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We note that other reports in relation to the Project were also completed by the author.

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During the course of the Project other data was obtained and other reports completed by other engineers and contracting firms.

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AECOM Imagine it. Delivered.

The Township of Uxbridge

Hydrogeological Investigation Detailed Design Services for Reconstruction of the Brock Street Culvert (Uxbridge, ON)

Prepared by:

AECOM Canada Ltd.
105 Commerce Valley Drive West, 7th Floor
Markham, ON L3T 7W3
Canada

T: 905.886.7022
F: 905.886.9494
www.aecom.com

Date: April, 2018

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Revision History

Rev #	Date	Revised By:	Revision Description
0	February 21, 2018	K. Ali	DRAFT for Internal Review
1	March 6, 2018	J. Murchison	FINAL DRAFT for Client Review
2	April 14, 2018	K. Ali	FINAL DRAFT with Geotechnical Memos
3	April 16, 2018	K. Ali	FINAL for Client

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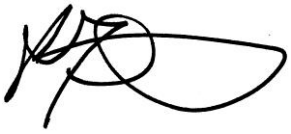
AECOM: 2015-04-13

Authors

Report Prepared By:

Kelly Ali, M.A.Sc., P.Eng.
Hydrogeologist

Report Reviewed By:



Jason A. Murchison, P.Geo., QP(ESA O.Reg.153)
Director, Geosciences (Hydrogeology/Geotechnical Engineering)
DCS Americas, Canada Region
Environment
C 705-717-2526 D 705-797-3280
Jason.Murchison@aecom.com

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Appendices

1. Introduction

The Township of Uxbridge (the 'Township') has retained AECOM Canada Ltd. (AECOM) to provide Detailed Design Services for Reconstruction of the Brock Street Culvert in the Community of Uxbridge, Ontario (the 'Site'). The Project involves removal of an existing culvert structure which encloses Uxbridge Brook between Centennial Drive and the northern limit of a parking lot situated approximately 100 m north of Brock Street which acted as a 'bottle-neck' and resultant flooding hazard during the Regional Storm (Hurricane Hazel) event. In its place, two (2) new culverts having a total span of approximately 11 m are planned to be constructed in a twinned configuration so as to provide additional flow capacity for the watercourse through the area and mitigate the current flooding hazard. The Site location is shown in **Figure 1**.

The depth from ground surface to the base of the new twin culverts is expected to vary along its length due to local variations in ground elevation. Based on the results of subsurface (geotechnical) investigations previously completed at and in the immediate vicinity of the Site in 2012 and 2017, it is expected that the full length of the culvert will involve excavations that will extend below the local shallow water table (unconfined), and in certain locations, potentially in the vicinity of a local confined artesian aquifer. As such, dewatering (and possibly depressurization) will be required so as to provide dry and stable working conditions during construction.

To support detailed design, tendering and ultimate construction of the Project, AECOM was retained by the Township to complete a *Hydrogeological Investigation* for the intent of characterizing local physical and hydrogeological conditions, quantifying potential dewatering / depressurization requirements for construction, assessing possible impacts to local water wells and/or groundwater dependant environmental features, and to recommend appropriate monitoring and/or mitigation measures, as required. This report provides a summary, interpretation, and discussion of the investigation results in sufficient content and detail to serve as technical support for a Category 3 Permit to Take Water (PTTW) application to the Ministry of the Environment and Climate Change (MOECC); inclusive of expected construction dewatering rates, treatment, monitoring, and discharge requirements.

1.1 Background Data Review

The following background information and reports were reviewed and considered by AECOM in the completion of this *Hydrogeological Investigation*:

- AECOM Canada Ltd. (AECOM), December 2017. Existing Culvert Plan & Profile Drawings. (**Appendix A**)
- V.A. Wood Associates Limited (V.A. Wood), September 2017. *Geotechnical Investigation, Culvert Reconstruction, Brock Street / Centennial Drive, Uxbridge, Ontario*. Reference No. 7171-17-6. (**Appendix B1**)
- GHD, September 2015. *Addendum to Environmental Study Report, Downtown Uxbridge Flood Reduction, Municipal Class Environmental Assessment, Township of Uxbridge*. File No. 088553.
- SRM Associates (SRM), November 2012. *Town of Uxbridge and Township of Durham, Downtown Uxbridge Flood Reduction, Schedule 'C' Municipal Class Environmental Assessment, Environmental Study Report*.

- Soil Engineers Ltd. (SEL), July 2012. *A Report to the Town of Uxbridge, A Soil Investigation for Proposed Culvert Replacement, Centennial Drive to North of Brock Street, Town of Uxbridge*. Reference No. 1204-S048. (**Appendix B2**)
- MOECC Water Well Record (WWR), Permit To Take Water (PTTW), and Environmental Activity and Sector Registry (EASR) databases within a 500 m Radius of the Site;
- Ontario Geological Survey (OGS) and Geological Survey of Canada (GSC) Quaternary Overburden and Bedrock Geology Mapping; and,
- Base mapping data from the Ministry of Natural Resources and Forestry (MNRF).

1.2 Study Area

The 'Project Study Area' (PSA) is defined as the area residing within a 500 m radius of the Site, as shown in **Figure 2**. The PSA is located within the developed limits of the Community of Uxbridge, in the Township of Uxbridge, Regional Municipality of Durham.

This *Hydrogeological Investigation* provides a characterization of physical, geological and hydrogeological conditions across the PSA, with specific emphasis on local conditions at the Site; including, topography and drainage, subsurface stratigraphy, and groundwater.

1.3 Project Description

The Project comprises a progressive (staged) work program that will involve sequential shored excavations for removal of the existing culvert structure and construction of a new twin culvert on Uxbridge Brook between approximately chainage 0+920 and 01+110, for a total length of about 190 m (excluding headwalls).

Preliminary drawings for the Project, as prepared by AECOM, including both plan and profile elements of the existing culvert alignment, are contained in **Appendix A**. Specifically, the following two (2) drawing sheets are appended:

- Sheet No. 01: Existing Culvert Plan & Profile (December 2017); and,
- Sheet No. 02: Existing Culvert Plan & Profile (December 2017).

2. Existing Geophysical Conditions

The results of two (2) Geotechnical Investigations (**Appendix B**) previously completed by V.A. Wood (September 2017) and SEL (November 2012) pertaining to the proposed Brock Street Culvert replacement project also were reviewed and considered, in conjunction with data recently collected as part of AECOM's current *Hydrogeological Investigation*. Existing regional and local physical and hydrogeological conditions were established based on a review of available surficial (overburden) and Paleozoic bedrock geologic mapping published by OGS, in addition to a review of the MOECC WWR database (**Appendix C**).

2.1 Regional Physiography and Drainage

The PSA includes lands that are situated within both the Oak Ridges Moraine (south and west) and Peterborough Drumlin Field (north and east) physiographic regions, as described by Chapman and Putnam (1984).

The Oak Ridges Moraine (ORM) is a distinct physiographic feature within southern Ontario that extends approximately 160 km from the Niagara Escarpment to the Trent River. The general elevation of the ORM is approximately 300 meters above sea level (mASL) and forms a prominent ridge creating a drainage divide for watercourses of the Lake Ontario basin and Georgian Bay drainage basin. The ORM is comprised of a complex stratigraphy of coarse textured sediments (gravel and sand) which allows water to drain vertically, recharging underlying aquifers, until it reaches less pervious beds and reappears as springs along the slopes of the moraine (Chapman and Putnam, 1984).

The Peterborough Drumlin Field occurs as a rolling till plain which extends across an area of approximately 4,532 km^2 (1,750 mi^2) from Simcoe County in the west to Hastings County in the east. The region contains more than 3,000 drumlins, in addition to many other drumlinoid hills and surface flutings of the till sheet (Chapman and Putnam, 1984). A series of deep valleys leading northward break the continuity of the till plain; many those valleys containing watercourses, of which Uxbridge Brook is one. Till soils occurring across the region tend to be composed predominantly of an undifferentiated matrix of sandy silt to silt that is commonly highly calcareous and rich in clastic content, however along the southern margin of the region and intersection with the ORM the till tends to be somewhat sandier.

The Uxbridge Brook subwatershed, being included as part of the greater Lake Simcoe watershed, traverses the PSA in a general south to north direction with its drainage being directed toward, and ultimately into Lake Simcoe via Pefferlaw Brook. The Uxbridge Brook subwatershed encompasses a drainage area of approximately 178 km^2 (20 km^2 of which being upstream of the Community of Uxbridge), originating as a series of seeps and springs along the northern flank of the ORM (Geomorphic Solutions, 2012).

2.2 Geological Conditions

2.2.1 Overburden Geology

Site-specific soil stratigraphy has been interpreted based on the results of *Geotechnical Investigations* previously completed by V.A. Wood (September 2017) and SEL (November 2012), 1:50,000 Surficial Geology of Southern Ontario mapping (OGS, 2003), 1:1,000,000 Quaternary Geology mapping (OGS, 2000), and a review of the MOECC WWR database.

Available surficial geology mapping from OGS indicates that shallow soils in the vicinity of the PSA are characterized by both Older and Modern Alluvial deposits comprised of clay, silt, sand, gravel, and in certain locations organic remains (OGS, 2003). Underlying these surficial deposits are Quaternary glaciolacustrine deposits of sand, gravelly sand, and gravel (near shore and beach deposits).

A complete description of the site-specific soil stratigraphy within each borehole drilled at the Site is provided in the geotechnical reports contained in **Appendix B**. For the purposes of this report, a summary narrative of the various major soil types encountered during the geotechnical investigations is presented below as support to the development of a conceptual site model of local hydrogeological conditions. Due to overlapping borehole identifications within the geotechnical reports, the year of drilling is included below to distinguish the boreholes.

Pavement Structure

Asphaltic concrete was noted by SEL at each of the five (5) boreholes drilled during their 2012 geotechnical investigation. Pavement thicknesses were noted as ranging between 50 m and 100 mm in the borehole logs.

No description of the upper 0.75 m of borehole depth was described or reported by V.A. Wood during completion of their 2017 geotechnical investigation. As such, no information is available for the presence / absence of pavement structure at these borehole locations.

Fill

Fill was encountered within all boreholes drilled at the Site, and was found to range in thickness from about 1.5 m to 6.5 m. The fill material is comprised predominately of sand, with a locally varying mixture of gravel and silt, although instances of finer grained materials (silty clay) was noted in BH4-12 and BH5-12, located in the northern aspect of the culvert length. The fill was noted in several boreholes to reside in a general loose state of compaction.

Peat / Topsoil

Peat was identified in BH1-12, BH1-17, BH4-17, BH5-17, BH6-17 and BH8-17, while topsoil was encountered within BH2-12, BH4-12 BH5-12 and BH4-17. In all instances the peat and/or topsoil was identified basal to the fill materials, and likely denotes the approximate elevation of the original ground surface at each location.

Gravelly Sand

Gravelly sand was identified between the fill or peat / topsoil and the underlying till soil within BH1-12, BH2-17, BH3-17, BH4-17, BH9-17, BH10-17 and at depth (below tills) in five boreholes BH1-12, BH3-12, BH4-12 and BH5-12. Shallower occurrences of this unit ranged between about 0.7 m and 3.5 m in thickness, while the deeper unit ranged from 0.6 m to greater than 5.4 m (depth of advancement at BH5-12) thick. Similarly, the upper unit was described as generally being loose to compact, while the deeper unit is described as being dense to very dense.

Silty Sand to Sandy Silt (Till)

Silty sand to sandy silt (till) was identified in all boreholes advanced in 2012 and 2017, with notable exception of BH1-12 and BH10-17. The till is identified on the borehole logs as residing either immediately below the fill / peat / topsoil, and/or beneath a finer-grained till unit. Clay and gravel content within the till varies from borehole to borehole, ranging in content from trace to some. In situ compaction of the silty sand to sandy silt (till) is described to range from loose to very dense and wet to saturated. The thickness of the silty sand to sandy silt (till) is reported to range from approximately 1.5 m to greater than 10.0 m.

Silt

Silt was identified within each of BH1-12, BH2-12, BH3-12 and BH5-12. No occurrences of silt were identified by V.A. Wood during their 2017 investigation program. Where present, the silt was found to either occur as a standalone layer within the overburden profile or interbedded with other coarser or finer-grained till materials. Trace to some clay was identified along with a trace amount of fine sand. In situ compaction of the silt is described to range from very loose to compact with occasional wet sand seams. Where present, the thickness of the silt is reported to range from approximately 1.4 m to 4.6 m.

Silty Clay (Till)

Silty clay till was identified in three boreholes; BH1-12, BH3-12, and BH5-12. The silty clay is described as possessing a still consistency and contains occasional wet sand seams. Where present, the thickness of this till unit is reported to range from approximately 1.9 m to 3.1 m.

2.2.2 Bedrock Geology

Based on the MOECC records for historical water supply wells in the vicinity, as well as the Uxbridge municipal supply wells, approximately 90 meters of overburden is anticipated to reside locally atop the bedrock surface. The underlying bedrock in the PSA is comprised of Upper Ordovician aged shale, limestone, dolostone and/or siltstone of the Blue Mountain Formation.

2.3 Hydrogeological Conditions

As part of AECOM's current *Hydrogeological Assessment*, four (4) of the monitoring wells installed by V.A. Wood in 2017 were developed by removing a minimum of three (3) wellbore volumes of water, or until a dry condition to improve hydraulic connection with the geological formation surrounding the well screen interval (PVC Schedule 40 @ 10-slot). Refer to **Figure 2** for monitoring well locations. Monitoring well construction details are provided on the borehole logs contained in **Appendix B**.

Flowing artesian conditions were previously identified at BH1-12 during SEL's 2012 geotechnical investigation. Similarly, groundwater levels were observed by AECOM at BH2-17 on November 23rd 2017 to be above ground surface (AGS) but could not be measured; however had been previously measured slightly below. The groundwater level at BH3-17 was measured to be above ground surface (1.3 to 1.6 mAGS) on all occasions. To facilitate the collection of stabilized groundwater level information, a temporary section of riser pipe was installed at BH3-17 by AECOM on October 20th, 2017 and November 23rd, 2017.

Subsequent to well development and water level monitoring activities, AECOM conducted a limited field parameter assessment which included: i) collection of a raw (untreated) groundwater quality sample from each of four (4) selected monitoring wells (BH3-17, BH4-17, BH5-17, and BH9-17); ii) collection of a surface water sample from Uxbridge Brook; and, iii) single well response (slug) testing at each of the selected monitoring well locations. The results AECOM's recent field assessment are summarized below and presented in **Appendix D** (SWRT Data) and **Appendix E** (Water Quality Data).

2.3.1 Groundwater Level Monitoring

As part of the current *Hydrogeological Assessment*, AECOM measured stabilized groundwater levels within boreholes BH3-17, BH4-17, BH5-17, and BH9-17 on October 12th and October 20th; and at BH1-17 through BH10-17 on November 23rd, 2017. Additionally following their geotechnical investigation V.A. Wood collected

groundwater level information at BH1-17 through BH11-17 on September 15th and November 15th, 2017. A summary of the groundwater level monitoring data obtained is provided in **Table 1.**

As shown in **Table 1**, groundwater elevations measured at monitoring wells BH1-17, BH2-17, BH4-17, BH5-17, BH6-17, BH7-17, BH8-17, BH9-17 targeting the shallow granular soils (native and fill) range between approximately 260.9 m and 264.8 m above sea level (ASL). The water level measured at BH3-17 by AECOM on October 20th and November 23rd, 2017 represents hydraulic (piezometric head) pressure within the confined aquifer between approximately 264.01 m and 264.31 mASL (1.33 to 1.59 mAGS).

Table 1: Groundwater Level Monitoring Summary

Monitoring Well ID	Screened Geologic Formation	Ground Elevation (mASL)	Screen Interval (mASL)	Groundwater Levels (mASL)				
				15-Sep-2017	*12-Oct-2017*	*20-Oct-2017*	*15-Nov-2017*	*23-Nov-2017*
BH1-17	Silty Sand & Sandy Silt	263.01	259.9 - 256.8	261.61	-	-	261.49	261.67
BH2-17	Sandy Silt	262.80	255.2 - 253.7	262.66	-	-	262.60	AGS
BH3-17	Sandy Silt over Sand & Gravel	262.72	256.7 - 253.6	-	-	264.05	-	264.31
BH4-17	Gravelly Sand over Sandy Silt	263.04	259.9 - 256.9	261.36	261.42	261.40	260.91	261.44
BH5-17	Silty Sand & Peat over Sandy Silt	265.74	259.6 - 256.5	262.96	263.13	263.42	262.69	263.53
BH7-17	Fill over Silty Sand over Gravelly Sand	265.68	262.7 - 259.5	262.39	-	-	262.63	262.38
BH8-17	Sandy Silt	265.81	259.7 - 256.6	264.59	-	-	264.13	264.80
BH9-17	Gravelly Sand over Sandy Silt	265.23	259.1 - 256.0	263.55	263.51	263.39	262.94	263.42
BH10-17	Fill over Gravelly Sand	264.77	261.8 - 258.6	262.45	-	-	262.33	261.94
BH11-17	Sandy Silt over Sandy Silt Till	264.75	258.7 - 255.6	261.64	-	-	261.09	-

Notes: "-" not measured
AGS water flowed above well top

On October 20th 2017, in situ electronic pressure / temperature dataloggers were installed to record fluctuations in groundwater levels over the course of one (1) month at BH4-17 and BH9-17. During that period, groundwater levels at the monitored wells fluctuated over a range of 0.14 m (BH4-17) and 0.24 m (BH9-17), and did not indicate any apparent trend at either location. It is anticipated that seasonal fluctuations in groundwater levels will occur and have not been fully captured by the monitoring conducted during this investigation. It is recommended that additional groundwater level measurements be obtained by the Contractor prior to construction to confirm the groundwater level information presented herein.

2.3.2 Hydrostratigraphy

Aquifers are classically defined as a geological unit that is sufficiently permeable to permit the extraction of a useable supply of water. Unconfined aquifers are aquifers which are open to receive water from the surface directly and in which the water table surface is free to fluctuate depending on the recharge or discharge rate. Conversely, confined aquifers are overlain by low permeability materials that form a confining layer (aquitard) which inhibits vertical groundwater movement. Hydrostratigraphy is the classification of various major stratigraphic units into aquifers and aquitards, with some simplification or combination of units with similar properties. The following defines the local geologic profile encountered during subsurface (geotechnical) investigations completed by SEL (2012) and V.A. Wood (2017), as described in **Section 2.2**, into hydrostratigraphic units:

- **Surficial Fill:** .....Unconfined Aquifer
- **Alluvial Deposits:**.....Unconfined Aquifer
- **Sandy Silt to Silty Sand (Till):**.....Aquitard (with permeable horizons)
- **Silty Clay (Till):**.....Aquitard (with permeable horizons)
- **Gravelly Sand:**.....Confined Aquifer (locally Artesian)

2.3.3 Hydraulic Conductivity

Single well response (slug) testing was conducted by AECOM on October 20th, 2017 to provide a current estimate of hydraulic conductivity (K) for the geological formation(s) present along the screened interval at monitoring wells BH3-17, BH4-17, BH5-17, and BH9-17. The testing program comprised rising head and falling head tests at each monitoring well location, however due the artesian condition existing at BH3-17, a falling head test was not conducted and the rising head tests at BH5-17 and BH9-17 were determined to be unrepresentative. The initial water level displacement and subsequent recovery response was monitored using a pressure transducer configured to record water levels at a one (1) second interval. Water level data obtained by the transducer was supplemented by the collection of periodic manual measurements using an electronic water level tape. Each test was considered complete once a minimum 90% water level recovery was achieved.

Upon completion of field testing, the slug test data was pre-processed and analyzed using AQTESOLV Professional® (Version 4.5) software program and the Bouwer-Rice Method (Hvorslev, 1951) numerical solution for unconfined (BH4-17, BH5-17, BH9-17) or confined (BH3-17) aquifers, as applicable. Results are presented in **Appendix D** and summarized in **Table 2**.

Table 2: Hydraulic Conductivity Estimates

Monitor	Screened Geologic Formation	Screen Elevation (m)	Ground Elevation (m)	Hydraulic Conductivity (m/s)	
				Rising Head	*Falling Head*
BH3-17	Sandy Silt over Sand & Gravel (Till & CA)	256.7 - 253.6	262.72	8.7×10^{-7}	n/a[1]
BH4-17	Gravelly Sand over Sandy Silt (UCA & Till)	259.9 - 256.9	263.04	1.4×10^{-6}	3.1×10^{-6}
BH5-17	Silty Sand, Peat over Sandy Silt (UCA & Till)	259.6 - 256.5	265.74	n/a[2]	3.3×10^{-6}
					1.1×10^{-6}
BH9-17	Gravelly Sand over Sandy Silt (UCA & Till)	259.1 - 256	265.23	n/a[2]	2.4×10^{-6}
					1.1×10^{-6}

Notes: 1. Not completed due to artesian conditions
2. Results not representative likely due to effects of screen straddling hydrogeological units

Based on this analysis, a K value of 3.3×10^{-6} m/sec was conservatively assumed for the unconfined granular aquifer in the area of the Uxbridge Brook Culvert Replacement, being generally consistent with the range of values presented in Freeze and Cherry (1979). A corresponding value of 2.4×10^{-6} m/s derived for the underlying confined aquifer. It should be noted that this analysis provides estimates of K for the geological formation in the immediate media zone surrounding the length of the monitoring well screen intervals.

2.3.4 Grain Size Analysis

During the geotechnical investigation completed in 2017 by V.A. Wood, soil samples were collected at various depths and submitted for analysis of grain size distribution and hydrometer analysis. Geotechnical laboratory testing results for these samples are included in the report included as **Appendix B**, and summarized in **Table 3.**

Table 3: Summary of Approximate Hydraulic Conductivity Values (Grain Size Analysis)

BH	Sample No.	Sample Elevation (m)	Soil Description	Classification	Typical Range of Hydraulic Conductivity (m/s)
BH1-17	5	258.21	Silt and fine sand	SM	1×10^{-5} to 1×10^{-7}
BH1-17	6	256.71	Silt and fine sand	SM	1×10^{-5} to 1×10^{-7}
BH2-17	5	258.01	Well graded sand and gravel, some silt	GM	1×10^{-4} to 1×10^{-6}
BH3-17	5	257.92	Well graded sand and gravel	GW	1×10^{-3}
BH3-17	6	256.42	Sandy silt, trace clay	ML	1×10^{-7} to 1×10^{-8}

Table 3: Summary of Approximate Hydraulic Conductivity Values (Grain Size Analysis)

BH	Sample No.	Sample Elevation (m)	Soil Description	Classification	Typical Range of Hydraulic Conductivity (m/s)
BH4-17	5	258.24	Gravelly sand, some silt	SP	$1x10^{-3}$ to $1x10^{-5}$
BH5-17	5	260.94	Silty sand, trace clay	SC	$1x10^{-6}$ to $1x10^{-8}$
BH5-17	7	257.94	Fine sand and silt	SM	$1x10^{-5}$ to $1x10^{-7}$
BH7-17	6	259.38	Gravelly sand, trace silt	SP	$1x10^{-3}$ to $1x10^{-5}$
BH8-17	8	256.51	Silt and fine sand, trace clay	SM	$1x10^{-5}$ to $1x10^{-7}$
BH9-17	7	257.43	Sandy silt, trace clay	ML	$1x10^{-7}$ to $1x10^{-8}$
BH11-17	5	259.95	Silty sand, some gravel	SM	$1x10^{-5}$ to $1x10^{-7}$
BH11-17	7	256.95	Sandy silt, trace clay	ML	$1x10^{-7}$ to $1x10^{-8}$

Based on the grain size distribution curves developed for each soil sample, approximate ranges in hydraulic conductivity values were assigned according to the Ontario Building Code 1997, Supplementary Guideline SB-6 (Percolation Time and Soil Descriptions) (OMMAH, August 15, 2006). This method is premised on the principles of the Unified Soil Classification System (USCS) and provides a range of hydraulic conductivity values for each soil type. Results are presented in **Table 3**.

Based on the foregoing assessment, the K value for the local shallow unconfined aquifer of $3.3x10^{-6}$ m/s, as measured at BH5-17, is within the typical range of the hydraulic conductivity expected based on grain size analysis and considered suitable for use in the dewatering assessment.

2.4 Groundwater Quality

A sample of groundwater was obtained by AECOM at each of monitoring wells BH3-17 and BH9-17 on October 12th, 2017, in addition to a sample of surface water from Uxbridge Brook approximately 5 meters south (upstream) of the existing culvert. The groundwater samples were obtained manually using a dedicated Waterra® tubing and foot valve pump assembly installed within the monitoring well immediately following purging of at least three (3) wellbore volumes to ensure that the samples were representative of the overburden source within the screened interval at each location. Both the groundwater and surface water samples were obtained unfiltered within laboratory prepared sample bottles and were maintained in a cooler on ice at all times following collection. The sample cooler was delivered under chain of custody documentation to the selected CALA and SCC-accredited environmental analytical laboratory (AGAT Laboratories).

The groundwater samples collected at monitoring wells BH3-17 and BH9-17 were analyzed for the Region of Durham's Sewer Use By-law (#55-2013) criteria (Table 1 – Sanitary Sewers; Table 2 – Storm Sewers), as well as for a general suite of inorganic chemical parameters for comparison against the Provincial Water Quality Objectives (MOE, 1994). The surface water sample from Uxbridge Brook was submitted for a general suite of inorganic chemical parameters for comparison against the Provincial Water Quality Objectives (MOE, 1994). The intent of the sampling was to assess discharge opportunities for dewatering effluent.

A parameter exceedance summary relative to the above noted standards is presented in **Table 4** (Sanitary Sewer Use), **Table 5** (Storm Sewer Use) and **Table 6** (PWQO). Laboratory certificates of analysis can be found in **Appendix E**.

Table 4: Parameter Exceedance Summary (Durham Sanitary Sewer Use By-Law)

Parameter Group	BH3-17	BH9-17
Metals & Inorganics	None	None
Organics	None	None
Microbiology	None	None

Table 5: Parameter Exceedance Summary (Durham Storm Sewer Use By-Law)

Parameter Group	BH3-17	BH9-17
Metals & Inorganics	Total Phosphorus, Total Suspended Solids	Total Phosphorus, Total Suspended Solids
Organics	None	None
Microbiology	None	None

Table 6: Parameter Exceedance Summary (Provincial Water Quality Objectives)

Parameter Group	BH3-17	BH9-17	Uxbridge Brook
Inorganics & General Water Quality	Total Phosphorus	Total Phosphorus	None
Metals	Iron	Iron, Lead	None

It is expected that the reported exceedances for Total Metals concentrations in the PWQO analyte suite are primarily related to the relatively high total suspended solids (TSS) load in the groundwater samples (267 mg/L and 283 mg/L), albeit below the Sanitary Sewer Use By-law criteria of 350 mg/L. During construction, a treatment system, such as decantation tanks may be required, as a minimum, to lower Total Suspended Solids in the dewatering effluent prior to discharge. For discharge to the municipal stormwater system or a surface water body (Uxbridge Brook), the collected water quality data indicate that phosphorus treatment may also be required. This can be completed through a chemical precipitation process using alum, as an example. The collected samples represent the groundwater and surface water quality in the vicinity of the culvert replacement at the time of sampling and variability should be expected at the time of construction.

2.5 Groundwater Resources

An inventory of local private water wells (i.e., domestic, commercial, industrial, etc.) was performed initially within a radius of approximately 500 m from the Site, by means of searching the MOECC WWR database. Results are shown in **Figure 2**. The results of this query are presented in **Appendix C**.

Windshield reconnaissance completed by AECOM on November 23rd, 2017 confirmed the presence of municipal supply along all roads (inferred from visible fire hydrants). No unregistered private wells were identified during a roadside visual survey within the PSA. A total of twelve (12) water supply wells were identified within the 500 m search area radius, with their construction having occurred between 1956 and 1983. Based on the current municipal servicing area, it is unlikely that these remain active.

Municipal water for the Community of Uxbridge is supplied by a series of three (3) drilled supply wells that are located approximately 750 m (MW7) and 850 m (MW5) to the southeast and 900 m (MW6) to the southwest, respectively.

3. Water Taking Plan

3.1 Construction Methods

The current construction plan for the Brock Street Culvert Replacement is to excavate from surface and utilize shoring to maintain vertical excavation walls. **Figure 3** provides a geologic cross-section that defines the north section and south section of the construction area, as divided by Brock Street. It is anticipated that the work will be staged such that the full length of the north section will at some point be fully excavated with shoring in place while at the same time Part A of the south section will be excavated to the top of the existing culvert (with shoring installed).

Based on the soil types encountered during sub-surface investigations completed by SEL (2012) and V.A. Wood (2017), shored excavations for culvert installation at Brock Street are interpreted to extend through the upper fill material and extend into the gravelly sand, silty sand and peat of the alluvial deposits of the upper unconfined aquifer.

The depth from ground surface to the base of the culvert will vary along the length of the work area and it is expected that all the excavations will extend below the local shallow water table. Dewatering will be required to manage groundwater seepage from water-bearing soil units that are intercepted within specific excavation areas, so as to provide dry and stable working conditions during construction. In this regard, dewatering to a minimum level of 1.0 m below the planned lowest excavation bottom elevation within each construction stage has been considered herein. The north section and south section will not be excavated simultaneously to the full construction depth. Therefore, the dewatering requirement for each stage of construction has been considered in this assessment, as follows:

Stage 1: Full excavation of the North Section plus the partial excavation of Part A of the South Section; and,

Stage 2: Full excavation of the South Section.

Based on the hydrostratigraphy depicted in **Figure 3**, a confined aquifer is interpreted by AECOM to underlie the Sandy Silt Till within the project area. V.A. Wood recently has completed an assessment of the potential for basal heave due to the upward pressure from the confining layer following the removal of soil during excavation and determined that the factor of safety is acceptable and that depressurization of the confined aquifer is *not* required for project construction. V.A. Wood further indicates that the water level in the unconfined aquifer must be reduced to at least 0.5 m below the base of excavations during construction. A copy of the technical opinion provided by V.A. Wood is contained in **Appendix G**.

Through installation of sheet pile shoring around the perimeter of each staged excavation, groundwater inflow to the construction area would be limited to seepage through the overburden soil existing at the base of excavation.

Recognizing the uncertainty associated with potential effectiveness of the sheet piles for groundwater cut-off, a dewatering assessment (water taking plan) has been completed herein that considers the following two (2) scenarios:

1. Horizontal groundwater flow within the Alluvial Unconfined Aquifer is effectively cut-off by the sheet pile installations (i.e., 80% or greater effectiveness); and,
2. Horizontal groundwater flow within the Alluvial Unconfined Aquifer is ineffectively cut-off by the sheet pile installations (i.e., 60% or greater effectiveness).

Measured groundwater levels for unconfined alluvial deposits within the project area range between approximately 260.9 m and 264.8 mASL, corresponding to water table depths less than 1.0 m up to 3.7 mBGS along the length of the culvert. A summary of the highest groundwater level measurements obtained within the various construction stage areas relative to the planned excavation depths is provided in **Table 7**.

Table 7: Summary of Inputs to Dewatering Calculations

Parameter	Stage #1 North Section	Stage #1 South Section (Part A)	Stage #2 South Section (Full Depth)
Location of Highest Water Level	BH8-17	BH5-17	BH2-17
Highest Water Level (mASL)	264.8	263.5	262.7
Base of Excavation (mASL)	258.4	262.0	259.0
Target Water Level (mASL)	257.4	261.0	258.0

Notes: It is understood the maximum required depth of excavation is 1 meter below the existing culvert base.

As indicated in **Section 2.3** for the purpose of estimating construction dewatering volumes, the hydraulic conductivity of the unconfined aquifer is conservatively assumed to be 3.3×10^{-6} m/s, based on single well testing results recently completed by AECOM at BH5-17.

3.2 Dewatering Assessment Methodology

It is anticipated that short-term dewatering will be required to remove water ingress within the shored excavations and to provide dry and stable working conditions during each stage of construction. In general, the excavations will collect water from three (3) primary sources:

- Lateral groundwater seepage through excavation sidewalls;
- Groundwater seepage through the base of the excavation; and,
- Overburden storage.

Depending on local weather patterns experienced during construction, incident precipitation may also represent a contributing source. Excavation areas should be sloped to prevent surface runoff from entering into the shored excavation areas.

3.2.1 Groundwater Seepage in Unconfined Aquifer

Groundwater inflow to each excavation area and to a level of 1.0 m below the lowest excavation elevation within each construction stage was calculated using the approach for radial flow to an unconfined aquifer (long-narrow system), as presented in Powers (2007). This calculation methodology is considered representative of equilibrium or long-term, steady-state conditions; and first requires that the dewatering radius of influence be calculated.

Calculation of the equivalent well radius (r_s) differs based on excavation geometry (Powers, 2007). The dewatering assumptions, excavation geometry and dimensions are provided in **Appendix F**. Based on assumed general excavation dimensions during both construction stages, they would be classified as long narrow excavations ($x/a > 1.5$), r_s is determined as an estimate of the distance from the centre of each excavation area to the adjacent dewatering system as follows:

$$r_s = \frac{a}{2} + D \quad (2)$$

Where: r_s = equivalent well radius (m)
a = excavation width (m)
D = dewatering system setback distance (m)

As the excavations of this project are to be shored (i.e., 1H:1V), consideration of excavation slope length was excluded from Equation 2. Using the noted parameters, the r_s value of approximately 7.5 m was determined for Stage 1 and Stage 2 excavations.

The radius of influence is equivalent to the radial distance away from an excavation area at which dewatering no longer results in a temporary water table drawdown. The following equation provides the (equivalent) radius of influence, assuming radial flow to a well, after an empirical relationship developed by Sichardt and Kryieleis (1930):

$$R_o = r_s + C(H - h)\sqrt{K} \quad (1)$$

Where: R_o = radius of influence (m)
r_s = equivalent well radius (m)
C = is a constant (unitless; 3000 for radial flow to pumped wells and between 1500 and 2000 for line flow to trenches or to a line of wellpoints)
H = pre-construction saturated aquifer thickness (m)
h = post-construction saturated aquifer thickness (m)
K = hydraulic conductivity (m/sec)

The pre-construction saturated aquifer thickness was determined using the measured highest water table elevation in the vicinity of each staged excavation area and the estimated elevation of the aquifer base considering the borehole information presented in **Appendix B**. A hydraulic conductivity (K) value was estimated from single well response tests recently completed by AECOM, as summarized in **Table 2**. Using the noted parameters, the calculated R_o for each of the dewatering segments ranged from approximately 15 m to 31 m in both Stage 1 and Stage 2.

Based on the R_o and r_s values determined above, along with previously defined H, h and K values, the dewatering rate (Q), or the steady-state groundwater inflow via the upper granular portion of the excavation depth during each of Stage 1 and Stage 2 was estimated using the following numerical solution for groundwater flow to a long narrow trench in an unconfined aquifer (Powers, 2007):

$$Q = 2\left[\frac{xK(H^2-h^2)}{2L}\right] + \frac{\pi K(H^2-h^2)}{\ln(R_O/r_S)} \quad (3)$$

Where: Q = groundwater inflow (m^3/day)
K = interpreted hydraulic conductivity (m/sec)
H = saturated thickness of the aquifer before pumping (m)
h = saturated thickness of the aquifer after pumping (m)
x = length of excavation (m)
a = width of excavation (m)
L = line source distance (m)
R_o = radius of influence (m)
r_s = equivalent well radius (m)

The calculation of groundwater inflow assumes that drawdown is occurring in an unconfined aquifer composed of homogeneous sediments. Report **Section 2.2** describes the heterogeneous fill and unconfined aquifer present in the vicinity of the Site. Based on this disagreement between field conditions and the assumption implicit in the mathematics, the results computed herein are considered to be conservative. The line source distance is taken to be the distance from the midpoint of the dewatering segment to the nearest source; the nearest unculverted portion of Uxbridge Brook.

As the above groundwater inflow equations addresses steady-state conditions, it does not account for the volume of water that is stored in the soils as pore water and would be drained during advanced dewatering or during the excavation process. This pre-drainage is addressed separately in **Section 3.2.4**.

The final factor to consider is the unknown geologic conditions that exist between the data points (boreholes) assessed for this analysis. It should be expected that geologic conditions may change over a relatively short distance and therefore might not be reflected in the dataset.

Using the parameters outlined above, typical daily dewatering rates have been calculated for the proposed excavations through the fill and unconfined aquifer with ineffective cut-off measures during Stage 1 and Stage 2 (**Table 8**). It is recommended that a three (3) times Factor of Safety (F_s) be applied to these values to account for potential variability in hydraulic conductivity throughout the formation, as well as implications of the water table potentially being higher at the time of construction than at the time of recent investigations. It is expected that the dewatering rate will be greatest during the initial stages of dewatering and will decrease over time as the groundwater table is lowered and steady state conditions are realized.

3.2.2 Vertical Seepage from Excavation Base

Vertical seepage of groundwater via the base of shored excavations where there is effective cut-off measures during Stage 1 and Stage 2 may occur due to a known upward hydraulic gradient existing within the Till. Darcy's Law is used to calculate vertical groundwater inflows into the excavation.

$$Q = KiA \tag{5}$$

Where: Q = groundwater inflow (m^3/day)
K = hydraulic conductivity (m/day)
i = vertical hydraulic gradient (1, unitless)
A = area of the excavation (m^2)

Based on the noted parameters above, vertical groundwater seepage via the floor of the excavation within the unconfined aquifer has been calculated for both the Stage 1 and Stage 2 excavations (**Table 8**). The calculation is based on a vertical gradient of one within the unconfined aquifer. It is recommended that a three (3) times Factor of Safety (F_s) be applied to these values to account for potential variability in hydraulic conductivity throughout the formation, as well as implications of the piezometric head being higher at the time of construction than at the time of recent investigations. It is expected that the dewatering rate will be greatest during the initial stages of dewatering and will decrease over time as the groundwater table is lowered and steady state conditions are realized.

3.2.3 Overburden Storage

Significant quantities of groundwater will be stored within the pore spaces of the overburden materials that will require removal to facilitate a dry working environment during excavation activities. The volume of water storage contained within the shored excavations across the fill and unconfined aquifer (V_s) with ineffective cut-off measures during Stage 1 and Stage 2 can be estimated as follows:

$$V_s = n * \left(xy + R_0 x + \frac{\pi {R_0}^2}{3}\right)(H - h) \tag{6}$$

Where: V_s = groundwater storage volume (m^3)
R_o = radius of influence (m)
x = saturated excavation length (m)
y = saturated excavation width (m)
n = effective porosity (unitless)

The volume of water storage within the proposed excavations within the fill and unconfined aquifer (Vs) with effective cut-off measures during Stage 1 and Stage 2 can be estimated as follows:

$$V_s = (xy) * (H - h) * n \quad (7)$$

Where: Vs = groundwater storage volume (m^3)
x = saturated excavation length (m)
y = saturated excavation width (m)
n = effective porosity (unitless)

Stored water is determined by considering the volume of soil to be dewatered and estimating the porosity. Sands and gravels typically have porosities ranging from 25-50% (Freeze and Cherry, 1979); a conservatively representative value of 40% was selected for the storage calculation for the upper granular soils. The dewatering R_o within the shored excavation is considered to be zero due to the complete cut off of the surrounding aquifer.

Using the Equations 6 and 7, the typical daily dewatering rates from overburden storage for excavations within the fill and unconfined aquifer with effective and ineffective cut-off measures during Stage 1 and Stage 2 are included in **Table 8**.

3.3 Dewatering Rate Estimate

Based on the dewatering rate assessment methodology provided in Section 3.2, the results of this assessment are summarized in **Table 8**.

Table 8: Construction Dewatering Rate Estimates

Parameter	Stage 1 – North (L/DAY)	Stage 2 – South (L/DAY)
SCENARIO A (Ineffective Groundwater Cutoff – 60%)		
Unconfined Aquifer (full depth excavation)	35,885	27,197
Unconfined Aquifer (Part A partial excavation)	18,191	NA
Vertical Seepage	355,178	216,881
Overburden Storage	2,386,074	926,730
TYPICAL TOTAL WATER-TAKING:	**2,795,328**	**1,170,808**
MAXIMUM (Q3) TOTAL WATER TAKING:	**3,613,838**	**1,658,964**
SCENARIO B (Effective Groundwater Cutoff – 80%)		
Unconfined Alluvial Aquifer (full depth excavation)	17,943	13,598
Unconfined Alluvial Aquifer (partial excavation)	9,096	NA
Vertical Seepage	355,178	216,881
Overburden Storage	1,340,534	564,667
TYPICAL TOTAL WATER-TAKING:	**1,722,750**	**795,146**
MAXIMUM (Q3) TOTAL WATER TAKING:	**2,487,183**	**1,256,106**

*Note: * Maximum (Q3) Total Water Taking considers a Factor of Safety of 3 applied to the calculations for horizontal flow and vertical seepage. Overburden storage assumed to be removed over a pre-drainage period of 3 days (i.e., Q/3).*

Based on the assessment completed herein and specified use of effectively watertight (i.e., >80%) sheet pile shoring around the complete perimeter of Stage 1 and Stage 2 construction excavations, dewatering calculations completed herein indicate that a Category 3 Permit To Take Water (PTTW) would be required from the MOECC. The PTTW should be applied for the maximum dewatering volume of Stage 1 [North Area plus South Area (A)]; a maximum rate of 7,530 L/min and a maximum daily taking of **3,613,838 L/day** would be appropriate. In this case a

typical rate would be anticipated to be about half the maximum at 1,806,919 L/day. In this regard the maximum volume is indicated to provide operational flexibility and to account for:

- Incident precipitation;
- Ineffective water tightness of the shoring (along joints or short-circuiting along the base); and/or,
- Presence of more permeable lenses or horizons in the geological deposits at the excavation base.

The maximum construction dewatering R_o calculated for the Project Area is calculated to be approximately 31 m in the North Area and 22 m in the South Area. Depending on the dewatering system used by the Contractor and the effectiveness of the support of excavation (SOE) measures selected at limiting groundwater inflow to the excavation area, R_o may vary and further evaluation could be required. It is estimated that vertical seepage could be reduced by as much as 73% if the side shoring is sufficiently keyed into the underlying till; effectively cutting off groundwater flow through the more permeable unconfined aquifer. Should potential receptors be identified, preparation and implementation of a detailed monitoring plan and consideration of pre and post construction surveys are recommended.

3.4 Complaints

For any complaints received in relation to construction dewatering activities at the Site, the following process is recommended to be implemented by the Contractor:

- Recording of the date and time the complaint was received.
- A copy of the complaint, if it is a written complaint.
- A summary of the complaint, if it is not a written complaint.
- A summary of measures taken, if any, to address the complaint.

4. Dewatering Discharge Plan

4.1 Method and Location of Discharge

It is proposed that dewatering effluent be discharged to the natural environment (Uxbridge Brook). An assessment of potential dewatering volumes to be discharged on a daily basis is provided in **Section 3** of this report. Any discharge of water would be subject to the terms and conditions of all required permits obtained by the Contractor based on actual encountered conditions and proposed dewatering pumping, treatment and discharge works configuration(s).

It is expected that the reported exceedances for Total Metals concentrations discussed in **Section 2.4** are primarily related to the relatively high total suspended solids (TSS) load in the groundwater samples (267 mg/L and 283 mg/L) although below the Sanitary Sewer Use By-law criteria of 350 mg/L. During construction, a treatment system, such as decantation tanks may be required, as a minimum, to reduce the TSS concentration in the dewatering effluent prior to discharge. For discharge to a surface water body (Uxbridge Brook), the collected water quality data indicate that phosphorus treatment may also be required. This can be completed through a chemical precipitation process using alum, as an example. The collected samples represent the groundwater and surface water quality in the vicinity of the culvert replacement at the time of sampling and variability should be expected at the time of construction.

The Contractor is responsible for designing, providing and maintaining all necessary means and methods to minimize the potential for erosion and sedimentation due to dewatering effluent discharge.

The intent of the Dewatering Discharge Plan is to mitigate impacts to soil quantity, surface water quality, and fish habitat. As such, erosion and sediment control measures will need to be in place prior to the outset of any construction activities. Mitigation measures, such as the use of an energy diffuser, will ensure that dewatering effluent will be discharged to the natural environment in such a manner that it does not result in scouring, erosion or physical alteration of the soil at the discharge location, stream channel or banks. In addition, it is recommended that silt fencing, potentially coupled with straw bales be installed downstream of the point of discharge to mitigate any residual solids entrained by the discharge water prior to entering the watercourse.

Prior to discharge, it is recommended that the water quality monitoring program described in **Section 6** be implemented by the Contractor. Water quality samples will need to be collected to ensure that all discharged water is comparable to the PWQOs.

4.2 Best Management Practices

It is recommended that the following Best Management Practices (BMPs) pertaining specifically to the discharge of dewatering effluent be implemented by the Contractor for this Project:

- Water quality sampling and analysis shall be conducted as described in **Section 6** of this report.
- With respect to any groundwater, stormwater or both that is discharged to land or a storm sewer, there is no visible petroleum hydrocarbon film or sheen present in the water, stormwater or both.
- With respect to any groundwater, stormwater or both that is discharged to land or a storm sewer that is within 30 m of a water body, turbidity of the discharge shall not exceed eight (8) Nephelometric Turbidity Units (NTU) above the background levels of the nearest waterbody.

- All erosion, sediment and total suspended solids (TSS) control measures required shall be used, operated and maintained in a manner that satisfies the recommendations of the manufacturer of the control measures.
- With respect to any groundwater, stormwater or both that is discharged to land or a storm sewer, there are appropriate temperature control measures.
- All control measures implemented and all materials collected or trapped by those measures shall be recovered and disposed of by the Contractor when they are no longer engaging in the activity.
- Any requirements stipulated by the Lake Simcoe Region Conservation Authority shall be met.

5. Environmental Considerations

5.1 Groundwater Resources

Based on a review of the MOECC Water Well Record database discussed in **Section 2.5** there are no identified supply wells within 350 meters of the work area, and wells identified between 350 m to 500 m are unlikely to remain active. A visual survey of the area confirms that the area within 500 m of the work zone is supplied with municipal water. Adverse impacts to existing groundwater users therefore are not anticipated in response to construction dewatering. Municipal water for the Community of Uxbridge is supplied by three (3) drilled water supply wells located greater than 750 m away from the Project Location. No impacts to the municipal well field are expected.

Given that the largest anticipated radius of influence is 31 m and there are no supply wells identified within this area, a residential well monitoring program is not considered to be required for this Project.

5.2 Wellhead Protection Areas

The Site is not located within the limits of a Wellhead Protection Area (WHPA) based on a review of current on-line mapping available from MOECC.

5.3 Ground Settlement

V.A Wood has assessed the potential of settlement to occur based on the drawdown and radius of influence described in this report. A memorandum summarizing the results of their assessment is included in **Appendix H**. A preconstruction survey on all building within 50 metres of the excavation is recommended.

5.4 Contaminant Migration

SRM Associated conducted Phase I and Phase II ESAs as part of their Municipal Class EA report in advance of the current project. Potential source of contamination were identified and investigated, and tested parameters were found to generally fall within acceptable standards.

Given that the limited predicted construction dewatering R_o (i.e., less than 31 m), it is anticipated that the impact of the dewatering activities on contaminant transport potential will be insignificant. No further investigation in this regard is recommended.

5.5 Surface Water Bodies

The nearest surface water body within the PSA is Uxbridge Brook. Along the length of the work area Uxbridge Brook will be maintained inside a culvert throughout the construction (staged transition from the old culvert to the replacement culvert). The planned construction methodology (i.e., sheet pile shored excavations) for the Project will limit the required dewatering of the shallow unconfined aquifer; however, the water table in the immediate vicinity of the base of the excavation will need to be lowered to provide dry and stable working conditions. Dewatering effluent is planned to be discharged to Uxbridge Brook; therefore any reductions in flow caused by the dewatering will be negated. Care should be taken by the Contractor during the discharge of treated dewatering effluent to the watercourse to protect against possible adverse impacts due to erosion, flows, temperature, and/or

water quality. Any discharge of water to Uxbridge Brook would be subject to the terms and conditions of all required permits obtained by the Contractor based on actual encountered conditions and proposed dewatering pumping, treatment and discharge works configuration(s).

5.6 Aquatic Resources

The Brock Street Culvert Replacement project involves the staged transfer of the surface water flow from the existing culvert to the new and improved culvert system. Potential effects of dewatering on aquatic resources will be addressed through the consultation and permitting process with the Lake Simcoe Region Conservation Authority and DFO/MNRF. Impacts on the quantity of surface water flow in Uxbridge Brook are not anticipated as the discharge of dewatering effluent will be returned to the watercourse channel.

6. Proposed Monitoring Program

6.1 Water-Taking Volumes

A daily record of the timing, rate and total volume of water pumped on a daily basis shall be maintained by the Contractor during periods of active dewatering using a calibrated flow meter.

6.2 Discharge Monitoring

Pre-assessment sampling of the water that is planned to be discharged is to be completed by the Contractor and submitted to an accredited environmental analytical laboratory for quality testing against PWQO. The intent of this sampling is to confirm both the background (raw) and Contractor's treated water quality prior to the outset of any dewatering discharge activities.

It is recommended that provisions be provided in the Contract Documents for the treatment of groundwater for high concentrations of TSS, metals, total phosphorus, and other parameters, if detected within the area of the excavations in excess of the associated PWQO thresholds.

During construction, a treatment system, such as decantation tanks will be required, as a minimum, to lower Total Suspended Solids in the effluent prior to discharge. For discharge to a surface water body, the collected water quality data indicate that phosphorus treatment may also be required. This can be completed through a chemical precipitation process using alum, as an example. The collected samples represent the groundwater and surface water quality in the vicinity of each monitoring well and Uxbridge Brook at the time of sampling and a certain amount of variability should be expected at the time of construction.

