESALs were calculated to be approximately 560,000 for Section 2 of Victoria Square Boulevard.

7.2 Rehabilitation Design

The information gathered by Golder during our field investigations and laboratory testing were used to develop a suitable rehabilitation design for the existing pavement on Victoria Square Boulevard, within the project limits.

7.2.1 Section 1 of Victoria Square Boulevard

Table 7 summarizes the parameter values that were used during the structural design analysis for the pavement rehabilitation between Woodbine Avenue (south connection) and Elgin Mills Road (Section 1). The required Structural Number (SN) for the rehabilitated pavement was calculated to be 112 mm. Additionally, the existing pavement structure was calculated to have an effective SN of 79 mm. Therefore, the pavement rehabilitation would require a structural improvement, as well as functional improvement.

Table 7: Summary of Parameter Values Used for Pavement Structural Design Analysis for Section 1

Parameter		Value
Design ESALs		1,000,000
Subgrade Resilient Modulus		27 MPa
Reliability		90%
Standard Deviation		0.45
Initial Serviceability		4.2
Terminal Serviceability		2.5
Structural Coefficient	Existing Hot Mix Asphalt	0.30
	New Hot Mix Asphalt	0.44
	Pulverized Asphalt Combined with underlying Granular Material	0.14
	Existing Granular Material	0.08
Drainage Coefficient	Existing Hot Mix Asphalt	1.0
	New Hot Mix Asphalt	1.0
	Pulverized Asphalt Combined with underlying Granular Material	1.0
	Existing Granular Material	0.9

Golder has considered various rehabilitation treatments for the project. Based on our investigation findings, including laboratory testing results that indicated that soils are frost susceptible and the existing granular materials are of relatively poor quality, and design analysis, the recommended design for Section 1 of Victoria Square Boulevard is as follows:

- Pulverize the existing asphalt and blend with an equal thickness the underlying granular materials;
- Remove 150 mm of the combined material;
- Grade and compact the combined granular materials and pulverized asphalt layer;
- Place 100 mm of binder course asphalt, in two lifts; and
- Place 50 mm of surface course asphalt.

7.2.2 Section 2 of Victoria Square Boulevard

Table 8 summarize the parameter values that were used during the structural design analysis for the pavement rehabilitation of Section 2. The required Structural Number (SN) for the rehabilitated pavement was calculated to be 103 mm. Additionally, the existing pavement structure was calculated to have an effective SN of 79 mm. Therefore, the pavement rehabilitation would require a structural improvement, as well as functional improvement.

Table 8: Summary of Parameter Values Used for Pavement Structural Design Analysis for Section 2

Parameter		Value
Design ESALs		560,000
Subgrade Resilient Modulus		27 MPa
Reliability		90%
Standard Deviation		0.45
Initial Serviceability		4.2
Terminal Serviceability		2.5
Structural Coefficient	Existing Hot Mix Asphalt	0.30
	New Hot Mix Asphalt	0.44
	Pulverized Asphalt Combined with underlying Granular Material	0.14
	Existing Granular Material	0.08
Drainage Coefficient	Existing Hot Mix Asphalt	1.0
	New Hot Mix Asphalt	1.0
	Pulverized Asphalt Combined with underlying Granular Material	1.0
	Existing Granular Material	0.9

Based on our investigation findings, including laboratory testing that indicated that the soil are frost susceptible and the existing granular materials are of relatively poor material, and design analysis, the recommended design for Section 2 of Victoria Square Boulevard between is as follows:

- Pulverize the existing asphalt and blend with an equal thickness the underlying granular materials;
- Remove 120 mm of the combined material;
- Grade and compact the combined granular materials and pulverized asphalt layer;
- Place 70 mm of binder course asphalt; and
- Place 50 mm of surface course asphalt.

7.3 Pavement Widening Design

It is understood that variable widening will be carried out throughout the project length. In order to match the grade of the rehabilitated pavement and to provide adequate frost protection taking into account that the soils are frost susceptible, the widening pavement structure design for Section 1 of Victoria Square Boulevard should be as follows:

- Excavate the existing granular materials and subgrade soils to the top of the subgrade (bottom of granular material) in the adjacent pavement, or 850 mm below the top of the final pavement surface grade, whichever is deeper;
- Place and compact Granular B to a depth of 300 mm below the final pavement surface grade, or a minimum thickness of 550 mm;
- Place and compact 150 mm of Granular A;
- Place 100 mm of binder course asphalt, in two lifts; and
- Place 50 mm of surface course asphalt.

In order to match the grade of the rehabilitated pavement and to provide adequate frost protection taking into account that the soils are frost susceptible, the widening pavement structure for Section 2 of Victoria Square Boulevard should be as follows:

- Excavate the existing granular materials and subgrade soils to the top of the subgrade (bottom of granular material) in the adjacent pavement, or 800 mm below the top of the final pavement surface grade, whichever is deeper;
- Place and compact Granular B to a depth of 270 mm below the final pavement surface grade, or a minimum thickness of 580 mm;
- Place and compact 150 mm of Granular A;
- Place 70 mm of binder course asphalt; and
- Place 50 mm of surface course asphalt.

7.4 Construction Considerations

The binder course asphalt for the pavement rehabilitation and widening should be a HL 8 asphalt mix, and the surface course asphalt should be a HL 3 asphalt mix. Both the surface and binder course asphalt mixes should be in compliance with the requirements of the City’s specifications. The asphalt cement in both the surface and binder course asphalt layers should be a PG 58-28 that meets the requirements of OPSS.MUNI 1101.

During rehabilitation and widening, drainage improvement should be considered to ensure that positive drainage is provided throughout the project length. Providing adequate provisions for drainage of subsurface water is critical to ensure that the pavement is not susceptible to frost heaving, particularly in the case when the subgrade soils are noted to be frost susceptible, as is the case with Victoria Square Boulevard. The ditches should be deepened and the silt and vegetation removed. The new granular layers should be daylighted to the ditches.

8.0 CLOSURE

We trust that this report meets your present requirements. If you have any questions or require further information, please do not hesitate to contact the undersigned.

Report Signature Page

GOLDER ASSOCIATES LTD.

LICENSED PROFESSIONAL ENGINEER
L. UZAROWSKI
June 5/18
PROVINCE OF ONTARIO

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LICENSED PROFESSIONAL ENGINEER
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05 JUN/18
PROVINCE OF ONTARIO

Lisa Coyne, P.Eng.
Principal, Senior Geotechnical Engineer

AJ/RR/LU/NK/LCC/aj/rb

\\golder.gds\gal\mississauga\active\2015\3 proj\1544413 hdr_ea victoria sq blvd_markham\5 - reports\pavement and geotech\final\1544413 final rpt pavement design victoria square 5'june'2018.docx

REFERENCES

Canadian Geotechnical Society. 2006. Canadian Foundation Engineering Manual (CFEM), 4th Edition. The Canadian Geotechnical Society, BiTech Publisher Ltd., British Columbia.

Canadian Highway Bridge Design Code (CHBDC) 2014 and Commentary on CAN/CSA-S6-14. Canadian Standard Association (CSA) Group.

Ontario Provincial Standard Specifications (OPSS)

OPSS.MUNI 1101	Material Specification for Performance Graded Asphalt Cement
OPSS.MUNI 501	Construction Specification for Compacting
OPSS.MUNI 539	Construction Specification for Temporary Protection Systems
OPSS.MUNI 804	Construction Specifications for Seed and Cover
OPSS.MUNI 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material
OPSS 902	Construction Specifications for Excavating and Backfilling - Structures

Ontario Provincial Standard Drawings (OPSD)

OPSD 803.010	Backfill and Cover for Concrete Culverts with Spans Less Than or Equal to 3.0 m
OPSD 3090.101	Foundation Frost Depths for Southern Ontario

ASTM International

ASTM D1586	Standard Test Method for Standard Penetration Test (SPT) and Split Barrel Sampling of Soils

Ontario Water Resources Act

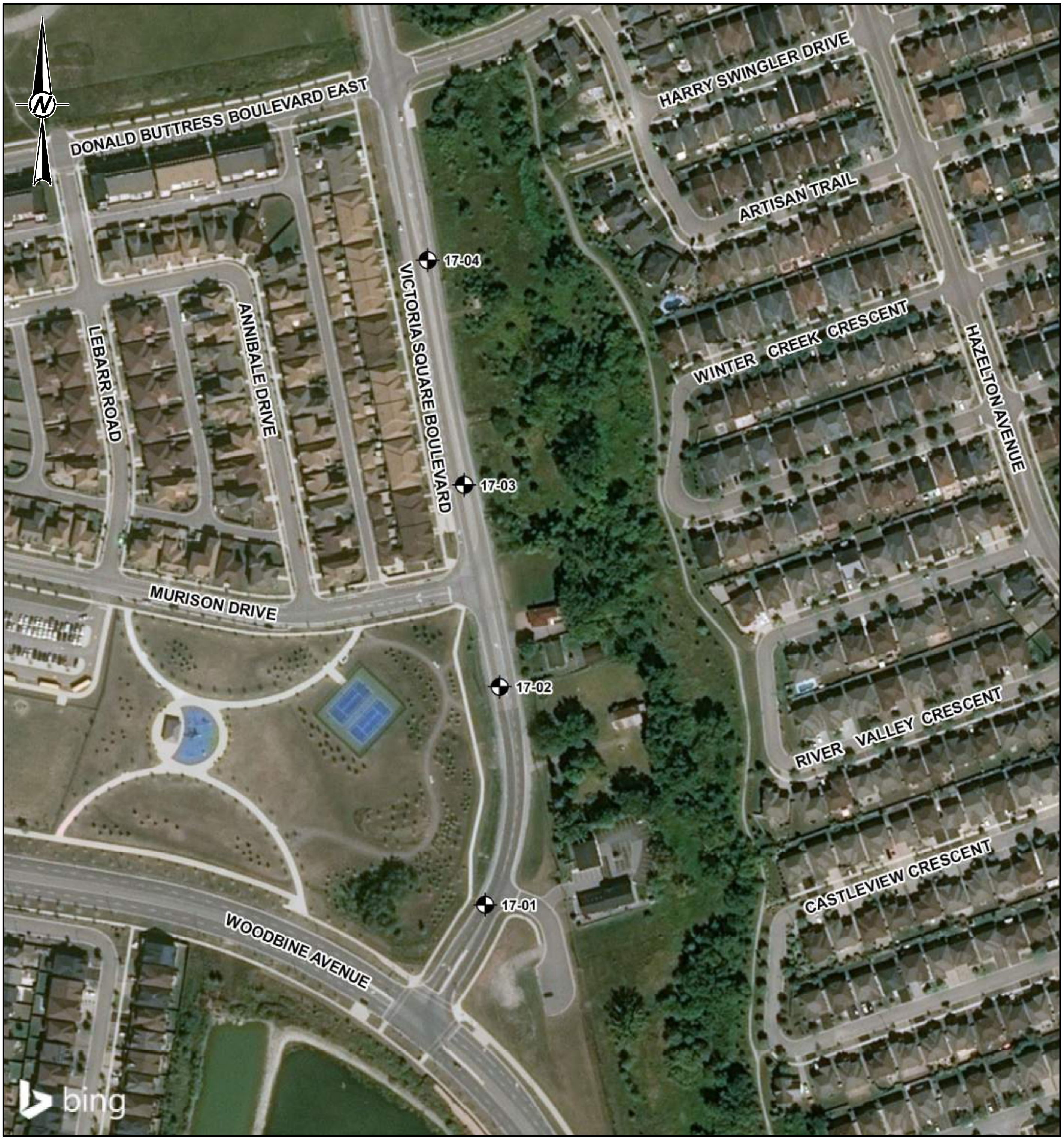
Ontario Regulation 903	Wells (as amended)

Ontario Occupational Health and Safety Act

Ontario Regulation 213	Construction Projects (as amended)

APPENDIX A

Borehole Location Plan



LEGEND

⌖ Borehole

0 100 200

1:3,000 METERS

REFERENCE(S)

1. IMAGERY - SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY
2. PRODUCED BY GOLDER ASSOCIATES LTD UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES AND FORESTRY, © QUEENS PRINTER 2018
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
HDR INC.