Regular sampling and testing of the actual discharge by the Contractor will be required during construction to verify that the effluent quality continues to comply with all required water quality criteria and permits, as applicable. The recommended frequency of confirmatory sample collection (notwithstanding any specific discharge permit requirements) is summarized in **Table 9**.

A visual inspection must be completed by the Contractor along with the collection of in-field turbidity and temperature measurements (both untreated and treated effluent discharge streams) on a daily basis during periods of active discharge for the duration of the dewatering system(s) operation.

Where the monitoring completed above identifies a significant amount of water level drawdown (i.e., in excess of 0.3 m at a monitored location more than 15 m away from the dewatering area), immediate action should be taken by the Contractor to assess and potentially modify their dewatering approach / methodology, and/or rate / duration of pumping, so as to limit the dewatering R_o and alleviate the observed groundwater level impact. Further commentary regarding drawdown and potential restrictions thereto are provided by V.A. Wood in their ground settlement memorandum contained in **Appendix H**.

Table 9: Groundwater Level Monitoring Program Details

	Dewatering Period	Measurement Frequency
Pre-Construction & During Construction	1st Week	Daily
	2nd Week to End of 1st Month	Weekly
	End of 1st Month to Program Completion	Bi-Weekly
Post-Construction	Monthly monitoring of shallow groundwater will be obtained for six months after construction has completed or until baseline conditions are obtained.	

6.3 Water Level Monitoring Program

It is recommended that existing monitoring wells be utilized to monitor groundwater levels in the vicinity of any active dewatering activities. Monitoring should begin prior to dewatering activities and continue until completion. The nearest monitoring well should be included in this program, in addition to any other monitoring wells that occur within the radius of influence.

7. Closure

This *Hydrogeological Investigation* was completed for the intended purpose of characterizing the physical and hydrogeological conditions, quantifying potential dewatering requirements for construction, assessing possible impacts to local water wells and groundwater dependant environmental features, and to recommend appropriate mitigation and monitoring measures, as required. This report provides a summary, interpretation and discussion of the investigation results, to serve as technical support for a Category 3 PTTW application to MOECC. Based on the available information and with the strict adherence of the Contractor to the monitoring programs and conditions described throughout this report, it is the opinion of AECOM that the discharge of groundwater will not cause an adverse effect to the environment.

Field borehole drilling, soil sampling and monitoring well installations were previously completed by SEL (2012) and V.A. Wood (2017). The results of these investigation programs were considered by AECOM in the completion of this *Hydrogeological Investigation*. AECOM has assumed that the information provided was factual and accurate. Judgement has been used by AECOM in the interpretation of the field information provided, however it is recognized that subsurface physical and chemical characteristics may vary between or beyond borehole locations given the variability observed in local geological and hydrogeological conditions.

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A Report to the Town of Uxbridge, A Soil Investigation for Proposed Culvert Replacement, Centennial Drive to North of Brock Street, Town of Uxbridge. Reference No. 1204-S048\SRM Associates, November 2012. Town of Uxbridge and Township of Durham, Downtown Uxbridge Flood Reduction, Schedule ‘C’ Municipal Class Environmental Assessment, Environmental Study Report.

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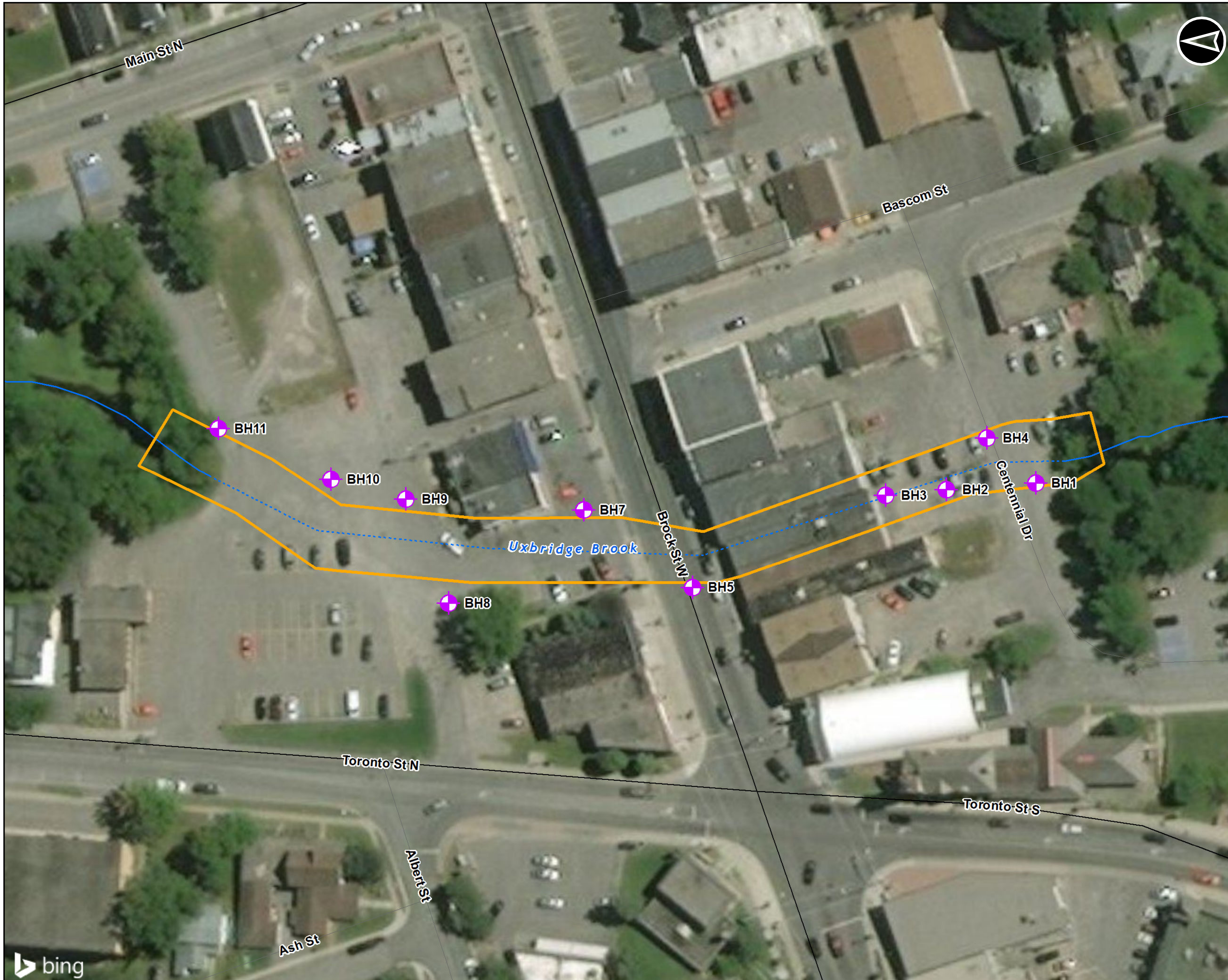
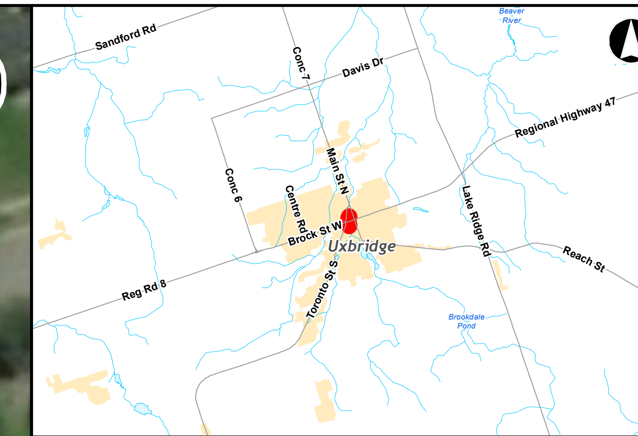
Figures





Legend

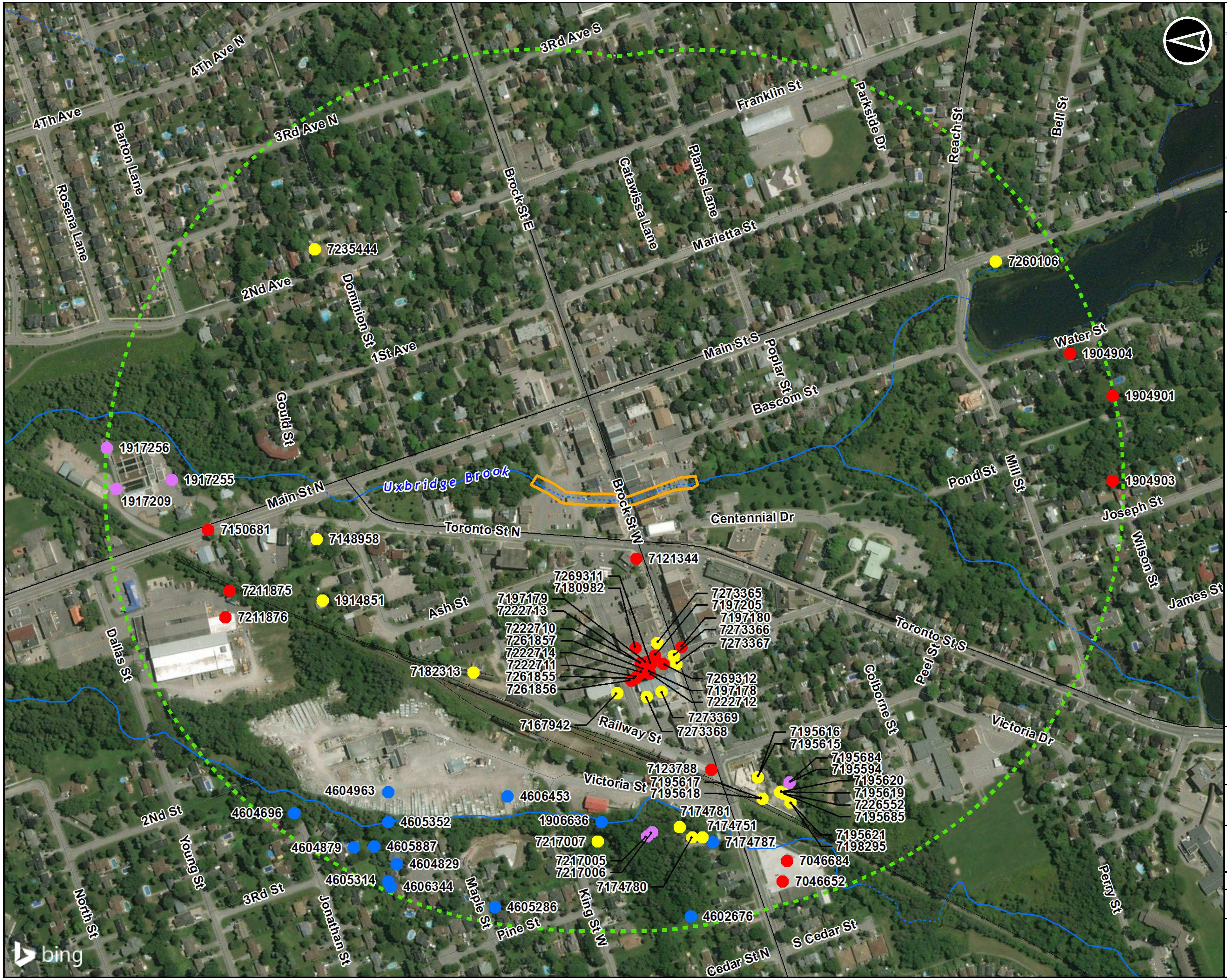
- Study Area
- Monitoring Well
- Major Road
- Local Road
- Permanent Stream
- Intermittent Stream

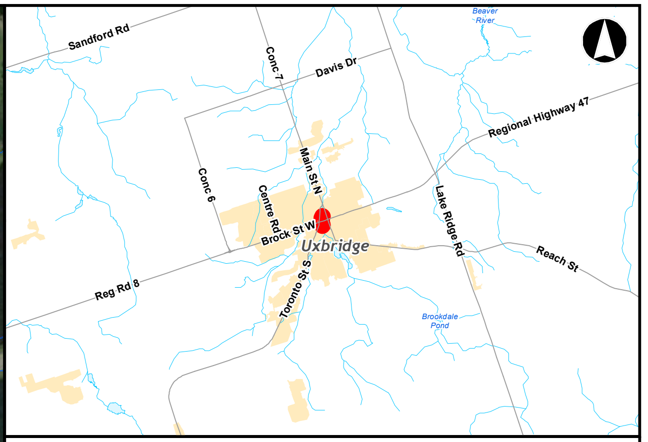
0 5 10 20 30 40
Metres

HYDROGEOLOGICAL INVESTIGATION
PROPOSED TWIN CULVERT (UXBRIDGE, ONTARIO)
THE REGIONAL MUNICIPALITY OF DURHAM

Study Area and Monitoring Well Location Map

Nov 2017	1:750 * when printed 11"x17"	Datum: NAD 1983 UTM Zone 17N Source: MNRF Image: © 2017 DigitalGlobe ©CNES (2017) Distribution Airbus DS © 2017 Microsoft Corporation
P#: 60551059		
AECOM		**Figure 1**





Legend

MOECC Water Well Records

- Observation / Test Hole
- Dewatering
- Water Supply
- Abandoned
- Study Area
- Study Area 500m Radius
- Major Road
- Local Road
- Railway
- Permanent Stream
- Intermittent Stream

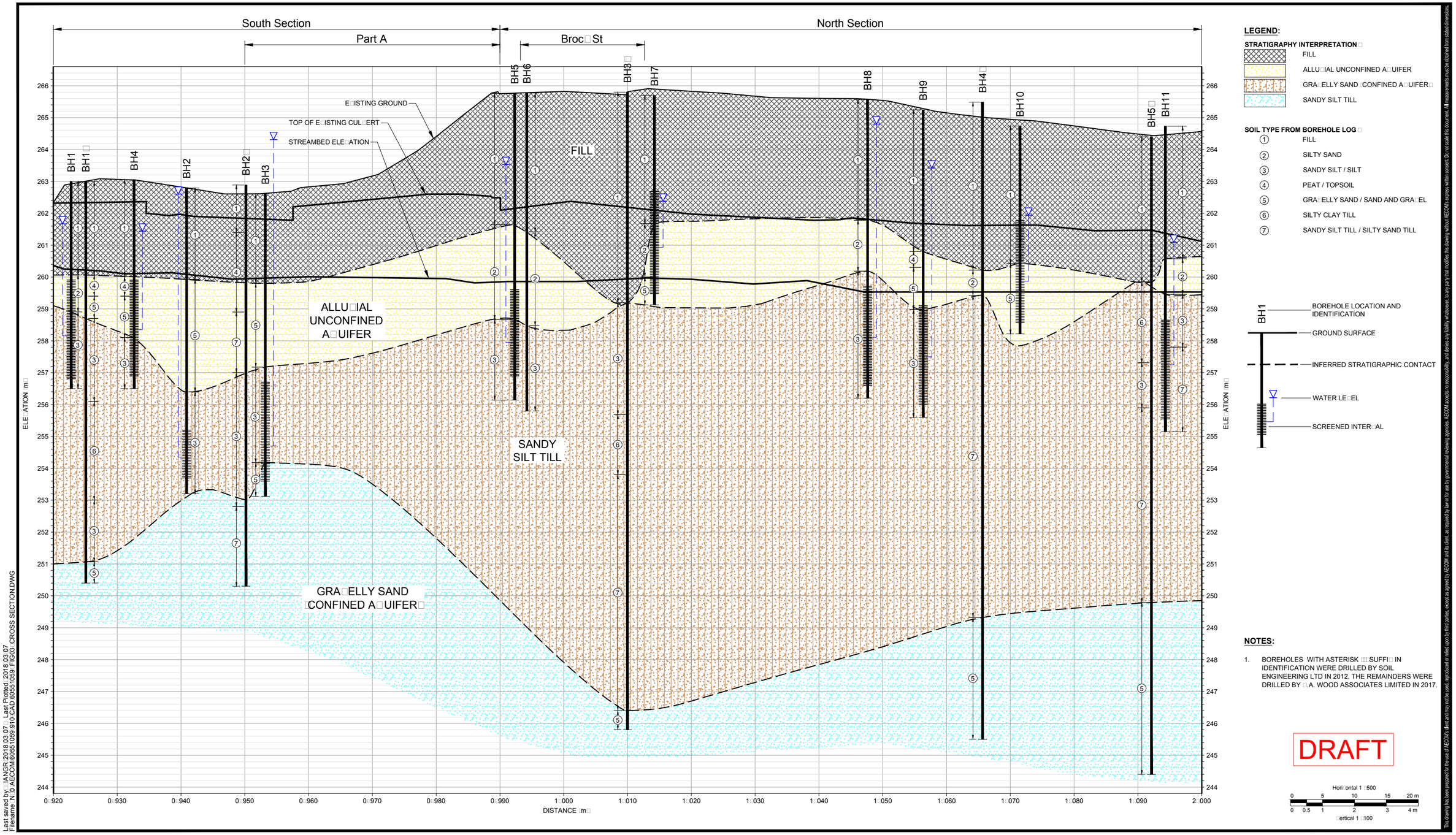
0 37.5 75 150 225 300

Metres

HYDROGEOLOGICAL INVESTIGATION
PROPOSED TWIN CULVERT (UXBRIDGE, ONTARIO)
THE REGIONAL MUNICIPALITY OF DURHAM

MOECC WATER WELL RECORDS

Dec 2017	1:4,300 * when printed 11"x17"	Datum: NAD 1983 UTM Zone 17N Source: MNRF, MOECC Image: © 2017 DigitalGlobe ©CNES (2017) Distribution Airbus DS © 2017 Microsoft Corporation
P#: 60551059		
AECOM		Figure 2



LEGEND:

STRATIGRAPHY INTERPRETATION

- FILL
- ALLUVIAL UNCONFINED AQUIFER
- GRAVELLY SAND CONFINED AQUIFER
- SANDY SILT TILL

SOIL TYPE FROM BOREHOLE LOG

1. FILL
2. SILTY SAND
3. SANDY SILT / SILT
4. PEAT / TOPSOIL
5. GRAVELLY SAND / SAND AND GRAVEL
6. SILTY CLAY TILL
7. SANDY SILT TILL / SILTY SAND TILL

BH1 — BOREHOLE LOCATION AND IDENTIFICATION

GROUND SURFACE

INFERRED STRATIGRAPHIC CONTACT

WATER LEVEL

SCREENED INTERVAL

NOTES:

1. BOREHOLES WITH ASTERISK (*) SUFFIX IN IDENTIFICATION WERE DRILLED BY SOIL ENGINEERING LTD IN 2012, THE REMAINDERS WERE DRILLED BY G.A. WOOD ASSOCIATES LIMITED IN 2017.

DRAFT

Horizontal 1:500

0 5 10 15 20 m

Vertical 1:100

0 0.5 1 2 3 4 m

AECOM

FIGURE: 3

GEOLOGICAL PROFILE

The Regional Municipality of Durham
Hydrogeological Investigation
Proposed Twin Culvert Uxbridge, Ontario

Project No. 60551019 Date: March, 2018

Last saved by: IANGR 2018.03.07 Last Plotted: 2018.03.07
Filename: N:\D\AECOM 60551059\910\CAD 60551059 FIG03 CROSS SECTION.DWG

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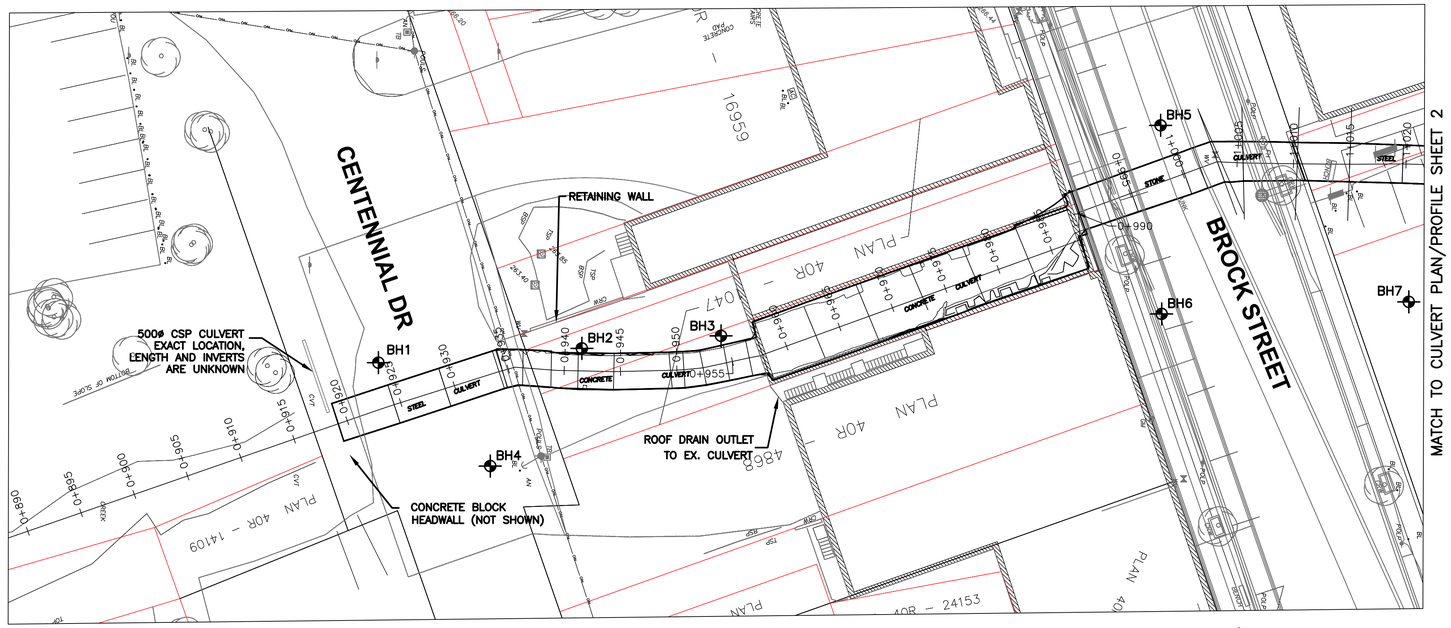
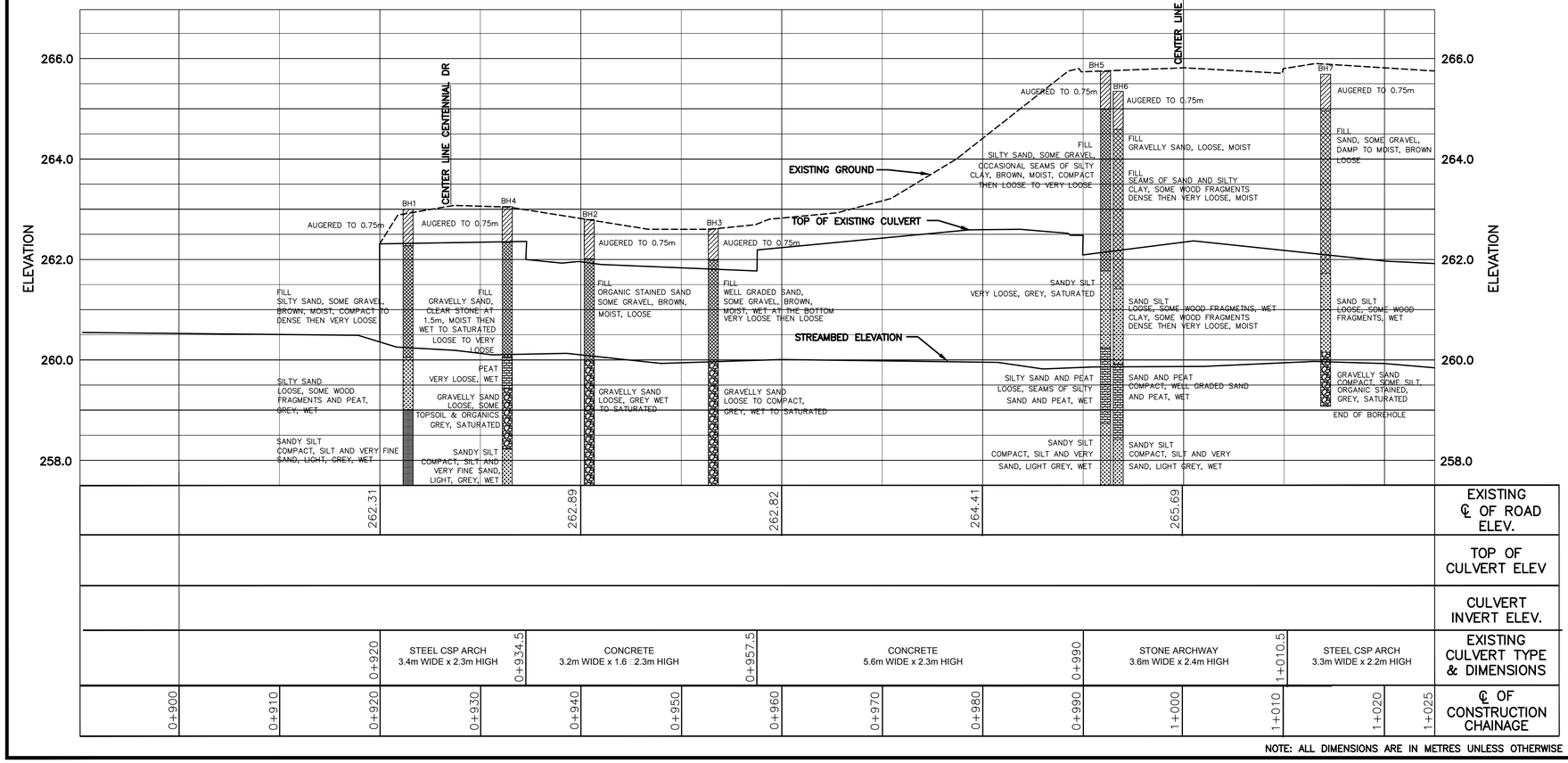
Appendix A

Existing Culvert Plan and Profile Drawings



EXISTING CULVERT PROFILE



NOTE: ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.

NOTES:

1.

KEY MAP

NO.	DATE	NAME	REVISIONS
1			

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513 Division Street, Cobourg, Ontario, Canada K9A 5G6
T905.372.2121 F905.372.3621

UTILITIES VERIFIED

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THE REGION ASSUMES NO RESPONSIBILITY FOR THE ACCURACY OF THE LOCATION OF EXISTING UTILITIES AS INDICATED ON THIS DRAWING.

SURVEY DATA DATE XXXXXX

SCALE
HORIZONTAL 5m 0 5m
VERTICAL 1m 0 1m

DRAWN:	L. SCOTT	DATE: DEC 2017
DESIGN:	J. TEEFY	DATE: DEC 2017
CHECKED:	J. TEEFY	DATE: DEC 2017
APPROVED:	P. MIDDAUGH	DATE: DEC 2017

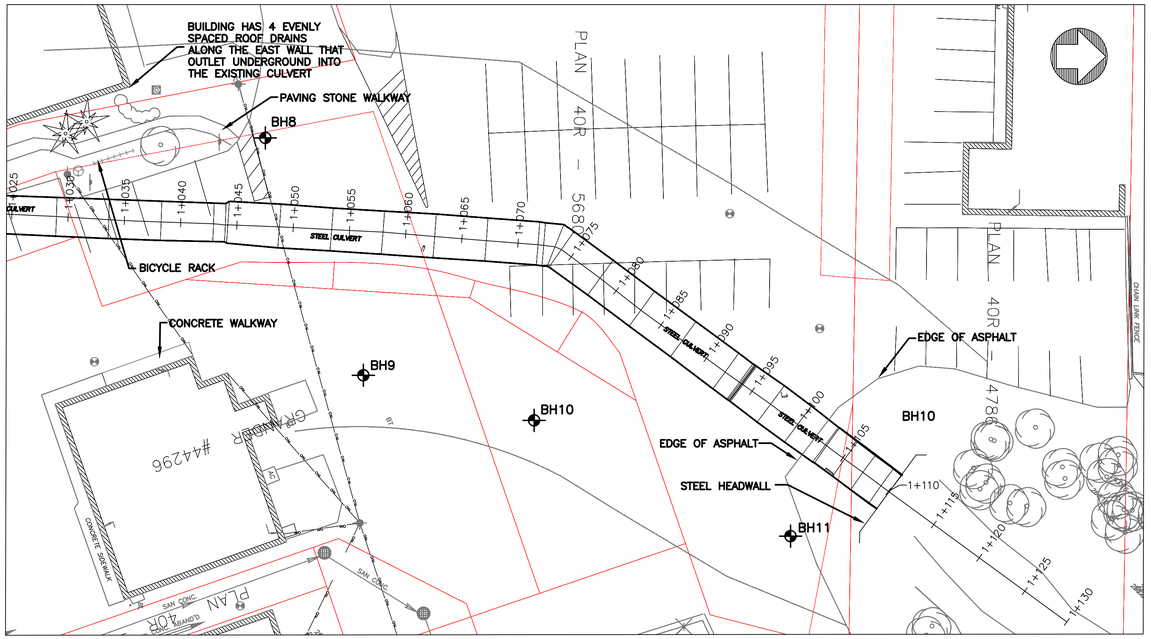
THE REGIONAL MUNICIPALITY OF DURHAM
WORKS DEPARTMENT
WHITBY ONTARIO

EXISTING CULVERT
PLAN & PROFILE

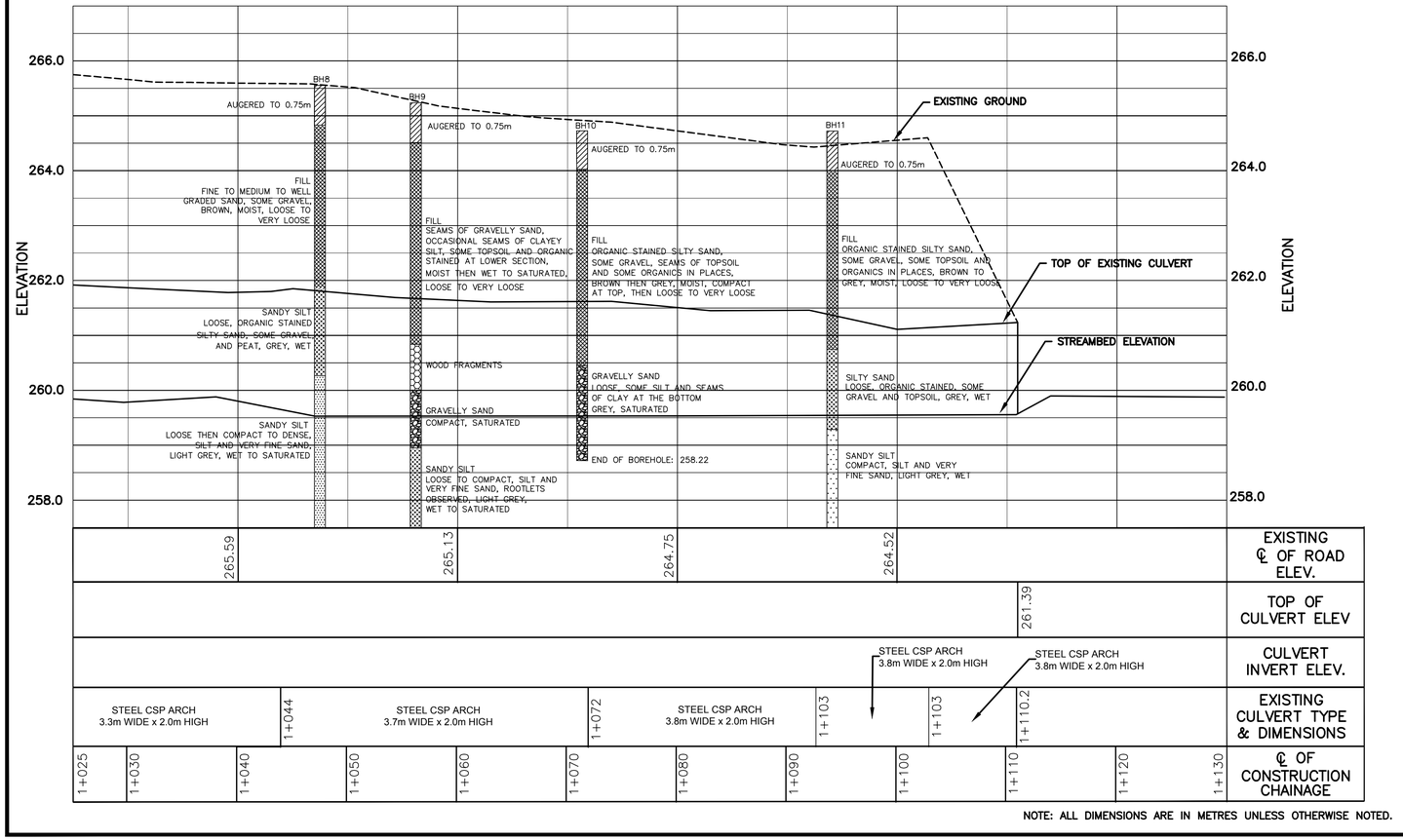
CONCESSION	REG. RD. NO.	AREA MUNICIPALITY
XXX	–	UXBRIDGE

DRAWING NUMBER	CONTRACT NUMBER	SHEET NUMBER
XXXX	XXXXX	01

MATCH TO CULVERT PLAN/PROFILE SHEET 1



EXISTING CULVERT PROFILE



NOTE: ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.

AECOM PN 60551059
Date: Nov 16, 2017
2014 OSIM Data Brock Street Culvert

	Year Constructed	Length	From	To	Span	Max Height	Type	Cover	General Description
315 - 1	1970	14.50	0+920	0+934.5	3.40	2.0	CPR-PA	0.5	Section 1 is a 3.4m+/- single span corrugated steel plate pipe arch culvert with approximately 0.5m of earth fill and an asphalt surface
									Corrugated plate steel pipe arch culvert is in generally good condition with light to moderate corrosion below the spring line and localized flaking along sharp radii seam.
315 - 2	1970	23.00	0+934.5	0+957.5	3.40	2.0	CPR-FRA	0.6	Section 2 is a 3.2m +/- span cast in place concrete open footing rigid frame culvert.
									Culvert is in fair to generally good condition with light to severe scour at the base of the west wall for 6m+/- length. Localized light to severe scaling and erosion at base of walls at other locations and at a storm sewer outlet. Severe honeycombing was noted on the walls at the north end (10m², poor).
315 - 3	1970	32.50	0+957.5	0+990	5.60	2.4	CPR-FRA	0.8	Section 3 is a 5.6m +/- cast in place concrete open footing culvert.
									Culvert is in generally good condition with localized severe scour of the concrete at drain outlets and localized light honeycombing (5m², poor). A precast concrete block section in the Northwest quadrant is in good condition.
315 - 4	1930	20.50	0+990	1+010.5	3.60	2.3	MAS-ACH	0.9	Section 4 is a 3.6m +/- span stone masonry arch culvert with approxiamtely 0.9m of earth fill.
									Culvert is in poor to fair condition with a wide crack in the west wall to the crown near the South end. Severe loss of mortar along the base of both walls noted with minor fill migration into barrel. Localized loss of stones at base of walls to a maximum depth of 0.5m. Extensive encrustation near north curb line of road. Severe loss of mortar in west wall at North catch basin with a potential for loss of stones and localized failure (15m², poor).
315 - 5	1970	33.50	1+010.5	1+044	3.30	2.2	CPS-PA	1.0	Section 5 is a 3.3m +/- corrugated steel pipe arch culvert with approximately 1.0m of earth fill.
									Culvert is in generally good condition with localized light corrosion. Localized light flaking was noted at the waterline and two perforations on the barrel wall (0.25m², poor).
315 - 6	1970	28.00	1+044	1+1072	3.70	2.2	CPS-PA	1.0	Section 6 is a 3.7m +/- span corrugated steel pipe arch culvert with approximately 1.0m of earth fill. Posts added to support span.
									Culvert is in generally fair condition with cracks at the bolt hole locations in the west culvert wall for 4.0m+/- at the top of the sharp corner radii. Distance between the cracks have been measured at 115mm (15m², poor). There is a welded patch along the east wall at the top of the sharp radii the full length of the culvert. Shoring has been installed throughout the barrel. The entire culvert was not placed in the normal position, the east wall is high, shifting the crown to the west.
315 - 7	1970	21.80	1+1072	1+093.8	3.80	2.1	CPS-PA	1.2	Section 7 is a 3.8m +/- corrugated steel pipe arch culvert with approximately 1.2m of earth fill. Posts added to support span.
									Culvert is in poor condition with cracks at bolt hole locations in the west culvert wall for 2.4m in the top of the bottom sharp radii. Distance between the cracks has been measured at 95mm. Several bolts are tilted (10m², poor). Shoring has been installed throughout the barrel.
315 - 8	1970	9.20	1+093.8	1+103	3.80	2.1	CPS-PA	1.5	Section 8 is a 3.8m +/- corrugated steel pipe arch culvert with approximately 1.3m of earth fill and an asphalt paved wearing surface. Posts / bracing added to support span.
									Culvert is in poor condition with cracks at bolt hole locations in the west culvert wall for 13m and the east culvert wall for 8m in the top of the bottom sharp radii. Distance between the cracks has been measured at 85mm (13m², poor). The culvert has been shored and sagging of the support beam was noted.
315 - 9	1980	7.20	1+103	1+110.2	3.80	2.1	CPS-PA	1.5	Section 9 is a 3.8m +/- corrugated steel pipe arch culvert with approximately 1.5m of earth fill and an asphalt paved wearing surface
									Corrugated steel pipe arch culvert is in good condition. Steel sheet pile headwall and retaining wall are in good condition.

NOTES:

1.

KEY MAP

NO.	DATE	NAME	REVISIONS
1			

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SURVEY DATA DATE XXXXXX

SCALE
HORIZONTAL 5m 0 5m
VERTICAL 1m 0 1m

DRAWN:	L. SCOTT	DATE: DEC 2017
DESIGN:	J. TEEFY	DATE: DEC 2017
CHECKED:	J. TEEFY	DATE: DEC 2017
APPROVED:	P. MIDDAUGH	DATE: DEC 2017

THE REGIONAL MUNICIPALITY OF DURHAM
WORKS DEPARTMENT
WHITBY ONTARIO

EXISTING CULVERT
PLAN & PROFILE

CONCESSION	REG. RD. NO.	AREA MUNICIPALITY
XXX	–	UXBRIDGE

DRAWING NUMBER	CONTRACT NUMBER	SHEET NUMBER
XXXX	XXXXX	02

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Appendix B

Geotechnical Investigation Reports

(CD only)

Soil Engineers Ltd.
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FAX: (705) 721-7864	FAX: (905) 542-2769	FAX: (905) 725-1315	FAX: (416) 754-8516	FAX: (705) 684-8522	FAX: (905) 725-1315	FAX: (905) 542-2769

A REPORT TO
THE TOWN OF UXBBRIDGE

A SOIL INVESTIGATION FOR PROPOSED CULVERT REPLACEMENT

CENTENNIAL DRIVE TO NORTH OF BROCK STREET

TOWN OF UXBRIDGE

Reference No. 1204-S048

JULY 2012

DISTRIBUTION

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TABLE OF CONTENTS

TABLES

DIAGRAMS

ENCLOSURES

1.0 **INTRODUCTION**

In accordance with written authorization dated April 11, 2012, from Mr. Dale Dionne, General Manager of SRM Associates, a soil investigation was carried out along a proposed culvert alignment from Centennial Drive to north of Brock Street in the Town of Uxbridge, for a proposed Culvert Replacement.

The purpose of the investigation was to reveal the subsurface conditions and to determine the engineering properties of the disclosed soils for the design and construction of the proposed project.

The findings and resulting geotechnical recommendations are presented in this Report.

2.0 SITE AND PROJECT DESCRIPTION

The Township of Uxbridge is situated on Peterborough Drumlin Field, where the lacustrine sand, silt, clay and water-laid till (reworked) in Lake Schomberg (glacial lake) has, in places, modified the drumlinized soil stratigraphy.

The investigation area is located between Toronto Street and Bascom Street, from Centennial Drive to north of Brock Street where an existing culvert is to be replaced with a new culvert to facilitate the discharge of flooding of an existing watercourse. The alignment of the culvert replacement passes through a built-up area of existing buildings, roadways and a parking lot.

The invert of the proposed culvert replacement is to be founded at El. 259.8± m at the south end, lowering to El. 259.4± m at the north end.

3.0 **FIELD WORK**

The field work, consisting of 5 boreholes to depths of 12.6 to 20.0 m, was performed on May 7, 8, 14, and 15, 2012, at the locations shown on the Borehole Location Plan and Subsurface Profile, Drawing No. 1. In addition, monitoring wells were installed to a depth of 6.1 m in 4 of the 5 boreholes, at Boreholes 2, 3, 4 and 5, for groundwater sampling and monitoring.

The boreholes were advanced at intervals to the sampling depths by a truck-mounted, continuous-flight and hollow-stem power-auger machine equipped for soil sampling. Standard Penetration Tests, using the procedures described on the enclosed "List of Abbreviations and Terms", were performed at the sampling depths. The test results are recorded as the Standard Penetration Resistance (or 'N' values) of the subsoil. The relative density of the granular strata and the consistency of the cohesive strata are inferred from the 'N' values. Split-spoon samples were recovered for soil classification and laboratory testing.

The field work was supervised and the findings recorded by a Geotechnical Technician.

The sampling depths and the depths of the soil strata changes were determined based on the data collected from Trimble Geoexplorer 6000 Series Global Navigation Satellite System (GNSS) at each of the borehole locations. The x, y and z coordinates for each borehole, with a maximum of 10 cm differential, are listed in Table 1.

Table 1 - GNSS Coordinates

Borehole No.	X Coordinate	Y Coordinate	Z Coordinate
1	650315.084 m E	4885630.733 m N	263.054 m
2	650313.131 m E	4885655.627 m N	262.894 m
3	650297.761 m E	4885713.626 m N	265.746 m
4	650278.627 m E	4885755.665 m N	265.449 m
5	650299.054 m E	4885791.165 m N	264.438m

4.0 **SUBSURFACE CONDITIONS**

Detailed descriptions of the encountered subsurface conditions are presented on the Borehole Logs, comprising Figures 1 to 5, inclusive. The revealed stratigraphy is plotted on the subsurface profile on Drawing No. 1, and the engineering properties of the disclosed soils are discussed herein.

The investigation has revealed that beneath a pavement structure consisting of 50 mm and 100 mm of asphaltic concrete and 200 to 650± mm of granular fill, a layer of earth fill to depths ranging from 1.5± to 6.6± m below pavement surface and, in places, layers of peat and topsoil, the site is underlain by a complex stratigraphy of silty sand till and sandy silt till, silty clay till, silt, and gravelly sand encountered at various locations and depths throughout the site. A localized deposit of silty fine sand was found in Borehole 4 beneath the earth fill and topsoil. Occasional wet sand and silt seams and layers, cobbles and boulders were encountered in the tills.

The upper layers of native soils have generally been weathered to a depth of 1.0 to 2.0± m beneath the surface of the native soils.

4.1 **Existing Pavement Structure** (All Boreholes)

The revealed pavement structure disclosed by the boreholes is presented in Table 2.

Table 2 - Revealed Pavement Structure

Borehole No.	Asphalt Thickness (mm)	Granular Fill Thickness (mm)
1	50	610
2	50	300
3	100	200
4	100	650
5	50	650

The asphaltic concrete ranges in thickness from 50 to 100 mm, with an average of 70 mm. The granular fill ranges from 200 to 650 mm in thickness, with an average of 482 mm.

The granular base consists of crushed gravel and pit-run material with a trace to some silt. The water content varies from 3% to 11%, with a median of 4%, indicating that the granular fill is in a moist to very moist condition.

Grain size analyses were performed on 2 representative samples; the results are plotted on Figure 6. While both samples failed to meet the requirements for Granular ‘A’, one sample met the requirements for Granular ‘B’ with a silt content of approximately 10% (the other sample had a silt content of 17%). The granular fill is only considered suitable for subgrade stabilization and structural backfill.

Frequent sampling and laboratory testing of the granular material should be conducted to assess its suitability for reuse as a road subgrade stabilization material or as a granular sub-base for road construction.

4.2 **Topsoil** (Boreholes 2, 4, 5)

The original topsoil, approximately 20 to 250 cm thick, was encountered underlying the earth fill. The topsoil is dark brown in colour, indicating that it contains appreciable amounts of roots and humus. These materials are unstable and compressible under loads; therefore, the topsoil is considered to be void of engineering value. Due to its humus content, it will generate an offensive odour and may produce volatile gases under anaerobic conditions. Therefore, the topsoil must not be buried deeper than 1.2 m below the finished grade so it will not have an adverse impact on the environmental well-being of the developed areas.

Since the topsoil is considered void of engineering value, it can only be used for general landscaping and landscape contouring purposes. A fertility analysis can determine the suitability of the topsoil as a planting material.

4.3 **Peat** (Borehole 1)

The peat, 0.8 m in thickness, was encountered immediately beneath the earth fill, overlying the upper gravelly sand stratum. The revealed peat deposit extends from 2.9 to 3.7 m from the prevailing ground surface.

The peat is amorphous-granular in texture and contains fine fibrous decaying vegetation. It was formed by the progressive accumulation of incompletely decomposed plants in a wet environment. The peat is black in colour and emits a musty odour of decaying vegetation.

The obtained 'N' value of 5 blows per 30 cm of penetration shows the deposit is very weak in shear strength and the amount of consolidation will correspond to the load applied.

The natural water content value was determined to be 205%. The very high water content value shows that the peat is highly compressible and would be unstable under loads. Since the peat is derived from vegetation, it will generate volatile gases under anaerobic conditions.

The peat is void of engineering value and cannot support structural loads.

4.4 **Earth Fill** (All Boreholes)

The earth fill consists of silty clay and silty sand materials and extends to depths ranging from 1.5 to 6.6 m below the prevailing ground surface. Sample examinations show that the silty clay fill contains a trace to some sand and a trace of gravel. Brick pieces were encountered in the silty sand fill in Borehole 3 and occasional wood debris was found in Boreholes 3 and 5.

The original topsoil was encountered in 3 of 5 boreholes, showing the site likely had not been stripped prior to filling the areas.

Sample examinations reveal that the composition of the silty clay fill and silty sand fill are similar to the underlying silty clay till and silty sand till, showing that the material is the spoil from vicinal construction.

The water content values of the samples were found to range from 2% to 61%, with a median of 19%, showing the fill is in a damp to wet, generally wet or saturated

condition. The high moisture content indicates that the earth fill contains original topsoil inclusions.

The obtained 'N' values range from 2 blows per 30 cm to 28 blows per 30 cm, with a median of 5 blows per 30 cm of penetration. This shows that the fill was loosely placed with minimal compaction and has since partially self-consolidated. The fill is considered to be unsuitable to support structures.

Grain size analyses were performed on 2 representative samples; the results are plotted on Figure 7.

As noted, the relative density of the fill is generally loose and non-uniform. In using the fill for structural backfill or for pavement construction, it should be subexcavated, inspected, sorted free of serious topsoil inclusions, proof-rolled and properly recompacted.

The fill is amorphous in structure; it will ravel and is susceptible to collapse in steep cuts.

One must be aware that in cuts in the till, the sides are prone to sudden collapse, particularly if the fill is in a wet condition.

One must also be aware that the samples retrieved from boreholes 10 cm in diameter may not be truly representative of the geotechnical and environmental quality of the fill, and do not indicate whether the topsoil beneath the earth fill was completely stripped. This should be further assessed by laboratory testing and/or test pits.

4.5 **Silty Clay Till** (Boreholes 1, 3 and 5)

The silty clay till was encountered beneath the original topsoil or the stratum of silt. It consists of a random mixture of soils; the particle sizes range from clay to gravel, with the clay fraction exerting the dominant influence on its soil properties. The structure of the till is heterogeneous and amorphous, showing it is a glacial deposit and has been reworked by the past glaciations. It contains a trace of sand and has a trace of gravel.

The samples were found to contain occasional wet sand and silt seams and layers. Hard resistance was occasionally encountered during augering, showing the till might be embedded with occasional cobbles and boulders.

The obtained 'N' values range from 9 to 16, with a median of 10 blows per 30 cm of penetration, indicating that the consistency of the silty clay till is stiff to very stiff.

A grain size analysis was performed on 1 representative sample; the gradation is plotted on Figure 8.

The Atterberg Limits of 1 representative sample and the water content values of all of the samples were determined. The results are plotted on the Borehole Logs and summarized below:

Liquid Limit	22%
Plastic Limit	15%
Natural Water Content	8% to 17% (median 13%)

The above results show that the silty clay till is a cohesive material with low plasticity. The natural water content values generally lie from below its plastic limit to close to its liquid limit, confirming the generally stiff consistency of the clay determined from the 'N' values.

Based on the above findings, the following engineering properties are deduced:

- High frost susceptibility and high soil-adfreezing potential.
- Low water erodibility.
- Low permeability, with an estimated coefficient of permeability of 10^{-6} cm/sec and runoff coefficients of:

Slope	
0% - 2%	0.15
2% - 6%	0.20
6% +	0.28

- A cohesive soil, its shear strength is primarily derived from consistency which is inversely related to its moisture content. It contains sand; therefore, its shear strength is augmented by internal friction.
- It will generally be stable in a relatively steep cut; however, prolonged exposure will allow the wet sand and silt seams and layers to become saturated, which may lead to localized sloughing.
- A very poor pavement-supportive material, with an estimated California Bearing Ratio (CBR) value of 3% or less.
- Moderate corrosivity to buried metal, with an estimated electrical resistivity of 4000 ohm·cm.

4.6 **Sandy Silt Till** and **Silty Sand Till** (Boreholes 2, 3, 4, 5)

These deposits are found underlying the original topsoil or silt, silty clay till or silty fine sand strata. They consist of a random mixture of particle sizes ranging from clay to gravel, with either sand or silt being the dominant fraction. They are amorphous in structure showing the deposits are glacial tills, parts of which have been reworked by the glacial lake.

Tactile examinations of the soil samples indicated that the tills are dense, displaying some cohesion. The samples were found to contain occasional sand layers which are often wet.

The obtained 'N' values range from 3 per 30 cm to 92 per 23 cm, with a median of 50 blows per 15 cm. This shows that the relative density of the tills is very loose to very dense, being generally very dense. The loose condition occurs in the upper layers, showing the zone has been weathered.

Intermittent hard resistance to augering was encountered, indicating the presence of cobbles and boulders in the strata.

The natural water content values of the samples were determined; the results are plotted on the Borehole Logs. The values range from 7% to 20%, with a median of 10%, confirming the generally very dense condition disclosed by the sample examinations.

Grain size analyses were performed on 4 representative samples; the results are plotted on Figure 9.

According to the above findings, the engineering properties are listed below:

- Highly frost susceptible and moderately water erodible.
- Low permeability, with an estimated coefficient of permeability of 10^{-4} to 10^{-6} cm/sec and runoff coefficients of:

Slope	
0% - 2%	0.07 to 0.15
2% - 6%	0.12 to 0.20
6% +	0.18 to 0.28

- Frictional soils, their shear strength is primarily derived from internal friction, and is augmented by cementation. Therefore, their strength is density dependent.
- They will be stable in steep cuts; however, under prolonged exposure, localized sheet collapse will likely occur.
- Fair pavement-supportive materials, with a CBR value of 8%.
- Moderately low corrosivity to buried metal, with an estimated electrical resistivity of 5000 ohm/cm.

4.7 **Silt** (Boreholes 1, 2, 3, 5)

Silt deposits were found at depths of 4.4 to 7.1 m. These deposits were encountered beneath the earth fill and topsoil layers or gravelly sand, overlying and underlying the silty clay till. In Borehole 2, the silt lies between layers of silty sand till and sandy silt till.

Sample examinations show that the silt is loose and in a wet condition. It contains a trace to some clay and occasional fine sand.

The natural moisture content values of the samples were found to range from 16% to 23%, with a median of 20%, confirming the wet condition.

The obtained 'N' values range from 5 to 26 with a median of 12, indicating that the relative density of the silt is loose to compact, being generally compact.

Grain size analyses were performed on 3 representative samples, and the gradations are plotted on Figure 10.

According to the above findings, the engineering properties relating to the project are given below:

- Highly frost susceptible, with high soil-adfreezing potential.
- Highly water erodible; it is susceptible to migration through small openings under seepage pressure.
- Relatively pervious, with an estimated coefficient of permeability of 10^{-4} to 10^{-6} cm/sec and runoff coefficients of:

Slope	
0% - 2%	0.07 to 0.15
2% - 6%	0.12 to 0.20
6% +	0.18 to 0.28

- The soil has a high capillarity and water retention capacity.
- A frictional soil, its shear strength is density dependent. Due to its dilatancy, the strength of the wet silt is susceptible to impact disturbance; i.e., the disturbance will induce a build-up of pore pressure within the soil mantle, resulting in soil dilation and a reduction in shear strength.

- In excavation, the moist silt will be stable in relatively steep cuts, while the wet silt will slough and run slowly with seepage bleeding from the cut face. It will boil with a piezometric head of 0.4 m.
- A poor pavement-supportive material, with an estimated CBR value of 4%.
- Moderately corrosive to buried metal, with an estimated electrical resistivity of 4500 ohm·cm.

4.8 **Silty Fine Sand** (Borehole 4)

The silty fine sand was found underlying the original topsoil at a depth of 5.5 m.

Sample examinations show that the sand is non-cohesive. It is generally in a wet condition and becomes highly dilatant when shaken by hand. Occasional sand seams and layers were found in the deposit; the laminated structure shows the sand is a lacustrine deposit.

The obtained 'N' value in the fine sand was 4. The relative density of the silt is thus inferred as very loose.

The natural water content value of the sample was determined to be 27%, indicating the soil is in a wet to water-bearing condition; the value is plotted on the Borehole Logs.

A grain size analysis was performed on 1 representative sample and the result is plotted on Figure 11.

According to the above findings, the engineering properties relating to the project are given below:

- Highly frost susceptible, with high soil-adfreezing potential.
- Highly water erodible; susceptible to migration through small openings under seepage pressure.
- Medium permeability, with an estimated coefficient of permeability of 10^{-6} cm/sec, and runoff coefficients of:

Slope	
0% - 2%	0.15
2% - 6%	0.20
6% +	0.28

- A frictional soil, its shear strength is density dependent. Due to its dilatancy, the strength of the wet silt is susceptible to impact disturbance; i.e., the disturbance will induce a build-up of pore pressure within the soil mantle, resulting in soil dilation and a reduction in shear strength.
- In relatively steep cuts, the sand will be stable in a damp to moist condition, but will slough if it is wet and run with water seepage.
- A fair pavement-supportive material, with an estimated CBR value of 10%.
- Moderately low corrosivity to buried metal, with an estimated electrical resistivity of 5000 ohm/cm.

4.9 **Gravelly Sand** (Boreholes 1, 3, 4, 5)

The gravelly sand was encountered below the layer of peat and, at a deeper depth, below the stratum of silt in Borehole 1. It contains a trace to some silt, with occasional boulders.

The gravelly sand extends beyond the maximum investigated depth in Boreholes 3, 4 and 5.

The obtained 'N' values range from 46 blows per 30 cm to 50 blows per 8 cm, with a median of 50 blows per 15 cm. This indicates that its relative density is dense to very dense, being generally very dense. The gravelly sand underlying the peat in Borehole 1 has an 'N' value of 4 and is in a very loose condition.

The natural water content values determined by laboratory testing were found to be 6% to 11%, with a median of 8%. Due to the pervious nature of the gravelly sand, a portion of the water in the gravelly sand likely was lost during sampling. The laboratory determined value is expected to not represent the in situ condition of the sand. The gravelly sand underlying the peat in Borehole 1 has a water content value of 21% and is in a wet condition.

Grain size analyses were performed on 2 representative samples; the results are plotted on Figure 12.

Based on sample examination, the following engineering properties are deduced:

- Low frost susceptibility and high water erodibility.
- Pervious, with an estimated coefficient of permeability of 10^{-3} cm/sec and runoff coefficients of:

Slope	
0% - 2%	0.04
2% - 6%	0.09
6% +	0.13

- A frictional soil, its shear strength is derived from internal friction and is therefore directly dependent on soil density.

- In cuts, the moist sand will be stable in a relatively steep slope and the dry sand will slough readily. It will run with water seepage and boil under a piezometric head of 0.4 m.
- A fair to good material to support flexible pavement, with an estimated CBR value of 15% to 25%.
- Low corrosivity to buried metal, with an estimated electrical resistivity of 6500 ohm·cm.

4.10 **Compaction Characteristics of the Revealed Soils**

The obtainable degree of compaction is primarily dependent on the soil moisture and, to a lesser extent, on the type of compactor used and the effort applied. As a general guide, the typical water content values of the revealed soils for Standard Proctor compaction are presented in Table 3.

Table 3 - Estimated Water Content for Compaction

Soil Type	Determined Natural Water Content (%)	Water Content (%) for Standard Proctor Compaction	
		100% (optimum)	Range for 95% or +
Granular Fill	3 to 11 (median 4)	6	3 to 11
Earth Fill	2 to 61 (median 19)	12	6 to 20
Silt	16 to 23 (median 20)	13	8 to 17
Silty Fine Sand	27	11	6 to 16
Silty Clay Till	8 to 17 (median 13)	15	11 to 20

Table 3 - Estimated Water Content for Compaction (cont'd)

Soil Type	Determined Natural Water Content (%)	Water Content (%) for Standard Proctor Compaction	
		100% (optimum)	Range for 95% or +
Silty Sand and Sandy Silt Tills	7 to 20 (median 10)	9	5 to 14
Drained Gravelly Sand	6 to 11 (median 8)	6	3 to 12

Based on the above findings, the in situ granular fill, silty clay till, and gravelly sand are generally suitable for a 95% or + Standard Proctor compaction. The silty fine sand and a portion of the earth fill are too wet and will require aeration or mixing with drier soils prior to Standard Proctor compaction. The soils can be aerated by spreading them thinly on the ground in the dry, warm weather. A portion of the earth fill is on the dry side of the optimum and will require wetting prior to structural compaction, particularly in the dry, warm weather and in areas where compaction is best performed on the wet side of the optimum.

The tills should be compacted using a heavy-weight, kneading-type roller. The earth fill and sands can be compacted by a smooth roller with or without vibration, depending on the water content of the soils being compacted. The lifts for compaction should be limited to 20 cm, or to a suitable thickness as assessed by test strips performed by the equipment which will be used at the time of construction.

The presence of boulders will prevent transmission of the compactive energy into the underlying material to be compacted. If an appreciable amount of boulders over 15 cm in size is mixed with the material, it must either be sorted or must not be used for structural backfill.

5.0 GROUNDWATER CONDITIONS

The boreholes were checked for groundwater upon their completion. The data are plotted on the borehole logs and summarized in Table 4.

Table 4 - Groundwater Levels

		Soil Colour Changes Brown to Grey	Seepage Encountered During Augering		Groundwater Level On Completion	
BH No.	Depth (m)	Depth (m)	Depth (m)	Comment	Depth (m)	El. (m)
1	12.7	3.7	4.0	Appreciable	0*	263.1
2	12.6	2.9	4.2	Moderate	4.9	258.0
3	20.0	3.6	4.1	Moderate	3.7	262.1
4	20.0	1.4	2.0	Some	2.4	263.1
5	20.0	0.7	2.7	Some	5.5	258.9

*Artesian condition, groundwater flowing out of the borehole.

Groundwater was encountered at depths ranging from 2.4± to 5.5± m from the prevailing ground surface, or El. 258.0± to El. 263.1± m. A subterranean artesian condition and artesian groundwater were encountered in the stratum of gravelly sand at a depth of over 12.0 m upon completion of Borehole 1. Groundwater was seen spouting out at the surface, showing the water in the gravelly sand stratum, in places, is under artesian condition. Some to moderate seepage was encountered in the earth fill, silty clay till and silty sand till strata in Boreholes 2 to 5, inclusive.

The colour of the revealed soils changed from brown to grey at depths ranging from 0.7 to 3.6 m. This indicates that the upper zone of the stratigraphy has oxidized and the groundwater regime is inferred to lie in the grey soils in the lower zone.

The groundwater yield from the silty clay and sandy silt tills, due to their low to relatively low permeabilities, is expected to be small and limited in quantity. The yield from the silty sand till, silt and gravelly sand will be moderate to appreciable and persistent. Groundwater will fluctuate with the seasons.

6.0 DISCUSSION AND RECOMMENDATIONS

The investigation has revealed that beneath a pavement structure consisting of 50 mm and 100 mm of asphaltic concrete and 200 to 650± mm of granular fill, a layer of earth fill to depths ranging from 1.5± to 6.6± m below the pavement surface and, in places, layers of peat and topsoil, the site is underlain by a complex stratigraphy of very loose to very dense, generally very dense silty sand till and sandy silt till; stiff to very stiff, generally stiff silty clay till; loose to compact, generally compact silt; and very loose to very dense, generally very dense gravelly sand encountered at various locations and depths throughout the site. A localized deposit of very loose silty fine sand was found in Borehole 4 beneath the earth fill and topsoil. Occasional wet sand and silt seams and layers, cobbles and boulders were encountered in the tills.

The upper layers of native soils have generally been weathered to a depth of 1.0 to 2.0± m beneath the surface of the native soils.

Groundwater was encountered at depths ranging from 2.4± to 5.5± m from the prevailing ground surface, or El. 258.0± to El. 263.1± m. An artesian condition was present at Borehole 1, resulting in the groundwater flowing spontaneously to the surface. Slight to moderate seepage was encountered in the earth fill, silty clay till and silty sand till strata in Boreholes 2 to 5, inclusive.

The colour of the revealed soils changed from brown to grey at depths of 0.7 to 3.6 m. This indicates that the upper zone of the stratigraphy has oxidized and the groundwater regime is inferred to lie in the grey soils in the lower zone.

The groundwater yield from the silty clay and sandy silt tills, due to their low to relatively low permeability, is expected to be small and limited in quantity. The yield from the silty sand till, silt and gravelly sand will be moderate to appreciable and persistent. Groundwater will fluctuate with the seasons.

The geotechnical findings which warrant special consideration are presented below:

1. The existing granular fill fails to meet the OPS Gradation Specification Requirements for Granular 'A' and a portion of the granular fill fails to meet the specification for Granular 'B'. Nevertheless, the granular fill can be used for road base material, if salvaged, for structural backfill and as a road subgrade stabilization material.
2. The original topsoil, 20 to 250 cm thick, will generate volatile gases under anaerobic conditions. It is unsuitable for engineering applications and must be stripped. For the environmental and geotechnical well-being of future development, it should not be buried over 1.2 m below the proposed finished grade or below any structures.
3. The earth fill, in its present state, is only suitable for supporting lightly loaded foundations or it can be subexcavated, inspected, sorted free of serious topsoil inclusions or any deleterious materials, if encountered, aerated and properly compacted.
4. Due to the occurrence of earth fill, topsoil and peat deposits, the footing subgrade must be inspected by a geotechnical engineer or a geotechnical technician under the supervision of a geotechnical engineer, to assess its suitability for bearing the designed foundations.
5. Excavation into the very stiff to hard and dense to very dense tills containing boulders may require extra effort and the use of a heavy-duty backhoe. Boulders larger than 15 cm in size are not suitable for structural backfill.

6. Earth fill extends to depths of up to 6.6 m, which indicates that the suitable founding level for the culvert is at least 1.1 m below the groundwater level. In order to limit water seepage that may impact the stability of the footing subgrade, the spread and/or strip foundations are to be constructed within sheeting enclosures.
7. As noted, artesian and subterranean artesian conditions were encountered in the gravelly sand stratum at a depth of 12.0 m. In view of the founding level of the proposed culvert replacement, the impact on the stability of the subgrade may need special consideration. However, should the condition occur, precautionary measures must be carried out to prevent subgrade soils being washed out.
8. In order to ensure that the integrity of the subgrade for the foundations and the stability of existing underground services, their location must be determined properly and properly shored against disruption by the construction of the culvert replacement. The sides of the excavation into the earth fill and filled sewer trenches must be properly protected against sloughing.

The recommendations appropriate for the project described in Section 2.0 are presented herein. One must be aware that the subsurface conditions may vary between boreholes. Should this become apparent during construction, a geotechnical engineer must be consulted to determine whether the following recommendations require revision.

6.1 **Culvert Foundations and Construction**

As noted, the proposed founding subgrade at the south end is at El. 259.8+ m lowering to El. 259.4+ m at the north end. The founding soils, based on the borehole results, are peat and loose gravelly sand (Borehole 1), topsoil (Borehole 2), silty sand

fill and sandy silt fill (Borehole 3), very loose silty fine sand (Borehole 4) and stiff silty clay till (Borehole 5).

This shows the sands at this level (excluding peat) are only suitable to bear foundation designed with net Allowable Soil Pressure (SLS) of 30 kPa with Factored Ultimate Soil Bearing Pressure of 50 kPa.

Higher Maximum Allowable Pressures (SLS) with Factored Ultimate Soil Bearing Pressures (ULS) on natural soil, and corresponding suitable founding levels are presented in Table 5.

Table 5 - Founding Levels

	Recommended Maximum Allowable Soil Pressure (SLS)/ Factored Ultimate Soil Bearing Pressure (ULS) and Suitable Founding Levels			
	100 kPa (SLS) 180 kPa (ULS)		**250 kPa (SLS) 400 kPa (ULS)**	
BH No.	**Depth (m)**	**El. (m)**	**Depth (m)**	**El. (m)**
1	6.2 or +	256.9 or -	12.2 or +	250.9 or -
2	6.2[A]	256.7[A]	9.1[B]	253.8[B]
3	7.0 or +	258.8 or -	10.0 or +	255.8 or -
4	7.5 or +	258.0 or -	8.5 or +	257.0 or -
5	5.5[C]	258.9[C]	8.5 or +	255.9 or -

[A]Due to loose silt found in the middle of the layer, the Maximum Allowable Soil Pressure (SLS) should be linearly reduced from 100 kPa to 75 kPa at depth of 8.0 m.
[B]Due to compact sand till found beneath the silt, the the Maximum Allowable Soil Pressure (SLS) should be linearly reduced from 250 kPa to 150 kPa at a depth of 10.7 m.
[C]Due to loose silt found beneath the till, the Maximum Allowable Soil Pressure (SLS) should be linearly reduced from 100 kPa to 75 kPa at depth of 7.1 m.

As shown above, the suitable founding level lies below the water table. The foundation must be constructed in sheeting enclosures driven into the stiff to hard or dense to very dense tills to facilitate suitable conditions for the footing construction.

In this case the loose fill, peat and weathered soil must be excavated and the subgrade must be inspected and proof-rolled. A test pit programme must be carried out prior to or during construction to verify the suitability of the in situ soils. Where unsuitable subgrade is detected, it must be replaced with properly compacted engineered fill to correspond to the designed foundations.

Founding the culvert on piles driven below the firm silty clay till and/or the silt is not recommended. This may allow artesian and subterranean artesian groundwater from the gravelly sand stratum to unstabilize the subgrade.

For foundations designed with a Maximum Allowable Soil Pressure (SLS) of 100 kPa or over, the loose fill, peat and weathered soil extending below the proposed founding level of the culvert must be excavated and the excavation must be backfilled with 20-mm Crusher-Run Limestone (or equivalent), compacted to 100% of its maximum Standard Proctor dry density up to the proposed founding level.

The proposed upstream and downstream ends have been designed to be protected by 300 mm in diameter riverstone. A minimum thickness of 600 mm is considered to be appropriate. Cut-off wall foundations must be constructed upstream from the culvert to prevent runoff from eroding the founding subgrade during flooding.

In order to ensure that the integrity of the subgrade for the foundations and underground services is not compromised during excavation, drawings must be reviewed and the depths and locations of the foundations and underground services must be identified. Otherwise, such foundations and services must be exposed for inspection prior to excavation for the culvert replacement.

To ensure that the condition of the subgrade is compatible with the design requirements, the subgrade must be inspected by a geotechnical engineer, or a geotechnical technician under the supervision of a geotechnical engineer, to assess its suitability for bearing the designed foundations.

6.2 Wing Wall Construction

The backfill against the wing walls must consist of free-draining material and subdrains must be provided. This measure is to prevent a build-up of ice pressure behind the wall which would impact its structural integrity. Rip-rap should be placed along the wet perimeter to prevent further wave erosion, and the side slopes of the embankment should be sodded to protect against rainwash erosion.

6.3 Engineered Fill

Engineered fill can replace the loose soils for foundation construction where earth fill is required to raise the site or when extended footings are required. The engineering requirements for a certifiable fill for pavement construction, municipal services, slab-on-grade, and footings designed with a Maximum Allowable Soil Pressure (SLS) of 150 kPa and a Factored Ultimate Soil Bearing Pressure (ULS) of 225 kPa are presented below:

1. All of the topsoil and peat must be removed. Any badly weathered soils must be subexcavated, sorted free of topsoil inclusions and deleterious materials, aerated and properly compacted to 98% of their maximum Standard Proctor dry density. The subgrade surface must be inspected and proof-rolled prior to any fill placement.

2. Inorganic soils must be used, and they must be uniformly compacted in lifts 20 cm thick to 98% or + of their maximum Standard Proctor dry density up to the proposed finished grade and/or slab-on-grade subgrade. The soil moisture must be properly controlled on the wet side of the optimum.
   If the structure foundations are to be built soon after the fill placement, the densification process for the engineered fill must be increased to 100% of the maximum Standard Proctor compaction.
3. If imported fill is to be used, the hauler is responsible for its environmental quality and must provide a document to certify that it is free of hazardous contaminants.
4. If the engineered fill is to be left over the winter months, adequate earth cover, or equivalent, must be provided for protection against frost action.
5. The engineered fill must extend over the entire graded area; the fill envelope and finished elevations must be clearly and accurately defined in the field and be precisely documented by qualified surveyors. Foundations partially on engineered fill must be reinforced and designed by a structural engineer to properly distribute the stress induced by the abrupt differential settlement (estimated to be 15± mm) between the natural soils and engineered fill.
6. The engineered fill must not be placed during the period from late November to early April, when freezing ambient temperatures occur either persistently or intermittently. This is to ensure that the fill is free of frozen soils, ice and snow.
7. Where the ground is wet due to subsurface water seepage, an appropriate subdrain scheme must be implemented prior to the fill placement, particularly if it is to be carried out on sloping ground.
8. Where the fill is to be placed on sloping ground steeper than 1 vertical:
   3 horizontal, the face of the sloping ground must be flattened to 3+ so that it is suitable for safe operation of the compactor and the required compaction can be obtained.

9. The fill operation must be inspected on a full-time basis by a technician under the direction of a geotechnical engineer.
10. The footing and underground services subgrade must be inspected by the geotechnical consulting firm that inspected the engineered fill placement. This is to ensure that the foundations are placed within the engineered fill envelope, and the integrity of the fill has not been compromised by interim construction, environmental degradation and/or disturbance by the footing excavation.
11. Any excavation carried out in the certified engineered fill must be reported to the geotechnical consultant who inspected the fill placement in order to document the locations of the excavation and/or to inspect reinstatement of the excavated areas to engineered fill status. If construction on the engineered fill does not commence within a period of 2 years from the date of certification, the condition of the engineered fill must be assessed for re-certification.
12. Despite stringent control in the placement of the engineered fill, variations in soil type and density may occur in the engineered fill. Therefore, the foundation must be properly reinforced and designed by the structural engineer for the project. The total and differential settlements of 25 mm and 15 mm, respectively, should be considered in the design of the foundations founded on engineered fill. In sewer construction, the engineered fill is considered to have the same structural proficiency as a natural inorganic soil.

6.4 **Backfill in Trenches and Excavated Areas**

The on-site organic-free native soils are suitable for trench backfill. In the zone within 1.0 m below the pavement subgrade and below the slab-on-grade, the backfill should be compacted to at least 98% of its maximum Standard Proctor dry density with the moisture content 2% to 3% drier than the optimum. In the lower zone, a 95% or + Standard Proctor compaction is considered to be adequate; however, the

material must be compacted on the wet side of the optimum. Backfill below the slab-on-grade which is sensitive to settlement must be compacted to at least 98% of its maximum Standard Proctor dry density.

The natural water content of the soils, as determined, indicates that the in situ granular fill, silty clay till, and gravelly sand are generally suitable for a 95% or + Standard Proctor compaction. The silty fine sand and a portion of the earth fill are too wet and will require aeration or mixing with drier soils prior to Standard Proctor compaction. The soils can be aerated by spreading them thinly on the ground in the dry, warm weather. A portion of the earth fill is on the dry side of the optimum and will require wetting prior to structural compaction, particularly in the dry, warm weather and in areas where compaction is best performed on the wet side of the optimum.

In normal underground services and slab-on-grade construction practice, the problem areas of road settlement largely occur adjacent to manholes, catch basins, services crossings, foundation walls and columns. In areas which are inaccessible to a heavy compactor, sand backfill should be used. The interface of the native soils and the sand backfill will have to be flooded for a period of several days.

The narrow trenches should be cut at 1 vertical:2 or + horizontal so that the backfill can be effectively compacted. Otherwise, soil arching will prevent the achievement of proper compaction. The lift of each backfill layer should either be limited to a thickness of 20 cm, or the thickness should be determined by test strips.

One must be aware of the possible consequences during trench backfilling and exercise caution as described below:

- When construction is carried out in freezing winter weather, allowance should be made for these following conditions. Despite stringent backfill monitoring, frozen soil layers may inadvertently be mixed with the structural trench backfill. Should the in situ soil have a water content on the dry side of the optimum, it would be impossible to wet the soil due to the freezing condition, rendering difficulties in obtaining uniform and proper compaction. Furthermore, the freezing condition will prevent flooding of the backfill when it is required, such as in a narrow vertical trench section, or when the trench box is removed. The above will invariably cause backfill settlement that may become evident within 1 to several years, depending on the depth of the trench which has been backfilled.
- In areas where the underground services construction is carried out during winter months, prolonged exposure of the trench walls will result in frost heave within the soil mantle of the walls. This may result in some settlement as the frost recedes, and repair costs will be incurred prior to final surfacing of the new pavement and the slab-on-grade construction.
- To backfill a deep trench, one must be aware that future settlement is to be expected, unless the side of the cut is flattened to at least 1 vertical: 1.5 + horizontal, and the lifts of the fill and its moisture content are stringently controlled; i.e., lifts should be no more than 20 cm (or less if the backfilling conditions dictate) and uniformly compacted to achieve at least 95% of the maximum Standard Proctor dry density, with the moisture content on the wet side of the optimum.
- It is often difficult to achieve uniform compaction of the backfill in the lower vertical section of a trench which is an open cut or is stabilized by a trench box, particularly in the sector close to the trench walls or the sides of the box. These sectors must be backfilled with sand. In a trench stabilized by a trench box, the void left after the removal of the box will be filled by the backfill. It

is necessary to backfill this sector with sand, and the compacted backfill must be flooded for 1 day, prior to the placement of the backfill above this sector, i.e., in the upper sloped trench section. This measure is necessary in order to prevent consolidation of inadvertent voids and loose backfill which will compromise the compaction of the backfill in the upper section. In areas where groundwater movement is expected in the sand fill mantle, seepage collars should be provided.

6.5 Sidewalks and Landscaping

The sidewalks in areas which are sensitive to frost-induced ground movement, such as entrances, must be constructed on a free-draining, non-frost-susceptible granular material such as Granular 'B'. It must extend to 1.2 m below the slab or pavement surface and be provided with positive drainage such as weeper subdrains connected to manholes or catch basins. Alternatively, the sidewalk should be properly insulated with 50-mm Styrofoam, or equivalent.

6.6 Pavement Design

Based on the borehole findings, the recommended pavement design for roadway construction is presented in Table 6.

Table 6 - Pavement Design (Roadway)

Course	Thickness (mm)	OPS Specifications
Asphalt Surface	40	HL-3
Asphalt Binder	50	HL-8
Granular Base	150	Granular 'A' or equivalent
Granular Sub-Base	300	Granular 'B' or equivalent

The pavement design for parking area construction is given in Table 7.

Table 7 - Pavement Design (Parking Area)

Course	Thickness (mm)	OPS Specifications
Asphalt Surface	25	HL-3
Asphalt Binder	35	HL-8
Granular Base	150	Granular 'A'
Granular Sub-Base	200	Granular 'B'

The existing granular fill, due to its high silt content, can only be used as road subgrade stabilization material; in using the granular fill as pavement sub-base material, its structural proficiency is considered to be half that of Granular 'B'. The existing asphalt surface can be pulverized and mixed with new Granular 'A' for the granular base construction.

The subgrade within a depth of 1.0 m from the underside of the granular sub-base must be properly surface compacted to 95% of its maximum Standard Proctor dry density, with the water content on the dry side of the optimum.

The granular base and sub-base should be compacted to 100% of their maximum Standard Proctor dry density.

Roadside drainage ditches should be provided, and the bottom of the ditch should be at or below the depth of the underside of the granular sub-base of the reconstructed roadway.

The subgrade will suffer a strength regression if water is allowed to saturate the mantle. The following measures should, therefore, be incorporated in the construction procedures and road design:

- The subgrade should be properly crowned and smooth-rolled to allow interim precipitation to be properly drained.
- Areas adjacent to the roads should be properly graded to prevent ponding of large amounts of water. Otherwise, the water will seep into the subgrade mantle and induce a regression of the subgrade strength, with costly consequences for the pavement construction.
- Prior to placement of the granular bases, the subgrade should be proof-rolled, and any soft spots and weathered soil should be rectified.
- In extreme cases during the wet seasons, the top 0.8 m of the subgrade should be replaced by compacted granular material with the silt content less than 8% to compensate for the inadequate strength of the soft subgrade.

6.7 **Soil Parameters for the Design of the Culvert**

The recommended soil parameters for the project design are given in Table 8.

Table 8 - Soil Parameters

Soil Unit Weight (kN/m³)	**Bulk**	**Immersed**
Earth Fill	20.5	11.5
Silty Sand Till and Sandy Silt Till	22.5	12.5
Silty Clay Till	22.0	12.5
Silt	21.0	10.5
Sands	20.0	10.8

Table 8 - Soil Parameters (cont'd)

Soil Strength Parameters	**Apparent Cohesion c (kPa)**	**Effective Friction Angle ϕ (°)**
Earth Fill	0	26
Silty Sand Till and Sandy Silt Till	2	31
Silty Clay Till	5	30
Silt	0	30
Sands	0	33
Coefficients of Friction		
Between Concrete and Granular Base		0.60
Between Concrete and Sound Natural Soil		0.40

6.8 Excavation

Excavation should be carried out in accordance with Ontario Regulation 213/91.

Excavation above groundwater should be sloped at 1 vertical:1 horizontal for stability. The sides of excavation into earth fill must be cut at 1 vertical: 1.5 horizontal for stability. The silty clay till contains occasional boulders. Therefore, extra effort will be required in excavation.

For excavation purposes, the types of soils are classified in Table 9.

Table 9 - Classification of Soils for Excavation

Material	**Type**
Sound Tills	2
Earth Fill, Weathered Soils and Gravelly Sand	3
Water-Bearing Silt	4

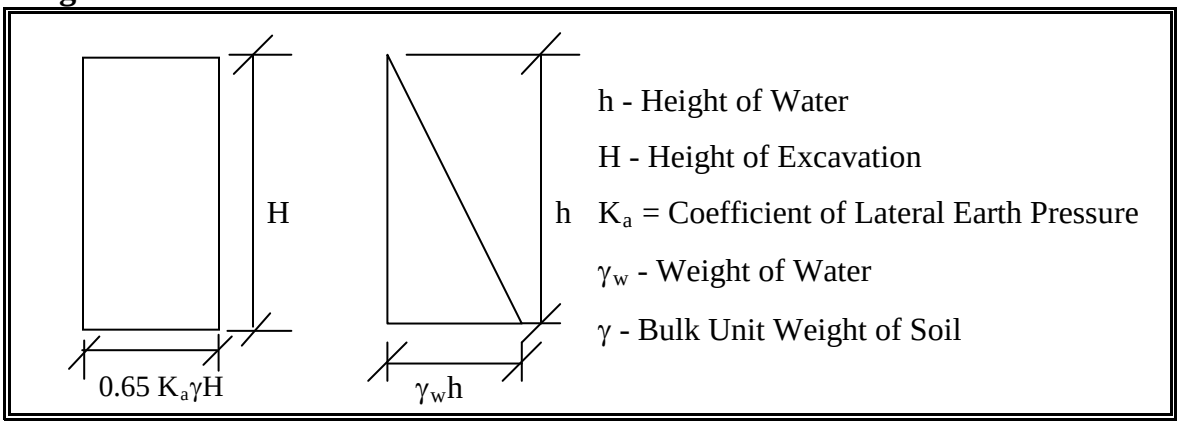
The groundwater yield from the silty clay and sandy silt tills, due to their low to relatively low permeability, is expected to be small and limited in quantity. The yield from the silty sand till, silt and gravelly sand will be moderate to appreciable and persistent. Groundwater will fluctuate with the seasons.

Where excavation is to be carried out in the water-bearing sands and silt, the possibility of flowing sides and bottom boiling dictates that the ground be predrained. However, due to the close proximity of the building envelopes, it may be very difficult to create enough drawdown required for excavation.

The sides of the bank or excavation can be sheeted. The sheeting structure should be driven to a depth below the bottom of the excavation equal to at least the height of water above the bed of the excavation.

The sheeting structure should be properly embedded into the tills deposits to prevent hydrostatic uplift and should be properly designed to support the earth pressure, hydrostatic pressure and applicable surcharge. The sheeting must not be driven to depths which may induce the artesian effect of the subterranean artesian condition from the gravelly sand stratum which will have an impact on the stability of the founding subgrade of the culvert replacement. It should be designed using the lateral earth pressure diagram shown in Diagram 1.

Diagram 1 - Lateral Earth Pressure



If tiebacks are to be used for the shoring structure, the anchors should be embedded into the hard or very dense tills. An average undrained shear strength of 100 kPa can be used for the design of the anchorage embedded in the silty clay till, sandy silt till and silty sand till. All the tieback anchors should be proof-loaded to at least 133% of the design load, and at least 1 full scale test should be carried out on 1 anchor.

Prospective contractors must be asked to assess the in situ subsurface conditions for soil cuts by digging test pits to at least 0.5 m below the intended bottom of excavation. These test pits should be allowed to remain open for a period of at least 4 hours to assess the trenching conditions.

7.0 LIMITATIONS OF REPORT

It should be noted that Phase One and Phase Two Environmental Site Assessments have been completed and the assessment and recommendations will be presented under separate cover, Reference No. 1204-S048E. Therefore, this report deals only with a study of the geotechnical aspects of the proposed project for the new alignment.

This report was prepared by Soil Engineers Ltd. for the account of The Town of Uxbridge and for review by its designated consultants and government agencies. The material in it reflects the judgement of Benjamin Shindman, M.A.Sc., Kelvin Lee, B.Eng., EIT., and Victor Chan, P.Eng., in light of the information available to it at the time of preparation. Any use which a Third Party makes of this report, or any reliance on decisions to be made based on it, are the responsibility of such Third Parties. Soil Engineers Ltd. accepts no responsibility for damages, if any, suffered by any Third Party as a result of decisions made or actions based on this report.

SOIL ENGINEERS LTD.

Benjamin Shindman, M.A.Sc.

Kelvin Lee, B.Eng., EIT

Victor S. Chan, P.Eng.
BS/KL/VSC:dd

LIST OF ABBREVIATIONS AND DESCRIPTION OF TERMS

The abbreviations and terms commonly employed on the borehole logs and figures, and in the text of the report are as follows:

1. SAMPLE TYPES

AS	Auger sample
CS	Chunk sample
DO	Drive open
DS	Denison type sample
FS	Foil sample
RC	Rock core with size and percentage of recovery
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash Sample

2. PENETRATION RESISTANCE/'N'

Dynamic Cone Penetration Resistance:

A continuous profile showing the number of blows for each foot of penetration of a 2-inch diameter 90° point cone driven by a 140-pound hammer falling 30 inches.
Plotted as _____

Standard Penetration Resistance or 'N' value:

The number of blows of a 140-pound hammer falling 30 inches required to advance a 2-inch O.D. drive open sampler one foot into undisturbed soil.
Plotted as 'O'

WH	Sampler advanced by static weight
PH	Sampler advanced by hydraulic pressure
PM	Sampler advanced by manual pressure
NP	No penetration

3. SOIL DESCRIPTION

a) Cohesionless Soils:

'N' (Blows/ft)	Relative Density
0 to 4	very loose
4 to 10	loose
10 to 30	compact
30 to 50	dense
over 50	very dense

b) Cohesive Soils:

Undrained Shear Strength (ksf)	'N' (Blows/ft)	Consistency
Less than 0.25	0 to 2	very soft
0.25 to 0.50	2 to 4	soft
0.50 to 1.0	4 to 8	firm
1.0 to 2.0	8 to 16	stiff
2.0 to 4.0	16 to 32	very stiff
over 4.0	over 32	hard

c) Method of Determination of Undrained Shear Strength of Cohesive Soils:

x 0.0 - Field vane test in borehole
The number denotes the sensitivity to remoulding.

△ - Laboratory vane test

□ - Compression test in laboratory

For a saturated cohesive soil, the undrained shear strength is taken as one half of the undrained compressive strength.

METRIC CONVERSION FACTORS

1 ft. = 0.3048 metres
1 lb. = 0.453 kg
1 inch = 25.4 mm
1 ksf = 47.88 kN/m^2

Soil Engineers Ltd.
CONSULTING SOIL, FOUNDATION & ENVIRONMENTAL ENGINEERS
100 NUGGET AVENUE, SCARBOROUGH, ONTARIO M1S 3A7 TEL: (416) 754-8515 FAX: (416) 754-8516

JOB NO: 1204-S048

LOG OF BOREHOLE NO: 1

FIGURE NO: 1

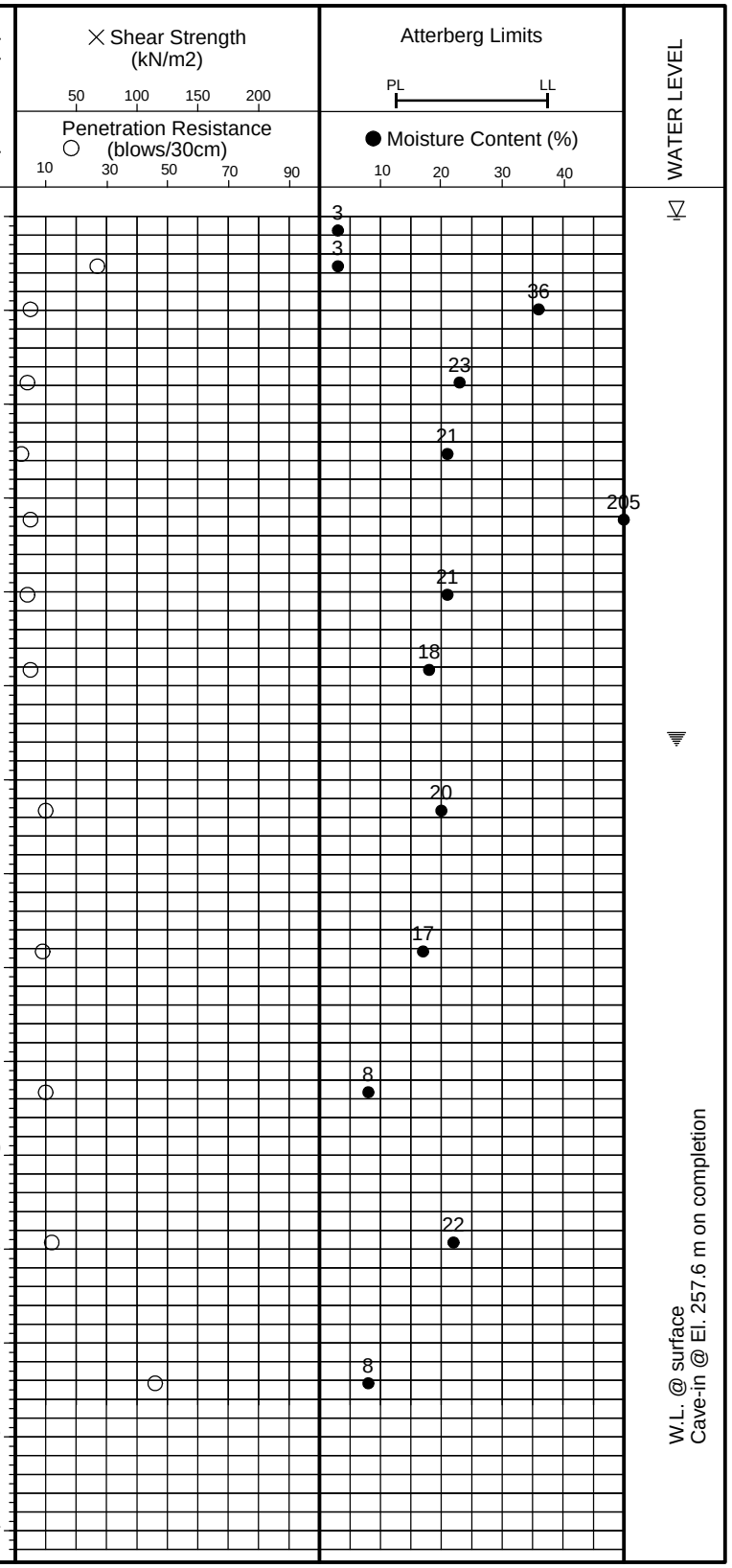
JOB DESCRIPTION: Proposed Culvert Replacement

JOB LOCATION: Centennial Drive to north of Brock Street
Town of Uxbridge

METHOD OF BORING: Flight-Auger

DATE: May 14, 2012

Depth Elev. (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)
0.0	Pavement Surface				0
263.1	**50 mm ASPHALTIC CONCRETE**	1A	AS		
	610 mm GRANULAR, Fill	1B	DO	27	
	Brown	2	DO	5	1
	SILTY CLAY, Fill and SILTY SAND, Fill				
	a trace of gravel occ. cobbles and boulders with organic material	3	DO	4	2
2.9		4	DO	2	
260.2	Black				3
	PEAT	5	DO	5	
3.7					
259.4	Grey, very loose **GRAVELLY SAND**	6	DO	4	4
4.4					
258.7	Grey, very loose **SILT** a trace to some clay a trace of fine sand occ. wet sand seams and layers	7	DO	5	5
		8	DO	10	6
7.0					7
256.1	Grey, stiff **SILTY CLAY, Till** traces of sand and gravel occ. wet sand and silt seams and layers, cobbles and boulders	9	DO	9	8
		10	DO	10	9
10.1					10
253.0	Grey, compact **SILT** traces of clay and fine sand occ. wet sand seams and layers	11	DO	12	11
12.0					12
251.1	Grey, dense **GRAVELLY SAND** some silt	12	DO	46	
12.7					13
250.4	**END OF BOREHOLE**				14



Soil Engineers Ltd.

JOB NO: 1204-S048

LOG OF BOREHOLE NO: 2

FIGURE NO: 2

JOB DESCRIPTION: Proposed Culvert Replacement

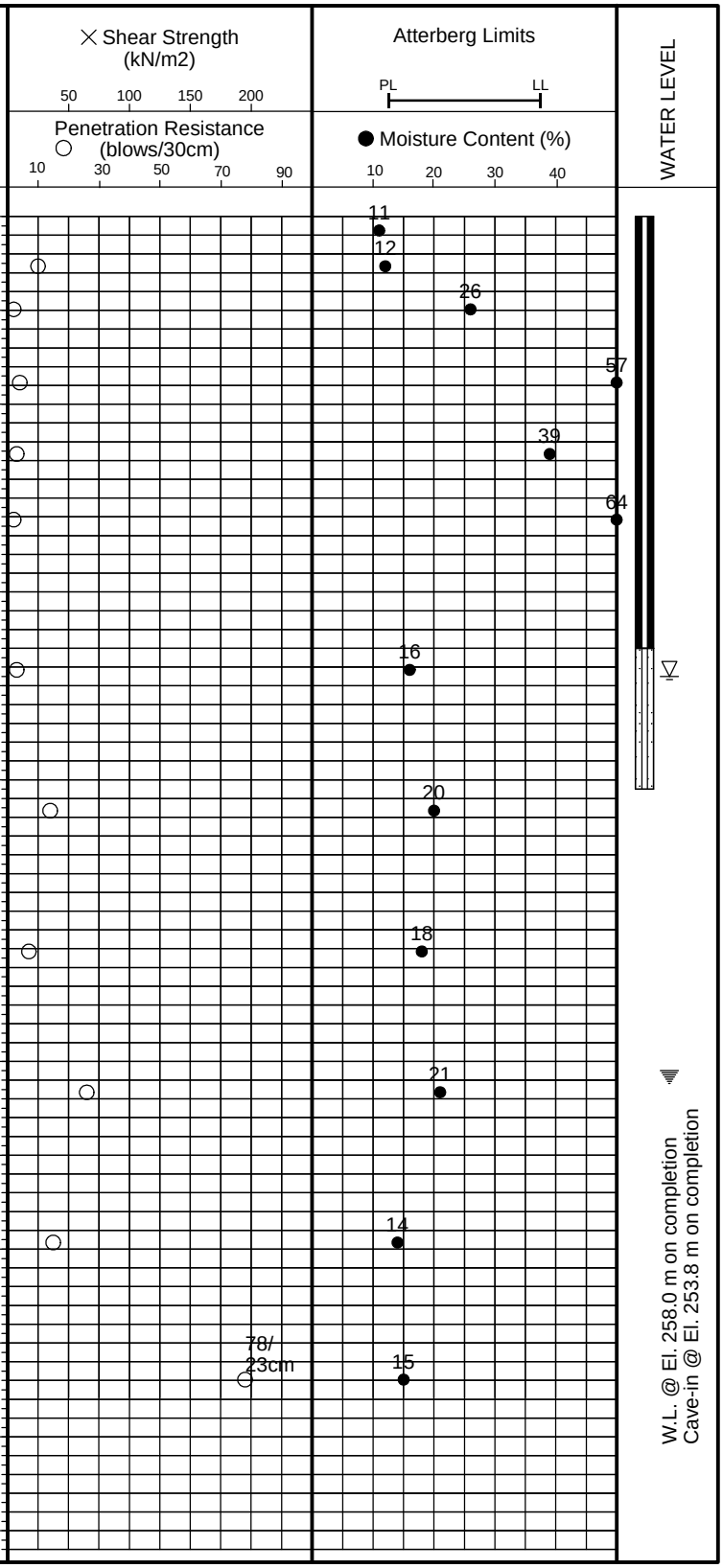
JOB LOCATION: Centennial Drive to north of Brock Street
Town of Uxbridge

METHOD OF BORING: Flight-Auger

DATE: May 14, 2012

Depth Elev. (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
0.0	Pavement Surface			
262.9	**50 mm ASPHALTIC CONCRETE**	1A	AS	
	300 mm GRANULAR, Fill	1B	DO	10
	Brown **SILTY SAND, Fill** a trace of gravel occ. cobbles and boulders with organic material	2	DO	2
1.5				
261.4		3	DO	4
	TOPSOIL			
	dark brown grey	4	DO	3
		5	DO	2
4.0				
258.9	Grey, very loose **SANDY SILT, Till** a trace to some clay a trace of gravel occ. wet sand and silt seams and layers, cobbles and boulders	6	DO	3
5.5				
257.4	Grey, loose to compact **SILT** some clay occ. wet sand seams and layers	7	DO	14
		8	DO	7
		9	DO	26
10.1				
252.8	Grey, compact to very dense **SILTY SAND, Till** a trace of clay a trace to some gravel occ. wet sand and silt seams and layers, cobbles and boulders	10	DO	15
		11	DO	78/ 23cm
12.6				
250.3	**END OF BOREHOLE**			

Installed 50 mm Ø monitoring well to 6.1 m (1.5 m screen)
Sand backfill from 4.6 m to 6.1 m
Bentonite holeplug from 0.0 m to 4.0 m
Provided with top and bottom caps



Soil Engineers Ltd.

JOB NO: 1204-S048

LOG OF BOREHOLE NO: 3

FIGURE NO: 3A

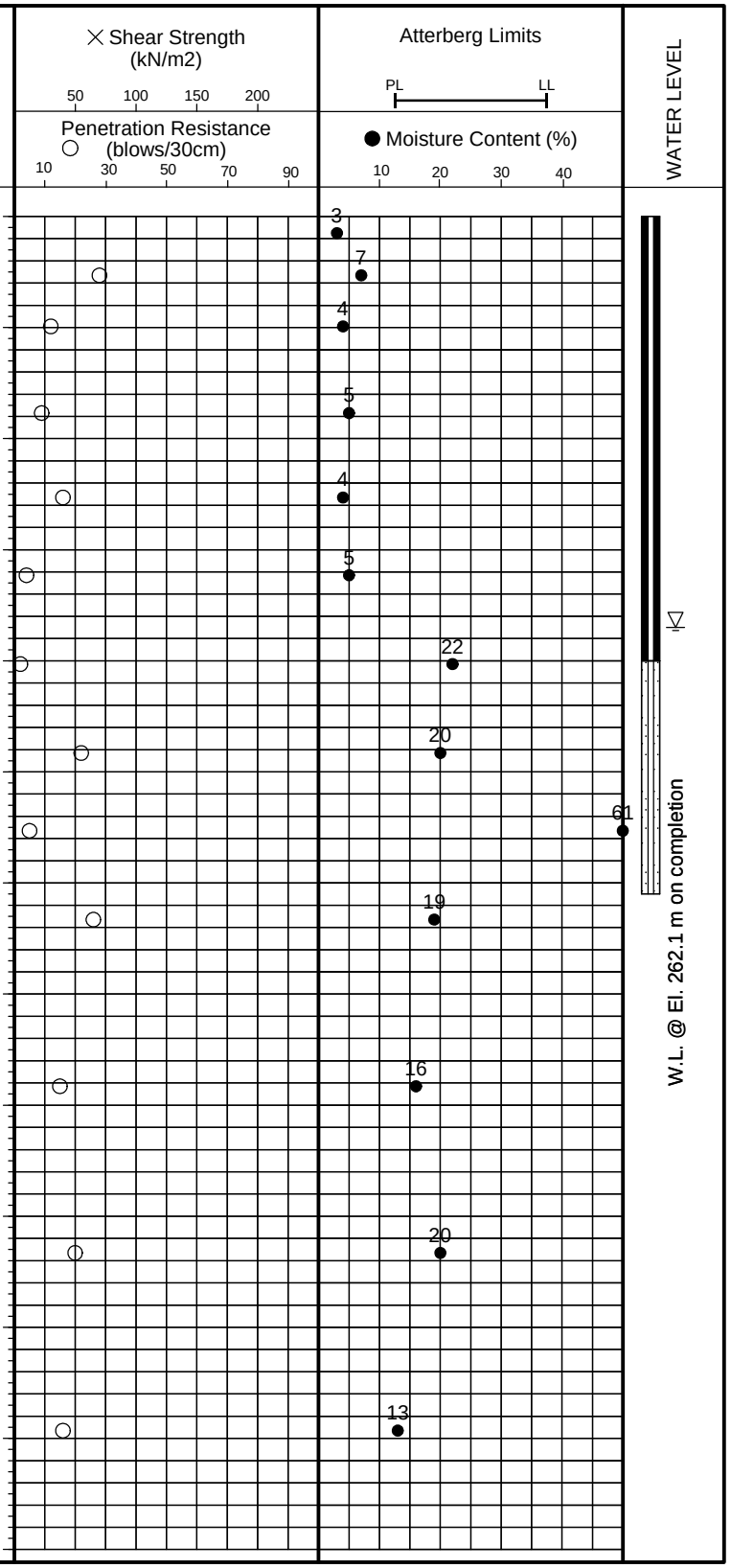
JOB DESCRIPTION: Proposed Culvert Replacement

JOB LOCATION: Centennial Drive to north of Brock Street
Town of Uxbridge

METHOD OF BORING: Flight-Auger

DATE: May 7, 2012

Depth / Elev. (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
0.0	Pavement Surface			
265.8	**100 mm ASPHALTIC CONCRETE**	1	AS	-
	200 mm GRANULAR, Fill			
	Brown	2	DO	28
		3	DO	12
	SILTY SAND, Fill and SAND, Fill			
		4	DO	9
	a trace of gravel occ. cobbles and boulders with organic material, wood and rock inclusions pieces of rock	5	DO	16
		6	DO	4
3.6				
262.2	Grey			
	FINE TO COARSE SAND, Fill a trace to some sand a trace of gravel occ. cobbles and boulders	7	DO	2
4.4				
261.4	Grey wood pieces	8	DO	22
	SILTY SAND, Fill and SANDY SILT, Fill brick fragments	9	DO	5
	a trace of gravel occ. cobbles and boulders with wood inclusions and brick fragments	10	DO	26
6.6				
259.2	Grey, compact			
	SILT clay layers	11	DO	15
	a trace to some fine sand occ. gravel, clay seams and layers and cobbles	12	DO	20
10.1				
255.7	Grey, stiff			
	SILTY CLAY, Till silt layers	13	DO	16
	some sand, a trace of gravel occ. wet sand and silt seams and layers, cobbles and boulders			
12.0				



Soil Engineers Ltd.