PROJECT
GEOTECHNICAL AND PAVEMENT INVESTIGATION
VICTORIA SQUARE BOULEVARD E.A., MARKHAM, ONTARIO

TITLE
BOREHOLE LOCATION PLAN

CONSULTANT

Golder Associates

YYYY-MM-DD	2018-06-04
DESIGNED	SO
PREPARED	SO
REVIEWED	AJ
APPROVED	LU

PROJECT NO.	CONTROL	REV.	FIGURE
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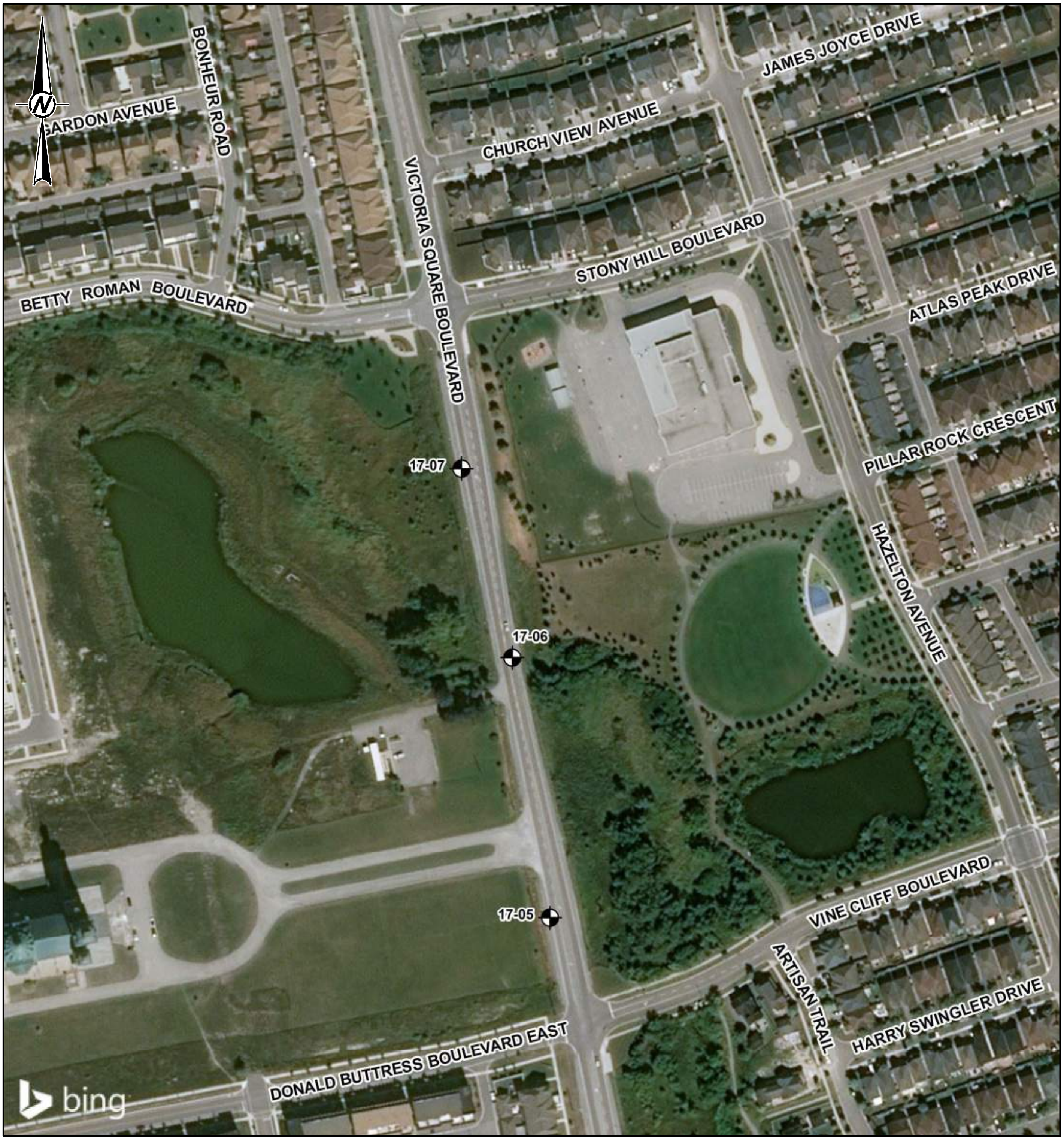

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⊕ Borehole

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PREPARED	SO
REVIEWED	AJ
APPROVED	LU

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REVIEWED	AJ
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PROJECT NO.	CONTROL	REV.	FIGURE
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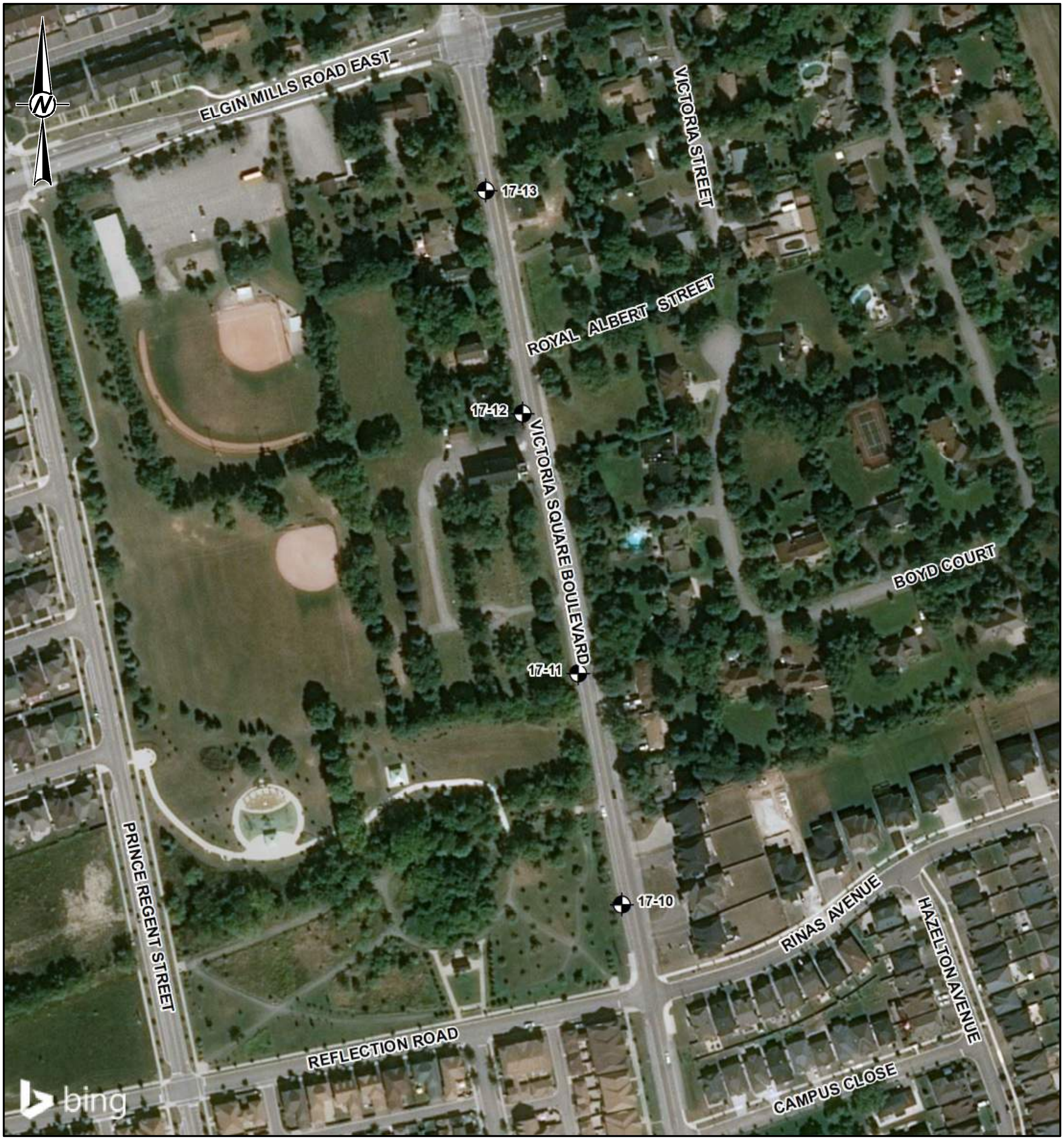

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⯐ Borehole

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1:3,000 METERS

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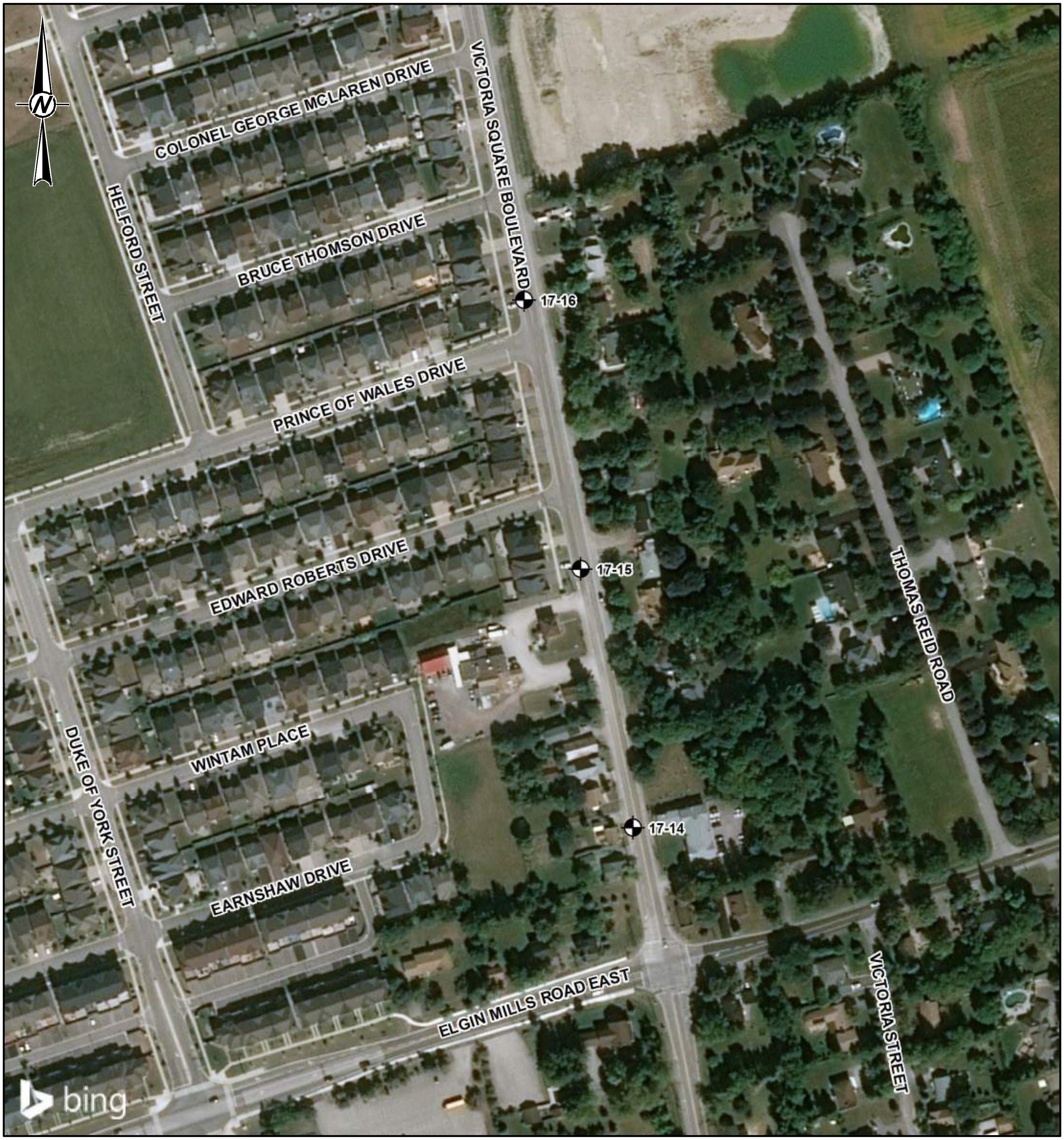

LEGEND

⊕ Borehole

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Golder Associates

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PROJECT NO.	CONTROL	REV.	FIGURE
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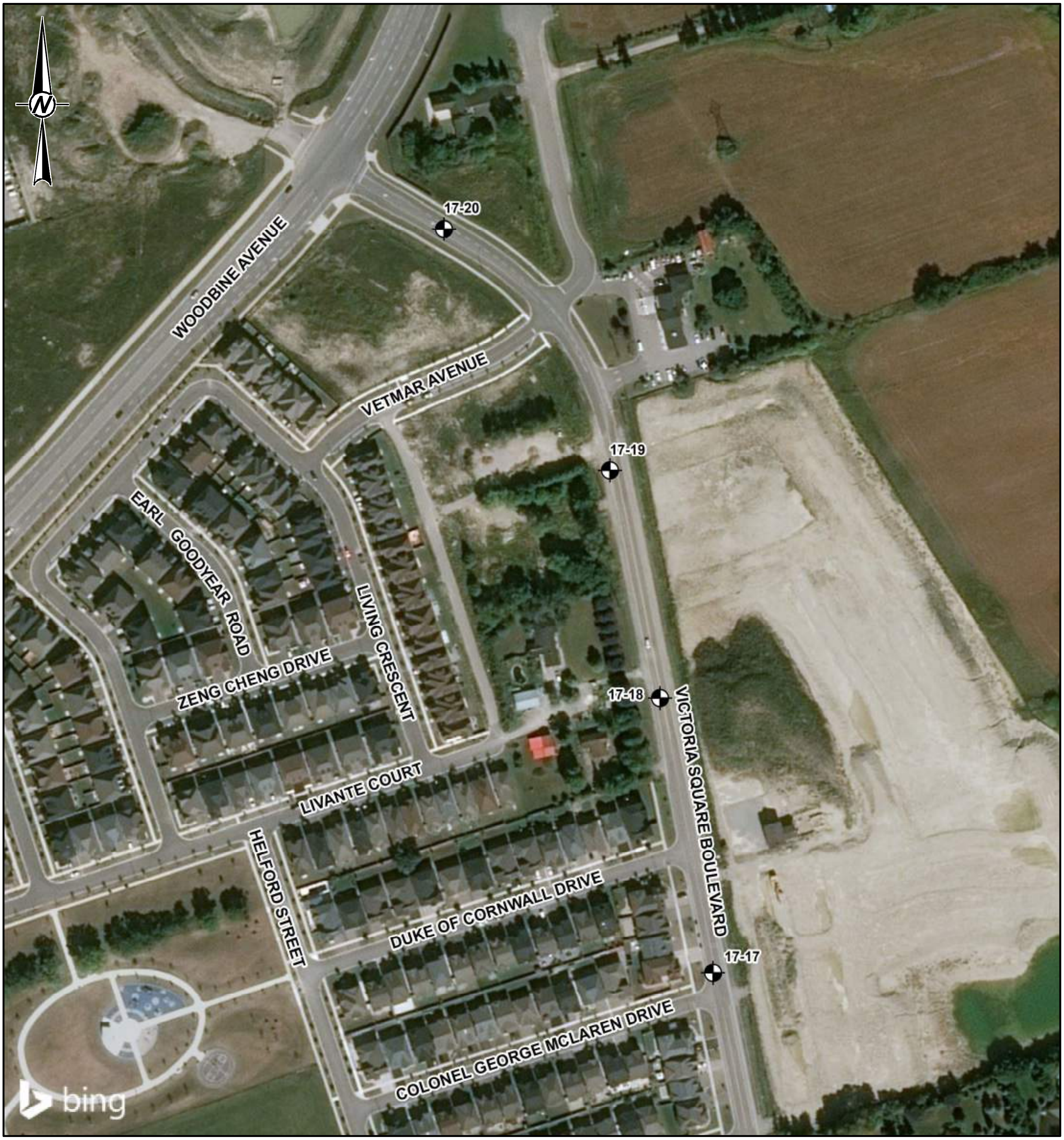