JOB NO: 1204-S048

LOG OF BOREHOLE NO: 3

FIGURE NO: 3B

JOB DESCRIPTION: Proposed Culvert Replacement

JOB LOCATION: Centennial Drive to north of Brock Street
Town of Uxbridge

METHOD OF BORING: Flight-Auger

DATE: May 7, 2012

Depth / Elev. (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)	Shear Strength (kN/m2) / Penetration Resistance (blows/30cm)	Atterberg Limits / Moisture Content (%)	WATER LEVEL
12.0 / 253.8	Grey, very dense **SILTY SAND, Till and SANDY SILT, Till** a trace of gravel occ. wet sand and silt seams and layers, cobbles and boulders	14	DO	72	12	○ 90	● 11	
		15	DO	92	13	○ 90	● 9	
14.6 / 251.2	Grey, very dense **SILTY SAND, Till** some gravel to gravelly a trace of clay occ. wet sand and silt seams and layers, cobbles and boulders	16	DO	50/ 13	14	50/ 13cm	● 10	
		17	DO	50/ 15	15	50/ 15cm	● 11	
17.7 / 248.1	Grey, very dense **SANDY SILT, Till** a trace of gravel occ. wet sand and silt seams and layers, cobbles and boulders	18	DO	92/ 23	16	92/ 23cm	● 13	
19.4 / 246.4	Grey, very dense **GRAVELLY SAND** a trace to some silt occ. cobbles and boulders	19	DO	50/ 15	17	50/ 15cm	● 9	
20.0 / 245.8	**END OF BOREHOLE**				18			
	Installed 50 mm Ø monitoring well to 6.1 m (1.5 m screen) Sand backfill from 4.0 m to 6.1 m Bentonite holeplug from 0.0 m to 4.0 m Provided with top and bottom caps				19			
					20			
					21			
					22			
					23			
					24			

W.L. @ El. 262.1 m on completion

Soil Engineers Ltd.

JOB NO: 1204-S048

LOG OF BOREHOLE NO: 4

FIGURE NO: 4A

JOB DESCRIPTION: Proposed Culvert Replacement

JOB LOCATION: Centennial Drive to north of Brock Street
Town of Uxbridge

METHOD OF BORING: Flight-Auger

DATE: May 8, 2012

Depth Elev. (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
0.0	Pavement Surface			
265.5	**100 mm ASPHALTIC CONCRETE**	1	DO	-
	650 mm GRANULAR, Fill	2	DO	34
		3	DO	14
	SILTY CLAY, Fill brown grey			
		4	AS	-
			DO	4
	a trace to some sand a trace of gravel occ. sand seams with organic material and root inclusions			
		5	DO	2
3.2	organic materials			
262.3	Grey	6	DO	2
	SILTY SAND, Fill and SANDY SILT, Fill traces of clay and gravel with organic material and root inclusions	7	DO	2
4.4				
261.1	Grey			
	SILTY CLAY, Fill some sand to sandy a trace of gravel	8	DO	6
5.3				
260.2	**TOPSOIL**	9	DO	4
	Grey, very loose, weathered **SILTY FINE SAND** a trace to some clay occ. sand seams and layers			
6.0				
259.5		10	DO	4
	Grey, loose to very dense			
	SILTY SAND, Till and SANDY SILT, Till weathered			
	a trace to some gravel a trace of clay occ. wet sand and silt seams and layers, cobbles and boulders	11	DO	8
		12	DO	60
		13	DO	50/ 15
12.0				

Depth Scale (m): 0 1 2 3 4 5 6 7 8 9 10 11 12

× Shear Strength (kN/m2): 50 100 150 200

Penetration Resistance ○ (blows/30cm): 10 30 50 70 90

Atterberg Limits: PL — LL

● Moisture Content (%): 10 20 30 40

Moisture Content ● values: 4, 4, 16, 14, 16, 20, 19, 27, 27, 20, 17, 8, 10

50/ 15cm

WATER LEVEL

W.L. @ El. 263.1 m on completion

Soil Engineers Ltd.

JOB NO: 1204-S048

LOG OF BOREHOLE NO: 4

FIGURE NO: 4B

JOB DESCRIPTION: Proposed Culvert Replacement

JOB LOCATION: Centennial Drive to north of Brock Street
Town of Uxbridge

METHOD OF BORING: Flight-Auger

DATE: May 8, 2012

Depth / Elev. (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)	Shear Strength (kN/m2) / Penetration Resistance (blows/30cm)	Atterberg Limits / Moisture Content (%)	WATER LEVEL
12.0					12			
253.5	Grey, loose to very dense **SILTY SAND, Till and SANDY SILT, Till** a trace to some gravel a trace of clay occ. wet sand and silt seams and layers, cobbles and boulders	14	DO	50/ 15		50/ 15cm	9	
13.0 252.5	Grey, dense to very dense				13			
	SILTY SAND, Till	15	DO	50/ 15	14	50/ 15cm	11	
	some gravel occ. wet sand and silt seams and layers, cobbles and boulders	16	DO	44	15		11	
16.2 249.3	Grey, very dense				16			
	GRAVELLY SAND	17	DO	50/ 10	17	50/ 10cm	11	
	a trace to some silt occ. cobbles and boulders	18	DO	50/ 15	18	50/ 15cm	6	
20.0 245.5	**END OF BOREHOLE** Installed 50 mm Ø monitoring well to 6.1 m (1.5 m screen) Sand backfill from 4.0 m to 6.1 m Bentonite holeplug from 0.0 m to 4.0 m Provided with top and bottom caps	19	DO	50/ 15	19 20	50/ 15cm	6	W.L. @ El. 263.1 m on completion
					21			
					22			
					23			
					24			

Soil Engineers Ltd.

JOB NO: 1204-S048

LOG OF BOREHOLE NO: 5

FIGURE NO: 5A

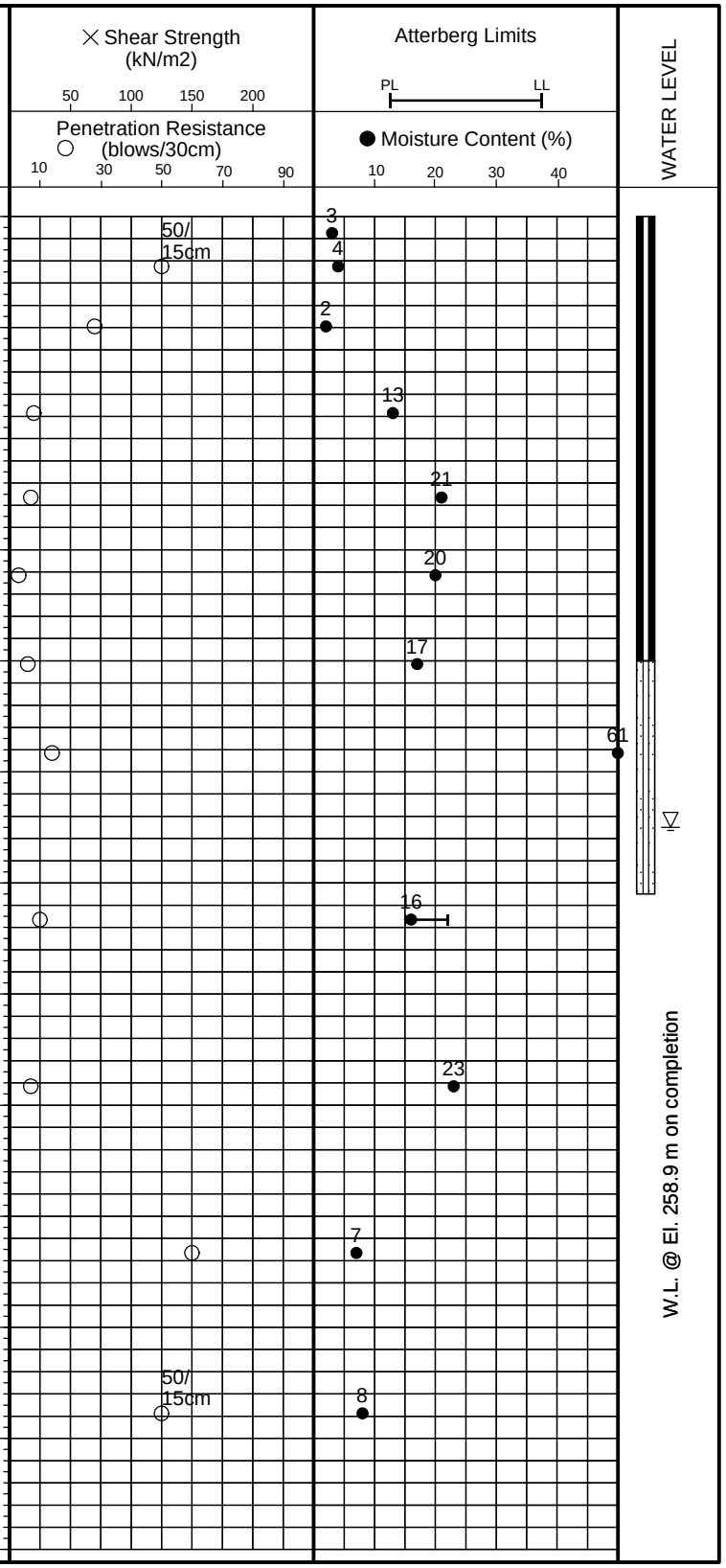
JOB DESCRIPTION: Proposed Culvert Replacement

JOB LOCATION: Centennial Drive to north of Brock Street
Town of Uxbridge

METHOD OF BORING: Flight-Auger

DATE: May 7 and 8, 2012

Depth Elev. (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
0.0	Pavement Surface			
264.4	**50 mm ASPHALTIC CONCRETE**	1	AS	-
	650 mm GRANULAR, Fill	2	DO	50/15
	Grey **SAND, Fill** (rock pieces) a trace of gravel with rock inclusions	3	DO	28
1.4				
263.0	Grey	4	DO	8
	SILTY CLAY, Fill (wood pieces) a trace to some sand a trace of gravel with wood, root and rock inclusions	5	DO	7
		6	DO	3
		7	DO	6
4.6				
259.8	**TOPSOIL**	8	DO	14
	Grey, stiff **SILTY CLAY, Till** (weathered) traces of sand and gravel (silt layers) occ. wet sand and silt seams and layers, cobbles and boulders	9	DO	10
7.1				
257.3	Grey, loose **SILT** some clay, a trace of fine sand occ. clay seams and layers	10	DO	7
8.5				
255.9	Grey, very dense	11	DO	60
	SILTY SAND, Till and SANDY SILT, Till (rock/boulder pieces) a trace of gravel occ. wet sand and silt seams and layers, cobbles and boulders with rock inclusions	12	DO	50/15
12.0				



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JOB NO: 1204-S048

LOG OF BOREHOLE NO: 5

FIGURE NO: 5B

JOB DESCRIPTION: Proposed Culvert Replacement

JOB LOCATION: Centennial Drive to north of Brock Street
Town of Uxbridge

METHOD OF BORING: Flight-Auger

DATE: May 7 and 8, 2012

Depth / Elev. (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)	× Shear Strength (kN/m2) 50 100 150 200 / ○ Penetration Resistance (blows/30cm) 10 30 50 70 90	Atterberg Limits PL — LL / ● Moisture Content (%) 10 20 30 40	WATER LEVEL
12.0 / 252.4	Grey, very dense **SILTY SAND, Till and SANDY SILT, Till** a trace of gravel occ. wet sand and silt seams and layers, cobbles and boulders	13	DO	62	12		10	
		14	DO	50/ 15	13	50/ 15cm	7	
14.6 / 249.8	Grey, very dense **GRAVELLY SAND** a trace of silt to silty occ. cobbles and boulders	15	DO	50/ 15	14	50/ 15cm	12	
		16	DO	50/ 15	15	50/ 15cm	8	
		17	DO	50/ 8	16	50/ 8cm	8	
20.0 / 244.4	**END OF BOREHOLE** Installed 50 mm Ø monitoring well to 6.1 m (1.5 m screen) Sand backfill from 4.0 m to 6.1 m Bentonite holeplug from 0.0 m to 4.0 m Provided with top and bottom caps	18	DO	50/ 15	17 18 19 20 21 22 23 24	50/ 15cm	10	W.L. @ El. 258.9 m on completion

Soil Engineers Ltd.

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GRAIN SIZE DISTRIBUTION

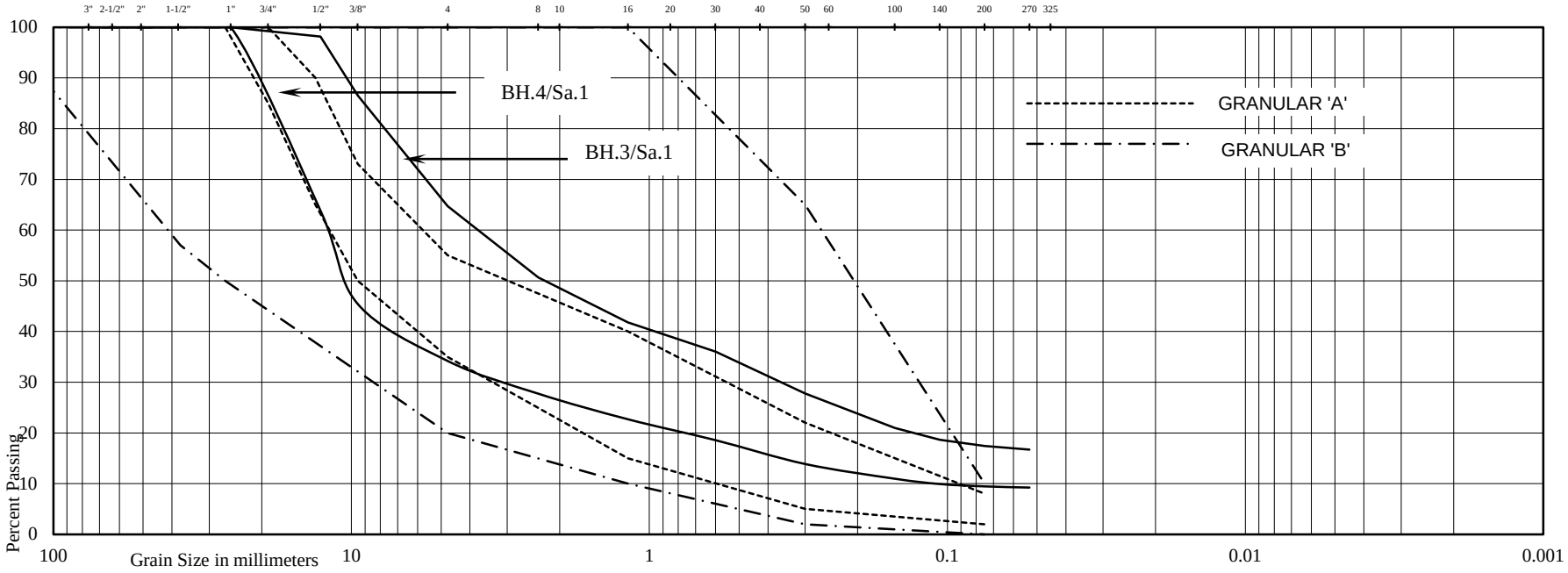
Reference No: 1204-S048

U.S. BUREAU OF SOILS CLASSIFICATION

GRAVEL		SAND				SILT	CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	V. FINE		

UNIFIED SOIL CLASSIFICATION

GRAVEL		SAND			SILT & CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	



Project:	Proposed Culvert Replacement		BH./Sa.	3/1	4/1
Location:	Centennial Drive to north of Brock Street, Town of Uxbridge		Liquid Limit (%) =	-	-
			Plastic Limit (%) =	-	-
Borehole No:	3	4	Plasticity Index (%) =	-	-
Sample No:	1	1	Moisture Content (%) =	3	4
Depth (m):	0.2	0.2	Estimated Permeability		
Elevation (m):	265.6	265.3	(cm./sec.) =	10^{-4}	10^{-2}

Classification of Sample [& Group Symbol]: GRANULAR, Fill
a trace to some silt

Figure: 6

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

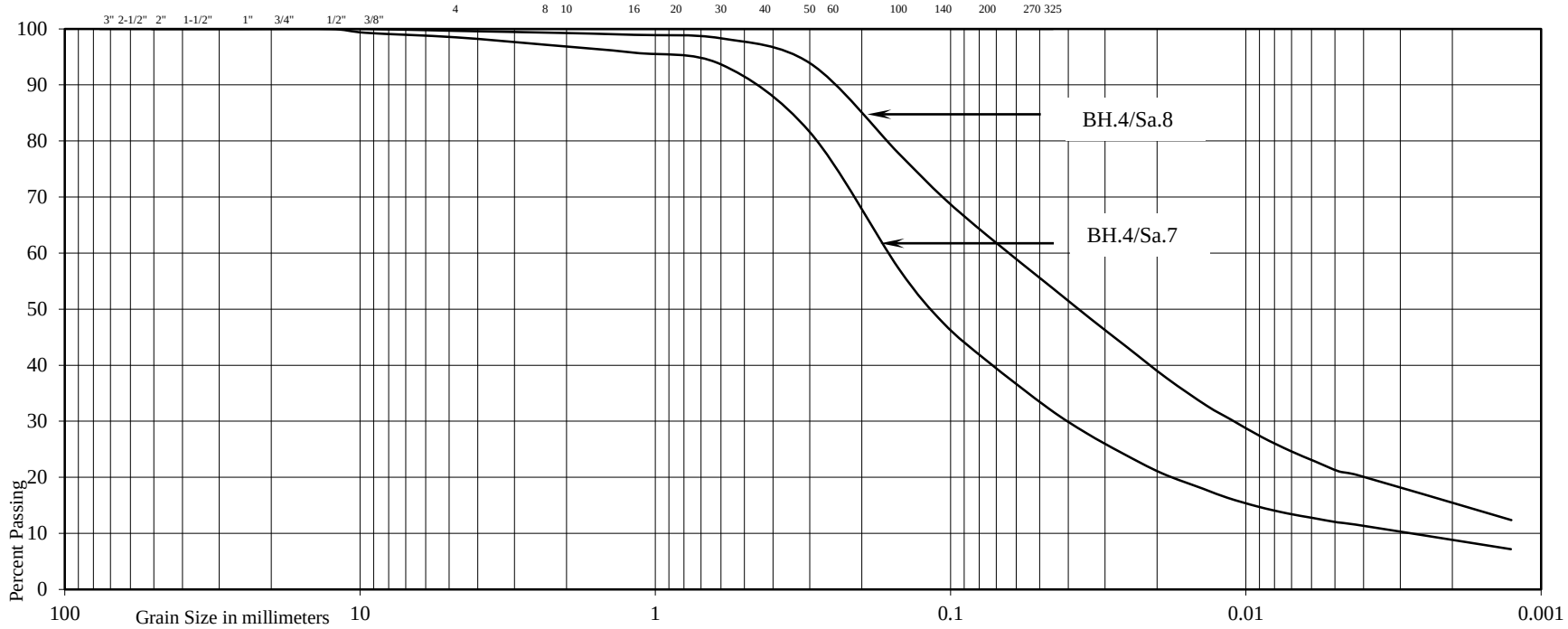
Reference No: 1204-S048

U.S. BUREAU OF SOILS CLASSIFICATION

GRAVEL		SAND				SILT	CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	V. FINE		

UNIFIED SOIL CLASSIFICATION

GRAVEL		SAND			SILT & CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	



Project: Proposed Culvert Replacement

Location: Centennial Drive to north of Brock Street, Town of Uxbridge

Borehole No:	4	4
Sample No:	7	8
Depth (m):	4.0	4.8
Elevation (m):	261.5	260.7

BH./Sa.	4/7	4/8
Liquid Limit (%) =	-	-
Plastic Limit (%) =	-	-
Plasticity Index (%) =	-	-
Moisture Content (%) =	19	27
Estimated Permeability (cm./sec.) =	10^{-6}	10^{-6}

Classification of Sample [& Group Symbol]:

BH.4/Sa.7 - SILTY SAND, Fill, some clay, a trace of gravel

BH.4/Sa.8 - SILTY CLAY, Fill, sandy

Figure: 7

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

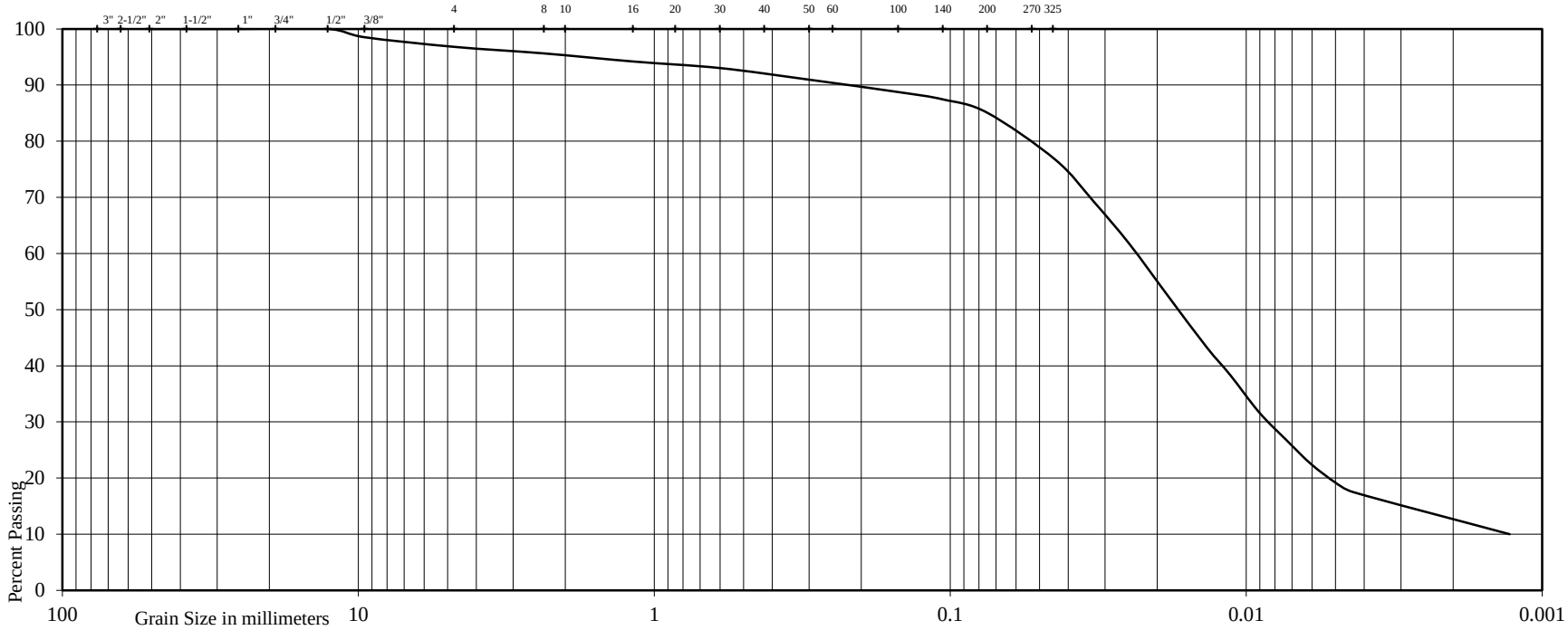
Reference No: 1204-S048

U.S. BUREAU OF SOILS CLASSIFICATION

GRAVEL		SAND				SILT	CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	V. FINE		

UNIFIED SOIL CLASSIFICATION

GRAVEL		SAND			SILT & CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	



Project: Proposed Culvert Replacement

Location: Centennial Drive to north of Brock Street, Town of Uxbridge

Borehole No: 5

Sample No: 9

Depth (m): 6.4

Elevation (m): 258.0

Liquid Limit (%) = 22

Plastic Limit (%) = 15

Plasticity Index (%) = 7

Moisture Content (%) = 16

Estimated Permeability (cm./sec.) = 10^{-6}

Classification of Sample [& Group Symbol]: SILTY CLAY, Till
traces of sand and gravel

Figure: 8

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

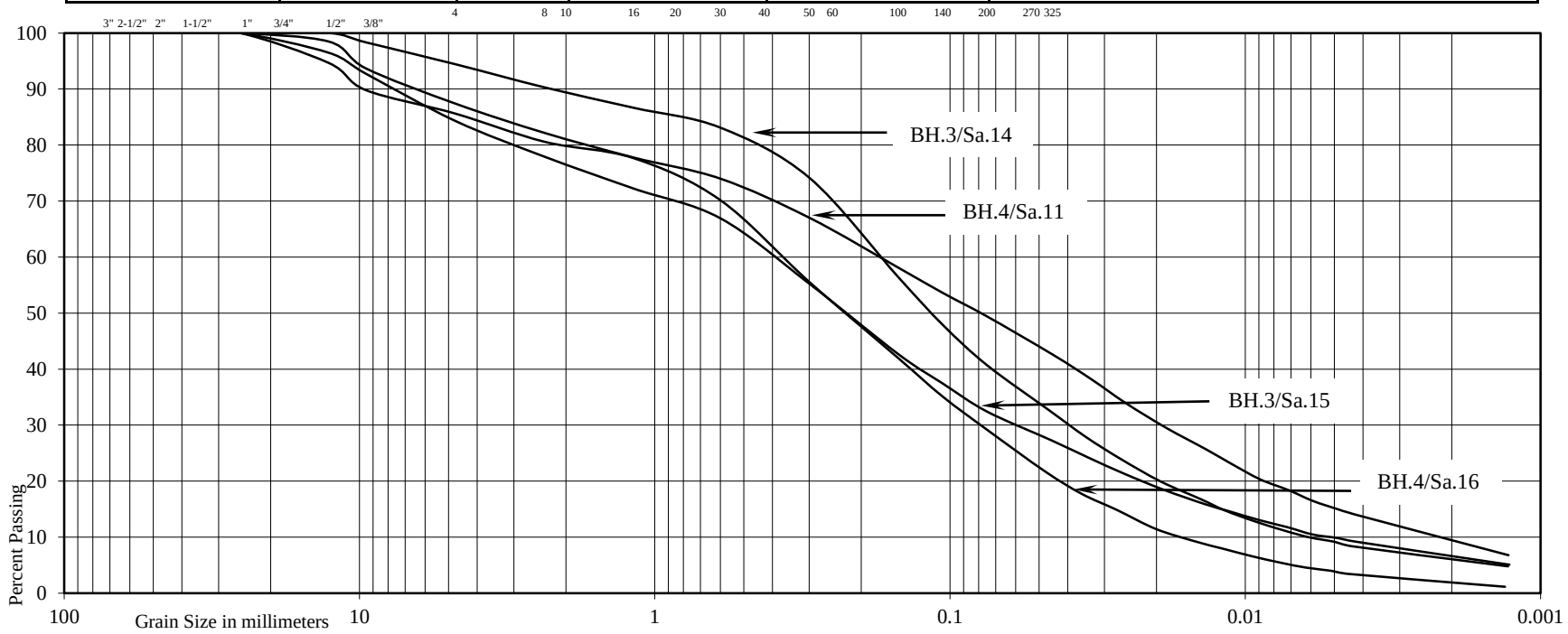
Reference No: 1204-S048

U.S. BUREAU OF SOILS CLASSIFICATION

GRAVEL		SAND				SILT	CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	V. FINE		

UNIFIED SOIL CLASSIFICATION

GRAVEL		SAND			SILT & CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	



Project: Proposed Culvert Replacement

Location: Centennial Drive to north of Brock Street, Town of Uxbridge

Borehole No:	3	3	4	4
Sample No:	14	15	11	16
Depth (m):	12.5	14.0	7.8	15.3
Elevation (m):	253.3	251.8	257.7	250.2

BH./Sa.	3/14	3/15	4/11	4/16
Liquid Limit (%) =	-	-	-	-
Plastic Limit (%) =	-	-	-	-
Plasticity Index (%) =	-	-	-	-
Moisture Content (%) =	11	9	17	11
Estimated Permeability (cm./sec.) =	10^{-5}	10^{-5}	10^{-6}	10^{-4}

Classification of Sample [& Group Symbol]: SILTY SAND, Till
traces to some clay and gravel

Figure: 9

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

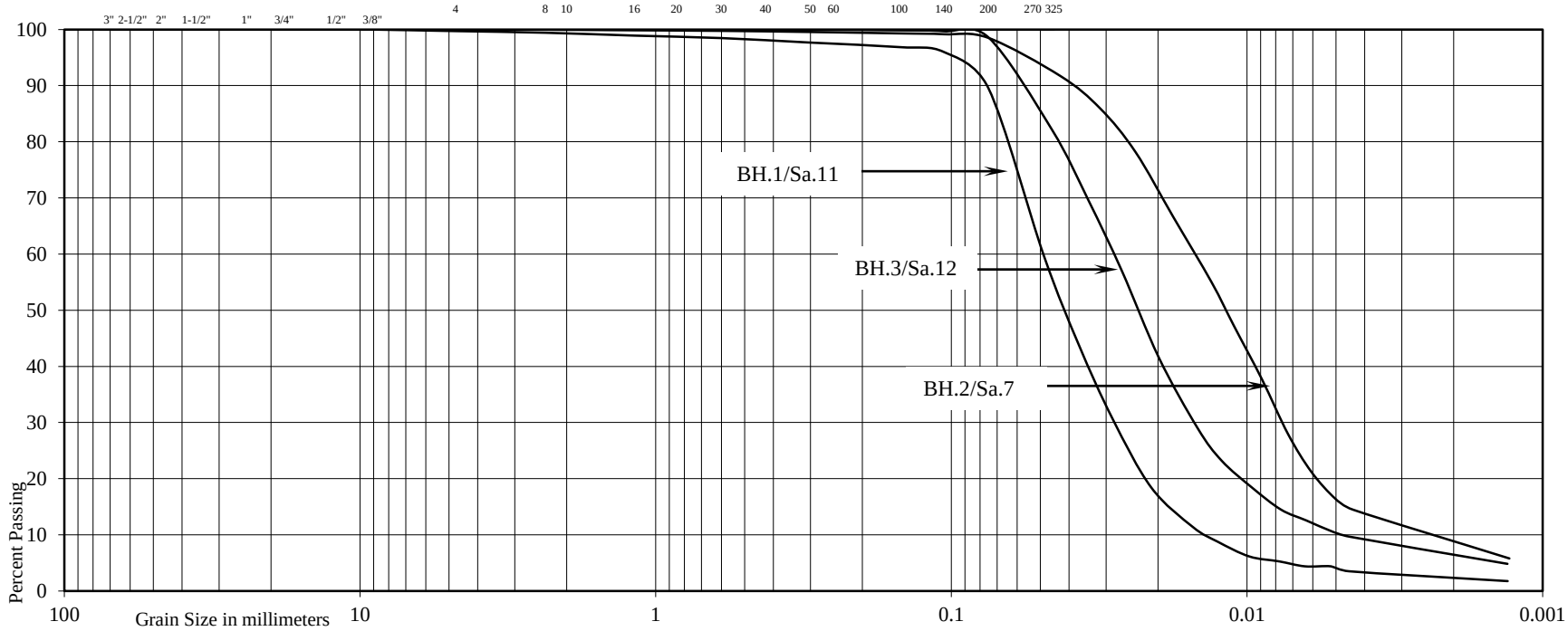
Reference No: 1204-S048

U.S. BUREAU OF SOILS CLASSIFICATION

GRAVEL		SAND				SILT	CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	V. FINE		

UNIFIED SOIL CLASSIFICATION

GRAVEL		SAND			SILT & CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	



Project: Proposed Culvert Replacement

Location: Centennial Drive to north of Brock Street, Town of Uxbridge

Borehole No:	1	2	3
Sample No:	11	7	12
Depth (m):	10.9	6.3	9.3
Elevation (m):	252.2	256.6	256.5

BH./Sa.	1/11	2/7	3/12
Liquid Limit (%) =	-	-	-
Plastic Limit (%) =	-	-	-
Plasticity Index (%) =	-	-	-
Moisture Content (%) =	22	20	20
Estimated Permeability (cm./sec.) =	10^{-4}	10^{-6}	10^{-5}

Classification of Sample [& Group Symbol]: SILT

a trace to some clay, a trace of fine sand

Figure: 10

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

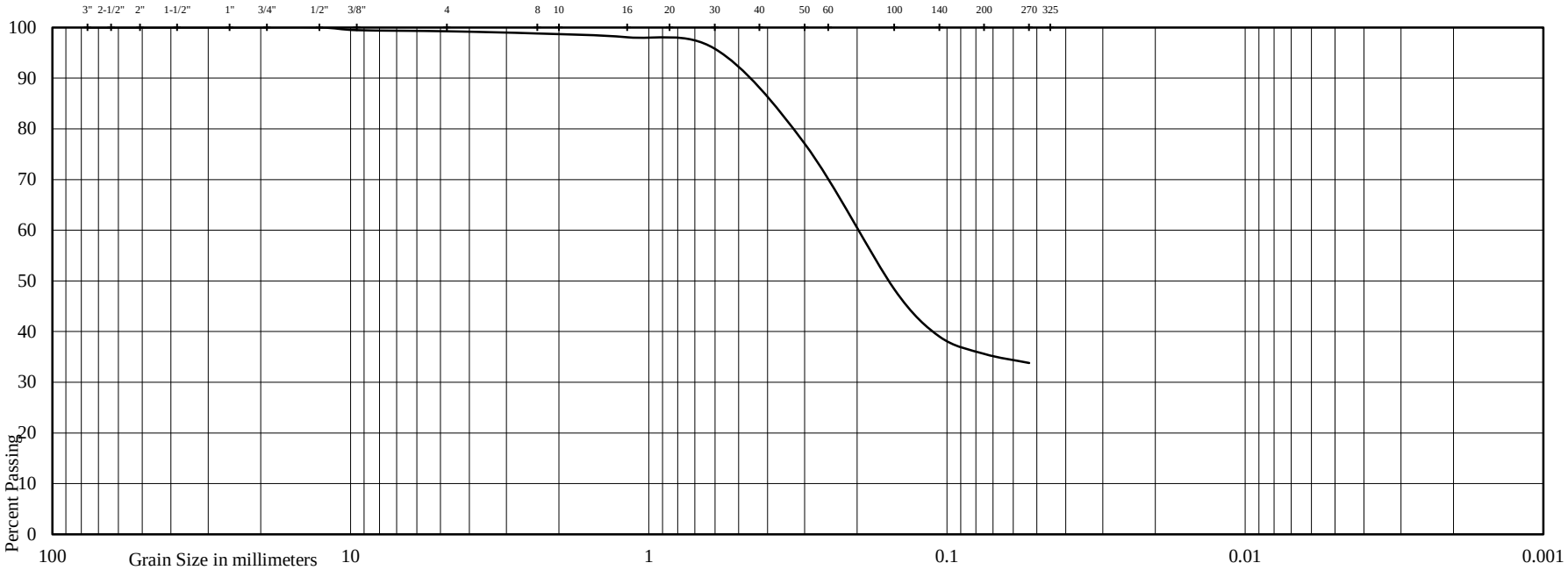
Reference No: 1204-S048

U.S. BUREAU OF SOILS CLASSIFICATION

GRAVEL		SAND				SILT	CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	V. FINE		

UNIFIED SOIL CLASSIFICATION

GRAVEL		SAND			SILT & CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	



Project: Proposed Culvert Replacement

Location: Centennial Drive to north of Brock Street, Town of Uxbridge

Borehole No: 4

Sample No: 9

Depth (m): 5.6

Elevation (m): 259.9

Liquid Limit (%) = -

Plastic Limit (%) = -

Plasticity Index (%) = -

Moisture Content (%) = 27

Estimated Permeability (cm./sec.) = 10^{-6}

Classification of Sample [& Group Symbol]: SILTY FINE SAND

Figure: 11

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

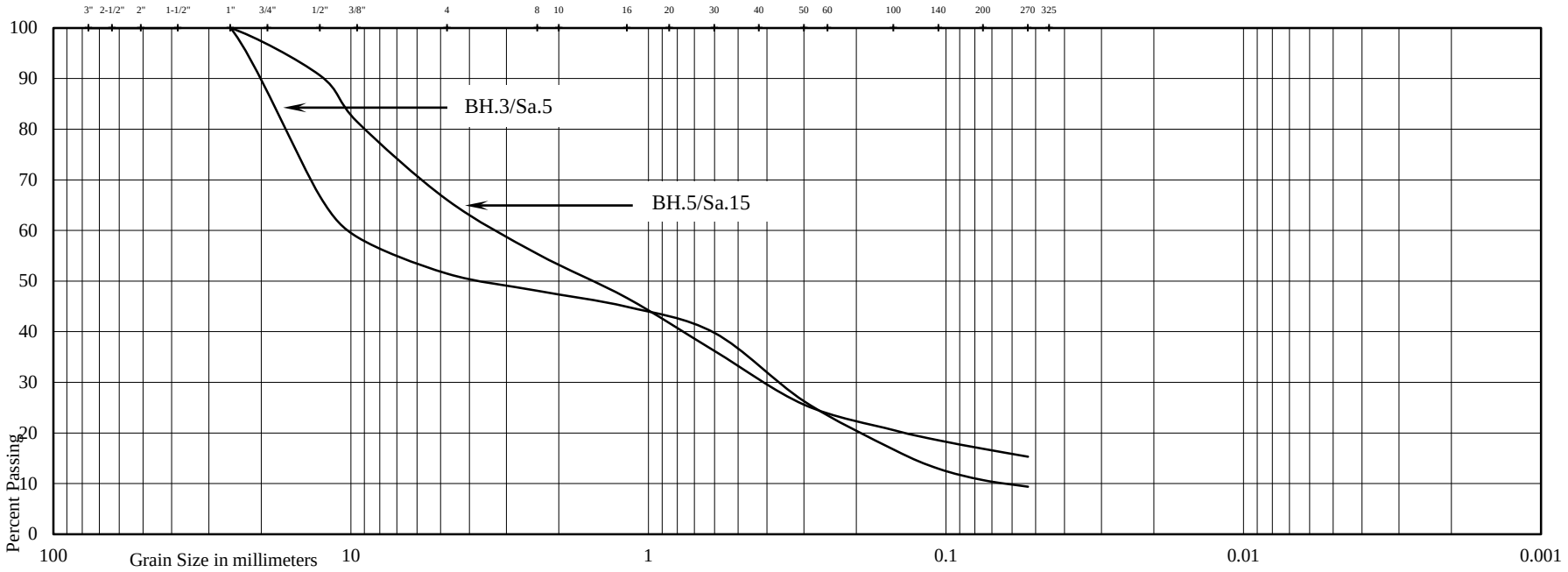
Reference No: 1204-S048

U.S. BUREAU OF SOILS CLASSIFICATION

GRAVEL		SAND				SILT	CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	V. FINE		

UNIFIED SOIL CLASSIFICATION

GRAVEL		SAND			SILT & CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

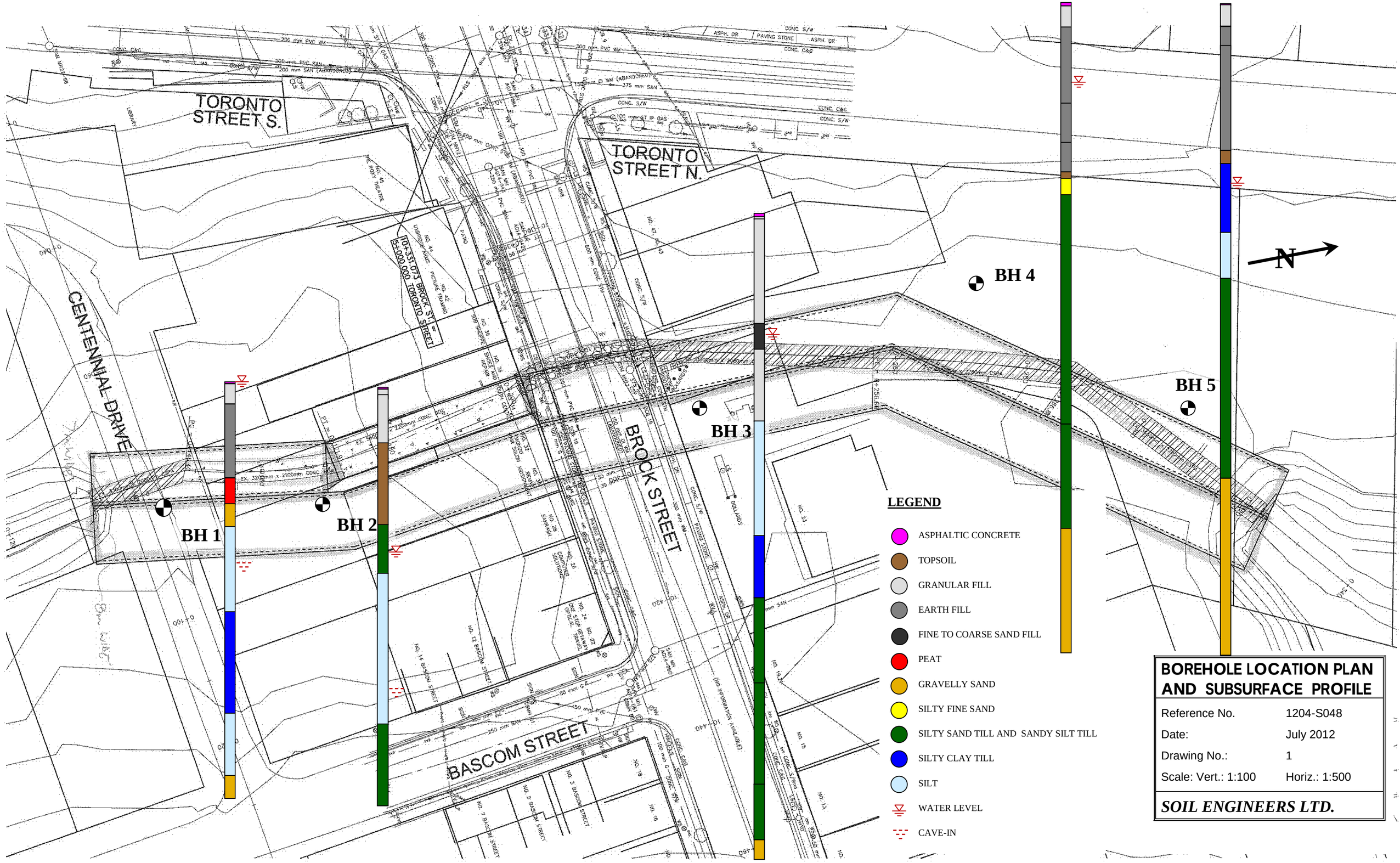


Project:	Proposed Culvert Replacement	
Location:	Centennial Drive to north of Brock Street, Town of Uxbridge	
Borehole No:	3	5
Sample No:	5	15
Depth (m):	2.5	15.3
Elevation (m):	263.3	249.1

BH./Sa.	3/5	5/15
Liquid Limit (%) =	-	-
Plastic Limit (%) =	-	-
Plasticity Index (%) =	-	-
Moisture Content (%) =	4	12
Estimated Permeability (cm./sec.) =	10^{-3}	10^{-3}

Classification of Sample [& Group Symbol]: GRAVELLY SAND
some silt

Figure: 12



BOREHOLE LOCATION PLAN AND SUBSURFACE PROFILE

Reference No.	1204-S048
Date:	July 2012
Drawing No.:	1
Scale: Vert.: 1:100	Horiz.: 1:500

SOIL ENGINEERS LTD.

V. A. WOOD ASSOCIATES LIMITED

CONSULTING GEOTECHNICAL ENGINEERS

1080 TAPSCOTT ROAD, UNIT 24, SCARBOROUGH, ONTARIO M1X 1E7

TELEPHONE: (416) 292-2868 • FAX No: (416) 292-5375

GEOTECHNICAL INVESTIGATION
CULVERT RECONSTRUCTION
BROCK STREET/CENTENNIAL DRIVE
UXBRIDGE, ONTARIO

Ref. No. 7171-17-6

Revised February 2018

Prepared for:

AECOM
300 Water Street
Whitby, Ontario
L1N 9J2

C O N T E N T S

A P P E N D I C E S

E N C L O S U R E S

*1.0 **INTRODUCTION***

V.A. Wood Associates Limited was retained by AECOM to carry out a geotechnical investigation for the proposed reconstruction of the existing culvert at Brock Street and Centennial Drive in Uxbridge, Ontario.

The replacement culvert will be a twin concrete structure and will be built by cut and fill. There are existing buildings along and adjacent the culvert alignment and shoring works to protect these buildings are required.

The culverts are located at the base of a wide valley which has been filled over the years and subsequently developed.

The purpose of the investigation was to reveal the subsurface conditions and to determine the relevant soil properties for the design and construction of the foundation of the replacement culvert and reinstatement of the road pavement, restoration of parking lot, and provide recommendations for shoring and dewatering works.

2.0 ***FIELD WORK***

The field work was carried out between August 26 and August 30, 2017 and consisted of eleven boreholes at the locations shown on Enclosure 1. The boreholes were advanced to the sampling depths by means of a power-auger machine, equipped for soil sampling. Standard Penetration tests were carried out at frequent intervals of depth and the results are shown on the Borehole Logs as N-values.

Monitoring wells, consisting of 50 mm diameter PVC pipes with 1.5 to 3 m screens at the bottom were installed in ten of the boreholes.

The field work was supervised by a soils technician and the soil samples were transported to our soils laboratory for further examination, classification and testing. The ground elevation at each borehole location was provided by I. B. W. Surveyors.

*3.0 **SUBSURFACE CONDITIONS***

Full details of the soils encountered in each borehole are given on the Borehole Logs, Enclosures 2 to 12 inclusive, and the following notes are intended to summarize this data.

All of the boreholes were augered to a depth of 0.75 m. No sampling or testing was carried out over this section.

*From a depth of 0.75 m, all of the boreholes encountered a layer of **fill**, which extended to a depth of between 2.9 and 4.4 m below grade. The fill varies in composition from gravelly sand to sandy silt, with seams of silty clay in places. Standard Penetration tests in the fill gave N-values between 1 and 34 blows/300mm, and generally less than 10 blows/300 mm.*

Based on the test results, the fill is considered to be in a generally loose to very loose condition.

*Except in Boreholes 2, 3 and 10, the fill was underlain by a deposit of **silt sand**, which extended to a depth of between 3.6 and 7 m below grade. This deposit generally contained peat, wood fragments and/or topsoil, and is likely to be alluvial in origin. Standard Penetration tests in this deposit gave N-values between 4 and 12 blows/300mm (24 blows/300mm in Borehole 9). The grain size distribution of the silty sand sections of this deposit are shown in Enclosures 13 and 14.*

Based on the test results, the silty sand with peat/wood/ topsoil is considered to have a generally loose relative density. It is noted that the alluvial deposit in most of the boreholes contained tree trunks and/or stumps.

The fill in Boreholes 2, 3 and 10, and the silty sand in Boreholes 4, 7 and 9 were underlain by a deposit of ***gravelly sand****, which extended to a depth of between 5.5 and 6.6 m below grade. This deposit is comprised generally of well graded sand and fine to medium sub-rounded gravel and is likely alluvial in origin. Standard Penetration tests in this deposit gave N-values between 4and 15 blows/300mm. The grain size distribution of representative samples of the gravelly sand are shown in Enclosures 15 to 18.*

Based on the test results, the gravelly sand is considered to have a generally loose to medium compact relative density.

The silty sand in Boreholes 1, 5, 6, 8 and 9, and the gravelly sand in Boreholes 2, 3, 4, 9 and 10 were underlain by a deposit of ***sandy silt****, which extended to a depth of between 17 and more than 9.6 m below grade (maximum depth investigated). This deposit is comprised of bedded silt and very fine sand. Standard Penetration tests in this deposit gave N-values between 3 and 40 blows/300mm. The grain size distribution of representative samples of the sandy silt are shown in Enclosures 19 to 24.*

Based on the test results, the sandy silt is considered to have a generally compact relative density (loose or dense in places).

*The sandy silt in Borehole 11 was underlain by a deposit of **sandy silt till**, which extended to a depth of more than 9.6 m below grade (maximum depth investigated). This glacial deposit is comprised of a sandy silt matrix which contained traces of fine gravel. Standard Penetration tests in this deposit gave N-values between 6 and 23 blows/300mm. The grain size distribution of a representative sample of the sandy silt till is shown in Enclosure 25.*

Based on the test results, the sand and gravel is considered to have a dense relative density

Based on the test results, the sandy silt till is considered to have loose to dense relative density.

*The sandy silt in Boreholes 2 and 3 was underlain by a deposit of **sand and gravel**, which extended to a depth of more than 9.6 m below grade (maximum depth investigated). Standard Penetration tests in this deposit gave N-values between 31 and 44 blows/300mm.*

Based on the test results, the sand and gravel is considered to have a dense relative density.

A longitudinal profile showing the summarized soil conditions is shown in Enclosure 1a.

4.0 ***GROUNDWATER CONDITIONS***

A monitoring well was installed in all of the boreholes, except in Borehole 6 which was located in the middle of the road (Brock Street). The construction of the monitoring wells are shown on the Monitoring Well Logs in Enclosures 2A to 12A. Monitoring of the ground water was carried out and the findings are as follows:

Date	*Well No.*	*Location of Ground Water*	
		Depth	*Elevation*
September 15, 2017	*MW1*	*1.4 m*	*261.61*
	MW2	*0.15 m*	*262.66*
	MW3	*Ground Surface (262.7)*	
	MW4	*1.68 m*	*261.36*
	MW5	*2.74 m*	*262.96*
	MW7	*3.29 m*	*262.39*
	MW8	*1.22 m*	*264.59*
	MW9	*1.68 m*	*263.55*
	MW10	*2.32 m*	*262.45*
	MW11	*3.11 m*	*261.64*
September 26, 2017	*MW1*	*no change*	
	MW2	*0.18*	*262.63*
	MW3	*1.5*	*261.2*
	MW4	*2.3*	*260.74*
	MW5	*no change*	
	MW7	*no change*	
	MW8	*no change*	
	MW9	*no change*	
	MW10	*no change*	
	MW11	*no change*	

*5.0 **DISCUSSION AND RECOMMENDATIONS***

5.1 General

The boreholes encountered 2.9 to 4.3 m of generally loose fill, followed by 0 to 3 m of silty sand with peat/wood, then 0 to 3.5 m of gravelly sand, then native bedded silt and fine sand, underlain by sand and gravel or sandy silt till in places. The ground water table is located a depth of between zero (artesian condition) and 3.29 m (Elev. 261.2 to Elev. 264.6).

The 190± m replacement culvert will be a twin closed concrete structure. It is noted that the subsurface conditions are not considered to be suitable for an open bottom culvert. It is understood that construction will be carried out in stages using open cuts, and that the creek will be effectively diverted at each stage. Full details of the proposed structure were not available at the time of this report and, therefore, the following recommendations should be reviewed when these details are available.

5.2 Foundations

It is understood that the invert of the culverts will be at Elev. 260.5± at the inlet and Elev.259.81± at the outlet. Based on the Borehole Logs, the foundation subgrade will likely be comprised mainly of gravelly sand between Sta. 0+150± and Sta. 0+180±, and bedded silt and sand between Sta. 0+215± and the outlet. These strata are considered capable of supporting an allowable bearing pressure (SLS bearing pressure) of at least 75 kPa.

From the inlet to Sta. 0+150±, and between Sta. 0+180± and Sta. 0+215±, the Borehole Logs indicate that sand and peat exist below the invert. The peat should be removed and replaced with approved compacted fill. In this case, the footings on the compacted fill may be designed to the allowable bearing pressure of 75 kPa. Additional boreholes (using hollow stem augers) should be put down when the building at No. 30 and 32 is removed.

It is understood that driven piles may be used south of Brock Street. In this case, they can be designed using an allowable steel stress of 6.5 N/mm^2 (10,000 psi) and the coefficient of horizontal reaction can be based on n_h of 2200 kN/m^3 above the water table and 1300 kN/m^3 below the water table.

For the design of members resisting lateral loads, the recommended soil parameters are:

Soil Parameter	*Existing Fill*	*Sand, Peat and Wood*	*Gravelly Sand*	*Sandy Silt*	*Compac-ted Fill (Granular)*
Unit Weight	*20 kN/m^3*	*15 kN/m^3*	*22 kN/m^3*	*20 kN/m^3*	*21 kN/m^3*
Friction Angle	*28^o*	*20^o*	*30^o*	*30^o*	*32^o*
Cohesion	*0*	*0*	*0*	*0*	*0*
Coeff. of Earth Pressure At Rest	*0.53*	*0.66*	*0.5*	*0.5*	*0.47*
Coeff. of Active Earth Pressure	*0.36*	*0.49*	*0.33*	*0.33*	*0.31*
Coeff. of Passive Earth Pressure	*2.8*	*2.0*	*3.0*	*3.0*	*3.2*
Coefficient of Friction	*--*	*--*	*0.45*	*0.4*	*0.4*

All foundation excavations should be inspected by geotechnical personnel from V.A. Wood Associates Limited to ensure the founding soils are similar to those identified in the Borehole Logs and that they are capable of supporting the design loads.

5.3 *Excavation Shoring and Groundwater Control*

A brief review of the site history indicates that the culvert accommodates the flow from two creeks which have been dammed south of Highway 8. The floodplain from the two creeks extended from Toronto St. in the west to Bascom St. and Main St. in the east. The land from Centennial Dr. in the south and for a distance of 100± m to the north of Brock St. has been backfilled to accommodate Brock St. W and the development to the north and south.

To minimize the volume of excavation and the extent of the disturbed area, we recommend that sheet piles be used for shoring. The sheet pile design should be carried out by a specialist designer/contractor and should protect the adjacent structures. The soil parameters given on the table in the preceding page may be used for the preliminary design. We anticipate that the installation of the sheet piles by vibration will be less disruptive than driven sheet piles.

A review of the water levels in the monitoring wells indicates that they are 0.6 to 4.5± m above the invert of the culvert. The dewatering method will depend on the water level at the time of construction. The possibility of basal heave will depend on the extent of

dewatering. If the water pressure under the base of the excavation is more than about 600 mm then basal heave will be a concern.

The dewatering works will cause a significant lowering of the ground water outside of the construction area. This will increase the effective pressures on the subsoils and could cause the settlement of the surrounding buildings and paved areas/ground surface. To prevent/minimize ground settlement and damage to the buildings and the lowering of the ground water outside of the construction area, a sheeted excavation is recommended below the water table. The sheeting should extend to a depth below the excavation grade at least equal to the water level above the excavation grade.

The main dewatering wells should be located within the excavation and the groundwater should not be lowered beyond what is required to build the culvert. Any well required outside of the excavation/sheet pile wall should be located as far as possible from the buildings and the ground water should not be lowered more than necessary. The ground water levels should be monitored through a system of monitoring well. A specialist dewatering consultant/contractor should be consulted for the design and construction and operation of the dewatering system.

A pre-construction survey and settlement monitoring of buildings, structures, paved areas, etc. within at least 100 m of the construction area is recommended.

It is anticipated that selected excavated sand and gravelly sand may be re-used as backfill. Backfill should be placed in horizontal loose layers 150 to 200mm thick and compacted to at least 98% SPMDD.

To minimize potential problems, backfilling operations should follow closely after excavation so that only a minimal length of trench slope is exposed.

Should construction be carried out in the winter season, particular attention should be given to make sure frozen material is not used as backfill.

5.4 Pavements

The pavement for the roadways and the parking lots will be reinstated. It is anticipated that a heavy duty asphalt will be required for the roadway and light duty asphalt will be required for the parking lots. Considering the traffic requirements and subsoil conditions, the following pavement designs are recommended:

	Car Parking Areas (Light Duty Asphalt)	*Roadways/Fire Route (Heavy Duty Asphalt)*
HL-3 Asphaltic Concrete	*50 mm*	*40 mm*
HL-8 Asphaltic Concrete	*--*	*75 mm*
Granular 'A' or 20 mm crusher run limestone	*150 mm*	*150 mm*
Granular 'B' or 50 mm crusher run limestone	*200 mm*	*300 mm*

The base and sub-base granular materials should be compacted to at least 98% SPMDD and the asphaltic concrete to 96% Marshall density. The thicknesses shown above are compacted thicknesses of the layers. We recommend that the top course asphalt not be placed until the base course asphalt has been in place for one winter season.

Frequent inspection by geotechnical personnel from V.A. Wood Associates Limited should be carried out during construction to verify the compaction of the subgrade, base courses and asphaltic concrete by in-situ density testing using nuclear gauges.

5.8 *Soil Chemical Analysis*

A sample of the existing fill from each the eleven boreholes were submitted for chemical analysis for metals and inorganic parameters for disposal purposes. The analysis was carried out by ALS Canada.

The test results are given in Appendix 'B' and reference to this shows that, except for SAR (sodium adsorption ratio) and EC (electrical conductivity) in all of the samples, and mercury in Sample BH6/5 and cadmium in Sample BH11/4, all of the parameters tested meet Table 1 standards of the current O/Reg 153/04 guidelines.

The cadmium and mercury values meet Table 2 standards for commercial/industrial property use. The high SAR and EC value were likely due to road salt.

6.0 STATEMENT OF LIMITATIONS

The Statement of Limitations presented on Appendix 'A' is an integral part of this report.

V.A. WOOD ASSOCIATES LIMITED

Prepared by:

Rene Quiambao, P. Eng.

Reviewed by:

V. Wood, M.Eng., P.Eng.,

RQ/VW

A P P E N D I C E S

STATEMENT OF LIMITATIONS

The conclusions and recommendations in this report are based on information determined at the borehole locations and on geological data of a general nature which may be available for the area investigated. Soil and groundwater conditions between and beyond the boreholes may differ from those encountered at the borehole locations and conditions may become apparent during construction which would not be detected or anticipated at the time of the soil investigation.

We recommend that we be retained to ensure that all necessary stripping, subgrade preparation and compaction requirements are met, and to confirm that the soil conditions do not deviate materially from those encountered in the boreholes. In cases where this recommendation is not followed, the company's responsibility is limited to interpreting accurately the information encountered at the borehole locations.

This report is applicable only to the project described in the introduction, constructed substantially in accordance with details of alignment and elevations quoted in the text.

APPENDIX 'B'

Soil Chemical Analysis

V.A. WOOD ASSOCIATES LIMITED
ATTN: Vic Wood
1080 Tapscott Rd
Unit 24
Scarborough ON M1X 1E7

Date Received: 11-SEP-17
Report Date: 18-SEP-17 13:36 (MT)
Version: FINAL

Client Phone: 416-292-2868

Certificate of Analysis

Lab Work Order #: L1989352

Project P.O. #: NOT SUBMITTED
Job Reference: 7171
C of C Numbers: 15-557089
Legal Site Desc:

Mathy Mahadeva
Account Manager

ANALYTICAL REPORT

Summary of Guideline Exceedances

ALS ID	Client ID	Grouping	Analyte	Result	Guideline Limit	Unit
Ontario Regulation 153/04 - April 15, 2011 Standards - T1-Soil-Res/Park/Inst/Ind/Com/Commu Property Use						
L1989352-1	7171-BH1/2	Saturated Paste Extractables	SAR	6.09	2.4	SAR
L1989352-2	7171-BH2/3	Physical Tests	Conductivity	1.36	0.57	mS/cm
		Saturated Paste Extractables	SAR	43.3	2.4	SAR
L1989352-3	7171-BH3/3	Physical Tests	Conductivity	1.22	0.57	mS/cm
		Saturated Paste Extractables	SAR	55.3	2.4	SAR
L1989352-4	7171-BH4/4	Physical Tests	Conductivity	1.26	0.57	mS/cm
		Saturated Paste Extractables	SAR	3.49	2.4	SAR
L1989352-5	7171-BH5/5	Physical Tests	Conductivity	0.693	0.57	mS/cm
		Saturated Paste Extractables	SAR	18.9	2.4	SAR
L1989352-6	7171-BH6/5	Physical Tests	Conductivity	2.15	0.57	mS/cm
		Saturated Paste Extractables	SAR	42.2	2.4	SAR
		Metals	Mercury (Hg)	0.361	0.27	ug/g
L1989352-7	7171-BH7/4	Physical Tests	Conductivity	1.14	0.57	mS/cm
		Saturated Paste Extractables	SAR	9.10	2.4	SAR
L1989352-8	7171-BH8/5	Physical Tests	Conductivity	0.576	0.57	mS/cm
		Saturated Paste Extractables	SAR	10.6	2.4	SAR
L1989352-9	7171-BH9/3	Physical Tests	Conductivity	0.665	0.57	mS/cm
		Saturated Paste Extractables	SAR	8.04	2.4	SAR
L1989352-10	7171-BH10/5	Physical Tests	Conductivity	0.681	0.57	mS/cm
		Saturated Paste Extractables	SAR	3.38	2.4	SAR
L1989352-11	7171-BH11/4	Physical Tests	Conductivity	0.711	0.57	mS/cm
		Saturated Paste Extractables	SAR	16.8	2.4	SAR
		Metals	Cadmium (Cd)	1.81	1.2	ug/g

* Please refer to the Reference Information section for an explanation of any qualifiers noted.

ANALYTICAL REPORT

Physical Tests - SOIL

		Guide Limits								
Lab ID				L1989352-1	L1989352-2	L1989352-3	L1989352-4	L1989352-5	L1989352-6	L1989352-7	L1989352-8	L1989352-9
Sample Date				29-AUG-17	29-AUG-17	30-AUG-17	30-AUG-17	29-AUG-17	29-AUG-17	28-AUG-17	26-AUG-17	26-AUG-17
Sample ID				7171-BH1/2	7171-BH2/3	7171-BH3/3	7171-BH4/4	7171-BH5/5	7171-BH6/5	7171-BH7/4	7171-BH8/5	7171-BH9/3
Analyte	**Unit**	**#1**	**#2**									
Conductivity	mS/cm	0.57	-	0.239	1.36	1.22	1.26	0.693	2.15	1.14	0.576	0.665
% Moisture	%	-	-	2.84	13.9	13.3	51.6	14.2	21.5	3.95	19.8	17.7
pH	pH units	-	-	8.04	8.75	7.76	7.16	7.68	7.44	7.94	7.42	7.58

Guide Limit #1: T1-Soil-Res/Park/Inst/Ind/Com/Commu Property Use

Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
Analytical result for this parameter exceeds Guide Limits listed. See Summary of Guideline Exceedances.

* Please refer to the Reference Information section for an explanation of any qualifiers noted.

Physical Tests - SOIL

		Guide Limits			
Lab ID				L1989352-10	L1989352-11
Sample Date				26-AUG-17	26-AUG-17
Sample ID				7171-BH10/5	7171-BH11/4
Analyte	**Unit**	**#1**	**#2**		
Conductivity	mS/cm	0.57	-	0.681	0.711
% Moisture	%	-	-	17.1	14.2
pH	pH units	-	-	10.85	7.33

Guide Limit #1: T1-Soil-Res/Park/Inst/Ind/Com/Commu Property Use

Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
Analytical result for this parameter exceeds Guide Limits listed. See Summary of Guideline Exceedances.

* Please refer to the Reference Information section for an explanation of any qualifiers noted.

Cyanides - SOIL

		Guide Limits									
				Lab ID	L1989352-1	L1989352-2	L1989352-3	L1989352-4	L1989352-5	L1989352-6	L1989352-7	L1989352-8	L1989352-9
				Sample Date	29-AUG-17	29-AUG-17	30-AUG-17	30-AUG-17	29-AUG-17	29-AUG-17	28-AUG-17	26-AUG-17	26-AUG-17
				Sample ID	7171-BH1/2	7171-BH2/3	7171-BH3/3	7171-BH4/4	7171-BH5/5	7171-BH6/5	7171-BH7/4	7171-BH8/5	7171-BH9/3
Analyte	Unit	#1	#2										
Cyanide, Weak Acid Diss	ug/g	0.051	-		<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050

Guide Limit #1: T1-Soil-Res/Park/Inst/Ind/Com/Commu Property Use

Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
Analytical result for this parameter exceeds Guide Limits listed. See Summary of Guideline Exceedances.

Cyanides - SOIL

		Guide Limits			
Lab ID				L1989352-10	L1989352-11
Sample Date				26-AUG-17	26-AUG-17
Sample ID				7171-BH10/5	7171-BH11/4
Analyte	**Unit**	**#1**	**#2**		
Cyanide, Weak Acid Diss	ug/g	0.051	-	<0.050	<0.050

Guide Limit #1: T1-Soil-Res/Park/Inst/Ind/Com/Commu Property Use

Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
Analytical result for this parameter exceeds Guide Limits listed. See Summary of Guideline Exceedances.

* Please refer to the Reference Information section for an explanation of any qualifiers noted.

Saturated Paste Extractables - SOIL

	Lab ID	L1989352-1	L1989352-2	L1989352-3	L1989352-4	L1989352-5	L1989352-6	L1989352-7	L1989352-8	L1989352-9
	Sample Date	29-AUG-17	29-AUG-17	30-AUG-17	30-AUG-17	29-AUG-17	29-AUG-17	28-AUG-17	26-AUG-17	26-AUG-17
	Sample ID	7171-BH1/2	7171-BH2/3	7171-BH3/3	7171-BH4/4	7171-BH5/5	7171-BH6/5	7171-BH7/4	7171-BH8/5	7171-BH9/3
Analyte	Unit	Guide Limits #1	Guide Limits #2							
SAR	SAR	2.4	-	6.09	43.3 SAR:M	55.3 SAR:M	3.49	18.9 SAR:M	42.2 SAR:M	9.10	10.6	8.04 SAR:M
Calcium (Ca)	mg/L	-	-	1.1	3.7	1.8	134	3.7	8.8	33.5	6.2	12.9
Magnesium (Mg)	mg/L	-	-	1.0	<1.0	<1.0	6.2	<1.0	<1.0	1.7	1.1	<1.0
Sodium (Na)	mg/L	-	-	36.9	301	267	152	133	456	199	110	105

Guide Limit #1: T1-Soil-Res/Park/Inst/Ind/Com/Commu Property Use

Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
Analytical result for this parameter exceeds Guide Limits listed. See Summary of Guideline Exceedances.

* Please refer to the Reference Information section for an explanation of any qualifiers noted.

ANALYTICAL REPORT

Saturated Paste Extractables - SOIL

Analyte	Unit	Guide Limits #1	Guide Limits #2	Lab ID: L1989352-10, Sample Date: 26-AUG-17, Sample ID: 7171-BH10/5	Lab ID: L1989352-11, Sample Date: 26-AUG-17, Sample ID: 7171-BH11/4
SAR	SAR	2.4	-	3.38 SAR:M	16.8 SAR:M
Calcium (Ca)	mg/L	-	-	43.3	5.3
Magnesium (Mg)	mg/L	-	-	<1.0	<1.0
Sodium (Na)	mg/L	-	-	80.8	140

Guide Limit #1: T1-Soil-Res/Park/Inst/Ind/Com/Commu Property Use

Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
Analytical result for this parameter exceeds Guide Limits listed. See Summary of Guideline Exceedances.

* Please refer to the Reference Information section for an explanation of any qualifiers noted.

Metals - SOIL

Analyte	Unit	Guide Limits #1	Guide Limits #2	Lab ID	L1989352-1	L1989352-2	L1989352-3	L1989352-4	L1989352-5	L1989352-6	L1989352-7	L1989352-8	L1989352-9
				Sample Date	29-AUG-17	29-AUG-17	30-AUG-17	30-AUG-17	29-AUG-17	29-AUG-17	28-AUG-17	26-AUG-17	26-AUG-17
				Sample ID	7171-BH1/2	7171-BH2/3	7171-BH3/3	7171-BH4/4	7171-BH5/5	7171-BH6/5	7171-BH7/4	7171-BH8/5	7171-BH9/3
Antimony (Sb)	ug/g	1.3	-		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Arsenic (As)	ug/g	18	-		1.7	1.6	1.8	2.1	1.6	1.8	1.6	2.6	2.8
Barium (Ba)	ug/g	220	-		28.8	30.7	27.4	98.3	38.6	46.8	33.0	77.2	88.5
Beryllium (Be)	ug/g	2.5	-		<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Boron (B)	ug/g	36	-		5.5	<5.0	<5.0	7.2	<5.0	<5.0	<5.0	6.9	8.2
Boron (B), Hot Water Ext.	ug/g	36	-		<0.10	0.19	0.17	0.85	0.10	0.56	0.18	0.31	0.45
Cadmium (Cd)	ug/g	1.2	-		<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Chromium (Cr)	ug/g	70	-		14.3	9.0	9.3	12.7	10.2	10.4	8.7	15.8	17.0
Cobalt (Co)	ug/g	21	-		3.3	2.6	2.8	2.5	3.1	3.3	2.6	4.9	5.7
Copper (Cu)	ug/g	92	-		8.1	7.7	7.8	6.0	5.8	6.9	5.5	12.5	13.1
Lead (Pb)	ug/g	120	-		6.3	21.7	21.3	3.2	6.0	83.3	34.1	35.5	75.7
Mercury (Hg)	ug/g	0.27	-		0.0095	0.0462	0.0939	0.0300	0.0202	0.361	0.0344	0.0938	0.0635
Molybdenum (Mo)	ug/g	2	-		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nickel (Ni)	ug/g	82	-		7.0	6.1	6.4	5.2	6.3	6.3	4.9	10.1	12.2
Selenium (Se)	ug/g	1.5	-		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Silver (Ag)	ug/g	0.5	-		<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Thallium (Tl)	ug/g	1	-		<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Uranium (U)	ug/g	2.5	-		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Vanadium (V)	ug/g	86	-		16.6	18.1	18.0	16.0	20.7	20.8	18.2	28.0	28.7
Zinc (Zn)	ug/g	290	-		26.5	42.4	64.4	24.1	20.0	31.2	29.6	44.8	70.9

Guide Limit #1: T1-Soil-Res/Park/Inst/Ind/Com/Commu Property Use

Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
Analytical result for this parameter exceeds Guide Limits listed. See Summary of Guideline Exceedances.

* Please refer to the Reference Information section for an explanation of any qualifiers noted.

Metals - SOIL

		Guide Limits			
Lab ID				L1989352-10	L1989352-11
Sample Date				26-AUG-17	26-AUG-17
Sample ID				7171-BH10/5	7171-BH11/4
Analyte	**Unit**	**#1**	**#2**		
Antimony (Sb)	ug/g	1.3	-	<1.0	<1.0
Arsenic (As)	ug/g	18	-	1.3	2.2
Barium (Ba)	ug/g	220	-	22.9	38.1
Beryllium (Be)	ug/g	2.5	-	<0.50	<0.50
Boron (B)	ug/g	36	-	<5.0	<5.0
Boron (B), Hot Water Ext.	ug/g	36	-	0.26	0.33
Cadmium (Cd)	ug/g	1.2	-	<0.50	1.81
Chromium (Cr)	ug/g	70	-	7.9	11.7
Cobalt (Co)	ug/g	21	-	2.2	3.4
Copper (Cu)	ug/g	92	-	3.7	8.2
Lead (Pb)	ug/g	120	-	9.9	37.0
Mercury (Hg)	ug/g	0.27	-	0.0263	0.0332
Molybdenum (Mo)	ug/g	2	-	<1.0	<1.0
Nickel (Ni)	ug/g	82	-	4.0	6.9
Selenium (Se)	ug/g	1.5	-	<1.0	<1.0
Silver (Ag)	ug/g	0.5	-	<0.20	<0.20
Thallium (Tl)	ug/g	1	-	<0.50	<0.50
Uranium (U)	ug/g	2.5	-	<1.0	<1.0
Vanadium (V)	ug/g	86	-	21.7	22.5
Zinc (Zn)	ug/g	290	-	30.3	40.0

Guide Limit #1: T1-Soil-Res/Park/Inst/Ind/Com/Commu Property Use

Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
Analytical result for this parameter exceeds Guide Limits listed. See Summary of Guideline Exceedances.

* Please refer to the Reference Information section for an explanation of any qualifiers noted.

Speciated Metals - SOIL

		Guide Limits									
Lab ID				L1989352-1	L1989352-2	L1989352-3	L1989352-4	L1989352-5	L1989352-6	L1989352-7	L1989352-8	L1989352-9
Sample Date				29-AUG-17	29-AUG-17	30-AUG-17	30-AUG-17	29-AUG-17	29-AUG-17	28-AUG-17	26-AUG-17	26-AUG-17
Sample ID				7171-BH1/2	7171-BH2/3	7171-BH3/3	7171-BH4/4	7171-BH5/5	7171-BH6/5	7171-BH7/4	7171-BH8/5	7171-BH9/3
Analyte	**Unit**	**#1**	**#2**									
Chromium, Hexavalent	ug/g	0.66	-	<0.20	<0.20	<0.20	0.26	<0.20	<0.20	<0.20	<0.20	<0.20

Guide Limit #1: T1-Soil-Res/Park/Inst/Ind/Com/Commu Property Use

Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
Analytical result for this parameter exceeds Guide Limits listed. See Summary of Guideline Exceedances.

* Please refer to the Reference Information section for an explanation of any qualifiers noted.

ANALYTICAL REPORT

Speciated Metals - SOIL

		Guide Limits			
Lab ID				L1989352-10	L1989352-11
Sample Date				26-AUG-17	26-AUG-17
Sample ID				7171-BH10/5	7171-BH11/4
Analyte	**Unit**	**#1**	**#2**		
Chromium, Hexavalent	ug/g	0.66	-	<0.20	<0.20

Guide Limit #1: T1-Soil-Res/Park/Inst/Ind/Com/Commu Property Use

Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
Analytical result for this parameter exceeds Guide Limits listed. See Summary of Guideline Exceedances.

* Please refer to the Reference Information section for an explanation of any qualifiers noted.

Reference Information

Qualifiers for Individual Parameters Listed:

Qualifier	Description
SAR:M	Reported SAR represents a maximum value. Actual SAR may be lower if both Ca and Mg were detectable.

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Method Reference**
B-HWS-R511-WT	Soil	Boron-HWE-O.Reg 153/04 (July 2011)	HW EXTR, EPA 6010B

A dried solid sample is extracted with calcium chloride, the sample undergoes a heating process. After cooling the sample is filtered and analyzed by ICP/OES.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

CN-WAD-R511-WT	Soil	Cyanide (WAD)-O.Reg 153/04 (July 2011)	MOE 3015/APHA 4500CN I-WAD

The sample is extracted with a strong base for 16 hours, and then filtered. The filtrate is then distilled where the cyanide is converted to cyanogen chloride by reacting with chloramine-T, the cyanogen chloride then reacts with a combination of barbituric acid and isonicotinic acid to form a highly colored complex.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

CR-CR6-IC-WT	Soil	Hexavalent Chromium in Soil	SW846 3060A/7199

This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846, Method 7199, published by the United States Environmental Protection Agency (EPA). The procedure involves analysis for chromium (VI) by ion chromatography using diphenylcarbazide in a sulphuric acid solution.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

EC-WT	Soil	Conductivity (EC)	MOEE E3138

A representative subsample is tumbled with de-ionized (DI) water. The ratio of water to soil is 2:1 v/w. After tumbling the sample is then analyzed by a conductivity meter.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

HG-200.2-CVAA-WT	Soil	Mercury in Soil by CVAAS	EPA 200.2/1631E (mod)

Soil samples are digested with nitric and hydrochloric acids, followed by analysis by CVAAS.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

MET-200.2-CCMS-WT	Soil	Metals in Soil by CRC ICPMS	EPA 200.2/6020A (mod)

This method uses a heated strong acid digestion with HNO3 and HCl and is intended to liberate metals that may be environmentally available. Silicate minerals are not solubilized. Dependent on sample matrix, some metals may be only partially recovered, including Al, Ba, Be, Cr, Sr, Ti, Tl, V, W, and Zr. Volatile forms of sulfur (including sulfide) may not be captured, as they may be lost during sampling, storage, or digestion. Analysis is by Collision/Reaction Cell ICPMS.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011), unless a subset of the Analytical Test Group (ATG) has been requested (the Protocol states that all analytes in an ATG must be reported).

MOISTURE-WT	Soil	% Moisture	Gravimetric: Oven Dried
PH-WT	Soil	pH	MOEE E3137A

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Method Reference**

A minimum 10g portion of the sample is extracted with 20mL of 0.01M calcium chloride solution by shaking for at least 30 minutes. The aqueous layer is separated from the soil and then analyzed using a pH meter and electrode.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

SAR-R511-WT	Soil	SAR-O.Reg 153/04 (July 2011)	SW846 6010C

A dried, disaggregated solid sample is extracted with deionized water, the aqueous extract is separated from the solid, acidified and then analyzed using a ICP/OES. The concentrations of Na, Ca and Mg are reported as per CALA requirements for calculated parameters. These individual parameters are not for comparison to any guideline.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

**ALS test methods may incorporate modifications from specified reference methods to improve performance.

Chain of Custody Numbers:

15-557089

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Workorder: L1989352 Report Date: 18-SEP-17

Client: V.A. WOOD ASSOCIATES LIMITED
1080 Tapscott Rd Unit 24
Scarborough ON M1X 1E7
Contact: Vic Wood

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
B-HWS-R511-WT	**Soil**							
Batch R3828286								
WG2615585-4 DUP		**L1988852-3**						
Boron (B), Hot Water Ext.		0.14	0.14		ug/g	2.1	30	14-SEP-17
WG2615585-2 IRM		**HOTB-SAL_SOIL5**						
Boron (B), Hot Water Ext.			128.3		%		70-130	14-SEP-17
WG2615585-3 LCS								
Boron (B), Hot Water Ext.			97.8		%		70-130	14-SEP-17
WG2615585-1 MB								
Boron (B), Hot Water Ext.			<0.10		ug/g		0.1	14-SEP-17
Batch R3829177								
WG2616578-4 DUP		**L1989352-11**						
Boron (B), Hot Water Ext.		0.33	0.33		ug/g	1.2	30	15-SEP-17
WG2616578-2 IRM		**HOTB-SAL_SOIL5**						
Boron (B), Hot Water Ext.			125.0		%		70-130	15-SEP-17
WG2616578-3 LCS								
Boron (B), Hot Water Ext.			110.6		%		70-130	15-SEP-17
WG2616578-1 MB								
Boron (B), Hot Water Ext.			<0.10		ug/g		0.1	15-SEP-17
CN-WAD-R511-WT	**Soil**							
Batch R3830913								
WG2613570-3 DUP		**L1989325-1**						
Cyanide, Weak Acid Diss		<0.050	<0.050	RPD-NA	ug/g	N/A	35	15-SEP-17
WG2613570-2 LCS								
Cyanide, Weak Acid Diss			95.0		%		80-120	15-SEP-17
WG2613570-1 MB								
Cyanide, Weak Acid Diss			<0.050		ug/g		0.05	15-SEP-17
WG2613570-4 MS		**L1989325-1**						
Cyanide, Weak Acid Diss			99.6		%		70-130	15-SEP-17
CR-CR6-IC-WT	**Soil**							
Batch R3826444								
WG2613572-4 CRM		**WT-SQC012**						
Chromium, Hexavalent			94.9		%		70-130	13-SEP-17
WG2613572-3 DUP		**L1989232-1**						
Chromium, Hexavalent		<0.20	<0.20	RPD-NA	ug/g	N/A	35	13-SEP-17
WG2613572-2 LCS								
Chromium, Hexavalent			96.5		%		80-120	13-SEP-17
WG2613572-1 MB								
Chromium, Hexavalent			<0.20		ug/g		0.2	13-SEP-17

Quality Control Report

Client: V.A. WOOD ASSOCIATES LIMITED
1080 Tapscott Rd Unit 24
Scarborough ON M1X 1E7
Contact: Vic Wood

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
CR-CR6-IC-WT	**Soil**							
Batch R3830869								
WG2617273-3 CRM		**WT-SQC012**						
Chromium, Hexavalent			85.7		%		70-130	18-SEP-17
WG2617273-4 DUP		**L1992202-1**						
Chromium, Hexavalent		<0.20	<0.20	RPD-NA	ug/g	N/A	35	18-SEP-17
WG2617273-2 LCS								
Chromium, Hexavalent			96.5		%		80-120	18-SEP-17
WG2617273-1 MB								
Chromium, Hexavalent			<0.20		ug/g		0.2	18-SEP-17
EC-WT	**Soil**							
Batch R3828610								
WG2615587-4 DUP		**WG2615587-3**						
Conductivity		0.189	0.190		mS/cm	0.6	20	14-SEP-17
WG2615863-1 LCS								
Conductivity			99.6		%		90-110	14-SEP-17
WG2615587-1 MB								
Conductivity			<0.0040		mS/cm		0.004	14-SEP-17
Batch R3828774								
WG2615589-4 DUP		**WG2615589-3**						
Conductivity		1.60	1.62		mS/cm	1.1	20	14-SEP-17
WG2615865-1 LCS								
Conductivity			99.1		%		90-110	14-SEP-17
WG2615589-1 MB								
Conductivity			<0.0040		mS/cm		0.004	14-SEP-17
HG-200.2-CVAA-WT	**Soil**							
Batch R3828494								
WG2615554-2 CRM		**WT-CANMET-TILL1**						
Mercury (Hg)			96.6		%		70-130	14-SEP-17
WG2615554-6 DUP		**WG2615554-5**						
Mercury (Hg)		0.0939	0.0839		ug/g	11	40	14-SEP-17
WG2615554-3 LCS								
Mercury (Hg)			103.5		%		80-120	14-SEP-17
WG2615554-1 MB								
Mercury (Hg)			<0.0050		mg/kg		0.005	14-SEP-17
MET-200.2-CCMS-WT	**Soil**							

Quality Control Report

Client: V.A. WOOD ASSOCIATES LIMITED
1080 Tapscott Rd Unit 24
Scarborough ON M1X 1E7
Contact: Vic Wood

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-200.2-CCMS-WT	**Soil**							
Batch R3829247								
WG2615554-2 CRM		**WT-CANMET-TILL1**						
Antimony (Sb)			99.5		%		70-130	14-SEP-17
Arsenic (As)			101.7		%		70-130	14-SEP-17
Barium (Ba)			103.1		%		70-130	14-SEP-17
Beryllium (Be)			98.5		%		70-130	14-SEP-17
Boron (B)			3.3		mg/kg		0-8.2	14-SEP-17
Cadmium (Cd)			108.8		%		70-130	14-SEP-17
Chromium (Cr)			104.3		%		70-130	14-SEP-17
Cobalt (Co)			103.0		%		70-130	14-SEP-17
Copper (Cu)			103.1		%		70-130	14-SEP-17
Lead (Pb)			102.6		%		70-130	14-SEP-17
Molybdenum (Mo)			109.9		%		70-130	14-SEP-17
Nickel (Ni)			102.1		%		70-130	14-SEP-17
Selenium (Se)			0.32		mg/kg		0.11-0.51	14-SEP-17
Silver (Ag)			0.23		mg/kg		0.13-0.33	14-SEP-17
Thallium (Tl)			0.137		mg/kg		0.077-0.18	14-SEP-17
Uranium (U)			105.6		%		70-130	14-SEP-17
Vanadium (V)			102.3		%		70-130	14-SEP-17
Zinc (Zn)			103.8		%		70-130	14-SEP-17
WG2615554-6 DUP		**WG2615554-5**						
Antimony (Sb)		0.15	0.18		ug/g	16	30	14-SEP-17
Arsenic (As)		1.78	1.81		ug/g	2.0	30	14-SEP-17
Barium (Ba)		27.4	27.5		ug/g	0.7	40	14-SEP-17
Beryllium (Be)		0.20	0.18		ug/g	8.3	30	14-SEP-17
Boron (B)		<5.0	<5.0	RPD-NA	ug/g	N/A	30	14-SEP-17
Cadmium (Cd)		0.173	0.157		ug/g	9.6	30	14-SEP-17
Chromium (Cr)		9.32	9.21		ug/g	1.2	30	14-SEP-17
Cobalt (Co)		2.82	2.84		ug/g	0.7	30	14-SEP-17
Copper (Cu)		7.75	7.94		ug/g	2.4	30	14-SEP-17
Lead (Pb)		21.3	24.8		ug/g	15	40	14-SEP-17
Molybdenum (Mo)		0.28	0.27		ug/g	2.9	40	14-SEP-17
Nickel (Ni)		6.38	6.47		ug/g	1.4	30	14-SEP-17
Selenium (Se)		<0.20	<0.20	RPD-NA	ug/g	N/A	30	14-SEP-17
Silver (Ag)		<0.10	<0.10	RPD-NA	ug/g	N/A	40	14-SEP-17

Quality Control Report

Client: V.A. WOOD ASSOCIATES LIMITED
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Scarborough ON M1X 1E7
Contact: Vic Wood

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-200.2-CCMS-WT	**Soil**							
Batch R3829247								
WG2615554-6 DUP		**WG2615554-5**						
Thallium (Tl)		0.060	0.064		ug/g	6.7	30	14-SEP-17
Uranium (U)		0.401	0.394		ug/g	1.6	30	14-SEP-17
Vanadium (V)		18.0	17.6		ug/g	1.8	30	14-SEP-17
Zinc (Zn)		64.4	66.7		ug/g	3.4	30	14-SEP-17
WG2615554-4 LCS								
Antimony (Sb)			99.2		%		80-120	14-SEP-17
Arsenic (As)			97.4		%		80-120	14-SEP-17
Barium (Ba)			102.5		%		80-120	14-SEP-17
Beryllium (Be)			90.6		%		80-120	14-SEP-17
Boron (B)			85.8		%		80-120	14-SEP-17
Cadmium (Cd)			99.2		%		80-120	14-SEP-17
Chromium (Cr)			98.4		%		80-120	14-SEP-17
Cobalt (Co)			100.2		%		80-120	14-SEP-17
Copper (Cu)			97.0		%		80-120	14-SEP-17
Lead (Pb)			98.3		%		80-120	14-SEP-17
Molybdenum (Mo)			100.8		%		80-120	14-SEP-17
Nickel (Ni)			98.0		%		80-120	14-SEP-17
Selenium (Se)			98.0		%		80-120	14-SEP-17
Silver (Ag)			99.5		%		80-120	14-SEP-17
Thallium (Tl)			99.9		%		80-120	14-SEP-17
Uranium (U)			100.8		%		80-120	14-SEP-17
Vanadium (V)			100.9		%		80-120	14-SEP-17
Zinc (Zn)			93.5		%		80-120	14-SEP-17
WG2615554-1 MB								
Antimony (Sb)			<0.10		mg/kg		0.1	14-SEP-17
Arsenic (As)			<0.10		mg/kg		0.1	14-SEP-17
Barium (Ba)			<0.50		mg/kg		0.5	14-SEP-17
Beryllium (Be)			<0.10		mg/kg		0.1	14-SEP-17
Boron (B)			<5.0		mg/kg		5	14-SEP-17
Cadmium (Cd)			<0.020		mg/kg		0.02	14-SEP-17
Chromium (Cr)			<0.50		mg/kg		0.5	14-SEP-17
Cobalt (Co)			<0.10		mg/kg		0.1	14-SEP-17
Copper (Cu)			<0.50		mg/kg		0.5	14-SEP-17
Lead (Pb)			<0.50		mg/kg		0.5	14-SEP-17

Quality Control Report

Client: V.A. WOOD ASSOCIATES LIMITED
1080 Tapscott Rd Unit 24
Scarborough ON M1X 1E7
Contact: Vic Wood

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-200.2-CCMS-WT	**Soil**							
Batch R3829247								
WG2615554-1 MB								
Molybdenum (Mo)			<0.10		mg/kg		0.1	14-SEP-17
Nickel (Ni)			<0.50		mg/kg		0.5	14-SEP-17
Selenium (Se)			<0.20		mg/kg		0.2	14-SEP-17
Silver (Ag)			<0.10		mg/kg		0.1	14-SEP-17
Thallium (Tl)			<0.050		mg/kg		0.05	14-SEP-17
Uranium (U)			<0.050		mg/kg		0.05	14-SEP-17
Vanadium (V)			<0.20		mg/kg		0.2	14-SEP-17
Zinc (Zn)			<2.0		mg/kg		2	14-SEP-17
MOISTURE-WT	**Soil**							
Batch R3825968								
WG2613568-3 DUP		**L1988852-2**						
% Moisture		6.25	5.89		%	6.1	20	12-SEP-17
WG2613568-2 LCS								
% Moisture			99.3		%		90-110	12-SEP-17
WG2613568-1 MB								
% Moisture			<0.10		%		0.1	12-SEP-17
PH-WT	**Soil**							
Batch R3827676								
WG2613554-1 DUP		**L1988849-1**						
pH		7.88	7.88	J	pH units	0.00	0.3	13-SEP-17
WG2614791-1 LCS								
pH			6.97		pH units		6.9-7.1	13-SEP-17
SAR-R511-WT	**Soil**							
Batch R3828534								
WG2615589-4 DUP		**WG2615589-3**						
Calcium (Ca)		8.9	9.0		mg/L	1.3	30	14-SEP-17
Sodium (Na)		336	339		mg/L	0.7	30	14-SEP-17
Magnesium (Mg)		2.8	2.4		mg/L	15	30	14-SEP-17
WG2615589-2 IRM		**WT SAR1**						
Calcium (Ca)			96.0		%		70-130	14-SEP-17
Sodium (Na)			101.2		%		70-130	14-SEP-17
Magnesium (Mg)			95.7		%		70-130	14-SEP-17
WG2615589-1 MB								
Calcium (Ca)			<1.0		mg/L		1	14-SEP-17
Sodium (Na)			<1.0		mg/L		1	14-SEP-17

Quality Control Report

Client: V.A. WOOD ASSOCIATES LIMITED
1080 Tapscott Rd Unit 24
Scarborough ON M1X 1E7
Contact: Vic Wood

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
SAR-R511-WT	**Soil**							
Batch R3828534								
WG2615589-1 MB								
Magnesium (Mg)			<1.0		mg/L		1	14-SEP-17
Batch R3828541								
WG2615587-4 DUP		**WG2615587-3**						
Calcium (Ca)		7.0	6.6		mg/L	6.9	30	14-SEP-17
Sodium (Na)		4.4	4.1		mg/L	7.2	30	14-SEP-17
Magnesium (Mg)		1.9	1.7		mg/L	9.4	30	14-SEP-17
WG2615587-2 IRM		**WT SAR1**						
Calcium (Ca)			97.4		%		70-130	14-SEP-17
Sodium (Na)			100.8		%		70-130	14-SEP-17
Magnesium (Mg)			98.4		%		70-130	14-SEP-17
WG2615587-1 MB								
Calcium (Ca)			<1.0		mg/L		1	14-SEP-17
Sodium (Na)			<1.0		mg/L		1	14-SEP-17
Magnesium (Mg)			<1.0		mg/L		1	14-SEP-17

Quality Control Report

Workorder: L1989352 Report Date: 18-SEP-17

Client: V.A. WOOD ASSOCIATES LIMITED
1080 Tapscott Rd Unit 24
Scarborough ON M1X 1E7
Contact: Vic Wood

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
J	Duplicate results and limits are expressed in terms of absolute difference.
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Quality Control Report

Workorder: L1989352 Report Date: 18-SEP-17

Client: V.A. WOOD ASSOCIATES LIMITED
1080 Tapscott Rd Unit 24
Scarborough ON M1X 1E7
Contact: Vic Wood

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Physical Tests							
% Moisture							
	7	28-AUG-17 08:00	12-SEP-17 09:00	14	15	days	EHTR
	8	26-AUG-17 12:00	12-SEP-17 09:01	14	17	days	EHTR
	9	26-AUG-17 12:00	12-SEP-17 09:02	14	17	days	EHTR
	10	26-AUG-17 08:00	12-SEP-17 09:03	14	17	days	EHTR
	11	26-AUG-17 08:00	12-SEP-17 09:04	14	17	days	EHTR
Cyanides							
Cyanide (WAD)-O.Reg 153/04 (July 2011)							
	7	28-AUG-17 08:00	12-SEP-17 08:00	14	15	days	EHTR
	8	26-AUG-17 12:00	12-SEP-17 08:00	14	17	days	EHTR
	9	26-AUG-17 12:00	12-SEP-17 08:00	14	17	days	EHTR
	10	26-AUG-17 08:00	12-SEP-17 08:00	14	17	days	EHTR
	11	26-AUG-17 08:00	12-SEP-17 08:00	14	17	days	EHTR

Legend & Qualifier Definitions:

EHTR-FM:	Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR:	Exceeded ALS recommended hold time prior to sample receipt.
EHTL:	Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT:	Exceeded ALS recommended hold time prior to analysis.
Rec. HT:	ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1989352 were received on 11-SEP-17 17:30.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1989352-COFC

COC Number [redacted] 557089

Page 1 of 1

Report To	Contact and company name below will appear on the final report	Report Format / Distribution	Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply
Company:	VAWOOD ASSOCIATES	Select Report Format: ☑ PDF ☐ EXCEL ☐ EDD (DIGITAL)	Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply
Contact:		Quality Control (QC) Report with Report ☐ YES ☐ NO	PRIORITY (Business Days): 4 day [P4] ☐ / 3 day [P3] ☐ / 2 day [P2] ☐ — EMERGENCY: 1 Business day [E1] ☐ / Same Day, Weekend or Statutory holiday [E0] ☐
Phone:		☐ Compare Results to Criteria on Report - provide details below if box checked	
	Company address below will appear on the final report	Select Distribution: ☐ EMAIL ☐ MAIL ☐ FAX	
Street:	5 Copp RD UG4	Email 1 or Fax: vawood@bellnet.ca	Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm
City/Province:		Email 2: rungombers@bellnet.ca	For tests that can not be performed according to the service level selected, you will be contacted.
Postal Code:		Email 3:	

Invoice To		Invoice Distribution	
	Same as Report To ☐ YES ☐ NO	Select Invoice Distribution: ☐ EMAIL ☐ MAIL ☐ FAX	
	Copy of Invoice with Report ☐ YES ☐ NO		
Company:		Email 1 or Fax	
Contact:		Email 2	

Project Information		Oil and Gas Required Fields (client use)	
ALS Account # / Quote #:		AFE/Cost Center:	PO#:
Job #:	7171	Major/Minor Code:	Routing Code:
PO / AFE:		Requisitioner:	
LSD:		Location:	
ALS Lab Work Order # (lab use only):	L1989352	ALS Contact: MM	Sampler:

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Metals + Inorganics	Number of Containers
1	7171 - BH1/2	29	am	Soil	✓	1
2	7171 - BH2/3	29	pm		✓	1
3	7171 - BH3/3	30	am		✓	1
4	7171 - BH4/4	30	pm		✓	1
5	7171 - BH5/5	29	pm		✓	1
6	7171 - BH6/5	29	pm		✓	1
7	7171 - BH7/4	28	am		✓	1
8	7171 - BH8/5	26	pm		✓	1
9	7171 - BH9/3	26	pm		✓	1
10	7171 - BH10/5	26	am		✓	1
11	7171 - BH11/4	26	am		✓	

Drinking Water (DW) Samples[1] (client use)	Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)	SAMPLE CONDITION AS RECEIVED (lab use only)
Are samples taken from a Regulated DW System? ☐ YES ☐ NO	Table 1	Frozen ☐ SIF Observations Yes ☑ No ☐
Are samples for human drinking water use? ☐ YES ☐ NO		Ice Packs ☐ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐
		Cooling Initiated ☐
		INITIAL COOLER TEMPERATURES °C: — FINAL COOLER TEMPERATURES °C: 22.8

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by:	Date:	Time:	Received by: AP	Date: 9/11/17	Time: 17:30
				9/9/17	515			

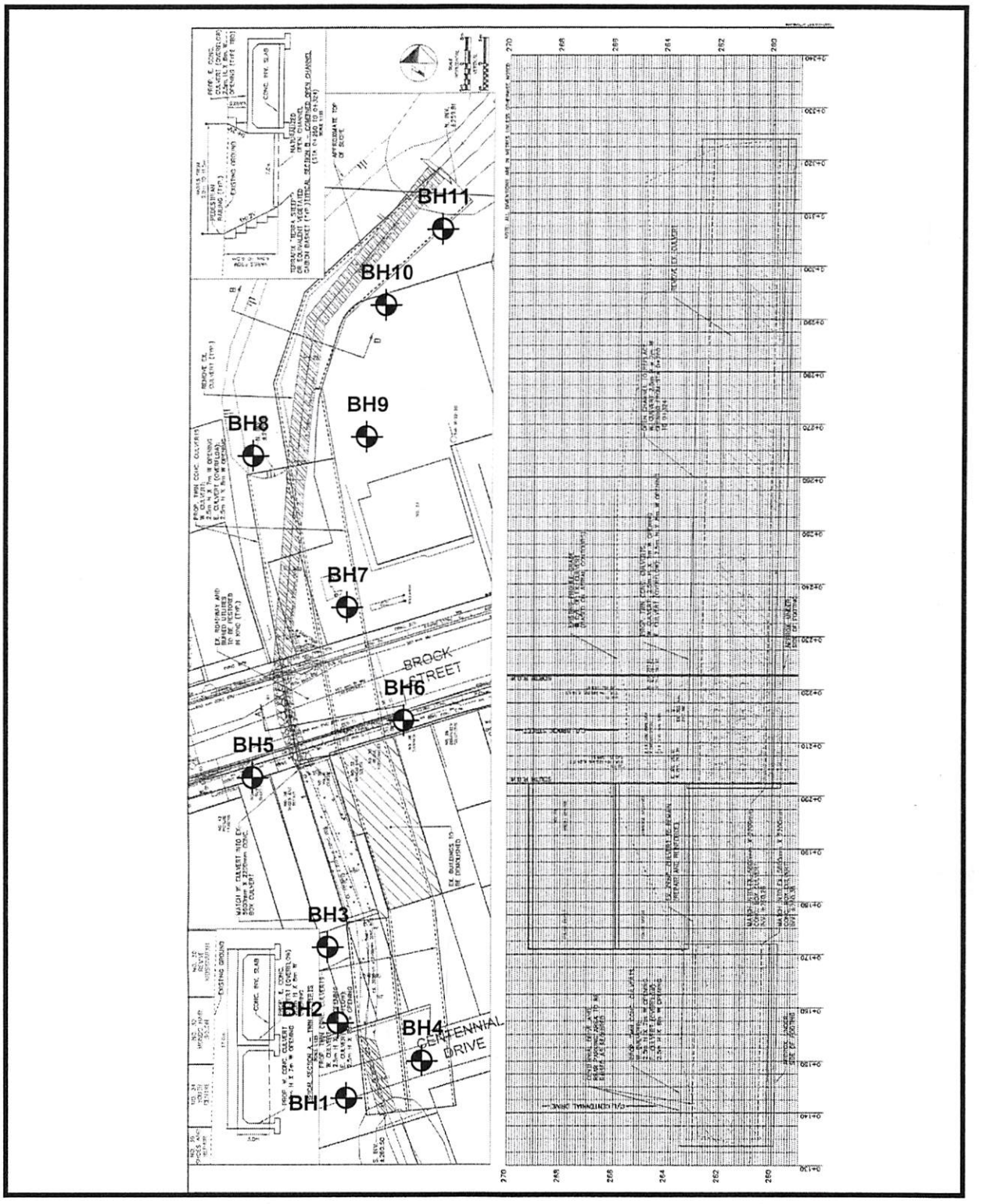
REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION — WHITE - LABORATORY COPY — YELLOW - CLIENT COPY — OCTOBER 2015 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