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⊕ Borehole

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TITLE
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Golder Associates

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APPENDIX B

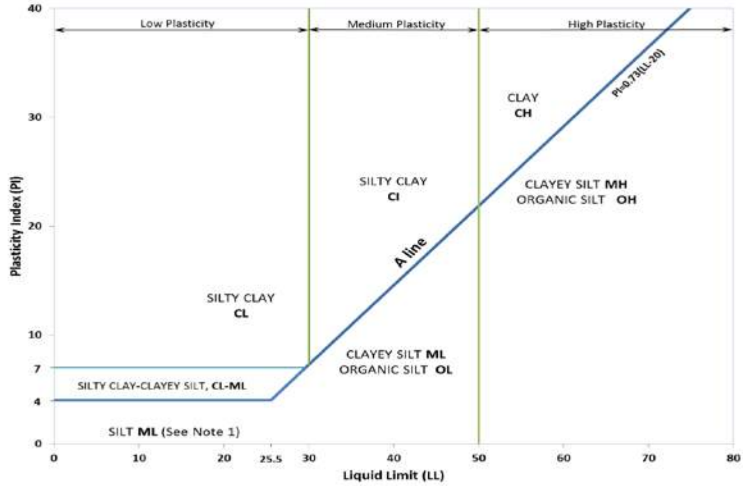
Record of Boreholes

METHOD OF SOIL CLASSIFICATION

The Golder Associates Ltd. Soil Classification System is based on the Unified Soil Classification System (USCS)

Organic or Inorganic	Soil Group	Type of Soil		Gradation or Plasticity	$Cu = \frac{D_{60}}{D_{10}}$	$Cc = \frac{(D_{30})^2}{D_{10} x D_{60}}$	Organic Content	USCS Group Symbol	Group Name
INORGANIC (Organic Content ≤30% by mass)	COARSE-GRAINED SOILS (>50% by mass is larger than 0.075 mm)	GRAVELS (>50% by mass of coarse fraction is larger than 4.75 mm)	Gravels with ≤12% fines (by mass)	Poorly Graded	<4	≤1 or ≥3	≤30%	GP	GRAVEL
				Well Graded	≥4	1 to 3		GW	GRAVEL
			Gravels with >12% fines (by mass)	Below A Line	n/a			GM	SILTY GRAVEL
				Above A Line	n/a			GC	CLAYEY GRAVEL
		SANDS (≥50% by mass of coarse fraction is smaller than 4.75 mm)	Sands with ≤12% fines (by mass)	Poorly Graded	<6	≤1 or ≥3		SP	SAND
				Well Graded	≥6	1 to 3		SW	SAND
			Sands with >12% fines (by mass)	Below A Line	n/a			SM	SILTY SAND
				Above A Line	n/a			SC	CLAYEY SAND

Organic or Inorganic	Soil Group	Type of Soil	Laboratory Tests	Field Indicators					Organic Content	USCS Group Symbol	Primary Name
				Dilatancy	Dry Strength	Shine Test	Thread Diameter	Toughness (of 3 mm thread)			
INORGANIC (Organic Content ≤30% by mass)	FINE-GRAINED SOILS (≥50% by mass is smaller than 0.075 mm)	SILTS (Non-Plastic or PI and LL plot below A-Line on Plasticity Chart below)	Liquid Limit <50	Rapid	None	None	>6 mm	N/A (can't roll 3 mm thread)	<5%	ML	SILT
				Slow	None to Low	Dull	3mm to 6 mm	None to low	<5%	ML	CLAYEY SILT
				Slow to very slow	Low to medium	Dull to slight	3mm to 6 mm	Low	5% to 30%	OL	ORGANIC SILT
			Liquid Limit ≥50	Slow to very slow	Low to medium	Slight	3mm to 6 mm	Low to medium	<5%	MH	CLAYEY SILT
				None	Medium to high	Dull to slight	1 mm to 3 mm	Medium to high	5% to 30%	OH	ORGANIC SILT
		CLAYS (PI and LL plot above A-Line on Plasticity Chart below)	Liquid Limit <30	None	Low to medium	Slight to shiny	~ 3 mm	Low to medium	0% to 30% **(see Note 2)**	CL	SILTY CLAY
			Liquid Limit 30 to 50	None	Medium to high	Slight to shiny	1 mm to 3 mm	Medium		CI	SILTY CLAY
			Liquid Limit ≥50	None	High	Shiny	<1 mm	High		CH	CLAY
HIGHLY ORGANIC SOILS (Organic Content >30% by mass)		Peat and mineral soil mixtures							30% to 75%	PT	SILTY PEAT, SANDY PEAT
		Predominantly peat, may contain some mineral soil, fibrous or amorphous peat							75% to 100%		PEAT



Note 1 – Fine grained materials with PI and LL that plot in this area are named (ML) SILT with slight plasticity. Fine-grained materials which are non-plastic (i.e. a PL cannot be measured) are named SILT.

Note 2 – For soils with <5% organic content, include the descriptor "trace organics" for soils with between 5% and 30% organic content include the prefix "organic" before the Primary name.

Dual Symbol — A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC and CL-ML.

For non-cohesive soils, the dual symbols must be used when the soil has between 5% and 12% fines (i.e. to identify transitional material between "clean" and "dirty" sand or gravel.

For cohesive soils, the dual symbol must be used when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart (see Plasticity Chart at left).

Borderline Symbol — A borderline symbol is two symbols separated by a slash, for example, CL/CI, GM/SM, CL/ML.

A borderline symbol should be used to indicate that the soil has been identified as having properties that are on the transition between similar materials. In addition, a borderline symbol may be used to indicate a range of similar soil types within a stratum.

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
SILT/CLAY	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

Percentage by Mass	Modifier
>35	Use 'and' to combine major constituents (*i.e.,* SAND and GRAVEL, SAND and CLAY)
> 12 to 35	Primary soil name prefixed with "gravelly, sandy, SILTY, CLAYEY" as applicable
> 5 to 12	some
≤ 5	trace

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.) split-spoon sampler for a distance of 300 mm (12 in.).

Cone Penetration Test (CPT)

An 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 (u) and sleeve frictions are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); 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, 60° 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

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
FS	Foil sample
GS	Grab Sample
RC	Rock core
SC	Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size
TP	Thin-walled, piston – note size
WS	Wash sample

SOIL TESTS

w	water content
PL , w_p	plastic limit
LL , 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, Gs)
DS	direct shear test
GS	specific gravity
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 (FV)	field vane (LV-laboratory vane test)
γ	unit weight

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

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

Term	SPT 'N' (blows/0.3m)[1]
Very Loose	0 - 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	>50

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects.
2. Definition of compactness descriptions based on SPT 'N' ranges from Terzaghi and Peck (1967) and correspond to typical average N_{60} values.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

COHESIVE SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N'[1,2] (blows/0.3m)
Very Soft	<12	0 to 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	>200	>30

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
2. SPT 'N' values should be considered ONLY an approximate guide to consistency; for sensitive clays (e.g., Champlain Sea clays), the N-value approximation for consistency terms does NOT apply. Rely on direct measurement of undrained shear strength or other manual observations.

Water Content

Term	Description
w < PL	Material is estimated to be drier than the Plastic Limit.
w ~ PL	Material is estimated to be close to the Plastic Limit.
w > PL	Material is estimated to be wetter than the Plastic Limit.

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

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
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, 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

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

(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_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 = σ'_p / σ'_{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

PROJECT: 1544413
LOCATION: See Borehole Location Plan

RECORD OF BOREHOLE: 17-01

BORING DATE: December 11, 2017

SHEET 1 OF 1
DATUM: Local

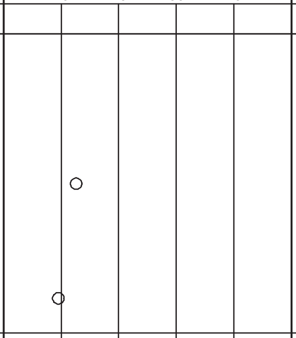
SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE						
0	Power Augering 108 mmSolid Stem Augers	ASPHALT	0.00					
		FILL - (SP/GP) SAND and GRAVEL; brown; non-cohesive, moist, very dense	0.13	1	SS	67		
		(CL) sandy SILTY CLAY, some gravel; brown; cohesive, w~PL, very stiff	0.69					
1				2	SS	17		
		(SM) CLAYEY SILTY SAND, some gravel; brown; non-cohesive, moist, compact	1.37	3	SS	19		9 46 32 13
2		END OF BOREHOLE	1.98					
3								
4								
5								
6								
7								
8								
9								
10								

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m
20 40 60 80
SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○
20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s
10^{-6} 10^{-5} 10^{-4} 10^{-3}
WATER CONTENT PERCENT
Wp ├──○W──┤ Wl
10 20 30 40



DEPTH SCALE
1 : 50

GOLDER

LOGGED: AJ
CHECKED: RR

PROJECT: 1544413

LOCATION: See Borehole Location Plan

RECORD OF BOREHOLE: 17-02

BORING DATE: December 14, 2017

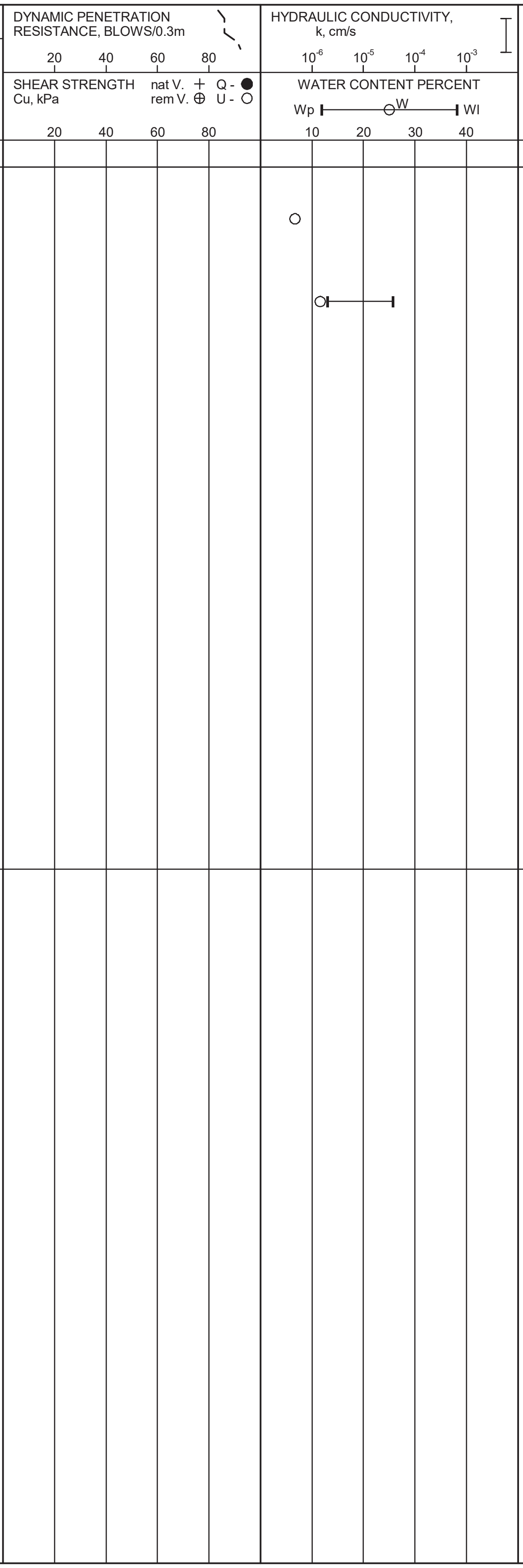
SHEET 1 OF 1

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE						
0	Power Augering 108 mmSolid Stem Augers	ASPHALT	0.00					Concrete
		FILL - (SP) gravelly SAND, some fines; brown; non-cohesive, moist, dense	0.13	1	SS	44	17 66 17	
1		(CL) gravelly sandy SILTY CLAY; mottled brown to grey to brown; non-cohesive, moist, very stiff	0.69	2	SS	20	16 32 32 20	
				3	SS	12		Bentonite Seal
2		(CL) SILTY CLAY, trace sand; brown; cohesive, w~PL, very stiff	2.13	4	SS	16		
3		(SM) CLAYEY SILTY SAND and GRAVEL; brown; non-cohesive, moist, very dense	2.90	5	SS	97/ 0.23		
4								Silica Sand Filter and Screen
5				6	SS	50/ 0.13		
		END OF BOREHOLE	5.18					
6								
7								
8								
9								
10								