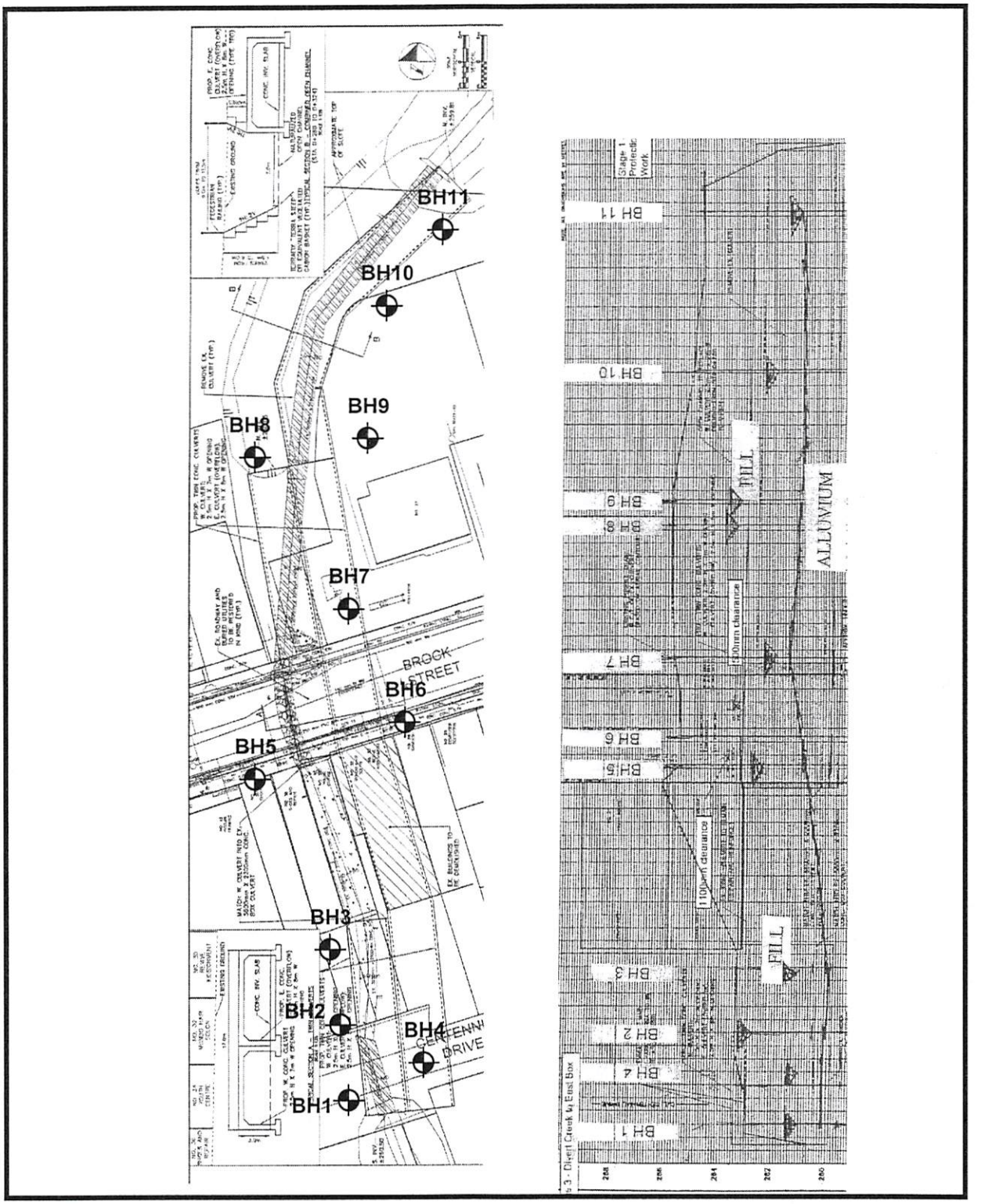
1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

DL

ENCLOSURES



BOREHOLE LOCATION PLAN



SUMMARIZED LONGITUDINAL SECTION

Reference No : 7171-17-6

Borehole No : 1

Enclosure No : 2

Client : AECOM

Project : Culvert Reconstruction

Method : Auger

Location : Brock St./Centennial Dr., Uxbridge, ON

Diameter : 110 mm

Datum Elevation : Geodetic

Date : August 29, 2017

Elevation m	Depth m	Description	Symbol	Water	Sample Number	Sample Type	N-value	Standard Penetration Test blows/300mm (20 40 60 80)	Moisture Content, % (10 30 50)	Remarks
263.01	0	Ground Surface								
		Augered to 0.75 m								50 mm diameter monitoring well to depth of 6.1 m
262.26										
	1				1	SS	34	○		
		FILL								
					2	SS	13	○		
	2	Silty sand, some gravel, brown, moist, compact to desne then very loose								
					3	SS	2	○		
260.11										
	3									
		SILTY SAND			4	SS	8	○		
		Loose, some wood fragments and peat, grey, wet								
259.01	4									
					5	SS	19	○		
	5	*SANDY SILT*								
		Compact, silt and very fine sand, light grey, wet								
	6				6	SS	20	○		
256.46										
		End of Borehole								
	7									
	8									

V.A. WOOD ASSOCIATES LIMITED

Disk :

Sheet : 1 of 1

Reference No : 7171-17-6

Borehole No : 2

Enclosure No : 3

Client : AECOM

Project : Culvert Reconstruction

Method : Auger

Location : Brock St./Centennial Dr., Uxbridge, ON

Diameter : 110 mm

Datum Elevation : Geodetic

Date : August 29, 2017

SUBSURFACE PROFILE					SAMPLE					
Elevation m	Depth m	Description	Symbol	Water	Number	Type	N-value	Standard Penetration Test blows/300mm 20 40 60 80	Moisture Content, % 10 30 50	Remarks
262.81	0	Ground Surface								
262.02		Augered to 0.75 m								50 mm diameter monitoring well to depth of 9.1 m
	1				1	SS	5	○		
		FILL			2	SS	3	○		
	2	Organic stained sand, some gravel, brown, moist, loose			3	SS	6	○		
259.91	3				4	SS	7	○		
	4									
		GRAVELLY SAND			5	SS	8	○		
	5	Loose, grey, wet to saturated								
	6									
256.41					6	SS	5	○		
	7									
		SANDY SILT			7	SS	23	○		
	8	loose then compact, silt and very fine sand, light grey, wet								
	9									
253.21		sand and gravel at the bottom			8	SS	31	○		
	10	End of Borehole								

V.A. WOOD ASSOCIATES LIMITED

Disk :

Sheet : 1 of 1

Reference No : 7171-17-6

Borehole No : 3

Enclosure No : 4

Client : AECOM

Project : Culvert Reconstruction

Method : Auger

Location : Brock St./Centennial Dr., Uxbridge, ON

Diameter : 110 mm

Datum Elevation : Geodetic

Date : August 30, 2017

SUBSURFACE PROFILE					SAMPLE					
Elevation m	Depth m	Description	Symbol	Water	Number	Type	N-value	Standard Penetration Test blows/300mm (20 40 60 80)	Moisture Content, % (10 30 50)	Remarks
262.72	0	Ground Surface								
		Augered to 0.75 m								
261.97										50 mm diameter monitoring well to depth of 9.1 m
	1	*FILL*			1	SS	3			
		Well graded sand, some gravel, brown, moist, wet at the bottom, very loose then loose			2	SS	6			
	2									
259.82					3	SS	6			
	3	*GRAVELLY SAND*			4	SS	5			
		Loose to compact, grey, wet to saturated								
	4									
					5	SS	15			
257.22	5									
	6	*SANDY SILT*			6	SS	3			
		Loose then compact, silt and very fine sand, light grey, wet to saturated								
	7				7	SS	18			
	8									
254.22										
	9	*SAND AND GRAVEL*								
		Dense, grey, saturated			8	SS	44			
253.12										
	10	End of Borehole								

V.A. WOOD ASSOCIATES LIMITED

Disk :

Sheet : 1 of 1

Reference No : 7171-17-6

Borehole No : 4

Enclosure No : 5

Client : AECOM

Project : Culvert Reconstruction

Method : Auger

Location : Brock St./Centennial Dr., Uxbridge, ON

Diameter : 110 mm

Datum Elevation : Geodetic

Date : August 30, 2017

Elevation m	Depth m	Description	Symbol	Water	Sample Number	Sample Type	N-value	Standard Penetration Test blows/300mm (20 40 60 80)	Moisture Content, % (10 30 50)	Remarks
263.04	0	Ground Surface								
		Augered to 0.75 m								50 mm diameter monitoring well to depth of 6.1 m
262.29										
	1	*FILL*			1	SS	5	○		
					2	SS	1	○		
	2	Gravelly sand, clear stone at 1.5 m, moist then wet to saturated, loose to very loose								
					3	SS	1	○		
260.14										
	3	*PEAT*			4	SS	4	○		
259.44		Very loose, wet								
	4	*GRAVELLY SAND*								
		Loose, some topsoil and organics, grey, saturated								
258.24					5	SS	8	○		
	5	*SANDY SILT*								
		Compact, silt and very fine sand, light grey, wet								
	6				6	SS	10	○		
256.49										
		End of Borehole								
	7									
	8									

V.A. WOOD ASSOCIATES LIMITED

Disk :

Sheet : 1 of 1

Reference No : 7171-17-6

Borehole No : 5

Enclosure No : 6

Client : AECOM

Project : Culvert Reconstruction

Method : Auger

Location : Brock St./Centennial Dr., Uxbridge, ON

Diameter : 110 mm

Datum Elevation : Geodetic

Date : August 29, 2017

SUBSURFACE PROFILE					SAMPLE					
Elevation m	Depth m	Description	Symbol	Water	Number	Type	N-value	Standard Penetration Test blows/300mm (20 40 60 80)	Moisture Content, % (10 30 50)	Remarks
265.74	0	Ground Surface								
		Augered to 0.75 m								50 mm diameter monitoring well to depth of 9.1 m
264.99	1				1	SS	16			
					2	SS	8			
	2	*FILL*								
		Silty sand, some gravel, occasional seams of silty clay, brown, moist, compact then loose to very loose			3	SS	3			
	3				4	SS	3			
261.74	4									
		SILTY SAND Very loose, grey, saturated			5	SS	1			
260.24	5									
	6	*SILTY SAND AND PEAT* Loose, seams of silty sand and peat, wet			6	SS	5			
258.74	7									
		SANDY SILT			7	SS	12			
	8	Compact, silt and very fine sand, light grey, wet								
	9									
256.14		some seams of clay			8	SS	20			
	10	End of Borehole								

V.A. WOOD ASSOCIATES LIMITED

Disk :

Sheet : 1 of 1

Reference No : 7171-17-6

Borehole No : 6

Enclosure No : 7

Client : AECOM

Project : Culvert Reconstruction

Method : Auger

Location : Brock St./Centennial Dr., Uxbridge, ON

Diameter : 110 mm

Datum Elevation : Geodetic

Date : August 29, 2017

Elevation m	Depth m	Description	Symbol	Water	Number	Type	N-value	Standard Penetration Test blows/300mm (20 40 60 80)	Moisture Content, % (10 30 50)	Remarks
265.41	0	Ground Surface								
		Augered to 0.75 m								50 mm diameter monitoring well to depth of 9.1 m
264.66										
	1	*FILL* Gravelly sand, loose, moist			1	SS	5	○		
264.01										
					2	SS	37	○		
	2	*FILL*			3	SS	2	○		
	3	Seams of sand and silty clay, some wood fragments, dense then very loose, moist			4	SS	1	○		
261.41	4									
		SANDY SILT Loose, some wood fragments, wet			5	SS	8	○		
259.91	5									
	6	*SAND AND PEAT* Compact, well graded sand and peat, wet			6	SS	12	○		
258.41	7									
		SANDY SILT			7	SS	7	○		
	8	Compact, silt and very fine sand, light grey, wet								
	9									
255.81					8	SS	34	○		
	10	End of Borehole								

V.A. WOOD ASSOCIATES LIMITED

Disk :

Sheet : 1 of 1

Reference No : 7171-17-6

Borehole No : 7

Enclosure No : 8

Client : AECOM

Project : Culvert Reconstruction

Method : Auger

Location : Brock St./Centennial Dr., Uxbridge, ON

Diameter : 110 mm

Datum Elevation : Geodetic

Date : August 28, 2017

SUBSURFACE PROFILE					SAMPLE					
Elevation m	Depth m	Description	Symbol	Water	Number	Type	N-value	Standard Penetration Test blows/300mm (20 40 60 80)	Moisture Content, % (10 30 50)	Remarks
265.68	0	Ground Surface								
		Augered to 0.75 m								50 mm diameter monitoring well to depth of 6.1 m
264.93										
	1				1	SS	4			
					2	SS	4			
	2	*FILL*								
		Sand, some gravel, damp to moist, brown, loose			3	SS	4			
	3									
		gravelly			4	SS	24			
261.68	4									
		SILTY SAND Loose, some wood fragments, grey, wet			5	SS	5			
	5									
260.18										
	6	*GRAVELLY SAND* Compact, some silt, organic stained, grey, saturated			6	SS	13			
259.13										
		End of Borehole								
	7									
	8									

V.A. WOOD ASSOCIATES LIMITED

Disk :

Sheet : 1 of 1

Reference No : 7171-17-6

Borehole No : 8

Enclosure No : 9

Client : AECOM

Project : Culvert Reconstruction

Method : Auger

Location : Brock St./Centennial Dr., Uxbridge, ON

Diameter : 110 mm

Datum Elevation : Geodetic

Date : August 26, 2017

Elevation m	Depth m	Description	Symbol	Water	Number	Type	N-value	Standard Penetration Test blows/300mm (20 40 60 80)	Moisture Content, % (10 30 50)	Remarks
265.81	0	Ground Surface								
		Augered to 0.75 m								
265.06										50 mm diameter monitoring well to depth of 9.1 m
	1				1	SS	9			
		FILL			2	SS	5			
	2	Fine to medium to well graded sand, some gravel, brown, moist, loose to very loose			3	SS	4			
	3				4	SS	1			
261.81	4									
		SILTY SAND			5	SS	4			
	5	Loose, organic stained silty sand, some gravel and peat, grey, wet								
260.31										
	6				6	SS	7			
	7	*SANDY SILT*								
		Loose then compact to dense, silt and very fine sand, light grey, wet to saturated			7	SS	19			
	8									
	9									
256.21					8	SS	40			
	10	End of Borehole								

V.A. WOOD ASSOCIATES LIMITED

Disk :

Sheet : 1 of 1

Reference No : 7171-17-6

Borehole No : 9

Enclosure No : 10

Client : AECOM

Project : Culvert Reconstruction

Method : Auger

Location : Brock St./Centennial Dr., Uxbridge, ON

Diameter : 110 mm

Datum Elevation : Geodetic

Date : August 25, 2017

Elevation m	Depth m	Description	Symbol	Water	Number	Type	N-value	Standard Penetration Test blows/300mm (20 40 60 80)	Moisture Content, % (10 30 50)	Remarks
265.23	0	Ground Surface								
		Augered to 0.75 m								
264.48										50 mm diameter monitoring well to depth of 9.1 m
	1	*FILL* Seams of gravelly sand, occasional seams of clayey silt, some topsoil and organic stained at the lower section, moist then wet to saturated, loose to very loose			1	SS	5			
					2	SS	10			
	2									
					3	SS	4			
	3	saturated			4	SS	2			
260.83	4									
		Wood fragments			5	SS	24			
260.03	5									
		GRAVELLY SAND Compact, saturated								
258.93	6				6	SS	8			
	7									
		SANDY SILT			7	SS	8			
	8	Loose to compact, silt and very fine sand, rootlets observed, light grey, wet to saturated								
	9									
255.63					8	SS	10			
	10	End of Borehole								

V.A. WOOD ASSOCIATES LIMITED

Disk :

Sheet : 1 of 1

Reference No : 7171-17-6

Borehole No : 10

Enclosure No : 11

Client : AECOM

Project : Culvert Reconstruction

Method : Auger

Location : Brock St./Centennial Dr., Uxbridge, ON

Diameter : 110 mm

Datum Elevation : Geodetic

Date : August 26, 2017

Elevation m	Depth m	Description	Symbol	Water	Sample Number	Sample Type	N-value	Standard Penetration Test blows/300mm (20 40 60 80)	Moisture Content, % (10 30 50)	Remarks
264.77	0	Ground Surface								
		Augered to 0.75 m								50 mm diameter monitoring well to depth of 9.1 m
264.02	1	*FILL* Organic stained silty sand, some gravel, seams of topsoil and some organics in places, brown then grey, moist, compact at the top, then loose to very loose			1	SS	18	○		
	2				2	SS	4	○	●	
		some topsoil			3	SS	1	○		
	3				4	SS	2	○	●	
260.47	4	*GRAVELLY SAND* Loose, some silt and seams of clay at the bottom, grey, saturated			5	SS	7	○		
	5									
	6	lt grey silt at the bottom			6	SS	4	○	●	
258.22		End of Borehole								
	7									
	8									
	9									
	10									

V.A. WOOD ASSOCIATES LIMITED

Disk :

Sheet : 1 of 1

Reference No : 7171-17-6

Borehole No : 11

Enclosure No : 12

Client : AECOM

Project : Culvert Reconstruction

Method : Auger

Location : Brock St./Centennial Dr., Uxbridge, ON

Diameter : 110 mm

Datum Elevation : Geodetic

Date : August 25, 2017

Elevation m	Depth m	Description	Symbol	Water	Sample Number	Sample Type	Sample N-value	Standard Penetration Test blows/300mm (20 40 60 80)	Moisture Content, % (10 30 50)	Remarks
264.75	0	Ground Surface								
		Augered to 0.75 m								50 mm diameter monitoring well to depth of 9.1 m
264	1				1	SS	9			
		FILL			2	SS	4			
	2	Organic stained silty sand, some gravel, some topsoil and organics in places, brown to grey, moist, loose to very loose			3	SS	3			
	3				4	SS	4			
260.75	4									
		SILTY SAND Loose, organic stained, some gravel and topsoil, grey, wet			5	SS	7			
259.35	5									
	6	***SANDY SILT*** Compact, silt and very fine sand, light grey, wet			6	SS	10			
257.75	7									
	8	***SANDY SILT TILL*** Loose to compact, trace fine gravel, light grey, wet to saturated			7	SS	6			
	9									
255.15					8	SS	23			
	10	End of Borehole								

V.A. WOOD ASSOCIATES LIMITED

Disk :

Sheet : 1 of 1

Project No: 7171-17-6

Project: Culvert Reconstruction

Client: AECOM

Location: Brock Rd./Centennial Dr., Uxbridge, ON

Monitoring Well No.: 1

Enclosure: 2A

Datum Elev.: 263.01 m

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Number	Type	Blows/ft	Recovery	Standard Penetration Test blows/ft (20 40 60 80)	Well Data	Remarks
0		Ground Surface	0 / 263							50 mm diameter PVC pipe
		Augered to 0.75 m	0.75 / 262.3							
1		***FILL***		1	SS	34				GWL at Elev.261.61 on 9-15-17 pm
		Silty sand, some gravel, brown, moist, compact to desne then very loose		2	SS	13				
2				3	SS	2				
3		***SILTY SAND*** Loose, some wood fragments and peat, grey, wet	2.9 / 260.1	4	SS	8				
4			4 / 259							
5		***SANDY SILT*** Compact, silt and very fine sand, light grey, wet		5	SS	19				
6				6	SS	20				
		End of Borehole	6.55 / 256.5							
7										
8										

Drilled By: Geotech Support Services Inc.

Drill Method: Auger

Drill Date: August 29, 2017

V A Wood Associates Ltd
1080 Tapscott Rd, Unit 24
Scarborough, ON
M1X 1E7

Hole Size: 110 mm

Datum: Geodetic

Project No: 7171-17-6

Project: Culvert Reconstruction

Client: AECOM

Location: Brock St./Centennial Dr., Uxbridge, ON

Monitoring Well No.: 2

Enclosure: 3A

Datum Elev.: 262.81 m

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Number	Type	Blows/ft	Recovery	Standard Penetration Test blows/ft (20 40 60 80)	Well Data	Remarks
0		Ground Surface	0							GWL at Elev. 262.66 0n 9-15-17 pm
		Augered to 0.75 m	262.8							
			0.7921							
1			262	1	SS	5				50 mm diameter PVC pipe
		FILL		2	SS	3				
2		Organic stained sand, some gravel, brown, moist, loose		3	SS	6				
			2.9							
3			259.9	4	SS	7				
4										
		GRAVELLY SAND		5	SS	8				
5		Loose, grey, wet to saturated								
6			6.4	6	SS	5				
			256.4							
7										
		SANDY SILT		7	SS	23				
8		loose then compact, silt and very fine sand, light grey, wet								
9										
		sand and gravel at the bottom	9.6	8	SS	31				
		End of Borehole	253.2							
10										

Drilled By: Geotech Support Services Inc.

Drill Method: Auger

Drill Date: August 29, 2017

V A Wood Associates Ltd
1080 Tapscott Rd, Unit 24
Scarborough, ON
M1X 1E7

Hole Size: 110 mm

Datum: Geodetic

Sheet: 1 of 1

Project No: 7171-17-6

Project: Culvert Reconstruction

Client: AECOM

Location: Brock St./Centennial Dr., Uxbridge, ON

Monitoring Well No.: 3

Enclosure: 4A

Datum Elev.: 262.72 m

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Number	Type	Blows/ft	Recovery	Standard Penetration Test blows/ft (1, 20, 40, 60, 80)	Well Data	Remarks
0		Ground Surface	0							
		Augered to 0.75 m	262.7							GWL at ground surface on 9-15-17
			0.75							
1		***FILL***	262	1	SS	3				50 mm diameter PVC pipe
				2	SS	6				
2		Well graded sand, some gravel, brown, moist, wet at the bottom, very loose then loose		3	SS	6				
			2.9							
3			259.8	4	SS	5				
4		***GRAVELLY SAND*** Loose to compact, grey, wet to saturated								
				5	SS	15				
5			5.5							
			257.2							
6				6	SS	3				
		SANDY SILT Loose then compact, silt and very fine sand, light grey, wet to saturated								
7										
				7	SS	18				
8			8.5							
			254.2							
9		***SAND AND GRAVEL*** Dense, grey, saturated		8	SS	44				
			9.6							
		End of Borehole	253.1							
10										

Drilled By: Geotech Support Services Inc.

Drill Method: Auger

Drill Date: August 30, 2017

V A Wood Associates Ltd
1080 Tapscott Rd, Unit 24
Scarborough, ON
M1X 1E7

Hole Size: 110 mm

Datum: Geodetic

Sheet: 1 of 1

Project No: 7171-17-6

Project: Culvert Reconstruction

Client: AECOM

Location: Brock St./Centennial Dr., Uxbridge, ON

Monitoring Well No.: 4

Enclosure: 5A

Datum Elev.: 263.04 m

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Number	Type	Blows/ft	Recovery	Standard Penetration Test blows/ft (1, 20, 40, 60, 80)	Well Data	Remarks
0		Ground Surface	0							
			263							50 mm diameter PVC pipe
		Augered to 0.75 m								
			0.75							
1			262.3	1	SS	5				
		FILL								
				2	SS	1				GWL at Elev.261.36 on 9-15-17 pm
2		Gravelly sand, clear stone at 1.5 m, moist then wet to saturated, loose to very loose								
				3	SS	1				
			2.9							
3			260.1							
		PEAT		4	SS	4				
		Very loose, wet	3.6							
			259.4							
4		***GRAVELLY SAND***								
		Loose, some topsoil and organics, grey, saturated								
			4.8	5	SS	8				
5			258.2							
		SANDY SILT								
		Compact, silt and very fine sand, light grey, wet								
6				6	SS	10				
			6.55							
		End of Borehole	256.5							
7										
8										

Drilled By: Geotech Support Services Inc.

Drill Method: Auger

Drill Date: August 30, 2017

V A Wood Associates Ltd
1080 Tapscott Rd, Unit 24
Scarborough, ON
M1X 1E7

Hole Size: 110 mm

Datum: Geodetic

Sheet: 1 of 1

Project No: 7171-17-6

Project: Culvert Reconstruction

Client: AECOM

Location: Brock St./Centennial Dr., Uxbridge, ON

Monitoring Well No.: 5

Enclosure: 6A

Datum Elev.: 265.74 m

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Number	Type	Blows/ft	Recovery	Standard Penetration Test blows/ft (1, 20, 40, 60, 80)	Well Data	Remarks
0		Ground Surface	0							
		Augered to 0.75 m	265.7 0.75							50 mm diameter PVC pipe
1			265	1	SS	16				
				2	SS	8				
2		***FILL***								
		Silty sand, some gravel, occasional seams of silty clay, brown, moist, compact then loose to very loose		3	SS	3				GWL at Elev.263.0 on 9-15-17 pm
3				4	SS	3				
4			4 261.7							
		SILTY SAND		5	SS	1				
5		Very loose, grey, saturated	5.5							
			260.2							
6		***SILTY SAND AND PEAT***		6	SS	5				
		Loose, seams of silty sand and peat, wet								
7			7 258.7							
		SANDY SILT		7	SS	12				
8		Compact, silt and very fine sand, light grey, wet								
9										
		some seams of clay	9.6	8	SS	20				
10		End of Borehole	256.1							

Drilled By: Geotech Support Services Inc.

Drill Method: Auger

Drill Date: August 29, 2017

V A Wood Associates Ltd
1080 Tapscott Rd, Unit 24
Scarborough, ON
M1X 1E7

Hole Size: 110 mm

Datum: Geodetic

Project No: 7171-17-6

Project: Culvert Reconstruction

Client: AECOM

Location: Brock St./Centennial Dr., Uxbridge, ON

Monitoring Well No.: 7

Enclosure: 8A

Datum Elev.: 265.68 m

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Number	Type	Blows/ft	Recovery	Standard Penetration Test blows/ft (1, 20, 40, 60, 80)	Well Data	Remarks
0		Ground Surface	0							
		Augered to 0.75 m	265.7							50 mm diameter PVC pipe
			0.75							
1			264.9	1	SS	4				
				2	SS	4				
2		*FILL*								
		Sand, some gravel, damp to moist, brown, loose		3	SS	4				
3		gravelly		4	SS	24				GWL at Elev.262.39 on 9-15-17 pm
			4							
4			261.7							
		SILTY SAND Loose, some wood fragments, grey, wet		5	SS	5				
5			5.5							
			260.2							
6		*GRAVELLY SAND* Compact, some silt, organic stained, grey, saturated		6	SS	13				
			6.55							
		End of Borehole	259.1							
7										
8										

Drilled By: Geotech Support Services Inc.

Drill Method: Auger

Drill Date: August 28, 2017

V A Wood Associates Ltd
1080 Tapscott Rd, Unit 24
Scarborough, ON
M1X 1E7

Hole Size: 110 mm

Datum: Geodetic

Sheet: 1 of 1

Project No: 7171-17-6

Project: Culvert Reconstruction

Client: AECOM

Location: Brock St./Centennial Dr., Uxbridge, ON

Monitoring Well No.: 8

Enclosure: 9A

Datum Elev.: 265.81 m

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Number	Type	Blows/ft	Recovery	Standard Penetration Test blows/ft (20 40 60 80)	Well Data	Remarks
0		Ground Surface	0							
		Augered to 0.75 m	265.8 0.75							50 mm diameter PVC pipe
1		***FILL*** Fine to medium to well graded sand, some gravel, brown, moist, loose to very loose	265.1	1	SS	9				GWL at Elev.264.59 on 9-15-17 pm
				2	SS	5				
2				3	SS	4				
3				4	SS	1				
4			4							
		SILTY SAND Loose, organic stained silty sand, some gravel and peat, grey, wet	261.8	5	SS	4				
5			5.5							
			260.3							
6				6	SS	7				
7		***SANDY SILT*** Loose then compact to dense, silt and very fine sand, light grey, wet to saturated								
8				7	SS	19				
9										
			9.6	8	SS	40				
10		End of Borehole	256.2							

Drilled By: Geotech Support Services Inc.

Drill Method: Auger

Drill Date: August 26, 2017

V A Wood Associates Ltd
1080 Tapscott Rd, Unit 24
Scarborough, ON
M1X 1E7

Hole Size: 110 mm

Datum: Geodetic

Sheet: 1 of 1

Project No: 7171-17-6

Project: Culvert Reconstruction

Client: AECOM

Location: Brock St./Centennial Dr., Uxbridge, ON

Monitoring Well No.: 9

Enclosure: 10A

Datum Elev.: 265.23 m

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Number	Type	Blows/ft	Recovery	Standard Penetration Test blows/ft (1, 20, 40, 60, 80)	Well Data	Remarks
0		Ground Surface	0							
		Augered to 0.75 m	265.2 0.75							50 mm diameter PVC pipe
1		***FILL*** Seams of gravelly sand, occasional seams of clayey silt, some topsoil and organic stained at the lower section, moist then wet to saturated, loose to very loose	264.5	1	SS	5				
				2	SS	10				GWL at Elev.263.55 on 9-15-17 pm
2				3	SS	4				
3		saturated		4	SS	2				
4			4.4							
		Wood fragments	260.8	5	SS	24				
5			5.2							
		GRAVELLY SAND Compact, saturated	260 6.3							
6				6	SS	8				
7		***SANDY SILT*** Loose to compact, silt and very fine sand, rootlets observed, light grey, wet to saturated	258.9	7	SS	8				
8										
9			9.6	8	SS	10				
		End of Borehole	255.6							
10										

Drilled By: Geotech Support Services Inc.

Drill Method: Auger

Drill Date: August 25, 2017

V A Wood Associates Ltd
1080 Tapscott Rd, Unit 24
Scarborough, ON
M1X 1E7

Hole Size: 110 mm

Datum: Geodetic

Sheet: 1 of 1

Project No: 7171-17-6

Project: Culvert Reconstruction

Client: AECOM

Location: Brock St./Centennial Dr., Uxbridge, ON

Monitoring Well No.: 10

Enclosure: 11A

Datum Elev.: 264.77 m

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Number	Type	Blows/ft	Recovery	Standard Penetration Test blows/ft (1, 20, 40, 60, 80)	Well Data	Remarks
0		Ground Surface	0							
		Augered to 0.75 m	264.8 0.75							50 mm diameter PVC pipe
1		***FILL*** Organic stained silty sand, some gravel, seams of topsoil and some organics in places, brown then grey, moist, compact at the top, then loose to very loose	264	1	SS	18				
2				2	SS	4				
		some topsoil		3	SS	1				GWL at Elev.262.45 on 9-15-17 pm
3				4	SS	2				
4			4.3							
		GRAVELLY SAND Loose, some silt and seams of clay at the bottom, grey, saturated	260.5	5	SS	7				
5										
6		lt grey silt at the bottom	6.55	6	SS	4				
		End of Borehole	258.2							
7										
8										
9										
10										

Drilled By: Geotech Support Services Inc.

Drill Method: Auger

Drill Date: August 26, 2017

V A Wood Associates Ltd
1080 Tapscott Rd, Unit 24
Scarborough, ON
M1X 1E7

Hole Size: 110 mm

Datum: Geodetic

Sheet: 1 of 1

Project No: 7171-17-6

Project: Culvert Reconstruction

Client: AECOM

Location: Brock St./Centennial Dr., Uxbridge, ON

Monitoring Well No.: 11

Enclosure: 12A

Datum Elev.: 264.75 m

SUBSURFACE PROFILE

Depth	Symbol	Description	Depth/Elev.	Number	Type	Blows/ft	Recovery	Standard Penetration Test blows/ft (20 40 60 80)	Well Data	Remarks
0		Ground Surface	0							
		Augered to 0.75 m	264.8							50 mm diameter PVC pipe
			0.75							
1		***FILL***	264	1	SS	9				
				2	SS	4				
2		Organic stained silty sand, some gravel, some topsoil and organics in places, brown to grey, moist, loose to very loose		3	SS	3				
3				4	SS	4				GWL at Elev.261.64 on 9-15-17 pm
			4							
4		***SILTY SAND***	260.8							
5		Loose, organic stained, some gravel and topsoil, grey, wet		5	SS	7				
			5.4							
6		***SANDY SILT***	259.4							
		Compact, silt and very fine sand, light grey, wet		6	SS	10				
7			7							
		SANDY SILT TILL	257.8							
8		Loose to compact, trace fine gravel, light grey, wet to saturated		7	SS	6				
9										
			9.6	8	SS	23				
10		End of Borehole	255.1							

Drilled By: Geotech Support Services Inc.

Drill Method: Auger

Drill Date: August 25, 2017

V A Wood Associates Ltd
1080 Tapscott Rd, Unit 24
Scarborough, ON
M1X 1E7

Hole Size: 110 mm

Datum: Geodetic

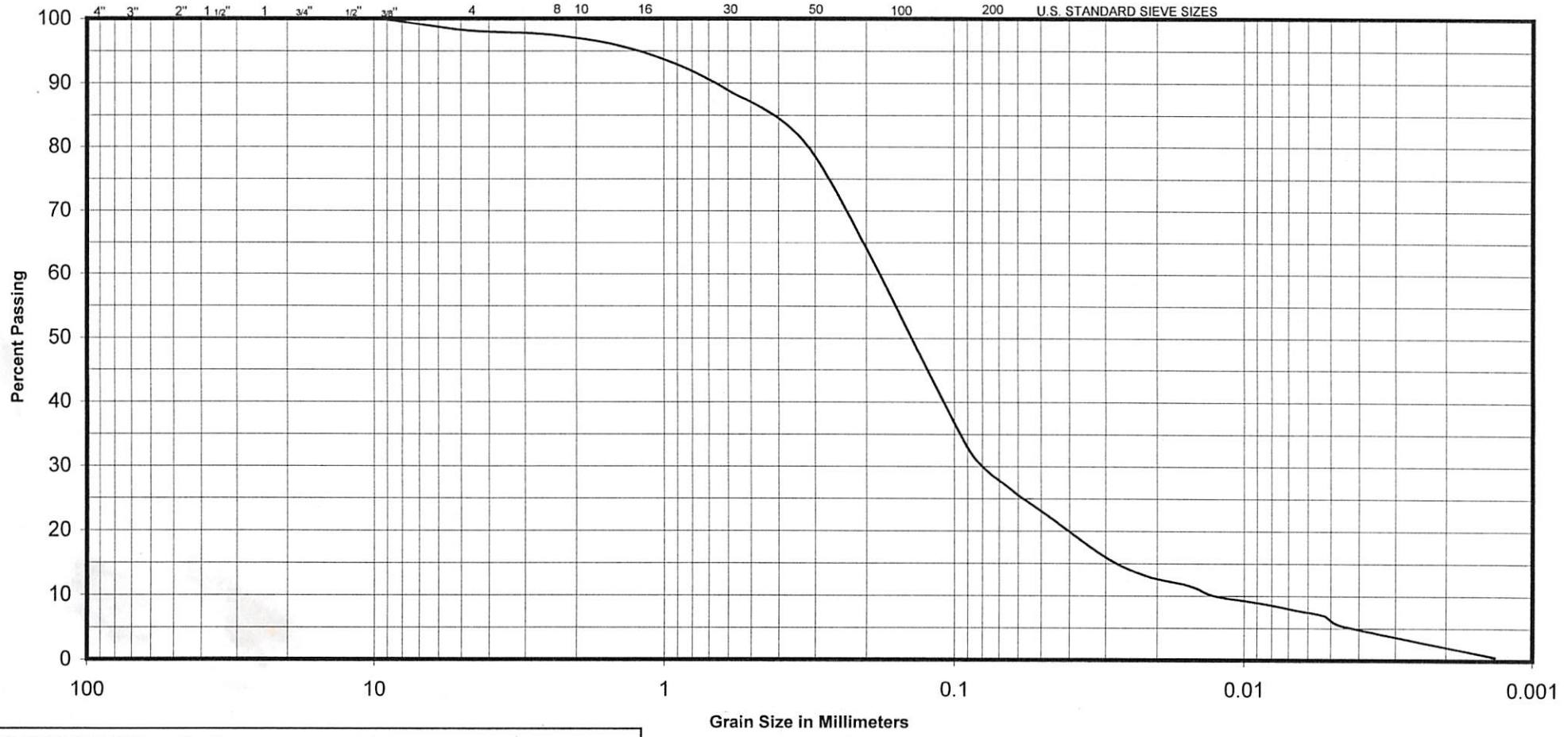
Sheet: 1 of 1

GRAIN SIZE DISTRIBUTION

OUR REFERENCE No.: 7171-17-6

GRAVEL		SAND			SILT & CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

UNIFIED SOIL CLASSIFICATION SYSTEM



PROJECT: Culvert Reconstruction
LOCATION: Brock St./Centennial Dr., Uxbridge, ON
BOREHOLE NO.: 5
SAMPLE NO.: 5
DEPTH : 4.8 m
DATE: September 2017

Silty SAND, trace clay

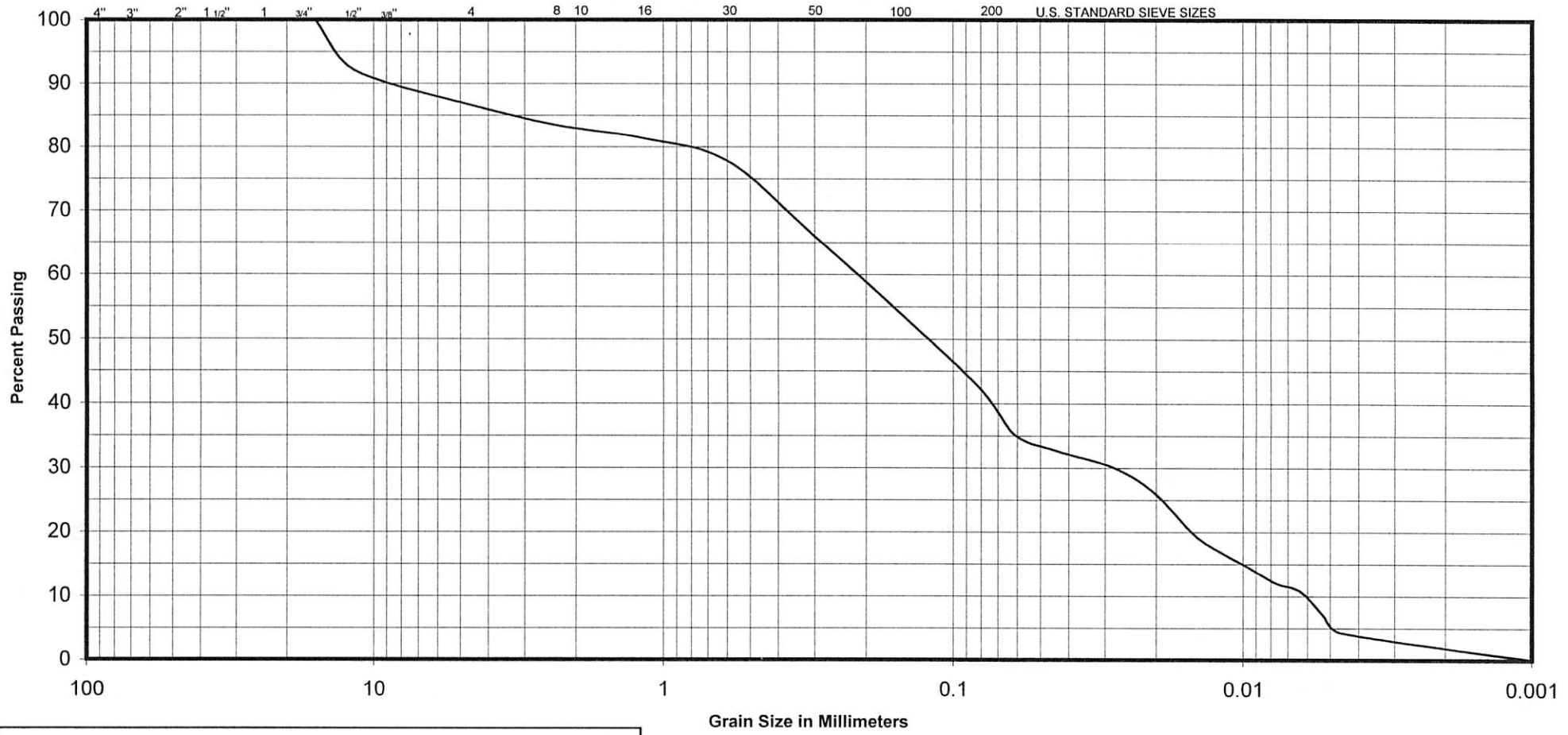
ENCLOSURE No.: 13

GRAIN SIZE DISTRIBUTION

OUR REFERENCE No.: 7171-17-6

GRAVEL		SAND			SILT & CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

UNIFIED SOIL CLASSIFICATION SYSTEM



PROJECT: Culvert Reconstruction
LOCATION: Brock St./Centennial Dr., Uxbridge, ON
BOREHOLE NO.: 11
SAMPLE NO.: 5
DEPTH : 4.8 m
DATE: September 2017

Silty SAND, some gravel

ENCLOSURE No.: 14

GRAIN SIZE DISTRIBUTION

OUR REFERENCE No.: 7171-17-6

GRAVEL		SAND			SILT & CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

UNIFIED SOIL CLASSIFICATION SYSTEM

PROJECT: Culvert Reconstruction
LOCATION: Brock St./Centennial Dr., Uxbridge, ON
BOREHOLE NO.: 2
SAMPLE NO.: 5
DEPTH : 4.8 m
DATE: September 2017

Well graded SAND and GRAVEL, some silt

ENCLOSURE No.: 15

GRAIN SIZE DISTRIBUTION

OUR REFERENCE No.: 7171-17-6

GRAVEL		SAND			SILT & CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

UNIFIED SOIL CLASSIFICATION SYSTEM

PROJECT: Culvert Reconstruction
LOCATION: Brock St./Centennial Dr., Uxbridge, ON
BOREHOLE NO.: 3
SAMPLE NO.: 5
DEPTH : 4.8 m
DATE: September 2017

Well graded SAND and GRAVEL

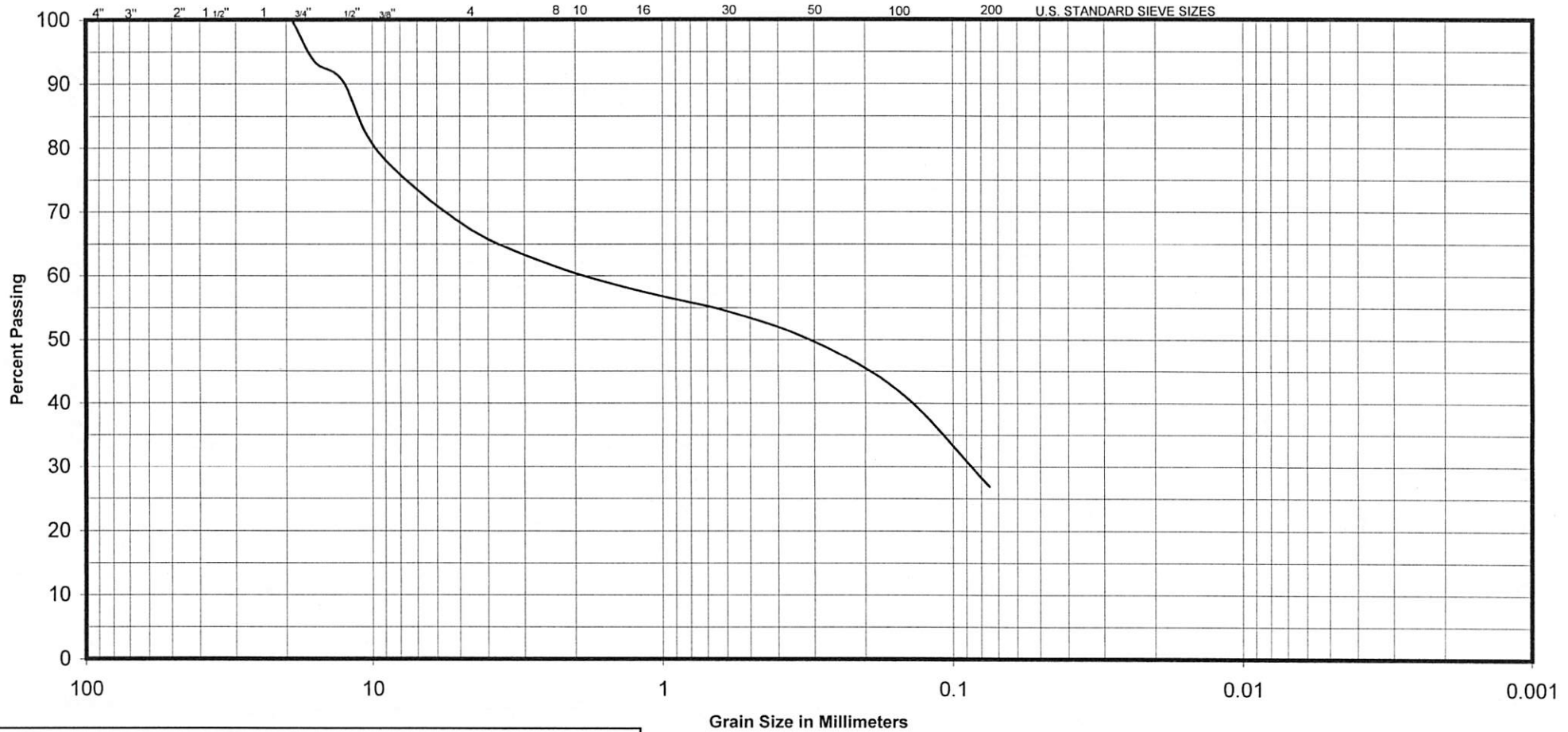
ENCLOSURE No.: 16

GRAIN SIZE DISTRIBUTION

OUR REFERENCE No.: 7171-17-6

GRAVEL		SAND			SILT & CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

UNIFIED SOIL CLASSIFICATION SYSTEM



PROJECT: Culvert Reconstruction
LOCATION: Brock St./Centennial Dr., Uxbridge, ON
BOREHOLE NO.: 4
SAMPLE NO.: 5
DEPTH : 4.8 m
DATE: September 2017

Gravelly SAND, some silt

ENCLOSURE No.: 17

GRAIN SIZE DISTRIBUTION

OUR REFERENCE No.: 7171-17-6

GRAVEL		SAND			SILT & CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

UNIFIED SOIL CLASSIFICATION SYSTEM

PROJECT: Culvert Reconstruction
LOCATION: Brock St./Centennial Dr., Uxbridge, ON
BOREHOLE NO.: 7
SAMPLE NO.: 6
DEPTH : 6.3 m
DATE: September 2017

Gravelly SAND, trace silt

ENCLOSURE No.: 18

GRAIN SIZE DISTRIBUTION

OUR REFERENCE No.: 7171-17-6

GRAVEL		SAND			SILT & CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

UNIFIED SOIL CLASSIFICATION SYSTEM

PROJECT: Culvert Reconstruction
LOCATION: Brock St./Centennial Dr., Uxbridge, ON
BOREHOLE NO.: 1
SAMPLE NO.: 5
DEPTH : 4.8 m
DATE: September 2017

SILT and Fine SAND

ENCLOSURE No.: 19

GRAIN SIZE DISTRIBUTION

OUR REFERENCE No.: 7171-17-6

GRAVEL		SAND			SILT & CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

UNIFIED SOIL CLASSIFICATION SYSTEM

PROJECT: Culvert Reconstruction
LOCATION: Brock St./Centennial Dr., Uxbridge, ON
BOREHOLE NO.: 1
SAMPLE NO.: 6
DEPTH : 6.3 m
DATE: September 2017

SILT and Fine SAND

ENCLOSURE No.: 20

GRAIN SIZE DISTRIBUTION

OUR REFERENCE No.: 7171-17-6

PROJECT: Culvert Reconstruction
LOCATION: Brock St./Centennial Dr., Uxbridge, ON
BOREHOLE NO.: 3
SAMPLE NO.: 6
DEPTH : 6.3 m
DATE: September 2017

Sandy SILT, trace clay

ENCLOSURE No.: 21

GRAIN SIZE DISTRIBUTION

OUR REFERENCE No.: 7171-17-6

PROJECT: Culvert Reconstruction
LOCATION: Brock St./Centennial Dr., Uxbridge, ON
BOREHOLE NO.: 5
SAMPLE NO.: 7
DEPTH : 7.8 m
DATE: September 2017

Fine SAND and SILT

ENCLOSURE No.: 22

GRAIN SIZE DISTRIBUTION

OUR REFERENCE No.: 7171-17-6

GRAVEL		SAND			SILT & CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

UNIFIED SOIL CLASSIFICATION SYSTEM

PROJECT: Culvert Reconstruction
LOCATION: Brock St./Centennial Dr., Uxbridge, ON
BOREHOLE NO.: 8
SAMPLE NO.: 8
DEPTH : 9.3 m
DATE: September 2017

SILT and Fine SAND, trace clay

ENCLOSURE No.: 23

GRAIN SIZE DISTRIBUTION

OUR REFERENCE No.: 7171-17-6

GRAVEL		SAND			SILT & CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

UNIFIED SOIL CLASSIFICATION SYSTEM

PROJECT: Culvert Reconstruction
LOCATION: Brock St./Centennial Dr., Uxbridge, ON
BOREHOLE NO.: 9
SAMPLE NO.: 7
DEPTH : 7.8 m
DATE: September 2017

Sandy SILT, trace clay

ENCLOSURE No.: 24

GRAIN SIZE DISTRIBUTION

OUR REFERENCE No.: 7171-17-6

GRAVEL		SAND			SILT & CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

UNIFIED SOIL CLASSIFICATION SYSTEM

PROJECT: Culvert Reconstruction
LOCATION: Brock St./Centennial Dr., Uxbridge, ON
BOREHOLE NO.: 11
SAMPLE NO.: 7
DEPTH : 7.8 m
DATE: September 2017

Sandy SILT, trace clay

ENCLOSURE No.: 25

AECOM Imagine it. Delivered.

Appendix C

MOECC Water Well Record Database Search Results

BOREHOLEID	WELL_ID	COMPLETED	DEPTH	DP_BED ROCK	STATIC _LEV	ZONE	X	Y	RELIABILTY	METHOD	WELL_TYPE	OPEN_ HOLE	DATE_COM PL	REMARKS	METHOD_1	OTHER_METH	THICKNESS
10073753	1904901	2/16/1977	98.5	0	3	17	650414.9	4885123	margin of error : 100 m - 300 m	Original Pre1985 UTM Rel Code 5: margin of error : 100 m - 300 m	Overburden		2/16/1977		Rotary (Convent.)		1
10073755	1904903	2/28/1977	57.3	0	0	17	650314.9	4885123	margin of error : 100 m - 300 m	Original Pre1985 UTM Rel Code 5: margin of error : 100 m - 300 m	Overburden		2/28/1977		Rotary (Convent.)		1
10073756	1904904	2/3/1977	72.5	0	-3	17	650464.9	4885173	margin of error : 100 m - 300 m	Original Pre1985 UTM Rel Code 5: margin of error : 100 m - 300 m	Overburden		2/3/1977		Rotary (Convent.)		1
1005916103	7260106	5/12/2015	0	0	0	17	650573	4885260	margin of error : 30 m - 100 m	on Water Well Record			5/12/2015				<Null>
1004238924	7195621	3/22/2011	7.6	0	0	17	649938	4885501	margin of error : 30 m - 100 m	on Water Well Record			3/22/2011		Cable Tool		12
1004261783	7198295	3/22/2011	0	0	0	17	649938	4885501	margin of error : 30 m - 100 m	on Water Well Record			3/22/2011				<Null>
1004238773	7195594	11/11/2011	0	0	0	17	649961	4885502	margin of error : 30 m - 100 m	on Water Well Record			11/11/2011				<Null>
1004239715	7195684	7/10/2010	0	0	0	17	649961	4885502	margin of error : 30 m - 100 m	on Water Well Record			7/10/2010		Rotary (Air)		<Null>
23046684	7046684	5/23/2007	0	0	0	17	649869	4885505	margin of error : 10 - 30 m	on Water Well Record			5/23/2007		Rotary (Convent.)		<Null>
1004239729	7195685	2/28/2011	0	0	0	17	649948	4885509	margin of error : 30 m - 100 m	on Water Well Record			2/28/2011		Rotary (Convent.)	DUAL ROTARY	<Null>
1005109717	7226552	11/11/2011	0	0	0	17	649948	4885509	margin of error : 30 m - 100 m	on Water Well Record			11/11/2011				<Null>
23046652	7046652	6/8/2007	0	0	0	17	649845	4885510	margin of error : 10 - 30 m	on Water Well Record			6/8/2007				<Null>
1004238918	7195619	10/8/2010	8.1	0	1.1	17	649950	4885513	margin of error : 30 m - 100 m	on Water Well Record			10/8/2010		Rotary (Air)		8
1004238921	7195620	11/10/2011	0	0	0	17	649950	4885513	margin of error : 30 m - 100 m	on Water Well Record			11/10/2011				<Null>
1004238912	7195617	3/22/2012	6.1	0	0	17	649942	4885534	margin of error : 30 m - 100 m	on Water Well Record			3/22/2012		Cable Tool		12
1004238915	7195618	11/10/2012	0	0	0	17	649942	4885534	margin of error : 30 m - 100 m	on Water Well Record			11/10/2012				<Null>
1004238906	7195615	10/8/2012	8.1	0	2	17	649967	4885539	margin of error : 30 m - 100 m	on Water Well Record			10/8/2012		Rotary (Air)		3
1004238909	7195616	11/10/2011	0	0	0	17	649967	4885539	margin of error : 30 m - 100 m	on Water Well Record			11/10/2011				<Null>
1003632028	7174782	7/26/2011	0	0	0	17	649891	4885592	margin of error : 30 m - 100 m	on Water Well Record			7/26/2011				<Null>
1003632038	7174787	7/26/2011	17.1	0	0	17	649891	4885592	margin of error : 30 m - 100 m	on Water Well Record			7/26/2011				3
1002449135	7123788	4/29/2009	7.6	0	0	17	649976	4885594	margin of error : 30 m - 100 m	on Water Well Record			4/29/2009		Auger		0.5
1003631966	7174751	8/2/2011	0	0	0	17	649897	4885604	margin of error : 30 m - 100 m	on Water Well Record			8/2/2011				<Null>
1003632024	7174780	7/21/2011	0	0	0	17	649897	4885616	margin of error : 30 m - 100 m	on Water Well Record			7/21/2011				<Null>
10294041	4602676	7/7/1956	18.3	0	0	17	649803.9	4885618	margin of error : 100 m - 300 m	Original Pre1985 UTM Rel Code 5: margin of error : 100 m - 300 m	Overburden		7/7/1956		Cable Tool		18
1004253544	7197180	1/22/2013	7.3	0	0	17	650120	4885629	margin of error : 30 m - 100 m	on Water Well Record			1/22/2013		Direct Push		4
1003632026	7174781	7/19/2011	0	0	0	17	649909	4885631	margin of error : 30 m - 100 m	on Water Well Record			7/19/2011				<Null>
1006272648	7273367	8/29/2016	0	0	0	17	650100	4885635	margin of error : 30 m - 100 m	on Water Well Record			8/29/2016				<Null>
1006272645	7273366	8/29/2016	0	0	0	17	650110	4885638	margin of error : 30 m - 100 m	on Water Well Record			8/29/2016				<Null>
1006218162	7269312	7/14/2016	6.1	0	0	17	650100	4885650	margin of error : 30 m - 100 m	on Water Well Record			7/14/2016		Direct Push		0.5
1006272654	7273369	8/30/2016	0	0	0	17	650068	4885652	margin of error : 30 m - 100 m	on Water Well Record			8/30/2016				<Null>
1006272642	7273365	8/29/2016	0	0	0	17	650125	4885657	margin of error : 30 m - 100 m	on Water Well Record			8/29/2016				<Null>
1004253744	7197205	1/22/2013	7.3	0	0	17	650110	4885660	margin of error : 30 m - 100 m	on Water Well Record			1/22/2013		Direct Push		4
1004716001	7217006	11/19/2013	0	0	-5.2	17	649903	4885663	margin of error : 30 m - 100 m	on Water Well Record			11/19/2013		Other Method	DR	<Null>
1006218159	7269311	7/14/2016	6.1	0	0	17	650100	4885665	margin of error : 30 m - 100 m	on Water Well Record			7/14/2016		Direct Push		4
1004898822	7222712	5/27/2014	6.1	0	0	17	650089	4885666	margin of error : 30 m - 100 m	on Water Well Record			5/27/2014		Direct Push		5
1004253538	7197178	1/22/2013	6.1	0	0	17	650092	4885668	margin of error : 10 - 30 m	on Water Well Record			1/22/2013		Direct Push		4
1004715998	7217005	11/19/2013	0	0	4.4	17	649898	4885669	margin of error : 30 m - 100 m	on Water Well Record			11/19/2013		Other Method	DUAL ROTARY	<Null>
1006272651	7273368	8/30/2016	0	0	0	17	650062	4885670	margin of error : 30 m - 100 m	on Water Well Record			8/30/2016				<Null>
1004253541	7197179	1/22/2013	8.2	0	0	17	650102	4885670	margin of error : 30 m - 100 m	on Water Well Record			1/22/2013		Direct Push		4
1005937310	7261857	3/22/2016	6.1	0	0	17	650094	4885673	margin of error : 30 m - 100 m	on Water Well Record			3/22/2016		Direct Push		6
1004898841	7222714	3/27/2014	6.1	0	0	17	650090	4885675	margin of error : 30 m - 100 m	on Water Well Record			3/27/2014		Direct Push		5
1004898803	7222710	5/27/2014	8.8	0	0	17	650101	4885676	margin of error : 30 m - 100 m	on Water Well Record			5/27/2014		Direct Push		5
1004898825	7222713	5/27/2014	6.1	0	0	17	650101	4885677	margin of error : 30 m - 100 m	on Water Well Record			5/27/2014		Direct Push		5
1004898819	7222711	5/27/2014	4.9	0	0	17	650085	4885681	margin of error : 30 m - 100 m	on Water Well Record			5/27/2014		Direct Push		3
1002037702	7121343	3/10/2009	4.6	0	0	17	650224	4885682	margin of error : 30 m - 100 m	on Water Well Record			3/10/2009		Other Method	DIRECT PUSH	0.91
1002037705	7121344	3/10/2009	4.6	0	0	17	650224	4885682	margin of error : 30 m - 100 m	on Water Well Record			3/10/2009		Other Method	DIRECT PUSH	0.91
1003781301	7180982	3/26/2012	0	0	0	17	650119	4885683	margin of error : 30 m - 100 m	on Water Well Record			3/26/2012		Direct Push		<Null>
1005937304	7261855	3/22/2016	4.6	0	0	17	650083	4885683	margin of error : 30 m - 100 m	on Water Well Record			3/22/2016		Direct Push		4
1005937307	7261856	3/22/2016	4.6	0	0	17	650081	4885688	margin of error : 30 m - 100 m	on Water Well Record			3/22/2016		Direct Push		4
1003557398	7167942	8/16/2011	0	0	0	17	650066	4885704	margin of error : 10 - 30 m	on Water Well Record			8/16/2011				<Null>
10075317	1906636	4/26/1983	22.6	0	1.2	17	649914.9	4885723	margin of error : 100 m - 300 m	Original Pre1985 UTM Rel Code 5: margin of error : 100 m - 300 m	Overburden		4/26/1983		Cable Tool		2
1004716004	7217007	12/21/2013	0	0	0	17	649892	4885727	margin of error : 30 m - 100 m	on Water Well Record			12/21/2013				<Null>
10297742	4606453	3/24/1976	23.8	0	0	17	649944.9	4885833	margin of error : 100 m - 300 m	Original Pre1985 UTM Rel Code 5: margin of error : 100 m - 300 m	Overburden		3/24/1976		Cable Tool		5
10296606	4605286	8/30/1972	7.9	0	2.7	17	649814.9	4885848	margin of error : 30 m - 100 m	Original Pre1985 UTM Rel Code 4: margin of error : 30 m - 100 m	Overburden		8/30/1972		Boring		1
1003886474	7182313	5/15/2012	0	0	0	17	650090	4885873	margin of error : 30 m - 100 m	on Water Well Record			5/15/2012				<Null>
10296155	4604829	5/11/1971	16.8	0	2.7	17	649864.9	4885963	margin of error : 30 m - 100 m	Original Pre1985 UTM Rel Code 4: margin of error : 30 m - 100 m	Overburden		5/11/1971		Cable Tool		30
10297635	4606344	9/13/1975	17.1	0	0	17	649838.9	4885970	margin of error : 30 m - 100 m	Original Pre1985 UTM Rel Code 4: margin of error : 30 m - 100 m	Overburden		9/13/1975		Cable Tool		1
10296287	4604963	7/2/1971	18.3	0	0.9	17	649949.9	4885973	margin of error : 30 m - 100 m	Original Pre1985 UTM Rel Code 4: margin of error : 30 m - 100 m	Overburden		7/2/1971		Cable Tool		3
10296633	4605314	6/22/1972	7.6	0	2.4	17	649844.9	4885973	margin of error : 30 m - 100 m	Original Pre1985 UTM Rel Code 4: margin of error : 30 m - 100 m	Overburden		6/22/1972		Boring		1
10296671	4605352	1/2/1973	21.3	0	0	17	649914.9	4885973	margin of error : 30 m - 100 m	Original Pre1985 UTM Rel Code 4: margin of error : 30 m - 100 m	Overburden		1/2/1973		Cable Tool		18
10297198	4605887	5/10/1974	18.3	0	0	17	649885.9	4885989	margin of error : 30 m - 100 m	Original Pre1985 UTM Rel Code 4: margin of error : 30 m - 100 m	Overburden		5/10/1974		Cable Tool		32
10296205	4604879	8/26/1971	21.3	0	5.5	17	649884.9	4886013	margin of error : 30 m - 100 m	Original Pre1985 UTM Rel Code 4: margin of error : 30 m - 100 m	Overburden		8/26/1971		Cable Tool		23
10083440	1914851	10/17/2000	0	0	0	17	650175	4886050	margin of error : 10 - 30 m	from gps			10/17/2000		Not Known		<Null>
1003235594	7148958	7/22/2010	0	0	0	17	650247	4886057	margin of error : 30 m - 100 m	on Water Well Record			7/22/2010				<Null>
1005280736	7235444	10/14/2014	0	0	3.7	17	650587	4886059	margin of error : 30 m - 100 m	on Water Well Record			10/14/2014				<Null>
10296026	4604696	8/21/1970	9.1	0	1.5	17	649924.9	4886083	margin of error : 30 m - 100 m	Original Pre1985 UTM Rel Code 4: margin of error : 30 m - 100 m	Overburden		8/21/1970		Boring		1
1004653517	7211875	11/7/2013	4.6	0	0	17	650186	4886159	margin of error : 30 m - 100 m	on Water Well Record			11/7/2013		Direct Push		2
1004653520	7211876	11/7/2013	4.6	0	0	17	650155	4886164	margin of error : 30 m - 100 m	on Water Well Record			11/7/2013		Direct Push		5
1003330574	7150681	8/16/2010	6	0	0	17	650258	4886184	margin of error : 30 m - 100 m	on Water Well Record			8/16/2010		Boring		0.75
11173421	1917255	7/1/2004	41	0	-1.7	17	650316	4886227	margin of error : 10 - 30 m	on Water Well Record	Overburden		7/1/2004		Rotary (Convent.)		1
11173375	1917209	6/10/2004	15.2	4	0	17	650306	4886292	margin of error : 10 - 30 m	on Water Well Record	Bedrock		6/10/2004		Rotary (Convent.)		1
11173422	1917256	6/30/2004	4.9	0	-2	17	650354	4886303	margin of error : 10 - 30 m	on Water Well Record	Overburden		6/30/2004		Rotary (Convent.)		0.5

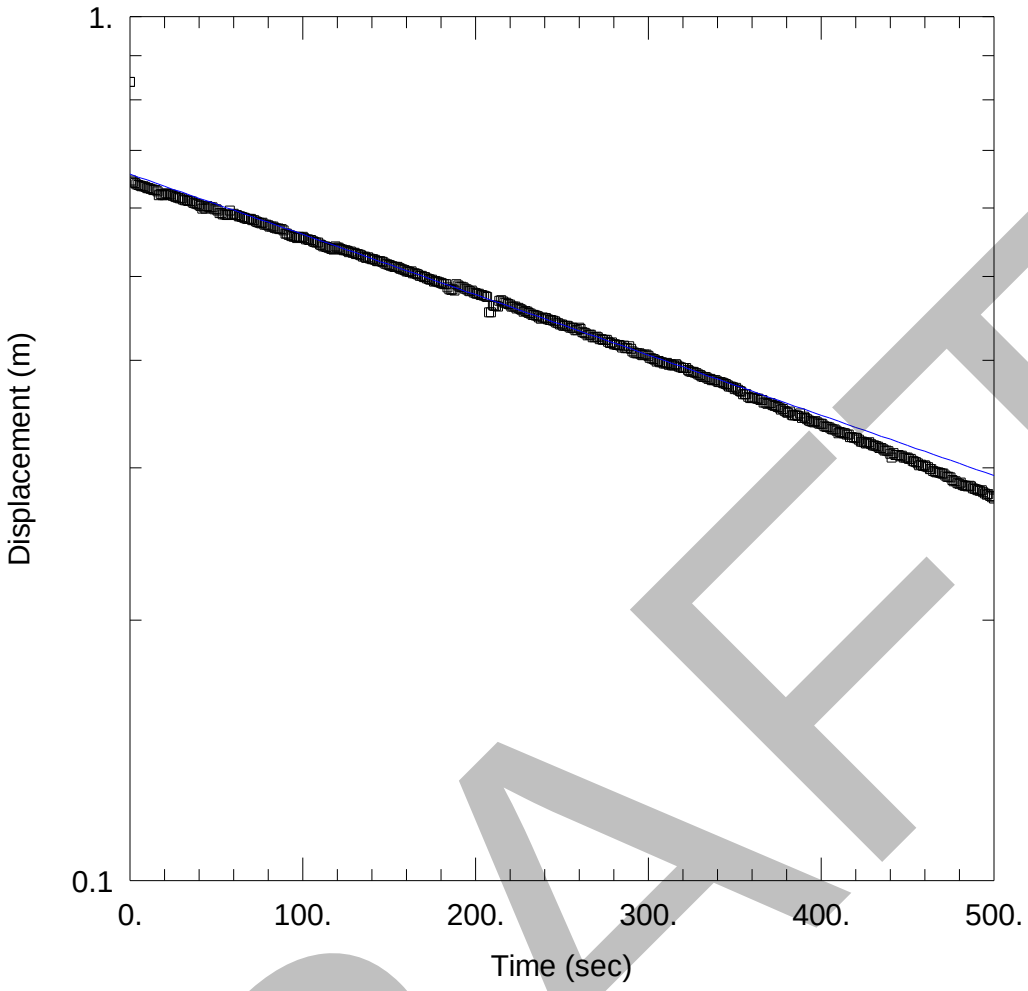
BOREHOLEID	WELL_ID	MATERIALCO	MATERIAL	MATERIAL2	MATERIAL3	DEPTH_M	ORIGINAL_D	UNIT	DEPTH_IN_M	ORIGINAL_D_1	UNIT_1	WATER_KIND	AUDIT_NO	TAG	COUNTY	TOWNSHIP	CONCESSION	LOT	RECEIVED
10073753	1904901	BLACK	TOPSOIL			0.3048	1	ft	<Null>	<Null>	<Null>	<Null>			DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	29	1/4/1978
10073755	1904903	BLACK	TOPSOIL			0.3048	1	ft	<Null>	<Null>	<Null>	<Null>			DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	29	1/4/1978
10073756	1904904	BLACK	TOPSOIL			0.3048	1	ft	<Null>	<Null>	<Null>	<Null>			DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	29	1/4/1978
1005916103	7260106	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	C23224		DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)			3/30/2016
1004238924	7195621	BROWN	SAND	GRAVEL	SILT	3.6576	12	ft	0	0	ft		Z136823	A111009	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	30	1/18/2013
1004261783	7198295	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0	0	ft		Z142747	A111009	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	30	3/8/2013
1004238773	7195594	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0	0	ft		Z142744	A108600	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	30	1/18/2013
1004239715	7195684	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0	0	m		Z117993	A108600	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	30	1/18/2013
23046684	7046684	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Z70384	A049081	DURHAM	UXBRIDGE TOWN			7/17/2007
1004239729	7195685	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0	0	ft		Z142748	A121066	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	30	1/18/2013
1005109717	7226552	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0	0	ft		Z142749	A121066	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	30	9/3/2014
23046652	7046652	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Z66289	A050277	DURHAM	UXBRIDGE TOWN			7/17/2007
1004238918	7195619	BROWN	SAND	GRAVEL	SILT	2.4384	8	ft	0	0	ft		Z117999	A121064	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	30	1/18/2013
1004238921	7195620	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0	0	ft		Z142745	A121064	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	30	1/18/2013
1004238912	7195617	BROWN	SAND	GRAVEL	SILT	3.6576	12	ft	0	0	ft		Z136824	A111010	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	30	1/18/2013
1004238915	7195618	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0	0	ft		Z142746	A111010	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	30	1/18/2013
1004238906	7195615	BROWN	SILT	GRAVEL		0.91439	3	ft	0	0	ft		Z117998	A121068	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	30	1/18/2013
1004238909	7195616	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0	0	ft		Z148713	A121068	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	30	1/18/2013
1003632028	7174782	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0	0	ft		Z142720	A121065	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	31	1/11/2012
1003632038	7174787	BLACK	WOOD FRAGMENTS	TOPSOIL	SANDY	0.91439	3	ft	0	0	ft		Z142719	A121065	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	31	1/11/2012
1002449135	7123788	BLACK	OTHER			0.1524	0.5	ft	0	0	ft		Z90866	A084294	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	30	6/8/2009
1003631966	7174751	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0	0	ft		Z142712	A121061	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	31	1/11/2012
1003632024	7174780	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0	0	ft		Z142710	A121062	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	31	1/11/2012
10294041	4602676	BROWN	CLAY			5.4864	18	ft	17.0688	56	ft	FRESH			DURHAM	UXBRIDGE TOWN	CON 06	31	9/6/1956
1004253544	7197180	BROWN	SAND			1.2192	4	ft	0	0	ft		Z165621	A143811	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)			2/14/2013
1003632026	7174781	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0	0	ft		Z142711	A121063	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	31	1/11/2012
1006272648	7273367	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Z241173	A205773	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)			10/17/2016
1006272645	7273366	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Z241174	A205772	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)			10/17/2016
1006218162	7269312	GREY				0.1524	0.5	ft	0	0	ft		Z235191	A205976	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)			8/17/2016
1006272654	7273369	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Z241134	A180353	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)			10/17/2016
1006272642	7273365	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Z241175	A184931	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)			10/17/2016
1004253744	7197205	BROWN	SAND			1.2192	4	ft	0	0	ft		Z164261	A143718	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)			2/14/2013
1004716001	7217006	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0	0	ft		Z170783	A129399	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	31	2/26/2014
1006218159	7269311	BROWN	SAND			1.2192	4	ft	0	0	ft		Z235189	A202597	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)			8/17/2016
1004898822	7222712	BROWN	FILL			1.524	5	ft	0	0	ft		Z188178	A164895	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)			6/27/2014
1004253538	7197178	BROWN	SAND			1.2192	4	ft	0	0	ft		Z165620	A143689	DURHAM	UXBRIDGE TOWN			2/14/2013
1004715998	7217005	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0	0	ft		Z170782	A129397	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)			2/26/2014
1006272651	7273368	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Z241130	A206085	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)			10/17/2016
1004253541	7197179	BROWN	SAND			1.2192	4	ft	0	0	ft		Z165619	A143812	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)			2/14/2013
1005937310	7261857	BROWN	SAND	SILT	SOFT	1.8288	6	ft	0	0	ft		Z229421	A197731	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)			4/25/2016
1004898841	7222714	BROWN	FILL			1.524	5	ft	0	0	ft		Z188180	A156286	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)			6/27/2014
1004898803	7222710	BROWN	FILL			1.524	5	ft	0	0	ft		Z188181	A165726	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)			6/27/2014
1004898825	7222713	BROWN	FILL			1.524	5	ft	0	0	ft		Z188179	A165725	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)			6/27/2014
1004898819	7222711	BROWN	FILL			0.91439	3	ft	0	0	ft		Z165717	A159289	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)			6/27/2014
1002037702	7121343	BROWN	FILL	SAND	LOOSE	0.91	0.91	m	0	0	m		Z096671	A078996	DURHAM	UXBRIDGE TOWN			4/2/2009
1002037705	7121344	BROWN	FILL	SAND	LOOSE	0.91	0.91	m	0	0	m		Z096673	A078988	DURHAM	UXBRIDGE TOWN			4/2/2009
1003781301	7180982	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0	0	ft		Z148368	A129219	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)			5/17/2012
1005937304	7261855	BROWN	SAND	SILT	SOFT	1.2192	4	ft	0	0	ft		Z229420	A197999	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)			4/25/2016
1005937307	7261856	BROWN	SAND	SILT	SOFT	1.2192	4	ft	0	0	ft		Z229422	A198030	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)			4/25/2016
1003557398	7167942	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	M08180	A085111	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	31	8/31/2011
10075317	1906636	BLACK	TOPSOIL			0.6096	2	ft	21.336	70	ft	FRESH			DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	31	6/28/1983
1004716004	7217007	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0	0	ft		Z170775	A129380	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	31	2/26/2014
10297742	4606453	YELLOW	CLAY	SAND	FILL	1.524	5	ft	21.9456	72	ft	FRESH			DURHAM	UXBRIDGE TOWN			4/9/1976
10296606	4605286	BROWN	TOPSOIL			0.3048	1	ft	2.7432	9	ft	FRESH			DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	32	1/4/1973
1003886474	7182313	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0	0	ft		Z141286		DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	31	6/12/2012
10296155	4604829		PREVIOUSLY DUG			9.144	30	ft	9.144	30	ft	FRESH			DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	32	9/14/1971
10297635	4606344	BLACK	TOPSOIL			0.3048	1	ft	15.24	50	ft	FRESH			DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	32	12/8/1975
10296287	4604963	BLACK	TOPSOIL	STONES		0.91439	3	ft	10.668	35	ft	FRESH			DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	32	1/5/1972
10296633	4605314		TOPSOIL			0.3048	1	ft	6.096	20	ft	FRESH			DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	32	1/15/1973
10296671	4605352	BROWN	CLAY	STONES		5.4864	18	ft	18.8976	62	ft	FRESH			DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	32	2/12/1973
10297198	4605887	BROWN	CLAY			9.7536	32	ft	17.0688	56	ft	FRESH			DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	32	7/4/1974
10296205	4604879	YELLOW	CLAY			7.0104	23	ft	19.2024	63	ft	FRESH			DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	31	11/30/1971
10083440	1914851	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	214812		DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	31	11/8/2000
1003235594	7148958	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0	0	m		Z105309	A091433	DURHAM	UXBRIDGE TOWN			7/29/2010
1005280736	7235444	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0	0	ft		Z194555		DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 07	32	1/14/2015
10296026	4604696		TOPSOIL			0.3048	1	ft	9.144	30	ft	FRESH			DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 06	32	3/2/1971
1004653517	7211875	BROWN	FILL	GRAVEL	LOOSE	0.6096	2	ft	0	0	ft		Z181206	A157775	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)			11/28/2013
1004653520	7211876	BROWN	FILL	SAND		1.524	5	ft	0	0	ft		Z181205	A157774	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)			11/28/2013
1003330574	7150681	BROWN	SAND	GRAVEL	TOPSOIL	0.75	0.75	m	2.4	2.4	m		Z109130	A094460	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)			9/1/2010
11173421	1917255	GREY	GRAVEL			0.3048	1	ft	10.8204	35.5	ft		Z13624	A013575	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 07	32	9/2/2004
11173375	1917209	GREY	GRAVEL			0.3048	1	ft	10.5095	34.48	ft		Z13626	A013573	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 07	32	9/2/2004
11173422	1917256	BLACK	TOPSOIL			0.1524	0.5	ft	24.9936	82	ft		Z13622	A005910	DURHAM	UXBRIDGE TOWNSHIP (UXBRIDGE)	CON 07	32	9/2/2004

BOREHOLEID	WELL_ID	LIC_NO _OF_	FINAL_STAT	USE1	USE2	STREET	CITY	SITE
10073753	1904901	2801	Observation Wells	Not Used	Municipal			
10073755	1904903	2801	Test Hole	Not Used	Municipal			
10073756	1904904	2801	Observation Wells	Not Used	Municipal			
1005916103	7260106	6809						
1004238924	7195621	2662	Observation Wells	Monitoring		VICTORIA DR	Uxbridge	OW _3
1004261783	7198295	2662	Abandoned-Supply			VICTORIA DR.	UXBRIDGE	OW-3
1004238773	7195594	2662	Abandoned-Other			VICTORIA DR	Uxbridge	PW1
1004239715	7195684	2662	Dewatering	Dewatering		VICTORIA ST. / BROCK ST W	Uxbridge	PW1
23046684	7046684	7215	Observation Wells	Not Used		168 BROCK ROAD	UXBRIDGE	
1004239729	7195685	2662	Dewatering	Dewatering		VICTORIA DR	Uxbridge	PW2
1005109717	7226552	2662	Abandoned-Other			VICTORIA DR.	UXBRIDGE	PW2
23046652	7046652	7241	Observation Wells			169 BROCK STREET WEST	UXBRIDGE	
1004238918	7195619	2662	Observation Wells	Monitoring		VICTORIA DR. BROCK ST. W	Uxbridge	OW1
1004238921	7195620	2662	Abandoned-Other			VICTORIA DR	Uxbridge	OW1
1004238912	7195617	2662	Observation Wells	Monitoring		VICTORIA DR	Uxbridge	
1004238915	7195618	2662	Abandoned-Other			VICTORIA DRIVE	Uxbridge	OW - 2
1004238906	7195615	2662	Observation Wells	Commerical		VICTORIA DR. / BROCK ST W	Uxbridge	
1004238909	7195616	2662	Abandoned-Other			VICTORIA DR. BROCK ST. W	Uxbridge	MW_2
1003632028	7174782	2662	Abandoned-Other	Municipal	Not Used	BROCK STREET	Uxbridge	GW-1
1003632038	7174787	2662		Municipal		BROCK STREET	Uxbridge	GW-1
1002449135	7123788	6809	Monitoring and Test Hole	Monitoring and Test Hole		RAILWAY ST. & BROCK ST. W.	Uxbridge	
1003631966	7174751	2662	Abandoned-Other	Not Used	Monitoring	BROCK STREET	Uxbridge	OW-01
1003632024	7174780	2662	Abandoned-Other	Municipal	Not Used	BROKC STREET	Uxbridge	GW-2
10294041	4602676	4623	Water Supply	Municipal				
1004253544	7197180	7241	Monitoring and Test Hole	Monitoring and Test Hole		85 BROCK STREET WEST	Uxbridge	WKQ-005671 A0-A05
1003632026	7174781	2662	Abandoned-Other	Municipal	Not Used	BROCK STREET	Uxbridge	GW-3
1006272648	7273367	7241						
1006272645	7273366	7241						
1006218162	7269312	7241	Monitoring and Test Hole	Test Hole	Monitoring	83 BROCK STREET WEST	Uxbridge	WKQ-001983 A0-A03
1006272654	7273369	7241						
1006272642	7273365	7241						
1004253744	7197205	7241		Monitoring and Test Hole		89 BROCK STREET WEST	Uxbridge	
1004716001	7217006	2662	Dewatering	Municipal	Dewatering	141 BROCK ST	Uxbridge	
1006218159	7269311	7241	Monitoring and Test Hole	Test Hole	Monitoring	83 BROCK STREET WEST	Uxbridge	WKQ-009183 A0-A03
1004898822	7222712	7241	Monitoring and Test Hole	Monitoring and Test Hole		83 BROCK STREET WEST	Uxbridge	
1004253538	7197178	7241	Monitoring and Test Hole	Monitoring and Test Hole		85 BROCK STREET WEST	Uxbridge	WKQ-005671 A0-A05
1004715998	7217005	2662	Dewatering	Municipal	Cooling And A/C	141 BROCK ST	Uxbridge	
1006272651	7273368	7241						
1004253541	7197179	7241	Monitoring and Test Hole	Monitoring and Test Hole		85 BROCK STREET WEST	Uxbridge	WKQ-005671 A0-A05
1005937310	7261857	7241	Monitoring and Test Hole	Test Hole	Monitoring	12 SPRUCE STREET	UXBRIDGE	WKQ-008777 A0-A02
1004898841	7222714	7241	Monitoring and Test Hole	Monitoring and Test Hole		83 BROCK ST. W	Uxbridge	
1004898803	7222710	7241	Monitoring and Test Hole	Monitoring and Test Hole		83 BROCK ST. W	Uxbridge	
1004898825	7222713	7241	Monitoring and Test Hole	Monitoring and Test Hole		85 BROCK ST. W	Uxbridge	
1004898819	7222711	7241	Monitoring and Test Hole	Monitoring and Test Hole		83 BROCK ST. W	Uxbridge	
1002037702	7121343	7241	Monitoring and Test Hole	Monitoring and Test Hole		49 BROCK STREET W	Uxbridge	WKQ-001112
1002037705	7121344	7241	Monitoring and Test Hole	Monitoring and Test Hole		49 BROCK STREET W	Uxbridge	WKQ-001111
1003781301	7180982	7241	Test Hole	Monitoring and Test Hole		83 BROCK ST	Uxbridge	
1005937304	7261855	7241	Monitoring and Test Hole	Test Hole	Monitoring	12 SPRUCE STREET	UXBRIDGE	WKQ-008777 A0-A02
1005937307	7261856	7241	Monitoring and Test Hole	Test Hole	Monitoring	12 SPRUCE STREET	UXBRIDGE	WKQ-008777 A0-A02
1003557398	7167942	7147						
10075317	1906636	4743	Water Supply	Commerical				
1004716004	7217007	2662	Abandoned-Other			126 KING ST	UXBIRDGE	
10297742	4606453	4743	Water Supply	Commerical				
10296606	4605286	1556	Water Supply	Domestic				
1003886474	7182313	5459	Abandoned-Other			RAILWAY ST	Uxbridge	
10296155	4604829	5459	Water Supply	Domestic				
10297635	4606344	4743	Water Supply	Domestic				
10296287	4604963	4743	Water Supply	Domestic				
10296633	4605314	5459	Water Supply	Domestic				
10296671	4605352	4743	Water Supply	Domestic				
10297198	4605887	4743	Water Supply	Domestic				
10296205	4604879	4743	Water Supply	Domestic				
10083440	1914851	1413	Abandoned-Other	Domestic				
1003235594	7148958	7386	Abandoned-Supply			90 TORONTO STREET NORTH	Uxbridge	ROLL# 182905000124300
1005280736	7235444	1413	Abandoned-Other			63 SECOND AVENUE	Uxbridge	
10296026	4604696	5459	Water Supply	Domestic				
1004653517	7211875	7241	Monitoring and Test Hole	Monitoring and Test Hole		18 DALLAS STREET	UXBRIDGE	
1004653520	7211876	7241	Monitoring and Test Hole	Monitoring and Test Hole		18 DALLAS STREET	UXBRIDGE	
1003330574	7150681	6946		Monitoring		124 MAIN ST. NORTH	UXBRIDGE	
11173421	1917255	2662	Dewatering			MAIN STREET	UXBRIDGE	
11173375	1917209	2662	Dewatering	Not Used		MAIN STREET	UXBRIDGE	
11173422	1917256	2662	Dewatering			MAIN STREET	UXBRIDGE	

AECOM Imagine it. Delivered.

Appendix D

Single Well Response Test Analysis



MW3 RISING HEAD TEST - LATE TIME

Data Set: \...\MW3FH - rev2.aqt
Date: 11/14/17 Time: 15:10:28

PROJECT INFORMATION

Company: AECOM
Client: Durham Region
Project: 60551059
Location: Uxbridge
Test Well: MW3
Test Date: Oct 20, 2017

AQUIFER DATA

Saturated Thickness: 0.3865 m Anisotropy Ratio (Kz/Kr): 1.

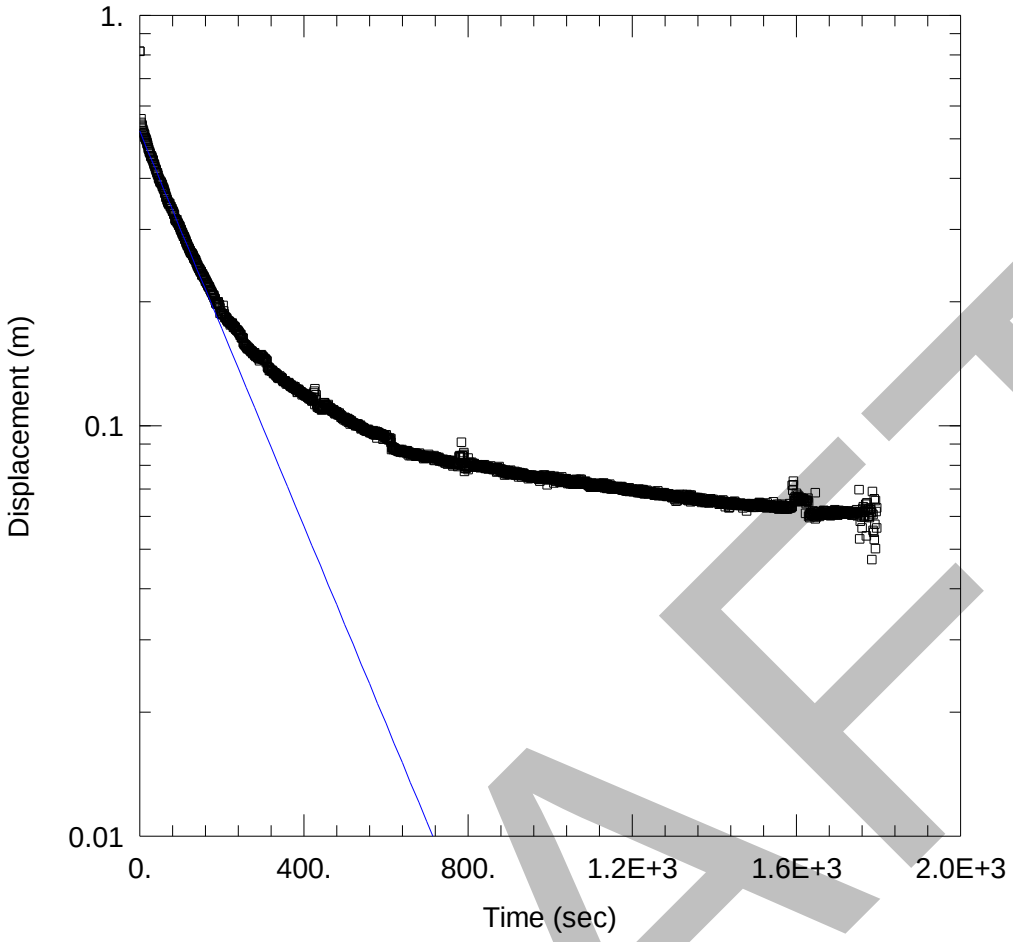
WELL DATA (MW3)

Initial Displacement: 0.84 m
Total Well Penetration Depth: 8.887 m
Casing Radius: 0.025 m
Static Water Column Height: 10.21 m
Screen Length: 3.048 m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev

K = 8.728E-7 m/sec y0 = 0.6568 m



MW4 FALLING HEAD TEST

Data Set: \...\MW4FH.aqt
Date: 11/08/17 Time: 11:13:44

PROJECT INFORMATION

Company: AECOM
Client: Durham Region
Project: 60551059
Location: Uxbridge
Test Well: MW3
Test Date: Oct 20, 2017

AQUIFER DATA

Saturated Thickness: 4.363 m Anisotropy Ratio (Kz/Kr): 1.

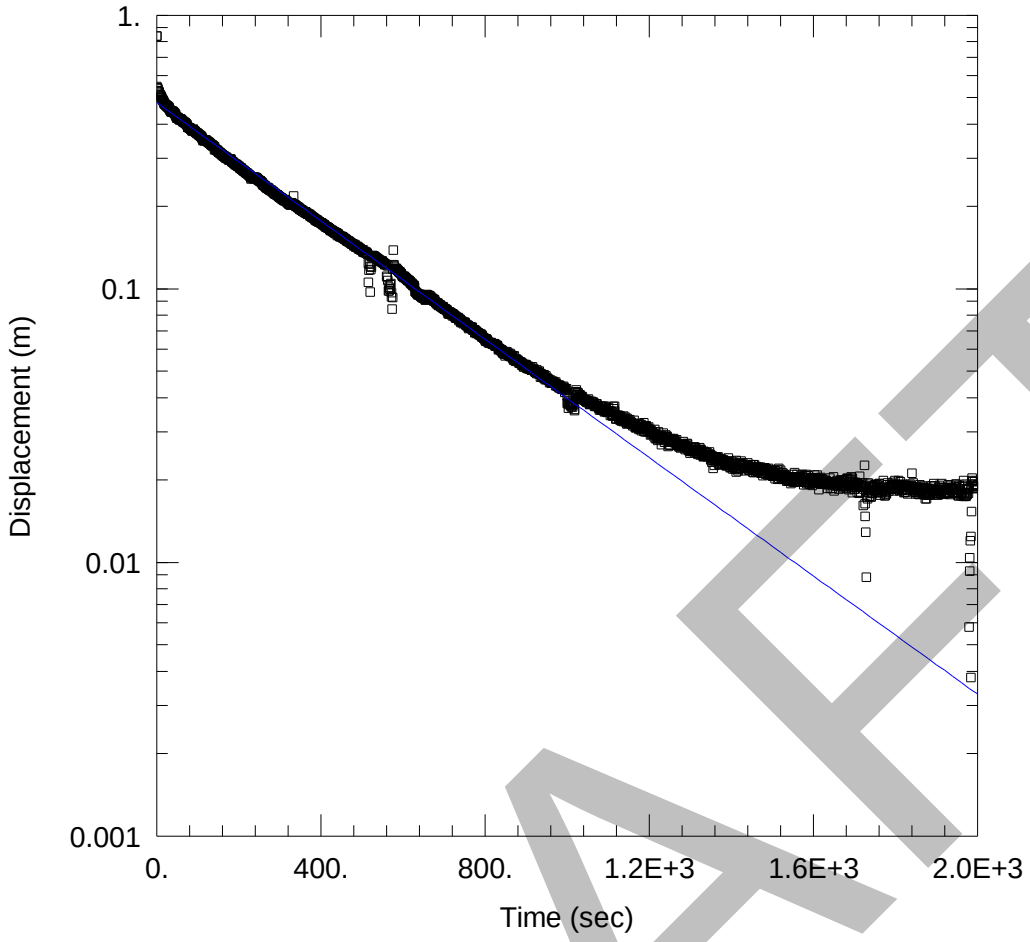
WELL DATA (MW4)

Initial Displacement: 0.8154 m
Total Well Penetration Depth: 6. m
Casing Radius: 0.025 m
Static Water Column Height: 4.363 m
Screen Length: 3.048 m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 3.12E-6 m/sec v0 = 0.5217 m



MW4 RISING HEAD TEST

Data Set: \...\MW4RH.aqt
Date: 11/08/17 Time: 11:13:47

PROJECT INFORMATION

Company: AECOM
Client: Durham Region
Project: 60551059
Location: Uxbridge
Test Well: MW3
Test Date: Oct 20, 2017

AQUIFER DATA

Saturated Thickness: 4.363 m Anisotropy Ratio (Kz/Kr): 1.

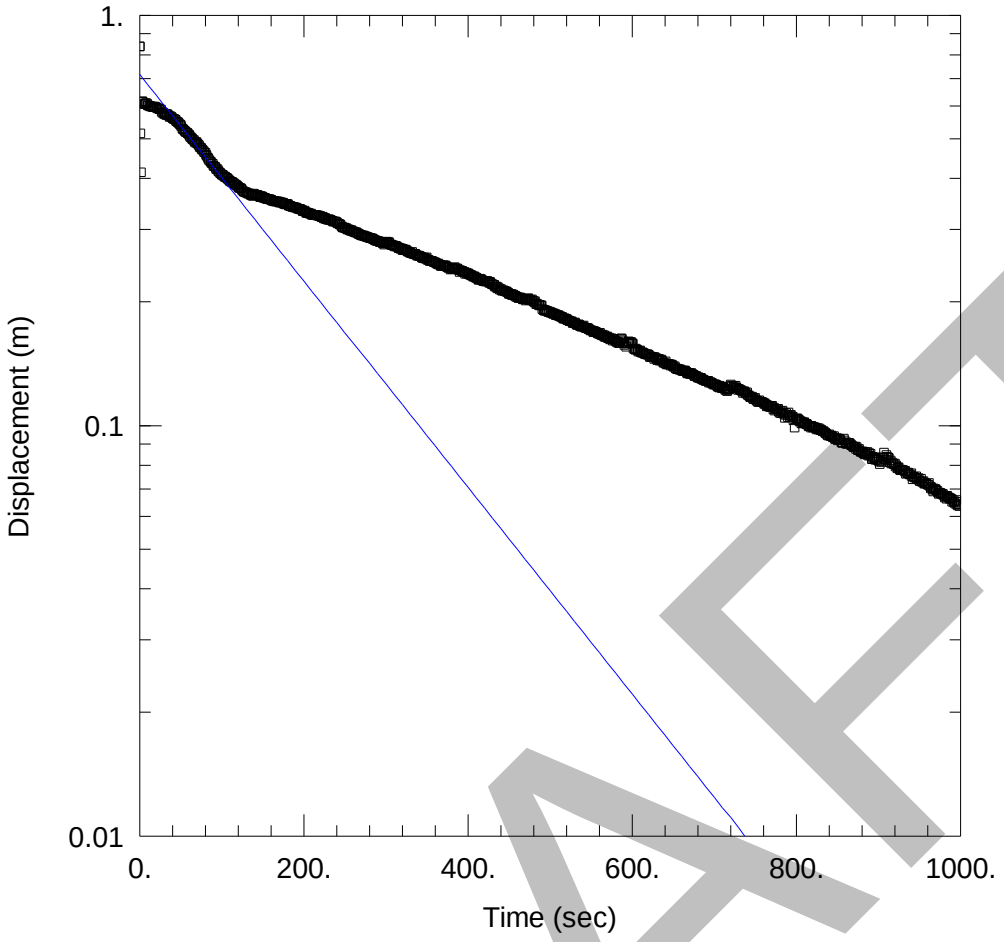
WELL DATA (MW4)

Initial Displacement: 0.84 m
Total Well Penetration Depth: 6. m
Casing Radius: 0.025 m
Static Water Column Height: 4.363 m
Screen Length: 3.048 m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 1.403E-6 m/sec v0 = 0.4793 m



MW5 FALLING HEAD TEST - EARLY TIME FIT

Data Set: \...\MW5FH_early.aqt
Date: 11/08/17 Time: 11:13:48

PROJECT INFORMATION

Company: AECOM
Client: Durham Region
Project: 60551059
Location: Uxbridge
Test Well: MW3
Test Date: Oct 20, 2017

AQUIFER DATA

Saturated Thickness: 6.655 m Anisotropy Ratio (Kz/Kr): 1.

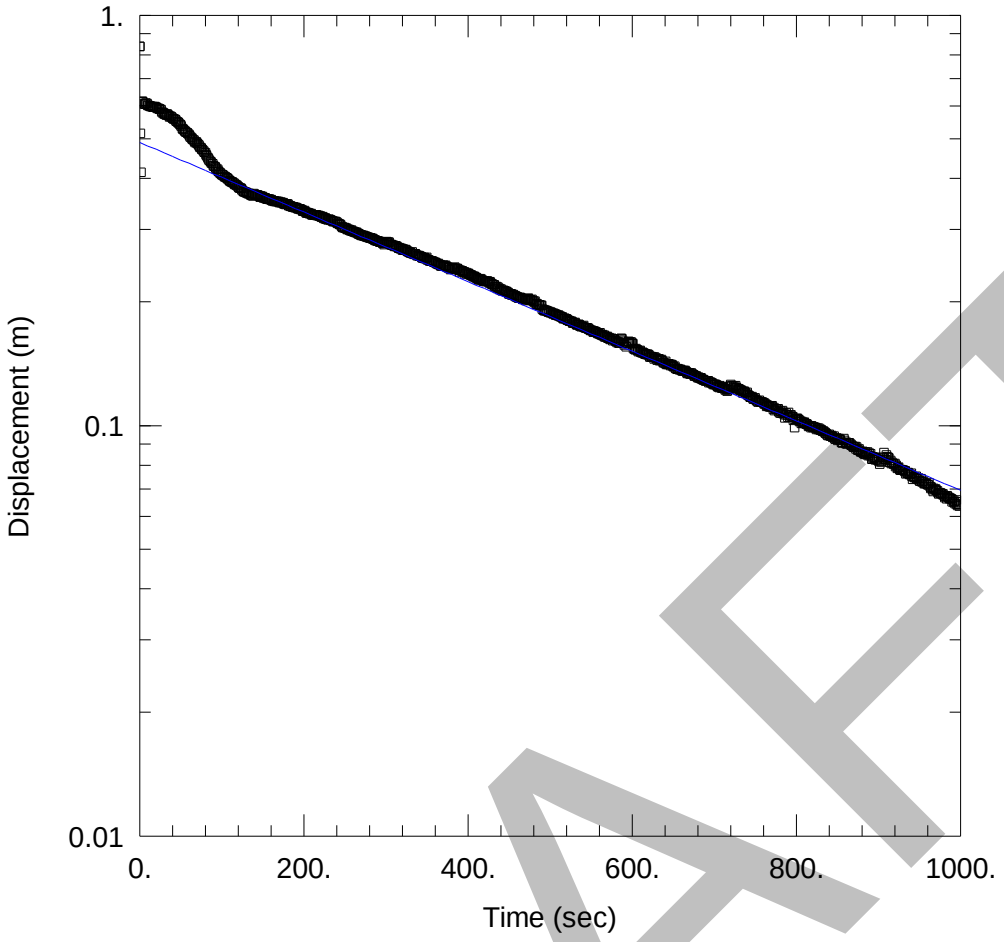
WELL DATA (MW5)

Initial Displacement: 0.84 m
Total Well Penetration Depth: 8.974 m
Casing Radius: 0.025 m
Static Water Column Height: 6.55 m
Screen Length: 3.048 m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 3.264E-6 m/sec v0 = 0.7168 m



MW5 FALLING HEAD TEST - LATETIME FIT

Data Set: \...\MW5FH_late.aqt
Date: 11/08/17 Time: 11:13:50

PROJECT INFORMATION

Company: AECOM
Client: Durham Region
Project: 60551059
Location: Uxbridge
Test Well: MW3
Test Date: Oct 20, 2017

AQUIFER DATA

Saturated Thickness: 6.655 m Anisotropy Ratio (Kz/Kr): 1.