DEPTH SCALE

1 : 50

GOLDER

LOGGED: AJ

CHECKED: RR

PROJECT: 1544413

LOCATION: See Borehole Location Plan

RECORD OF BOREHOLE: 17-03

BORING DATE: December 11, 2017

SHEET 1 OF 1

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE									
0	Power Augering 108 mmSolid Stem Augers	ASPHALT	■	0.00							
		FILL - (SP) gravelly SAND, some fines; brown; non-cohesive, moist, very dense	▩	0.15	1	SS	50/ 0.05		○		
1					2	SS	130/ 0.20				28 60 12
		(CL) sandy SILTY CLAY, trace gravel, trace organics; grey; cohesive, w<PL, stiff	▨	1.37	3	SS	10				
2		END OF BOREHOLE		1.98							
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: AJ

CHECKED: RR

PROJECT: 1544413
LOCATION: See Borehole Location Plan

RECORD OF BOREHOLE: 17-04

BORING DATE: December 14, 2017

SHEET 1 OF 1
DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm
HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: STRATA PLOT	SOIL PROFILE: ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE									
0	Power Augering 108 mmSolid Stem Augers	ASPHALT	■	0.00							
		ASPHALT grindings	■	0.13	1	SS	50/ 0.10				
1		FILL - (SM) SILTY SAND, some gravel, some organics; brown to black; non-cohesive, moist, compact	▩	0.69	2	SS	20				
		FILL - (CL) sandy SILTY CLAY, trace gravel; brown; cohesive, w~PL, stiff	▩	1.30	3	SS	14		○		3 25 37 35
2		END OF BOREHOLE		1.98							
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE
1 : 50

GOLDER

LOGGED: AJ
CHECKED: RR

PROJECT: 1544413

LOCATION: See Borehole Location Plan

RECORD OF BOREHOLE: 17-05

BORING DATE: December 14, 2017

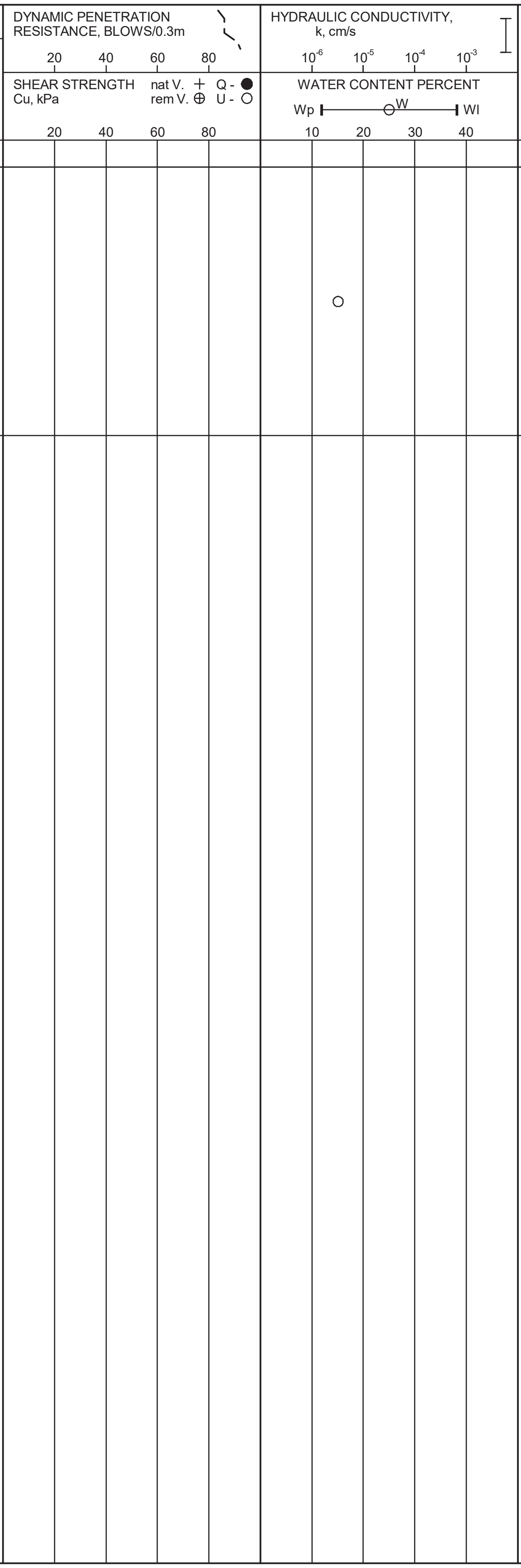
SHEET 1 OF 1

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m
		GROUND SURFACE					
0	Power Augering 108 mmSolid Stem Augers	ASPHALT	■	0.00			
		(SP/GP) SAND and GRAVEL; brown; non-cohesive, moist, very dense		0.14	1	SS	50/ 0.13
1		(CL) sandy SILTY CLAY to SILTY CLAY, some sand, trace gravel; brown; cohesive, w~PL, very stiff to stiff	▨	0.69	2	SS	19
					3	SS	14
2		END OF BOREHOLE		1.98			



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

GOLDER

LOGGED: AJ

CHECKED: RR

PROJECT: 1544413

RECORD OF BOREHOLE: 17-06

SHEET 1 OF 2

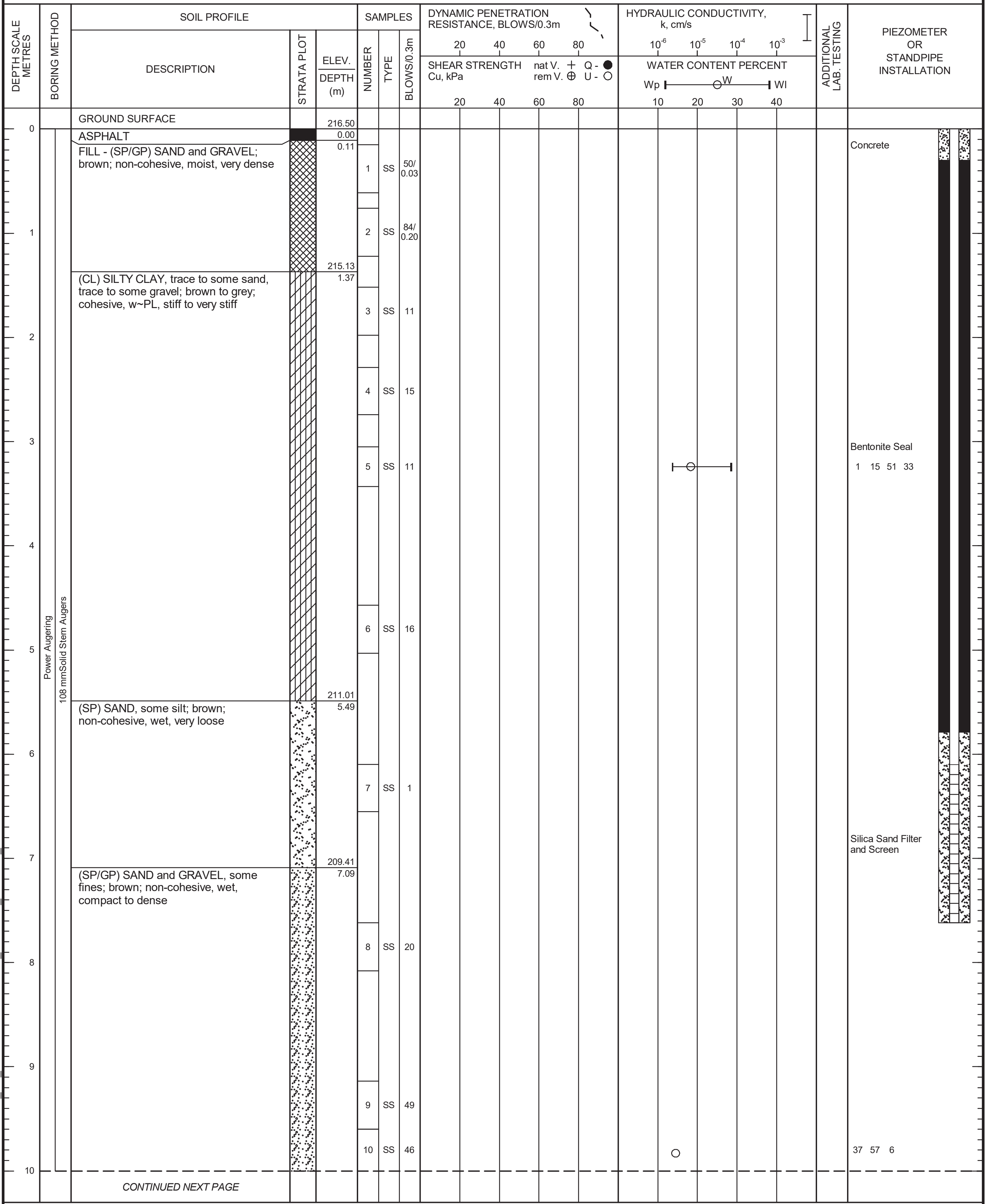
LOCATION: See Borehole Location Plan

BORING DATE: December 11, 2017

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC



DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	216.50
ASPHALT	0.00
FILL - (SP/GP) SAND and GRAVEL; brown; non-cohesive, moist, very dense	0.11
(CL) SILTY CLAY, trace to some sand, trace to some gravel; brown to grey; cohesive, w~PL, stiff to very stiff	215.13 1.37
(SP) SAND, some silt; brown; non-cohesive, wet, very loose	211.01 5.49
(SP/GP) SAND and GRAVEL, some fines; brown; non-cohesive, wet, compact to dense	209.41 7.09

NUMBER	TYPE	BLOWS/0.3m	
1	SS	50/ 0.03	
2	SS	84/ 0.20	
3	SS	11	
4	SS	15	
5	SS	11	1 15 51 33
6	SS	16	
7	SS	1	
8	SS	20	
9	SS	49	
10	SS	46	37 57 6

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 50

GOLDER

LOGGED: AJ

CHECKED: RR

PROJECT: 1544413

LOCATION: See Borehole Location Plan

RECORD OF BOREHOLE: 17-06

BORING DATE: December 11, 2017

SHEET 2 OF 2

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
10		END OF BOREHOLE NOTE: 1. Water encountered at a depth of 5.79 m (Elev. 210.70 m)		206.45 10.05							
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: AJ

CHECKED: RR

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PROJECT: 1544413

LOCATION: See Borehole Location Plan

RECORD OF BOREHOLE: 17-07

BORING DATE: December 14, 2017

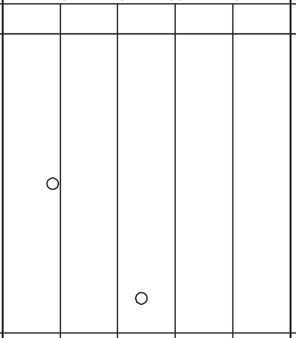
SHEET 1 OF 1

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● rem V. ⊕ U - ○) 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10⁻⁶ 10⁻⁵ 10⁻⁴ 10⁻³ / WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE									
0	Power Augering 108 mmSolid Stem Augers	ASPHALT		0.00							
		(SP/GP) SAND and GRAVEL, trace silt; brown; non-cohesive, moist, very dense		0.13	1	SS	60/ 0.13				
		FILL - (SM) Silty SAND, some gravel, trace clay, trace asphalt; brown; non-cohesive, moist, compact		0.69							
1					2	SS	17		○		
		(ML) sandy SILT, some clay, trace gravel; brown; non-cohesive, wet, compact		1.11							
					3	SS	13		○		4 23 61 12
2		END OF BOREHOLE		1.98							



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DEPTH SCALE

1 : 50

GOLDER

LOGGED: AJ

CHECKED: RR

PROJECT: 1544413

LOCATION: See Borehole Location Plan

RECORD OF BOREHOLE: 17-08

BORING DATE: December 11, 2017

SHEET 1 OF 1

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE									
0	Power Augering 108 mmSolid Stem Augers	ASPHALT	■	0.00							
		FILL - (SP/GP) SAND and GRAVEL; brown; non-cohesive, moist, very dense	▨	0.14	1	SS	65				
1		FILL - (CL) sandy SILTY CLAY, trace gravel, trace organics; non-cohesive, moist to wet, loose	▨	0.69	2	SS	8				
					3	SS	9		⊢○—⊣		2 40 37 21
2		END OF BOREHOLE		1.98							
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: AJ

CHECKED: RR

PROJECT: 1544413

LOCATION: See Borehole Location Plan

RECORD OF BOREHOLE: 17-09

BORING DATE: December 14, 2017

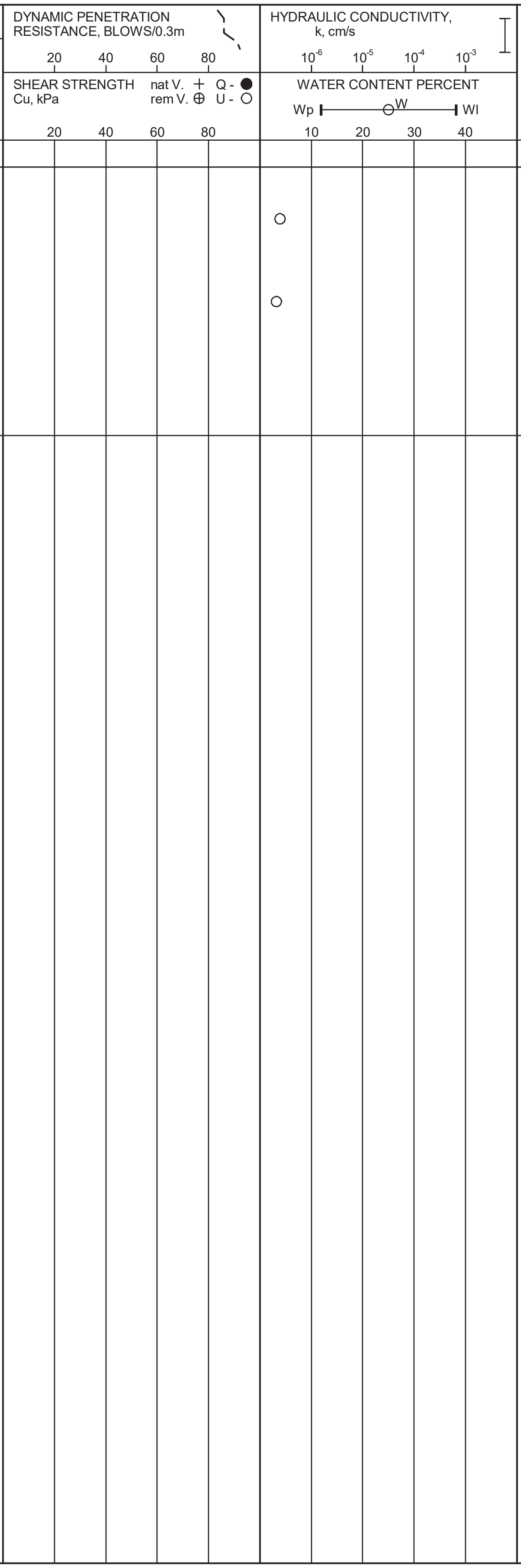
SHEET 1 OF 1

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE							
0	Power Augering 108 mmSolid Stem Augers	ASPHALT		0.00					
		FILL - (SP) gravelly SAND, some fines, trace silt; brown; non-cohesive, moist, very dense		0.15	1	SS	50/ 0.03		27 60 13
1					2	SS	50/ 0.13		
		(CL) sandy SILTY CLAY, trace gravel, trace organics; brown; cohesive, w~PL, stiff		1.37	3	SS	13		
2		END OF BOREHOLE		1.98					
3									
4									
5									
6									
7									
8									
9									
10									



DEPTH SCALE

1 : 50

GOLDER

LOGGED: AJ

CHECKED: RR

PROJECT: 1544413
LOCATION: See Borehole Location Plan

RECORD OF BOREHOLE: 17-10

BORING DATE: December 11, 2017

SHEET 1 OF 1
DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm
HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m				
		GROUND SURFACE									
0	Power Augering 108 mmSolid Stem Augers	(SP/GP) SAND and GRAVEL; brown; non-cohesive, moist, compact		0.00	1	SS	29				
1		(SP/GP) SAND and GRAVEL, some silty clay; brown; non-cohesive, moist, compact		0.69	2	SS	18				
		(CL) sandy SILTY CLAY, trace gravel, trace organics; brown; cohesive, w~PL, very stiff		1.37	3	SS	17		○		
2		END OF BOREHOLE		1.98							
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE
1 : 50

GOLDER

LOGGED: AJ
CHECKED: RR

PROJECT: 1544413

LOCATION: See Borehole Location Plan

RECORD OF BOREHOLE: 17-11

BORING DATE: December 13, 2017

SHEET 1 OF 1

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ : 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl : 10 20 30 40

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE								
0	Power Augering 108 mmSolid Stem Augers	ASPHALT	■	0.00						
		FILL - (SP/GP) SAND and GRAVEL, some silt; brown; non-cohesive, moist, very dense	▩	0.14	1	SS	50/ 0.05			
1		(CL) SILTY CLAY, some to trace sand, trace gravel, trace organics; dark grey to brown; cohesive, w~PL, very stiff to stiff	▨	0.91	2	SS	19	○		
					3	SS	10			
2		(SP) SAND, some silt, trace clay; brown; non-cohesive, moist to wet, compact to very dense		2.13	4	SS	21			
3					5	SS	50	○		0 90 6 4
4										
5					6	SS	49			
		END OF BOREHOLE		5.18						
6										
7										
8										
9										
10										

DEPTH SCALE

1 : 50

GOLDER

LOGGED: AJ

CHECKED: RR

PROJECT: 1544413

LOCATION: See Borehole Location Plan

RECORD OF BOREHOLE: 17-12

BORING DATE: December 11, 2017

SHEET 1 OF 1

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: STRATA PLOT	SOIL PROFILE: ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE									
0	Power Augering 108 mmSolid Stem Augers	ASPHALT	■	0.00							
		FILL - (SP/GP) SAND and GRAVEL, some silt; brown; non-cohesive, moist, very dense	▨	0.08	1	SS	81				
1		FILL - (CL) SILTY CLAY, some sand; brown; cohesive, w~PL, stiff	▨	0.69	2	SS	8		○		
		(SM) SILTY SAND; brown; non-cohesive, moist, loose	⁙	1.37	3	SS	8				
2		END OF BOREHOLE		1.98							

DEPTH SCALE

1 : 50

GOLDER

LOGGED: AJ

CHECKED: RR

PROJECT: 1544413
LOCATION: See Borehole Location Plan

RECORD OF BOREHOLE: 17-13

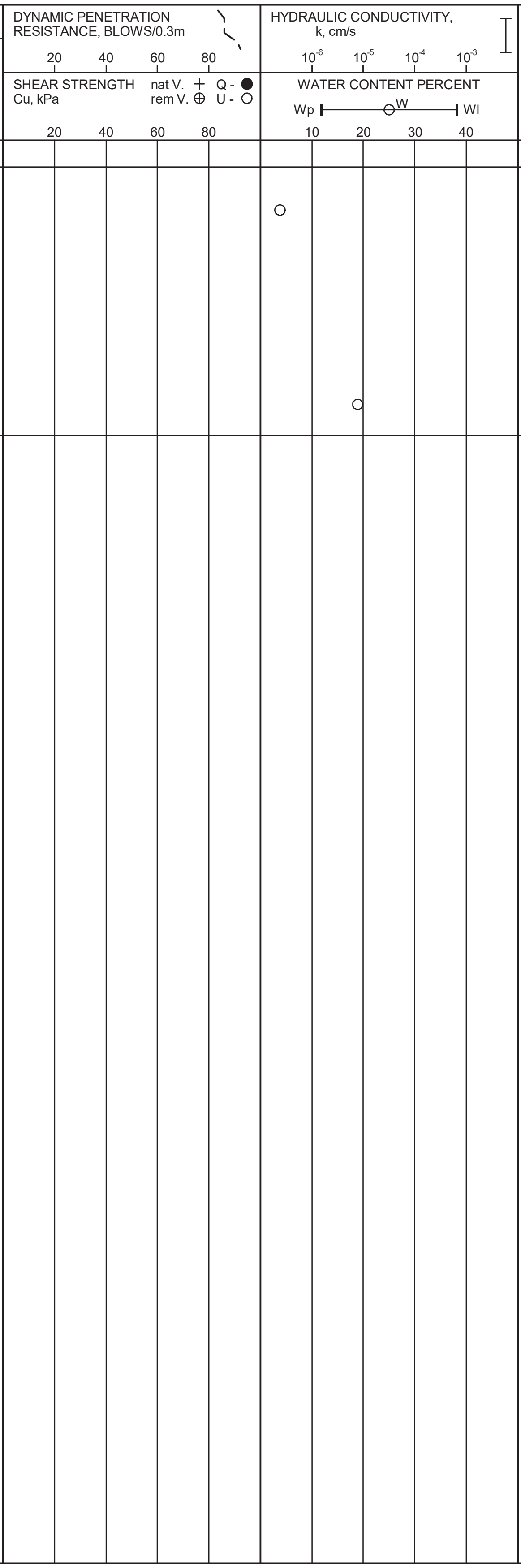
BORING DATE: December 13, 2017

SHEET 1 OF 1
DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE							
0	Power Augering 108 mmSolid Stem Augers	ASPHALT	■	0.00					
		(SP) gravelly SAND, some fines; brown; non-cohesive, moist, very dense		0.14	1	SS	50/ 0.03		21 58 11
1		(CL) SILTY CLAY, some sand, some gravel, trace organics; brown; cohesive, w<PL, very stiff	▨	0.69	2	SS	17		
		(ML) sandy SILT; brown; non-cohesive, moist, compact		1.37	3	SS	16		
2		END OF BOREHOLE		1.98					
3									
4									
5									
6									
7									
8									
9									
10									



DEPTH SCALE
1 : 50

GOLDER

LOGGED: AJ
CHECKED: RR

PROJECT: 1544413

LOCATION: See Borehole Location Plan

RECORD OF BOREHOLE: 17-14

BORING DATE: December 13, 2017

SHEET 1 OF 1

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 / SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} / WATER CONTENT PERCENT Wp ⊢○W⊣ Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE									
0	Power Augering 108 mmSolid Stem Augers	ASPHALT	■	0.00							
		FILL - (SP) gravelly SILTY SAND, some clay; brown; non-cohesive, moist, compact	▨	0.15	1	SS	17		○		23 37 29 11
1		(CL) sandy SILTY CLAY, trace gravel, trace organics; brown	▨	0.76	2	SS	8		⊢○—⊣		
		(SM) SILTY SAND; brown; non-cohesive, moist, loose	▨	1.37	3	SS	6				
2		END OF BOREHOLE		1.98							
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: AJ

CHECKED: RR

PROJECT: 1544413

LOCATION: See Borehole Location Plan

RECORD OF BOREHOLE: 17-15

BORING DATE: December 13, 2017

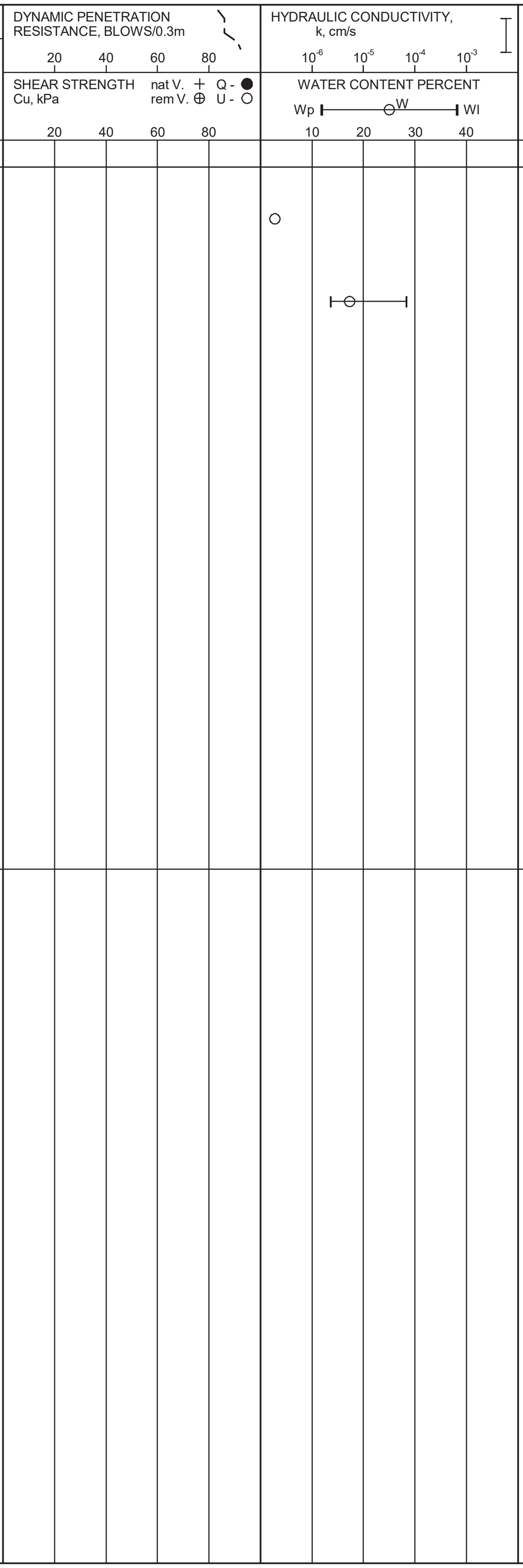
SHEET 1 OF 1

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE						
0	Power Augering 108 mmSolid Stem Augers	ASPHALT	0.00					
		FILL - (SP) gravelly SAND, some fines; brown; non-cohesive, moist, compact to dense	0.15	1	SS	30		Concrete 18 60 12
1		(CL) SILTY CLAY, some sand, trace gravel; brown; cohesive, w<PL, stiff to very stiff	0.69	2	SS	13		
				3	SS	18		Bentonite Seal
2		(ML) SILT, some sand, trace clay; brown; non-cohesive, moist, compact to dense	2.13	4	SS	19		
3				5	SS	47		0 9 86 5
								Silica Sand Filter and Screen
4		(SM) SILTY SAND; brown; non-cohesive, moist, dense	4.04					
5				6	SS	49		
		END OF BOREHOLE	5.18					
6								
7								
8								
9								
10								



DEPTH SCALE

1 : 50

GOLDER

LOGGED: AJ

CHECKED: RR

PROJECT: 1544413

RECORD OF BOREHOLE: 17-16

SHEET 1 OF 1

LOCATION: See Borehole Location Plan

BORING DATE: December 13, 2017

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE									
0	Power Augering 108 mmSolid Stem Augers	ASPHALT	■	0.00							
		FILL - (SP/GP) SAND and GRAVEL; brown; non-cohesive, moist, very dense	▩	0.13	1	SS	50/ 0.13				
1		(CL) sandy SILTY CLAY, some sand, trace gravel; brown; cohesive, w<PL, stiff to very stiff	▨	0.69	2	SS	11		○		3 27 33 37
					3	SS	14				
2		END OF BOREHOLE		1.98							
3											
4											
5											
6											
7											
8											
9											
10											

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DEPTH SCALE

1 : 50

GOLDER

LOGGED: AJ

CHECKED: RR

PROJECT: 1544413

LOCATION: See Borehole Location Plan

RECORD OF BOREHOLE: 17-17

SHEET 1 OF 1

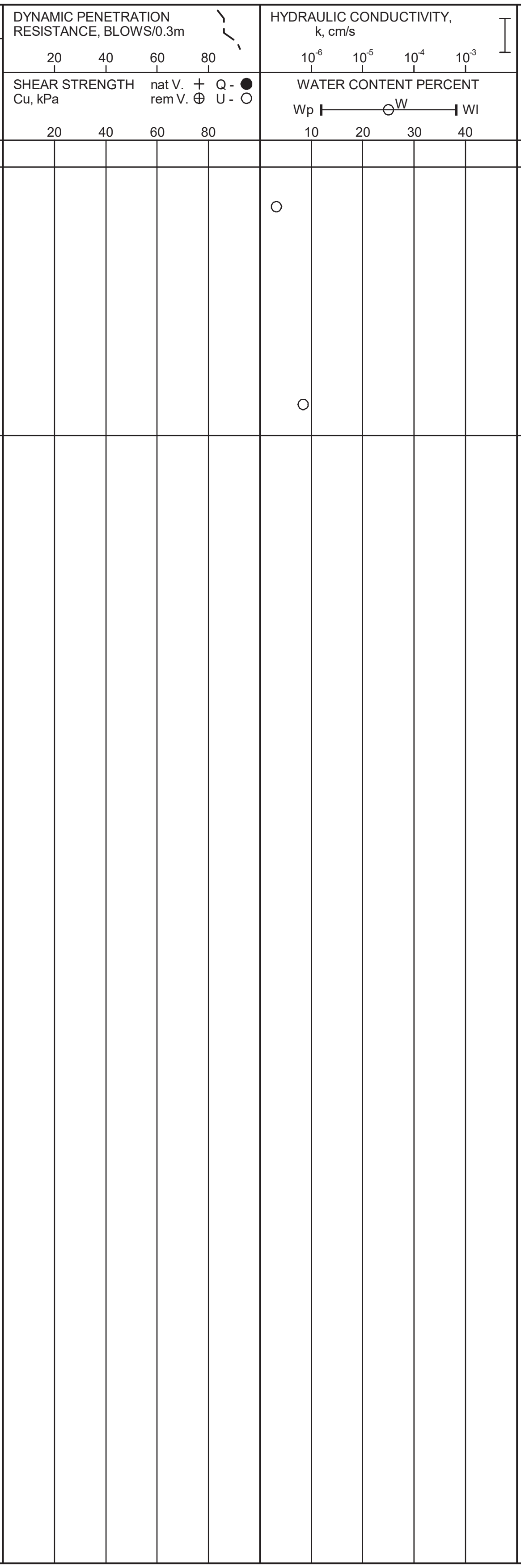
BORING DATE: December 13, 2017

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE							
0	Power Augering 108 mmSolid Stem Augers	ASPHALT		0.00					
		FILL - (SP/GP) SAND and GRAVEL, trace to silt; brown; non-cohesive, moist, very dense		0.11	1	SS	50/ 0.13		
1		(CL) sandy SILTY CLAY, trace gravel, trace organics; brown; cohesive, w<PL, stiff		0.69	2	SS	11		
		(SM) SILTY SAND, trace gravel, trace clay; brown; non-cohesive, moist, compact		1.37	3	SS	25		3 63 29 5
2		END OF BOREHOLE		1.98					
3									
4									
5									
6									
7									
8									
9									
10									



DEPTH SCALE

1 : 50

GOLDER

LOGGED: AJ

CHECKED: RR

PROJECT: 1544413

LOCATION: See Borehole Location Plan

RECORD OF BOREHOLE: 17-18

BORING DATE: December 13, 2017

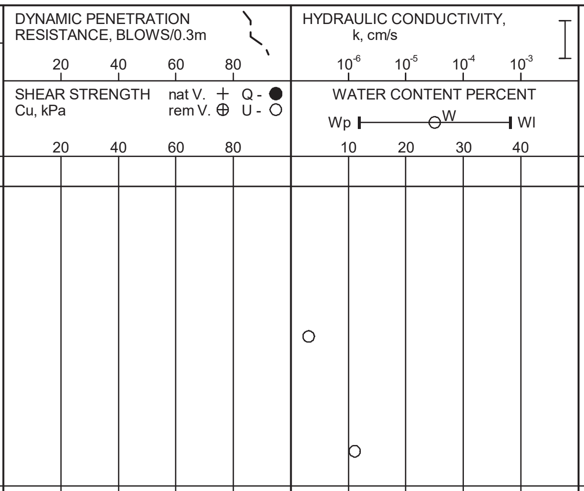
SHEET 1 OF 1

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE							
0	Power Augering 108 mmSolid Stem Augers	ASPHALT	■	0.00					
		FILL - (SP) gravelly SAND, some fines; brown; non-cohesive, moist, very dense to dense	▩	0.13	1	SS	101		
1					2	SS	31		22 60 18
		(CL) SILTY CLAY, some sand, trace gravel; brown; cohesive, w<PL, very stiff	▨	1.37	3	SS	16		
2		END OF BOREHOLE		1.98					



DEPTH SCALE

1 : 50

GOLDER

LOGGED: AJ

CHECKED: RR

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PROJECT: 1544413

LOCATION: See Borehole Location Plan

RECORD OF BOREHOLE: 17-19

BORING DATE: December 13, 2017

SHEET 1 OF 1

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

BORING METHOD: Power Augering, 108 mmSolid Stem Augers

DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	WATER CONTENT PERCENT	PIEZOMETER OR STANDPIPE INSTALLATION
GROUND SURFACE							
ASPHALT	■	0.00					
FILL - (SP/GP) SAND and GRAVEL, some fines; brown; non-cohesive, moist, very dense to compact	▩	0.08	1	SS	50/ 0.15		
			2	SS	20	○	45 45 10
(CL) sandy SILTY CLAY, trace gravel; brown to grey; cohesive, w<PL, very stiff to hard	▨	1.37	3	SS	18		
			4	SS	20		
			5	SS	33	○	3 31 50 14
(CL) SILTY CLAY, trace sand, trace gravel; grey; cohesive, w~PL, very stiff	▨	4.11	6	SS	18		
END OF BOREHOLE		5.18					

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ : 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl : 10 20 30 40

ADDITIONAL LAB. TESTING

DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10

DEPTH SCALE

1 : 50

GOLDER

LOGGED: AJ

CHECKED: RR

PROJECT: 1544413

LOCATION: See Borehole Location Plan

RECORD OF BOREHOLE: 17-20

BORING DATE: December 13, 2017

SHEET 1 OF 1

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE									
0	Power Augering 108 mmSolid Stem Augers	ASPHALT	■	0.00							
		FILL - (SP/GP) SAND and GRAVEL, trace silt; brown; non-cohesive, moist, dense	▩	0.13	1	SS	36				
1		(CL) sandy SILTY CLAY, trace gravel; brown; cohesive, w<PL, very stiff	▨	0.69	2	SS	18		○		
					3	SS	21				
2		END OF BOREHOLE		1.98							
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: AJ

CHECKED: RR

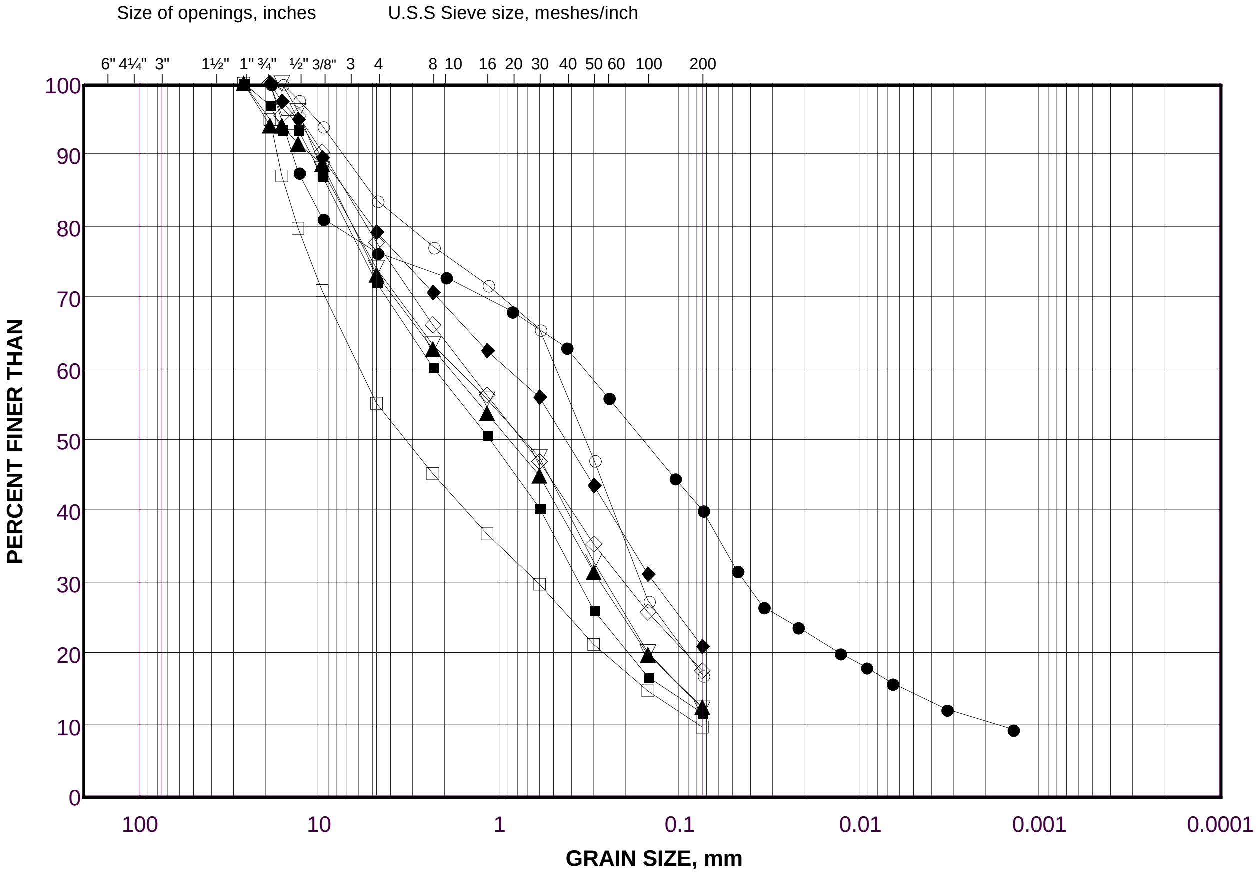
APPENDIX C

Laboratory Testing Results

GRAIN SIZE DISTRIBUTION

Pavement Granular Material

FIGURE C1



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	17-14	1	0.15 - 0.61
■	17-15	1	0.15 - 0.61
◆	17-13	1	0.15 - 0.61
▲	17-09	1	0.15 - 0.61
▽	17-03	1	0.15 - 0.61
○	17-02	1	0.15 - 0.61
□	17-19	2	0.76 - 1.22
△	17-18	2	0.76 - 1.22

Project Number: 1544413

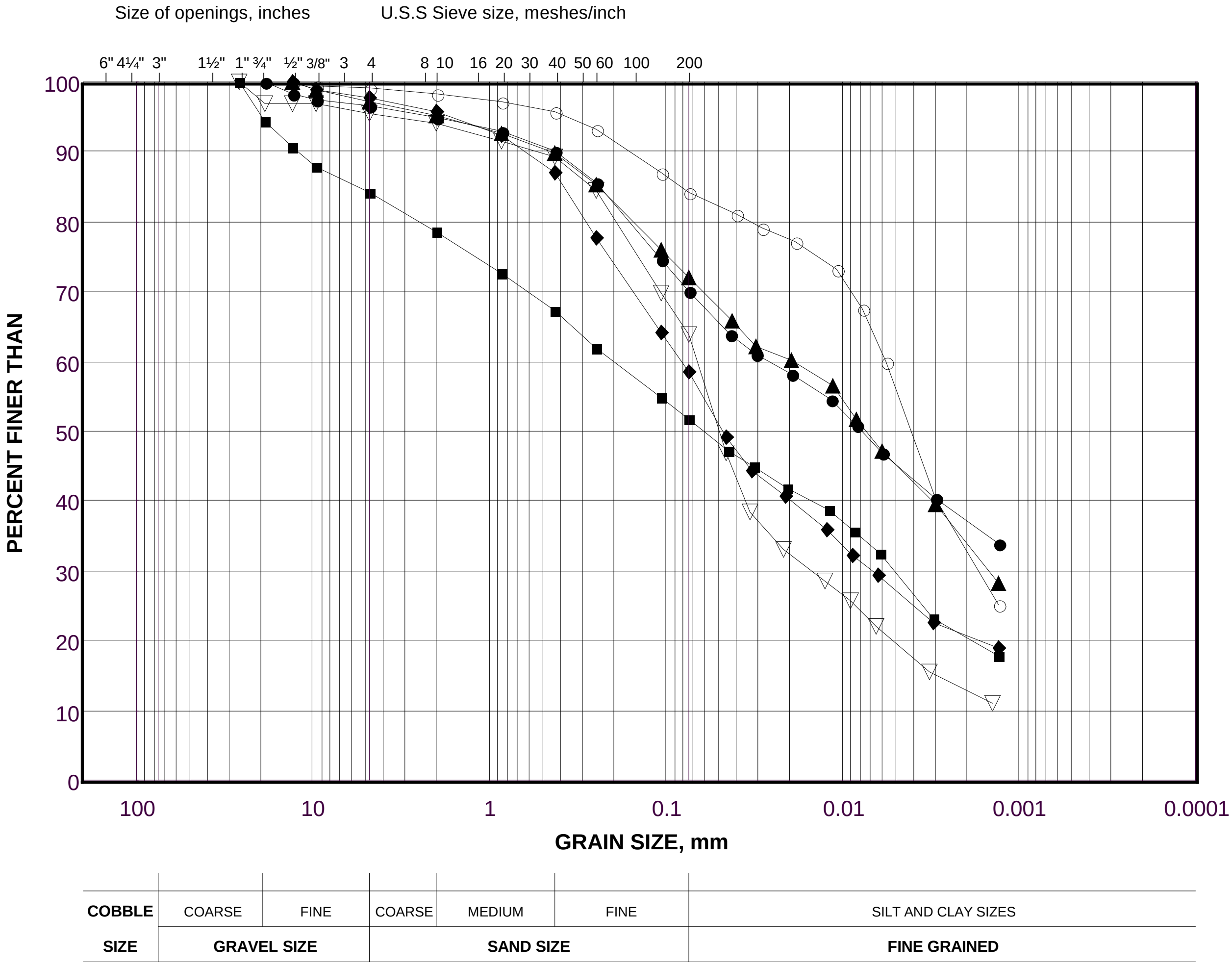
Checked By: AJ

Golder Associates

Date: 29-Jan-18

GRAIN SIZE DISTRIBUTION
Sandy Silty Clay

FIGURE C2



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	17-16	2	0.76 - 1.22
■	17-02	2	0.76 - 1.22
◆	17-08	3	1.52 - 1.98
▲	17-04	3	1.52 - 1.98
▽	17-19	5	3.05 - 3.51
❍	17-06	5	3.05 - 3.51

Project Number: 1544413

Checked By: AJ

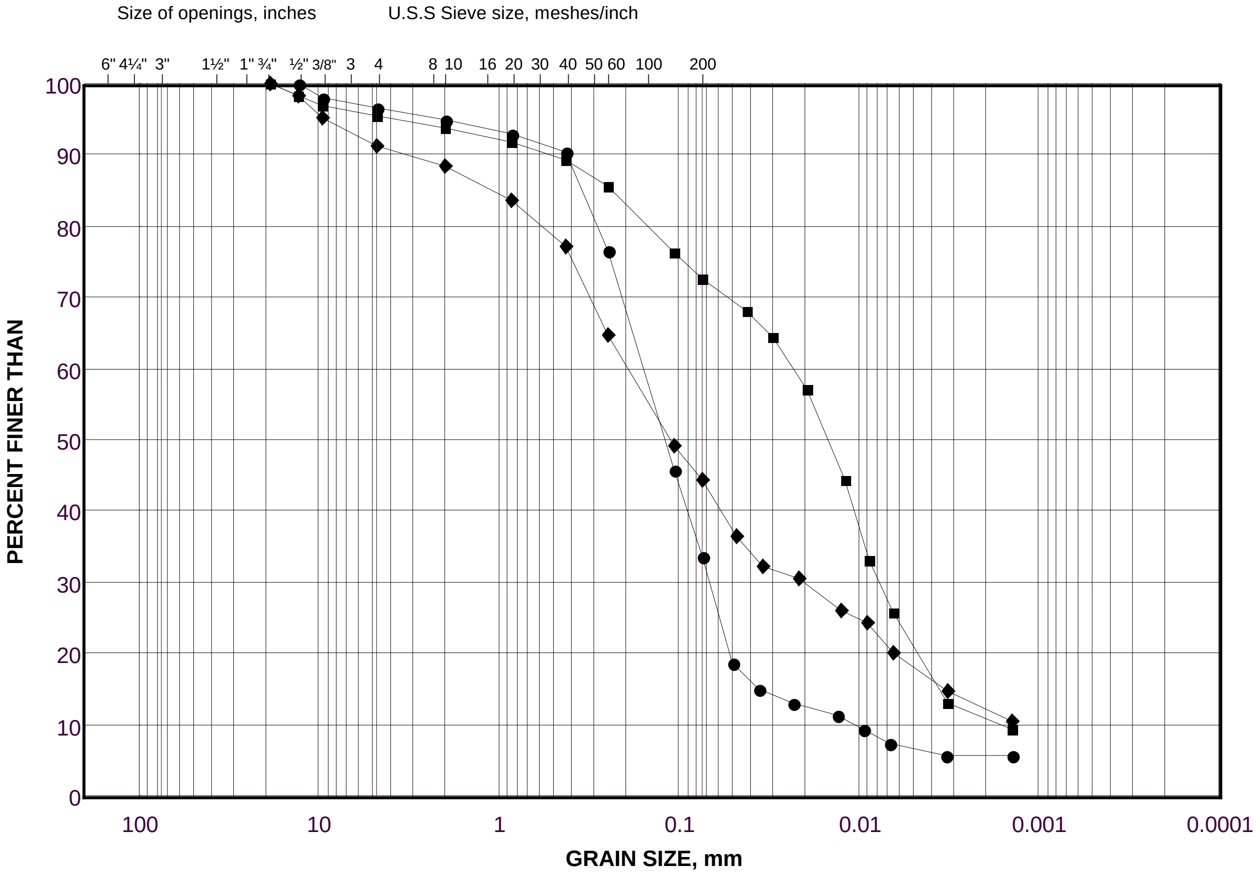
Golder Associates

Date: 29-Jan-18

GRAIN SIZE DISTRIBUTION

Silty Sand to Sandy Silt

FIGURE C3



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	**GRAVEL SIZE**		**SAND SIZE**			**FINE GRAINED**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	17-17	3	1.52 - 1.98
■	17-07	3	1.52 - 1.98
◆	17-01	3	1.52 - 1.98

Project Number: 1544413

Checked By: AJ

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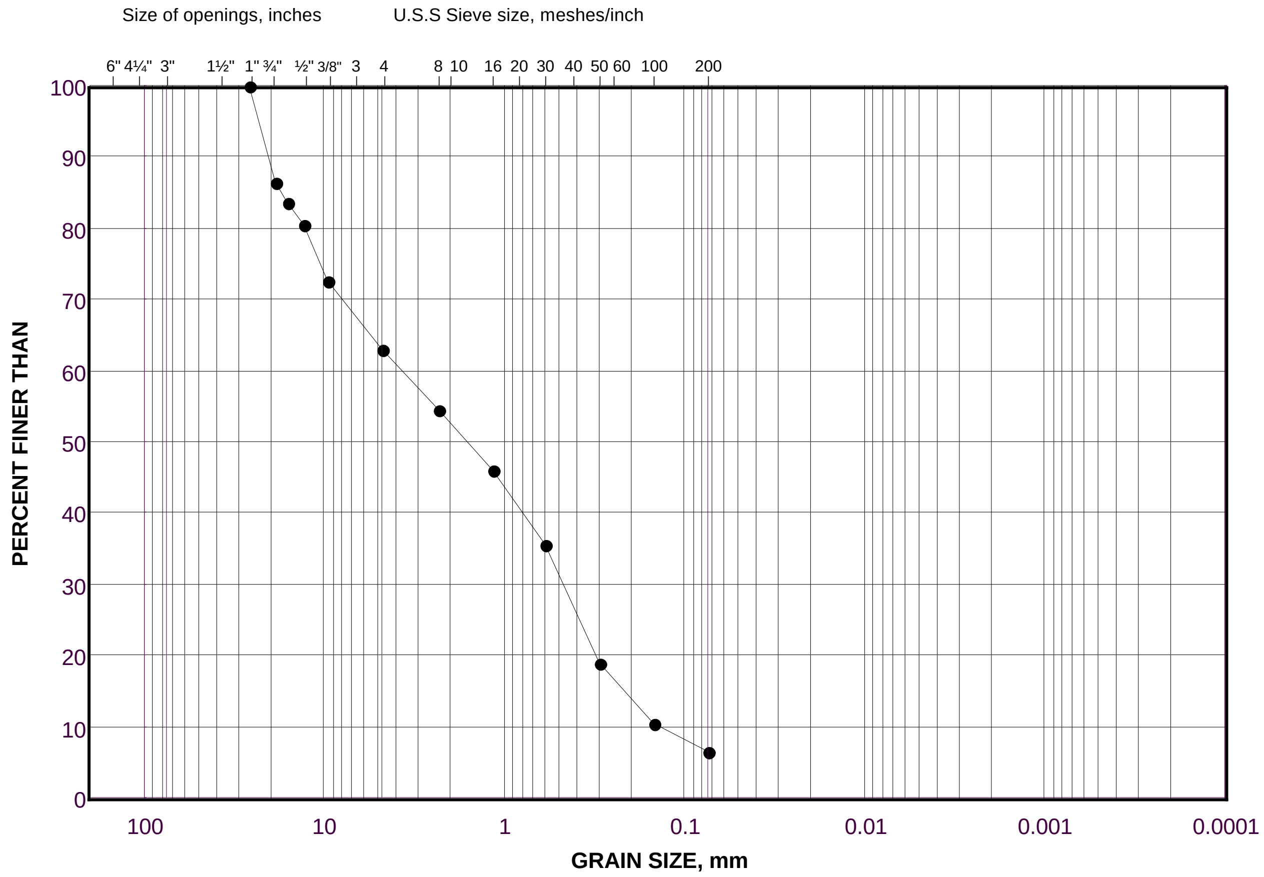
Date: 29-Jan-18

GRAIN SIZE DISTRIBUTION

Sand and Gravel

FIGURE C4



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	**GRAVEL SIZE**		**SAND SIZE**			**FINE GRAINED**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	17-06	9	9.14 - 9.60

Project Number: 1544413

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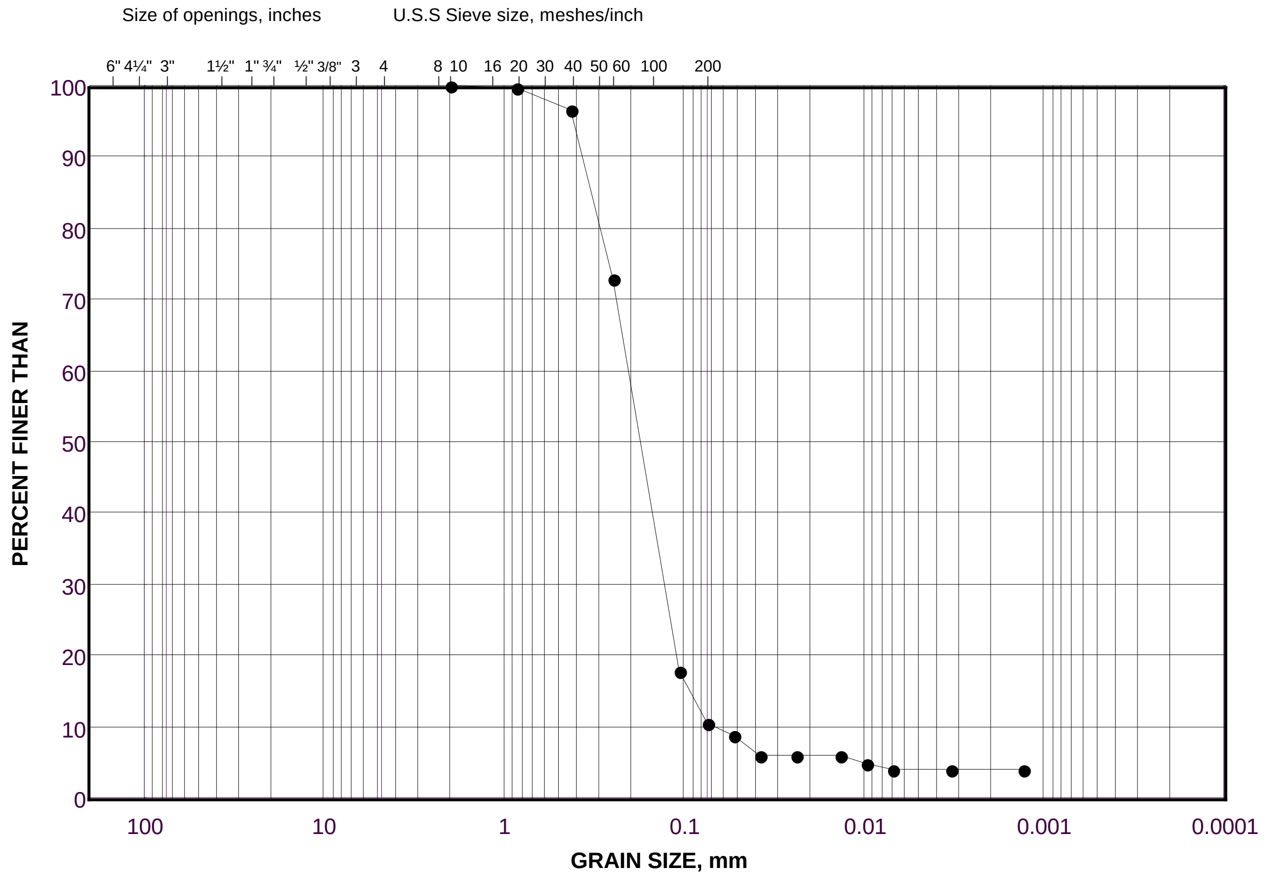
Date: 29-Jan-18

GRAIN SIZE DISTRIBUTION

Sand

FIGURE C5



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	**GRAVEL SIZE**		**SAND SIZE**			**FINE GRAINED**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	17-11	5	3.05 - 3.51

Project Number: 1544413

Checked By: AJ

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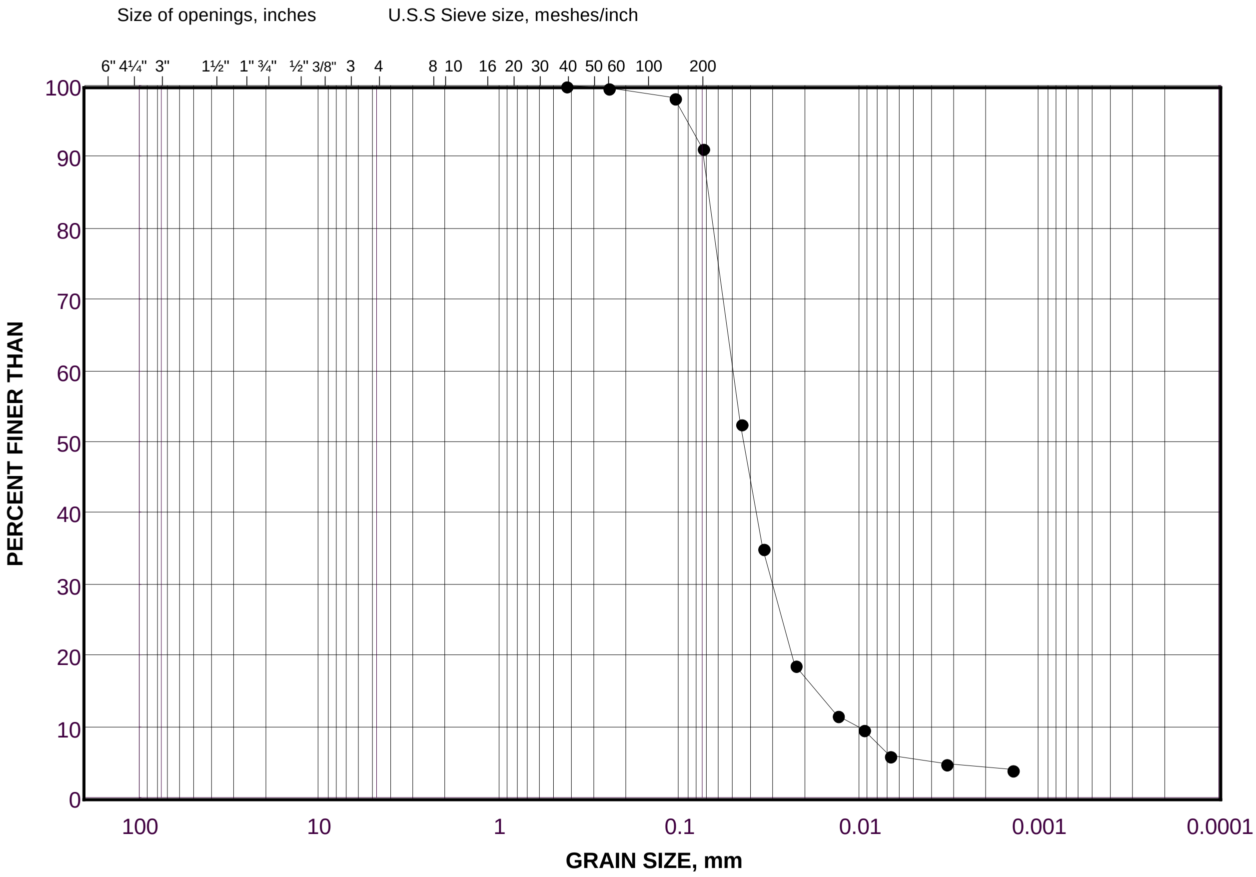
Date: 29-Jan-18

GRAIN SIZE DISTRIBUTION

Silt

FIGURE C6



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	**GRAVEL SIZE**		**SAND SIZE**			**FINE GRAINED**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	17-15	5	3.05 - 3.51

Project Number: 1544413

Checked By: AJ

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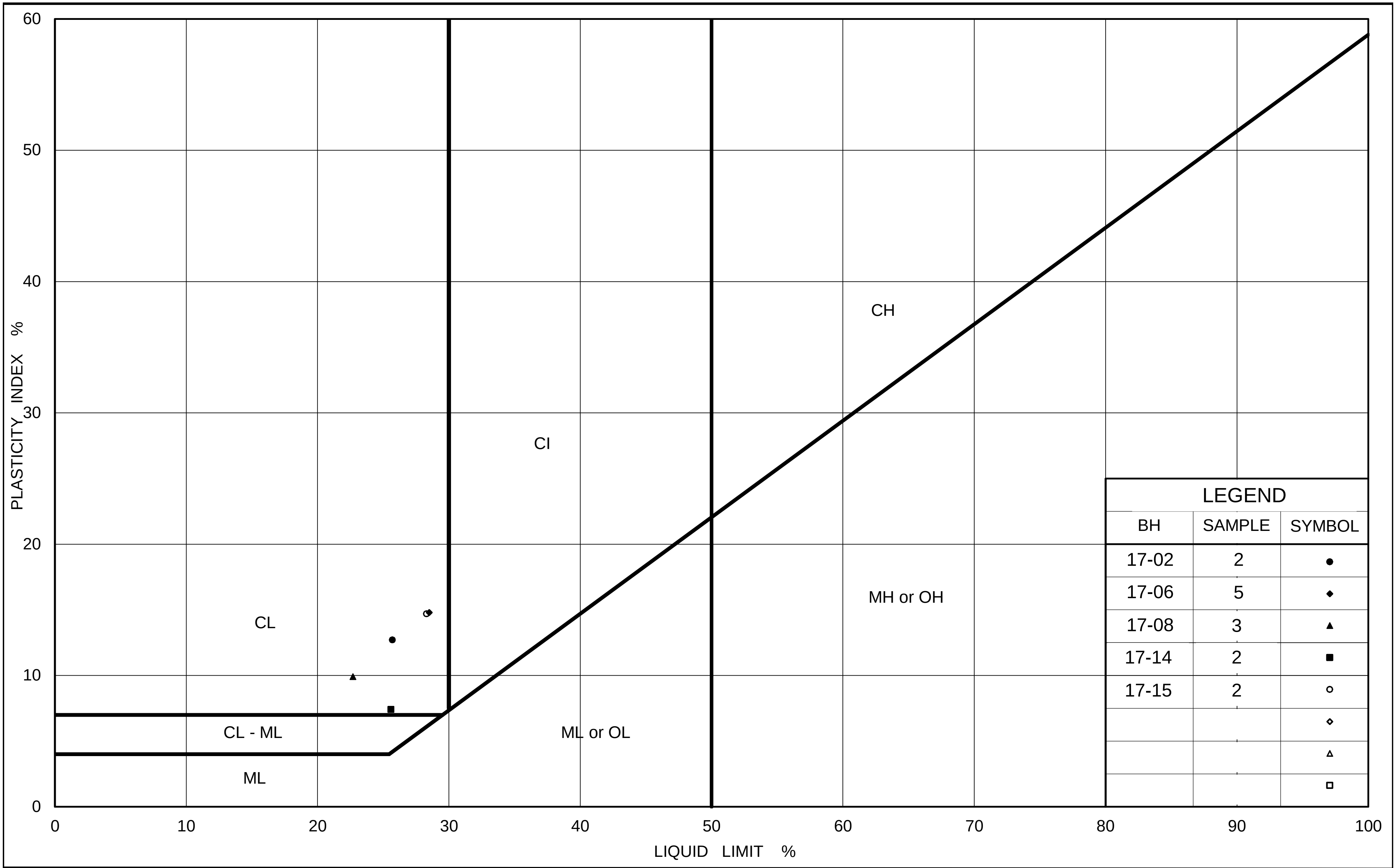
Date: 29-Jan-18



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PLASTICITY CHART
Silty Clay

Figure No. C7

Project No. 1544413

Checked By: AJ

SUMMARY OF WATER CONTENT DETERMINATIONS

ASTM D2216

PROJECT NUMBER	1544413
PROJECT NAME	HDR/EA Victoria Sq Blvd/Markham
DATE TESTED	January 2018

Borehole No.	Sample No.	Depth (ft)	Depth (m)	Water Content (%)	Atterberg Limits LL, PL, PI
17-01	2	2.50 - 4.00	0.76-1.22	12.6%	
17-01	3	5.00 - 6.50	1.52-1.98	9.5%	
17-02	1	0.50 - 2.00	0.15-0.61	6.7%	
17-02	2	2.50 - 4.00	0.76-1.22	11.6%	LL=25.7, PL=13.0, PI=12.7
17-03	1	0.50 - 2.00	0.15-0.61	3.6%	
17-04	3	5.00 - 6.50	1.52-1.98	16.2%	
17-05	2	2.50 - 4.00	0.76-1.22	15.1%	
17-06	5	10.00 - 11.50	3.05-3.51	18.3%	LL=28.5, PL=13.7, PI=14.8
17-06	10	31.50 - 33.00	9.60-10.06	14.5%	
17-07	2	2.50 - 4.00	0.76-1.22	8.7%	
17-07	3	5.00 - 6.50	1.52-1.98	24.1%	
17-08	3	5.00 - 6.50	1.52-1.98	14.6%	LL=22.7, PL=12.8, PI=9.9
17-09	1	0.50 - 2.00	0.15-0.61	3.9%	
17-09	2	2.50 - 4.00	0.76-1.22	3.2%	
17-10	3	5.00 - 6.50	1.52-1.98	10.4%	
17-11	2	2.50 - 4.00	0.76-1.22	15.2%	
17-11	5	10.00 - 11.50	3.05-3.51	7.0%	
17-12	2	2.50 - 4.00	0.76-1.22	19.9%	
17-13	1	0.50 - 2.00	0.15-0.61	3.8%	
17-13	3	5.00 - 6.50	1.52-1.98	18.9%	
17-14	1	0.50 - 2.00	0.15-0.61	8.0%	
17-14	2	2.50 - 4.00	0.76-1.22	19.4%	LL=25.6, PL=18.2, PI=7.4
17-15	1	0.50 - 2.00	0.15-0.61	2.8%	
17-15	2	2.50 - 4.00	0.76-1.22	17.3%	LL=28.3, PL=13.6, PI=14.7
17-15	5	10.00 - 11.50	3.05-3.51	10.9%	
17-16	2	2.50 - 4.00	0.76-1.22	16.4%	
17-17	1	0.50 - 2.00	0.15-0.61	3.2%	
17-17	3	5.00 - 6.50	1.52-1.98	8.4%	
17-18	2	2.50 - 4.00	0.76-1.22	3.1%	
17-18	3	5.00 - 6.50	1.52-1.98	11.1%	
17-19	2	2.50 - 4.00	0.76-1.22	3.0%	
17-19	5	10.00 - 11.50	3.05-3.51	12.5%	NL/NP
17-20	2	2.50 - 4.00	0.76-1.22	10.4%	

Checked By: RR

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