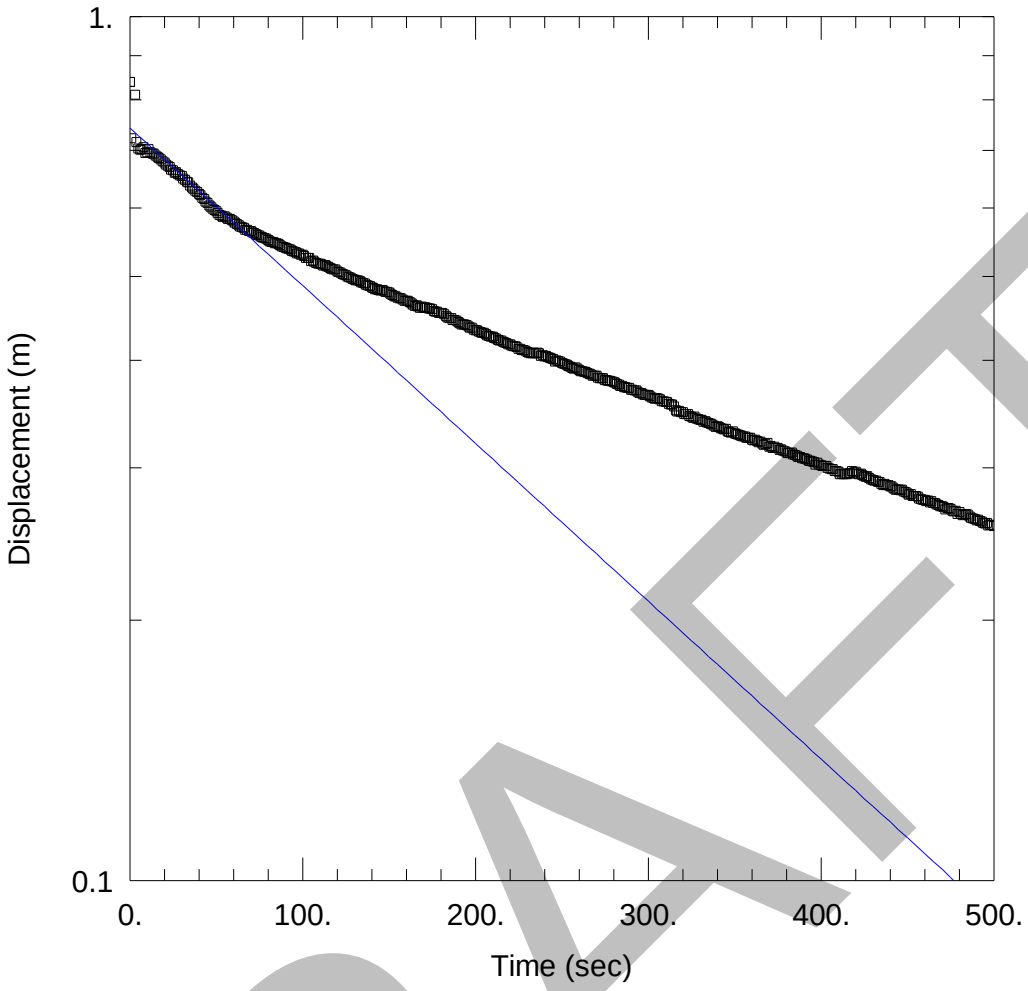
WELL DATA (MW5)

Initial Displacement: 0.84 m
Total Well Penetration Depth: 8.974 m
Casing Radius: 0.025 m
Static Water Column Height: 6.55 m
Screen Length: 3.048 m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 1.1E-6 m/sec v0 = 0.4893 m



MW9 FALLING HEAD TEST - EARLY TIME

Data Set: \...\MW9FH.aqt
Date: 11/14/17 Time: 15:02:44

PROJECT INFORMATION

Company: AECOM
Client: Durham Region
Project: 60551059
Location: Uxbridge
Test Well: MW3
Test Date: Oct 20, 2017

AQUIFER DATA

Saturated Thickness: 7.28 m Anisotropy Ratio (Kz/Kr): 1.

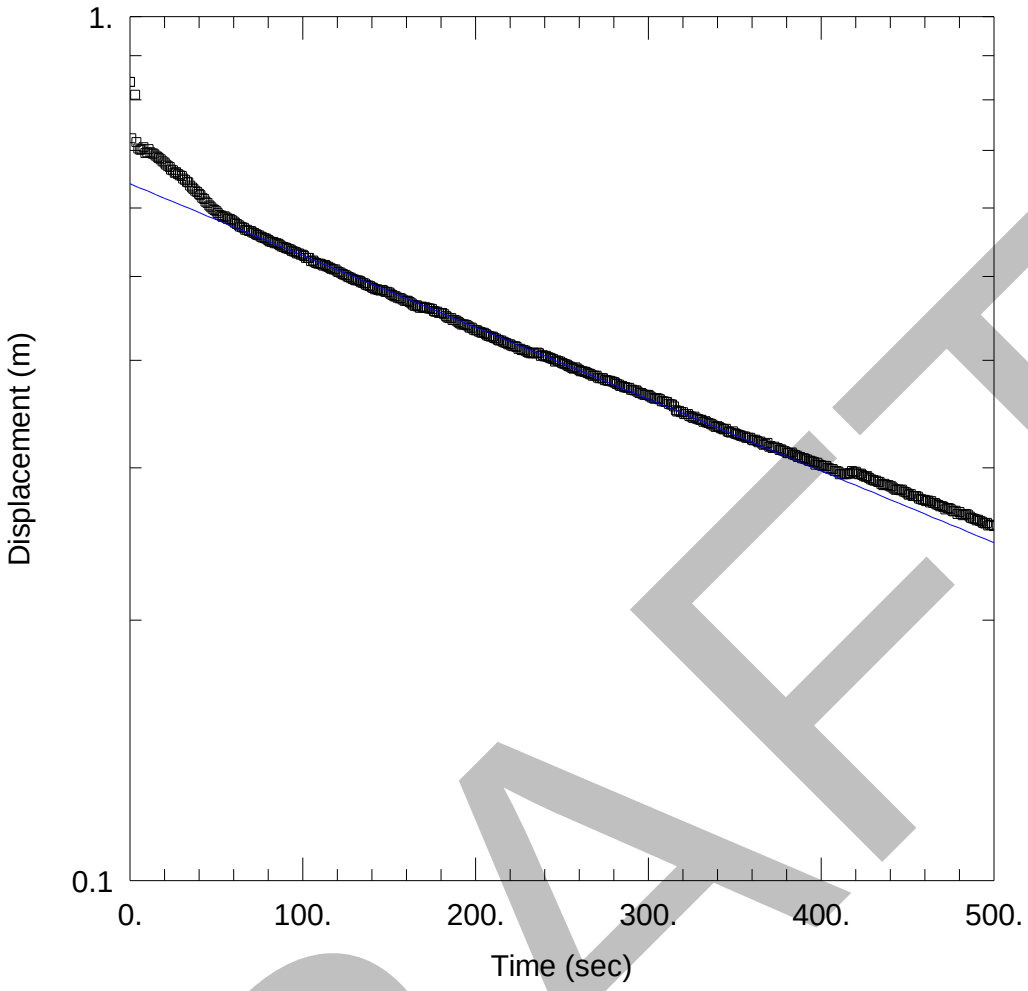
WELL DATA (MW9)

Initial Displacement: 0.84 m
Total Well Penetration Depth: 9.114 m
Casing Radius: 0.025 m
Static Water Column Height: 7.28 m
Screen Length: 3.048 m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 2.37E-6 m/sec y0 = 0.7431 m



MW9 FALLING HEAD TEST - LATE TIME

Data Set: \...\MW9FH late.aqt
Date: 11/14/17 Time: 15:01:51

PROJECT INFORMATION

Company: AECOM
Client: Durham Region
Project: 60551059
Location: Uxbridge
Test Well: MW3
Test Date: Oct 20, 2017

AQUIFER DATA

Saturated Thickness: 7.28 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW9)

Initial Displacement: 0.84 m
Total Well Penetration Depth: 9.114 m
Casing Radius: 0.025 m
Static Water Column Height: 7.28 m
Screen Length: 3.048 m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 1.078E-6 m/sec y0 = 0.6399 m

AECOM Imagine it. Delivered.

Appendix E

Water Quality Analysis Results

AGAT Laboratories

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CLIENT NAME: AECOM CANADA LTD
105 COMMERCE VALLEY DR.W 7TH FLOOR
MARKHAM, ON L3T7W3
(905) 886-7022

ATTENTION TO: Kelly Ali

PROJECT: 60551059

AGAT WORK ORDER: 17T271523

MICROBIOLOGY ANALYSIS REVIEWED BY: Scott Ross, Operations Manager

TRACE ORGANICS REVIEWED BY: Oksana Gushyla, Trace Organics Lab Supervisor

WATER ANALYSIS REVIEWED BY: Mike Muneswar, BSc (Chem), Senior Inorganic Analyst

DATE REPORTED: Oct 31, 2017

PAGES (INCLUDING COVER): 17

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

AGAT Laboratories

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Certificate of Analysis

AGAT WORK ORDER: 17T271523

PROJECT: 60551059

CLIENT NAME: AECOM CANADA LTD

ATTENTION TO: Kelly Ali

SAMPLING SITE:

SAMPLED BY:Kelly Ali

Microbiological Analysis (water)

DATE RECEIVED: 2017-10-13

DATE REPORTED: 2017-10-31

				SAMPLE DESCRIPTION:	MW3	MW9
				SAMPLE TYPE:	Water	Water
				DATE SAMPLED:	2017-10-12	2017-10-12
Parameter	Unit	G / S	RDL	8823761	8823792	
Escherichia coli	CFU/100mL	200	2	ND	ND	

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to Limits for Storm Sewer Discharge - The Regional Municipality of Durham - By-Law No. 55-2013
Guideline values are for general reference only. The guidelines provided may or may not be relevant for the intended use. Refer directly to the applicable standard for regulatory interpretation.

8823761-8823792 RDL >1 indicates dilutions of the sample.
ND - Not Detected.

Certified By:

AGAT Laboratories

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Certificate of Analysis

AGAT WORK ORDER: 17T271523

PROJECT: 60551059

CLIENT NAME: AECOM CANADA LTD

ATTENTION TO: Kelly Ali

SAMPLING SITE:

SAMPLED BY:Kelly Ali

Durham Sanitary - Organics

DATE RECEIVED: 2017-10-13

DATE REPORTED: 2017-10-31

					SAMPLE DESCRIPTION:	MW3	MW9
					SAMPLE TYPE:	Water	Water
					DATE SAMPLED:	2017-10-12	2017-10-12
Parameter	Unit	G / S: A	G / S: B	RDL		8823761	8823792
Oil and Grease (animal/vegetable) in water	mg/L	150		0.5		<0.5[<A]	1.2[<A]
Oil and Grease (mineral) in water	mg/L	15		0.5		<0.5[<A]	<0.5[<A]
Methylene Chloride	mg/L	2	0.0052	0.0003		<0.0003[<B]	<0.0003[<B]
trans-1,3-Dichloropropylene	mg/L	0.14	0.0056	0.0003		<0.0003[<B]	<0.0003[<B]
cis- 1,2-Dichloroethylene	mg/L	4	0.0056	0.0002		<0.0002[<B]	<0.0002[<B]
Methyl Ethyl Ketone	mg/L	8		0.0009		<0.0009[<A]	<0.0009[<A]
Chloroform	mg/L	0.04	0.002	0.0002		<0.0002[<B]	<0.0002[<B]
Benzene	mg/L	0.01	0.002	0.0002		<0.0002[<B]	<0.0002[<B]
Trichloroethylene	mg/L	0.4	0.008	0.0002		<0.0002[<B]	<0.0002[<B]
Toluene	mg/L	0.27	0.002	0.0002		<0.0002[<B]	<0.0002[<B]
Tetrachloroethylene	mg/L	1	0.0044	0.0001		<0.0001[<B]	<0.0001[<B]
Ethylbenzene	mg/L	0.16	0.002	0.0001		<0.0001[<B]	<0.0001[<B]
1,1,2,2-Tetrachloroethane	mg/L	1.4	0.017	0.001		<0.001[<B]	<0.001[<B]
Styrene	mg/L	0.2		0.0001		<0.0001[<A]	<0.0001[<A]
1,2-Dichlorobenzene	mg/L	0.05	0.0056	0.0001		<0.0001[<B]	<0.0001[<B]
1,4-Dichlorobenzene	mg/L	0.08	0.0068	0.0001		<0.0001[<B]	<0.0001[<B]
Total Xylenes	mg/L	1.4	0.0044	0.0001		<0.0001[<B]	<0.0001[<B]
PCBs	mg/L	0.001	0.0004	0.0002		<0.0002[<B]	<0.0002[<B]
Di-n-butyl phthalate	mg/L	0.08	0.015	0.0005		<0.0005[<B]	<0.0005[<B]
Bis(2-Ethylhexyl)phthalate	mg/L	0.012	0.0088	0.0005		<0.0005[<B]	<0.0005[<B]

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: A Refers to Limits for Sanitary Sewer Discharge - The Regional Municipality of Durham - By-Law No. 55-2013, B Refers to Limits for Storm Sewer Discharge - The Regional Municipality of Durham - By-Law No. 55-2013
Guideline values are for general reference only. The guidelines provided may or may not be relevant for the intended use. Refer directly to the applicable standard for regulatory interpretation.

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Certificate of Analysis

AGAT WORK ORDER: 17T271523

PROJECT: 60551059

CLIENT NAME: AECOM CANADA LTD

ATTENTION TO: Kelly Ali

SAMPLING SITE:

SAMPLED BY:Kelly Ali

Durham Sanitary Sewer Use By-Law - Inorganics

DATE RECEIVED: 2017-10-13

DATE REPORTED: 2017-10-31

					SAMPLE DESCRIPTION:		MW9
					SAMPLE TYPE:		Water
					DATE SAMPLED:		2017-10-12
Parameter	Unit	G / S: A	G / S: B	RDL	8823761	RDL	8823792
pH	pH Units	6.0-10.5	6.0-9.0	NA	8.12	NA	8.13
BOD (5)	mg/L	300	15	5	<5[<B]	5	<5[<B]
Fluoride	mg/L	10		0.05	<0.05[<A]	0.05	<0.05[<A]
Sulphate	mg/L	1500		0.10	1.58[<A]	0.10	0.25[<A]
Total Cyanide	mg/L	2	0.02	0.002	<0.002[<B]	0.002	<0.002[<B]
Total Kjeldahl Nitrogen	mg/L	100	1	0.10	0.26[<B]	0.10	0.26[<B]
Phenols	mg/L	1	0.008	0.001	<0.001[<B]	0.001	<0.001[<B]
Total Phosphorus	mg/L	10	0.4	0.05	0.48[B-A]	0.10	0.46[B-A]
Total Suspended Solids	mg/L	350	15	10	283[B-A]	10	267[B-A]
Total Aluminum	mg/L	50		0.020	0.736[<A]	0.020	1.55[<A]
Total Antimony	mg/L	5		0.020	<0.020[<A]	0.020	<0.020[<A]
Total Arsenic	mg/L	1	0.02	0.020	<0.020[<B]	0.020	<0.020[<B]
Total Cadmium	mg/L	0.7	0.008	0.020	<0.020[<A]	0.020	<0.020[<A]
Total Chromium	mg/L	2	0.08	0.030	<0.030[<B]	0.030	<0.030[<B]
Total Cobalt	mg/L	5		0.020	<0.020[<A]	0.020	<0.020[<A]
Total Copper	mg/L	3	0.05	0.030	<0.030[<B]	0.030	<0.030[<B]
Total Lead	mg/L	1	0.12	0.020	<0.020[<B]	0.020	<0.020[<B]
Total Manganese	mg/L	5	0.15	0.030	0.059[<B]	0.030	0.108[<B]
Total Mercury	mg/L	0.01	0.01	0.0001	<0.0001[<A]	0.0001	<0.0001[<A]
Total Molybdenum	mg/L	5		0.020	<0.020[<A]	0.020	<0.020[<A]
Total Nickel	mg/L	2	0.08	0.030	<0.030[<B]	0.030	<0.030[<B]
Total Selenium	mg/L	1	0.02	0.020	<0.020[<B]	0.020	<0.020[<B]
Total Silver	mg/L	5	0.12	0.020	<0.020[<B]	0.020	<0.020[<B]
Total Tin	mg/L	5		0.025	<0.025[<A]	0.025	<0.025[<A]
Total Titanium	mg/L	5		0.020	0.042[<A]	0.020	0.066[<A]
Total Zinc	mg/L	2	0.04	0.020	<0.020[<B]	0.020	<0.020[<B]

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: A Refers to Limits for Sanitary Sewer Discharge - The Regional Municipality of Durham - By-Law No. 55-2013, B Refers to Limits for Storm Sewer Discharge - The Regional Municipality of Durham - By-Law No. 55-2013
Guideline values are for general reference only. The guidelines provided may or may not be relevant for the intended use. Refer directly to the applicable standard for regulatory interpretation.

8823761-8823792 Elevated RDLs indicate the degree of sample dilutions prior to analysis in order to keep the analytes within the calibration range of the instruments and to reduce matrix interferences.

Certified By:

AGAT Laboratories

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Certificate of Analysis

AGAT WORK ORDER: 17T271523

PROJECT: 60551059

CLIENT NAME: AECOM CANADA LTD

ATTENTION TO: Kelly Ali

SAMPLING SITE:

SAMPLED BY:Kelly Ali

Water Quality Assessment - Ground Water Samples (PWQO)

DATE RECEIVED: 2017-10-13

DATE REPORTED: 2017-10-31

		SAMPLE DESCRIPTION:		MW3		MW9
		SAMPLE TYPE:		Water		Water
		DATE SAMPLED:		2017-10-12		2017-10-12
Parameter	Unit	G / S	RDL	8823761	RDL	8823792
Electrical Conductivity	uS/cm		2	352	2	335
pH	pH Units	6.5-8.5	NA	8.12	NA	8.13
Saturation pH				7.26		7.33
Langelier Index				0.86		0.80
Total Hardness (as CaCO3)	mg/L		0.5	193	0.5	174
Total Dissolved Solids	mg/L		20	174	20	160
Alkalinity (as CaCO3)	mg/L		5	192	5	184
Bicarbonate (as CaCO3)	mg/L		5	192	5	184
Carbonate (as CaCO3)	mg/L		5	<5	5	<5
Hydroxide (as CaCO3)	mg/L		5	<5	5	<5
Fluoride	mg/L		0.05	<0.05	0.05	<0.05
Chloride	mg/L		0.10	1.23	0.10	1.50
Nitrate as N	mg/L		0.05	<0.05	0.05	<0.05
Nitrite as N	mg/L		0.05	<0.05	0.05	<0.05
Bromide	mg/L		0.05	<0.05	0.05	<0.05
Sulphate	mg/L		0.10	1.58	0.10	0.25
Ortho Phosphate as P	mg/L		0.10	<0.10	0.10	0.10
Reactive Silica	mg/L		0.10	21.3	0.10	20.9
Ammonia as N	mg/L		0.02	0.19	0.02	0.20
Ammonia-Un-ionized	mg/L	0.02	NA	0.016	NA	0.017
Total Phosphorus	mg/L	0.03	0.01	0.48	0.02	0.46
Total Organic Carbon	mg/L		0.5	1.2	0.5	3.0
Colour	TCU		5	<5	5	6
Turbidity	NTU		0.5	68.6	0.5	224
Calcium	mg/L		0.05	54.3	0.05	46.9
Magnesium	mg/L		0.05	14.0	0.05	13.7
Sodium	mg/L		0.05	6.12	0.05	6.60
Potassium	mg/L		0.05	1.19	0.05	1.55
Aluminum	mg/L		0.004	0.324	0.004	0.567
Antimony	mg/L	0.020	0.003	<0.003	0.003	<0.003

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Certificate of Analysis

AGAT WORK ORDER: 17T271523

PROJECT: 60551059

CLIENT NAME: AECOM CANADA LTD

ATTENTION TO: Kelly Ali

SAMPLING SITE:

SAMPLED BY:Kelly Ali

Water Quality Assessment - Ground Water Samples (PWQO)

DATE RECEIVED: 2017-10-13

DATE REPORTED: 2017-10-31

		SAMPLE DESCRIPTION:		MW3		MW9
		SAMPLE TYPE:		Water		Water
		DATE SAMPLED:		2017-10-12		2017-10-12
Parameter	Unit	G / S	RDL	8823761	RDL	8823792
Arsenic	mg/L	0.1	0.003	<0.003	0.003	<0.003
Barium	mg/L		0.002	0.066	0.002	0.069
Beryllium	mg/L	0.011	0.001	<0.001	0.001	<0.001
Boron	mg/L	0.20	0.010	0.019	0.010	0.022
Cadmium	mg/L	0.0002	0.0001	<0.0001	0.0001	<0.0001
Chromium	mg/L		0.003	<0.003	0.003	<0.003
Cobalt	mg/L	0.0009	0.0005	<0.0005	0.0005	<0.0005
Copper	mg/L	0.005	0.001	0.001	0.001	0.001
Iron	mg/L	0.3	0.01	0.57	0.01	1.59
Lead	mg/L	0.005	0.001	0.001	0.001	0.006
Manganese	mg/L		0.002	0.052	0.002	0.099
Mercury	mg/L		0.0001	<0.0001	0.0001	<0.0001
Molybdenum	mg/L	0.04	0.002	<0.002	0.002	<0.002
Nickel	mg/L	0.025	0.003	<0.003	0.003	<0.003
Selenium	mg/L	0.1	0.004	<0.004	0.004	<0.004
Silver	mg/L	0.0001	0.0001	<0.0001	0.0001	<0.0001
Strontium	mg/L		0.005	0.257	0.005	0.232
Thallium	mg/L	0.0003	0.0003	<0.0003	0.0003	<0.0003
Tin	mg/L		0.002	<0.002	0.002	<0.002
Titanium	mg/L		0.002	0.016	0.002	0.027
Tungsten	mg/L	0.03	0.010	<0.010	0.010	<0.010
Uranium	mg/L	0.005	0.002	<0.002	0.002	<0.002
Vanadium	mg/L	0.006	0.002	0.003	0.002	0.004
Zinc	mg/L	0.02	0.005	0.007	0.005	0.007
Zirconium	mg/L	0.004	0.004	<0.004	0.004	<0.004
Cation Sum	meq/L		NA	4.17	NA	3.81
Anion Sum	meq/L			3.91		3.73
% Difference/ Ion Balance	%		NA	3.28	NA	1.08

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AGAT Laboratories

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Certificate of Analysis

AGAT WORK ORDER: 17T271523

PROJECT: 60551059

CLIENT NAME: AECOM CANADA LTD

ATTENTION TO: Kelly Ali

SAMPLING SITE:

SAMPLED BY:Kelly Ali

Water Quality Assessment - Ground Water Samples (PWQO)

DATE RECEIVED: 2017-10-13

DATE REPORTED: 2017-10-31

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to PWQO (mg/L)
Guideline values are for general reference only. The guidelines provided may or may not be relevant for the intended use. Refer directly to the applicable standard for regulatory interpretation.

8823761-8823792 Elevated RDLs indicate the degree of sample dilutions prior to analysis in order to keep the analytes within the calibration range of the instruments and to reduce matrix interferences.
The calculation of Un-ionized Ammonia was based on lab measured parameters (pH and temperature) rather than the field parameters, these were not provided to the lab.The temperature is recorded at the time of pH measurement. Values are reported as calculated.

Certified By:

AGAT Laboratories

Guideline Violation

AGAT WORK ORDER: 17T271523

PROJECT: 60551059

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CLIENT NAME: AECOM CANADA LTD

ATTENTION TO: Kelly Ali

SAMPLEID	SAMPLE TITLE	GUIDELINE	ANALYSIS PACKAGE	PARAMETER	UNIT	GUIDEVALUE	RESULT
8823761	MW3	Durham Storm	Durham Sanitary Sewer Use By-Law - Inorganics	Total Phosphorus	mg/L	0.4	0.48
8823761	MW3	Durham Storm	Durham Sanitary Sewer Use By-Law - Inorganics	Total Suspended Solids	mg/L	15	283
8823761	MW3	PWQO (mg/L)	Water Quality Assessment - Ground Water Samples (PWQO)	Iron	mg/L	0.3	0.57
8823761	MW3	PWQO (mg/L)	Water Quality Assessment - Ground Water Samples (PWQO)	Total Phosphorus	mg/L	0.03	0.48
8823792	MW9	Durham Storm	Durham Sanitary Sewer Use By-Law - Inorganics	Total Phosphorus	mg/L	0.4	0.46
8823792	MW9	Durham Storm	Durham Sanitary Sewer Use By-Law - Inorganics	Total Suspended Solids	mg/L	15	267
8823792	MW9	PWQO (mg/L)	Water Quality Assessment - Ground Water Samples (PWQO)	Iron	mg/L	0.3	1.59
8823792	MW9	PWQO (mg/L)	Water Quality Assessment - Ground Water Samples (PWQO)	Lead	mg/L	0.005	0.006
8823792	MW9	PWQO (mg/L)	Water Quality Assessment - Ground Water Samples (PWQO)	Total Phosphorus	mg/L	0.03	0.46

AGAT Laboratories

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Quality Assurance

CLIENT NAME: AECOM CANADA LTD

AGAT WORK ORDER: 17T271523

PROJECT: 60551059

ATTENTION TO: Kelly Ali

SAMPLING SITE:

SAMPLED BY:Kelly Ali

Microbiology Analysis

RPT Date: Oct 31, 2017			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Microbiological Analysis (water)															
Escherichia coli	8815166		ND	ND	NA	< 1									

Comments: ND – Not detected; NA - % RPD Not Applicable

Certified By:

AGAT Laboratories

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Quality Assurance

CLIENT NAME: AECOM CANADA LTD

AGAT WORK ORDER: 17T271523

PROJECT: 60551059

ATTENTION TO: Kelly Ali

SAMPLING SITE:

SAMPLED BY:Kelly Ali

Trace Organics Analysis

RPT Date: Oct 31, 2017			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Durham Sanitary - Organics															
Oil and Grease (animal/vegetable) in water		TW	< 0.5	< 0.5	NA	< 0.5	NA	60%	130%	101%	60%	130%	99%	60%	130%
Oil and Grease (mineral) in water		TW	< 0.5	< 0.5	NA	< 0.5	NA	60%	130%	100%	60%	130%	96%	60%	130%
Methylene Chloride	8815473		< 0.0003	< 0.0003	NA	< 0.0003	113%	60%	130%	100%	60%	130%	83%	60%	130%
trans-1,3-Dichloropropylene	8815473		< 0.0003	< 0.0003	NA	< 0.0003	80%	60%	130%	82%	60%	130%	75%	60%	130%
cis- 1,2-Dichloroethylene	8815473		< 0.0002	< 0.0002	NA	< 0.0002	115%	60%	130%	82%	60%	130%	117%	60%	130%
Methyl Ethyl Ketone	8815473		< 0.0009	< 0.0009	NA	< 0.0009	96%	60%	130%	82%	60%	130%	115%	60%	130%
Chloroform	8815473		< 0.0002	< 0.0002	NA	< 0.0002	122%	60%	130%	75%	60%	130%	81%	60%	130%
Benzene	8815473		< 0.0002	< 0.0002	NA	< 0.0002	81%	60%	130%	82%	60%	130%	84%	60%	130%
Trichloroethylene	8815473		< 0.0002	< 0.0002	NA	< 0.0002	76%	60%	130%	100%	60%	130%	71%	60%	130%
Toluene	8815473		< 0.0002	< 0.0002	NA	< 0.0002	76%	60%	130%	90%	60%	130%	81%	60%	130%
Tetrachloroethylene	8815473		< 0.0001	< 0.0001	NA	< 0.0001	72%	60%	130%	79%	60%	130%	71%	60%	130%
Ethylbenzene	8815473		< 0.0001	< 0.0001	NA	< 0.0001	75%	60%	130%	82%	60%	130%	86%	60%	130%
1,1,2,2-Tetrachloroethane	8815473		< 0.001	< 0.001	NA	< 0.001	80%	60%	130%	90%	60%	130%	86%	60%	130%
Styrene	8815473		< 0.0001	< 0.0001	NA	< 0.0001	76%	60%	130%	74%	60%	130%	77%	60%	130%
1,2-Dichlorobenzene	8815473		< 0.0001	< 0.0001	NA	< 0.0001	102%	60%	130%	102%	60%	130%	101%	60%	130%
1,4-Dichlorobenzene	8815473		< 0.0001	< 0.0001	NA	< 0.0001	116%	60%	130%	109%	60%	130%	102%	60%	130%
PCBs		TW	< 0.0002	< 0.0002	NA	< 0.0002	101%	60%	130%	100%	60%	130%	99%	60%	130%
Di-n-butyl phthalate		TW	< 0.0005	< 0.0005	NA	< 0.0005	99%	60%	130%	100%	60%	130%	115%	60%	130%
Bis(2-Ethylhexyl)phthalate		TW	< 0.0005	< 0.0005	NA	< 0.0005	96%	60%	130%	101%	60%	130%	104%	60%	130%

Comments: Tap water analysis has been performed as QC sample testing for duplicate and matrix spike due to insufficient sample volume.
When the average of the sample and duplicate results is less than 5x the RDL, the Relative Percent Difference (RPD) will be indicated as Not Applicable (NA).

Certified By:

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5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
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Quality Assurance

CLIENT NAME: AECOM CANADA LTD

AGAT WORK ORDER: 17T271523

PROJECT: 60551059

ATTENTION TO: Kelly Ali

SAMPLING SITE:

SAMPLED BY:Kelly Ali

Water Analysis

RPT Date: Oct 31, 2017

PARAMETER	Batch	Sample Id	DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
			Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Durham Sanitary Sewer Use By-Law - Inorganics															
BOD (5)	8819263		64	62	3.2%	< 5	101%	75%	125%	NA			NA		
Total Cyanide	8816722		<0.002	<0.002	NA	< 0.002	102%	80%	120%	95%	90%	110%	98%	70%	130%
Total Kjeldahl Nitrogen	8820280		69.9	71.8	2.7%	< 0.10	100%	80%	120%	101%	80%	120%	98%	70%	130%
Phenols	8819259		<0.001	<0.001	NA	< 0.001	96%	90%	110%	102%	90%	110%	104%	80%	120%
Total Phosphorus	8824904		<0.05	<0.05	NA	< 0.05	105%	90%	110%	103%	90%	110%	100%	80%	120%
Total Suspended Solids	8824595		<10	<10	NA	< 10	98%	80%	120%	NA			NA		
Total Aluminum	8824334		0.090	0.083	NA	< 0.020	101%	90%	110%	100%	80%	120%	96%	70%	130%
Total Antimony	8824334		<0.020	<0.020	NA	< 0.020	95%	90%	110%	93%	80%	120%	97%	70%	130%
Total Arsenic	8824334		<0.020	<0.020	NA	< 0.020	101%	90%	110%	98%	80%	120%	104%	70%	130%
Total Cadmium	8824334		<0.020	<0.020	NA	< 0.020	98%	90%	110%	98%	80%	120%	104%	70%	130%
Total Chromium	8824334		<0.030	<0.030	NA	< 0.030	101%	90%	110%	101%	80%	120%	104%	70%	130%
Total Cobalt	8824334		<0.020	<0.020	NA	< 0.020	98%	90%	110%	99%	80%	120%	101%	70%	130%
Total Copper	8824334		<0.030	<0.030	NA	< 0.030	105%	90%	110%	105%	80%	120%	106%	70%	130%
Total Lead	8824334		<0.020	<0.020	NA	< 0.020	97%	90%	110%	97%	80%	120%	97%	70%	130%
Total Manganese	8824334		<0.030	<0.030	NA	< 0.030	95%	90%	110%	95%	80%	120%	97%	70%	130%
Total Mercury	8824334		<0.0001	<0.0001	NA	< 0.0001	101%	90%	110%	104%	90%	110%	94%	80%	120%
Total Molybdenum	8824334		<0.020	<0.020	NA	< 0.020	99%	90%	110%	95%	80%	120%	99%	70%	130%
Total Nickel	8824334		<0.030	<0.030	NA	< 0.030	100%	90%	110%	100%	80%	120%	101%	70%	130%
Total Selenium	8824334		0.049	0.049	NA	< 0.020	99%	90%	110%	94%	80%	120%	103%	70%	130%
Total Silver	8824334		<0.020	<0.020	NA	< 0.020	99%	90%	110%	112%	80%	120%	112%	70%	130%
Total Tin	8824334		<0.025	<0.025	NA	< 0.025	96%	90%	110%	95%	80%	120%	101%	70%	130%
Total Titanium	8824334		<0.020	<0.020	NA	< 0.020	94%	90%	110%	89%	80%	120%	94%	70%	130%
Total Zinc	8824334		<0.020	<0.020	NA	< 0.020	100%	90%	110%	100%	80%	120%	106%	70%	130%
Water Quality Assessment - Ground Water Samples (PWQO)															
Electrical Conductivity	8820604		1280	1280	0.0%	< 2	99%	80%	120%	NA			NA		
pH	8820604		7.39	7.31	1.1%	NA	101%	90%	110%	NA			NA		
Total Dissolved Solids	8823878		1040	1080	3.8%	< 20	100%	80%	120%	NA			NA		
Alkalinity (as CaCO3)	8820604		689	706	2.4%	< 5	95%	80%	120%	NA			NA		
Bicarbonate (as CaCO3)	8820604		689	706	2.4%	< 5	NA			NA			NA		
Carbonate (as CaCO3)	8820604		<5	<5	NA	< 5	NA			NA			NA		
Hydroxide (as CaCO3)	8820604		<5	<5	NA	< 5	NA			NA			NA		
Fluoride	8830426	8830426		< 0.05	NA	< 0.05	99%	90%	110%	103%	90%	110%	90%	80%	120%
Chloride	8830426	8830426	71500	70.3	199.6%	< 0.10	93%	90%	110%	109%	90%	110%	103%	80%	120%
Nitrate as N	8830426	8830426	< 250	< 0.05	NA	< 0.05	93%	90%	110%	107%	90%	110%	110%	80%	120%
Nitrite as N	8830426	8830426	< 250	< 0.05	NA	< 0.05	NA	90%	110%	98%	90%	110%	96%	80%	120%
Bromide	8830426	8830426		< 0.05	NA	< 0.05	93%	90%	110%	110%	90%	110%	89%	80%	120%
Sulphate	8830426	8830426		199	1.5%	< 0.10	93%	90%	110%	108%	90%	110%	105%	80%	120%
Ortho Phosphate as P	8830426	8830426		< 0.10	NA	< 0.10	93%	90%	110%	108%	90%	110%	98%	80%	120%

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Quality Assurance

CLIENT NAME: AECOM CANADA LTD

AGAT WORK ORDER: 17T271523

PROJECT: 60551059

ATTENTION TO: Kelly Ali

SAMPLING SITE:

SAMPLED BY:Kelly Ali

Water Analysis (Continued)

RPT Date: Oct 31, 2017

PARAMETER	Batch	Sample Id	DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
			Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Reactive Silica	8826274		18.3	18.1	1.1%	< 0.05	99%	90%	110%	101%	90%	110%	99%	80%	120%
Ammonia as N	8825087		0.06	0.06	NA	< 0.02	99%	90%	110%	98%	90%	110%	84%	80%	120%
Total Phosphorus	8824904		0.03	0.03	NA	< 0.01	105%	90%	110%	103%	90%	110%	100%	70%	130%
Total Organic Carbon	8823761	8823761	1.2	1.1	NA	< 0.5	99%	90%	110%	105%	90%	110%	94%	80%	120%
Colour	8830531		35	35	0.0%	< 5	107%	90%	110%	NA			NA		
Turbidity	8823761	8823761	68.6	69.3	1.0%	< 0.5	101%	90%	110%	NA			NA		
Calcium	8821253		83.4	83.8	0.5%	< 0.05	100%	90%	110%	100%	90%	110%	102%	70%	130%
Magnesium	8821253		18.5	18.9	2.1%	< 0.05	102%	90%	110%	101%	90%	110%	104%	70%	130%
Sodium	8821253		13.0	12.9	0.8%	< 0.05	101%	90%	110%	101%	90%	110%	104%	70%	130%
Potassium	8821253		10.1	10.3	2.0%	< 0.05	103%	90%	110%	103%	90%	110%	104%	70%	130%
Aluminum	8821518		0.008	0.010	NA	< 0.004	102%	90%	110%	106%	90%	110%	103%	70%	130%
Antimony	8821518		<0.003	<0.003	NA	< 0.003	98%	90%	110%	96%	90%	110%	99%	70%	130%
Arsenic	8821518		<0.003	<0.003	NA	< 0.003	102%	90%	110%	103%	90%	110%	110%	70%	130%
Barium	8821518		0.076	0.076	0.0%	< 0.002	103%	90%	110%	103%	90%	110%	105%	70%	130%
Beryllium	8821518		<0.001	<0.001	NA	< 0.001	95%	90%	110%	94%	90%	110%	101%	70%	130%
Boron	8821518		0.250	0.265	5.8%	< 0.010	107%	90%	110%	107%	90%	110%	120%	70%	130%
Cadmium	8821518		0.0001	<0.0001	NA	< 0.0001	101%	90%	110%	101%	90%	110%	121%	70%	130%
Chromium	8821518		0.007	0.008	NA	< 0.003	101%	90%	110%	103%	90%	110%	111%	70%	130%
Cobalt	8821518		0.0015	0.0015	NA	< 0.0005	99%	90%	110%	102%	90%	110%	102%	70%	130%
Copper	8821518		0.004	0.004	NA	< 0.001	107%	90%	110%	106%	90%	110%	104%	70%	130%
Iron	8821518		<0.01	<0.01	NA	< 0.01	106%	90%	110%	102%	90%	110%	105%	70%	130%
Lead	8821518		<0.001	<0.001	NA	< 0.001	104%	90%	110%	104%	90%	110%	96%	70%	130%
Manganese	8821518		0.128	0.125	2.4%	< 0.002	99%	90%	110%	100%	90%	110%	106%	70%	130%
Molybdenum	8821518		0.023	0.022	4.4%	< 0.002	99%	90%	110%	97%	90%	110%	101%	70%	130%
Nickel	8821518		0.013	0.012	NA	< 0.003	101%	90%	110%	104%	90%	110%	99%	70%	130%
Selenium	8821518		0.006	0.009	NA	< 0.004	98%	90%	110%	99%	90%	110%	111%	70%	130%
Silver	8821518		<0.0001	<0.0001	NA	< 0.0001	101%	90%	110%	110%	90%	110%	113%	70%	130%
Strontium	8821518		4.10	4.04	1.5%	< 0.005	99%	90%	110%	98%	90%	110%	107%	70%	130%
Thallium	8821518		<0.0003	<0.0003	NA	< 0.0003	103%	90%	110%	104%	90%	110%	96%	70%	130%
Tin	8821518		<0.002	<0.002	NA	< 0.002	91%	90%	110%	97%	90%	110%	97%	70%	130%
Titanium	8821518		0.049	0.052	5.9%	< 0.002	99%	90%	110%	98%	90%	110%	106%	70%	130%
Tungsten	8821518		<0.010	<0.010	NA	< 0.010	97%	90%	110%	98%	90%	110%	100%	70%	130%
Uranium	8821518		0.047	0.045	4.3%	< 0.002	100%	90%	110%	101%	90%	110%	99%	70%	130%
Vanadium	8821518		<0.002	0.003	NA	< 0.002	98%	90%	110%	99%	90%	110%	110%	70%	130%
Zinc	8821518		0.007	0.007	NA	< 0.005	102%	90%	110%	108%	90%	110%	115%	70%	130%
Zirconium	8821518		<0.004	<0.004	NA	< 0.004	98%	90%	110%	100%	90%	110%	101%	70%	130%

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Quality Assurance

CLIENT NAME: AECOM CANADA LTD

AGAT WORK ORDER: 17T271523

PROJECT: 60551059

ATTENTION TO: Kelly Ali

SAMPLING SITE:

SAMPLED BY:Kelly Ali

Water Analysis (Continued)

RPT Date: Oct 31, 2017			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper

Comments: NA signifies Not Applicable.
Duplicate Qualifier: As the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Certified By:

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Method Summary

CLIENT NAME: AECOM CANADA LTD

AGAT WORK ORDER: 17T271523

PROJECT: 60551059

ATTENTION TO: Kelly Ali

SAMPLING SITE:

SAMPLED BY:Kelly Ali

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Microbiology Analysis			
Escherichia coli	MIC-93-7010	EPA 1604	Membrane Filtration
Trace Organics Analysis			
Oil and Grease (animal/vegetable) in water	VOL-91-5011	EPA SW-846 3510C & SM5520	GRAVIMETRIC
Oil and Grease (mineral) in water	VOL-91-5011	EPA SW-846 3510C & SM5520	GRAVIMETRIC
Methylene Chloride	VOL-91-5001	EPA SW-846 5030B & 8260B	(P&T)GC/MS
trans-1,3-Dichloropropylene	VOL-91-5001	EPA SW-846 5030B & 8260B	(P&T)GC/MS
cis- 1,2-Dichloroethylene	VOL-91-5001	EPA SW-846 5030B & 8260B	(P&T)GC/MS
Methyl Ethyl Ketone	VOL-91-5001	EPA SW-846 5030B & 8260B	(P&T)GC/MS
Chloroform	VOL-91-5001	EPA SW-846 5030B & 8260B	(P&T)GC/MS
Benzene	VOL-91-5001	EPA SW-846 5030B & 8260B	(P&T)GC/MS
Trichloroethylene	VOL-91-5001	EPA SW-846 5030B & 8260B	(P&T)GC/MS
Toluene	VOL-91-5001	EPA SW-846 5030B & 8260B	(P&T)GC/MS
Tetrachloroethylene	VOL-91-5001	EPA SW-846 5030B & 8260B	(P&T)GC/MS
Ethylbenzene	VOL-91-5001	EPA SW-846 5030B & 8260B	(P&T)GC/MS
1,1,2,2-Tetrachloroethane	VOL-91-5001	EPA SW-846 5030B & 8260B	(P&T)GC/MS
Styrene	VOL-91-5001	EPA SW-846 5030B & 8260B	(P&T)GC/MS
1,2-Dichlorobenzene	VOL-91-5001	EPA SW-846 5030B & 8260B	(P&T)GC/MS
1,4-Dichlorobenzene	VOL-91-5001	EPA SW-846 5030B & 8260B	(P&T)GC/MS
Total Xylenes	VOL-91-5001	EPA SW-846 5030B & 8260B	(P&T)GC/MS
PCBs	ORG-91-5112	EPA SW-846 3510C & 8082A	GC/ECD
Di-n-butyl phthalate	ORG-91-5114	EPA SW-846 3510C & 8270D	GC/MS
Bis(2-Ethylhexyl)phthalate	ORG-91-5114	EPA SW-846 3510C & 8270D	GC/MS

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Method Summary

CLIENT NAME: AECOM CANADA LTD

AGAT WORK ORDER: 17T271523

PROJECT: 60551059

ATTENTION TO: Kelly Ali

SAMPLING SITE:

SAMPLED BY:Kelly Ali

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Water Analysis			
pH	INOR-93-6000	SM 4500-H+ B	PC TITRATE
BOD (5)	INOR-93-6006	SM 5210 B	DO METER
Fluoride	MET-93-6103	SM 4110 B	ION CHROMATOGRAPH
Sulphate	MET-3-6103	SM 4110 B	ION CHROMATOGRAPH
Total Cyanide	INOR-93-6051	MOE 3015 & SM 4500 CN- A,B,C	TECHNICON AUTO ANALYZER
Total Kjeldahl Nitrogen	INOR-93-6048	QuiKChem 10-107-06-2-I & SM 4500-Norg D	LACHAT FIA
Phenols	INOR-93-6050	MOE ROPHEN-E 3179 & SM 5530 D	TECHNICON AUTO ANALYZER
Total Phosphorus	INOR-93-6022	SM 4500-P B&E	SPECTROPHOTOMETER
Total Suspended Solids	INOR-93-6028	SM 2540 D	BALANCE
Total Aluminum	MET-93-6103	EPA SW-846 3010A & 6020A	ICP-MS
Total Antimony	MET-93-6103	EPA SW-846 3010A & 6020A	ICP-MS
Total Arsenic	MET-93-6103	EPA SW-846 3010A & 6020A	ICP-MS
Total Cadmium	MET-93-6103	EPA SW-846 3010A & 6020A	ICP-MS
Total Chromium	MET-93-6103	EPA SW-846 3010A & 6020A	ICP-MS
Total Cobalt	MET-93-6103	EPA SW-846 3010A & 6020A	ICP-MS
Total Copper	MET-93-6103	EPA SW-846 3010A & 6020A	ICP-MS
Total Lead	MET-93-6103	EPA SW-846 3010A & 6020A	ICP-MS
Total Manganese	MET-93-6103	EPA SW-846 3010A & 6020A	ICP-MS
Total Mercury	MET-93-6100	EPA SW 846 7470 & 245.1	CVAAS
Total Molybdenum	MET-93-6103	EPA SW-846 3010A & 6020A	ICP-MS
Total Nickel	MET-93-6103	EPA SW-846 3010A & 6020A	ICP-MS
Total Selenium	MET-93-6103	EPA SW-846 3010A & 6020A	ICP-MS
Total Silver	MET-93-6103	EPA SW-846 3010A & 6020A	ICP-MS
Total Tin	MET-93-6103	EPA SW-846 3010A & 6020A	ICP-MS
Total Titanium	MET-93-6103	EPA SW-846 3010A & 6020A	ICP-MS
Total Zinc	MET-93-6103	EPA SW-846 3010A & 6020A	ICP-MS
Electrical Conductivity	INOR-93-6000	SM 2510 B	PC TITRATE
Saturation pH			CALCULATION
Langelier Index		SM 2330B	CALCULATION
Total Hardness (as CaCO3)	MET-93-6105	EPA SW-846 6010C & 200.7	ICP/OES
Total Dissolved Solids	INOR-93-6028	SM 2540 C	BALANCE
Alkalinity (as CaCO3)	INOR-93-6000	SM 2320 B	PC TITRATE
Bicarbonate (as CaCO3)	INOR-93-6000	SM 2320 B	PC TITRATE
Carbonate (as CaCO3)	INOR-93-6000	SM 2320 B	PC TITRATE
Hydroxide (as CaCO3)	INOR-93-6000	SM 2320 B	PC TITRATE
Fluoride	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Chloride	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Nitrate as N	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Nitrite as N	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Bromide	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Sulphate	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Ortho Phosphate as P	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Reactive Silica	INOR-93-6047	SmartChem Method SIL-001-A & SM 4500 Si-F 18 &19th	DISCRETE ANALYZER
Ammonia as N	INOR-93-6059	QuikChem 10-107-06-1-J & SM 4500 NH3-F	LACHAT FIA
Ammonia-Un-ionized		MOE REFERENCE, PWQOs Tab 2	CALCULATION
Total Organic Carbon	INOR-93-6049	EPA 415.1 & SM 5310 B	SHIMADZU CARBON ANALYZER
Colour	INOR-93-6046	SM 2120 B	SPECTROPHOTOMETER

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Method Summary

CLIENT NAME: AECOM CANADA LTD

AGAT WORK ORDER: 17T271523

PROJECT: 60551059

ATTENTION TO: Kelly Ali

SAMPLING SITE:

SAMPLED BY:Kelly Ali

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Turbidity	INOR-93-6044	SM 2130 B	NEPHELOMETER
Calcium	MET-93-6105	EPA SW-846 6010C & 200.7	ICP/OES
Magnesium	MET-93-6105	EPA SW-846 6010C & 200.7	ICP/OES
Sodium	MET-93-6105	EPA SW-846 6010C & 200.7	ICP/OES
Potassium	MET-93-6105	EPA SW-846 6010C & 200.7	ICP/OES
Aluminum	MET-93-6103	SW-846 6020A & 200.8	ICP-MS
Antimony	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Arsenic	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Barium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Beryllium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Boron	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Cadmium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Chromium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Cobalt	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Copper	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Iron	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Lead	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Manganese	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Mercury	MET-93-6100	EPA SW-846 7470 & 245.1	CVAAS
Molybdenum	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Nickel	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Selenium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Silver	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Strontium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Thallium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Tin	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Titanium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Tungsten	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Uranium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Vanadium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Zinc	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Zirconium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Cation Sum		SM 1030 E	CALCULATION
Anion Sum		SM 1030 E	CALCULATION
% Difference/ Ion Balance		SM 1030 E	CALCULATION

(1) 38.36-4.1
3.2 & 27

AGAT Laboratories

5835 Coopers Avenue
Mississauga, Ontario L4Z 1Y2
Ph: 905.712.5100 Fax: 905.712.5122
webearth.agatlabs.com

Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water intended for human consumption)

Laboratory Use Only

Work Order #: 17T271523

Cooler Quantity: 1 cooler & med

Arrival Temperatures: (2) 3.4 | 2.6 | 3.3 / 3.4 | 3.1 | 2.8

Custody Seal Intact: ☐ Yes ☐ No ☐ N/A

Notes:

Report Information:

Company: AECOM Canada Ltd.
Contact: Kelly Ali
Address: 105 Commerce Valley Drive West
Markham, Ontario, L3T 7W3
Phone: 905-747-7598 Fax:
Reports to be sent to:
1. Email: Kelly.Ali@aecom.com
2. Email:

Regulatory Requirements:

☐ No Regulatory Requirement

(Please check all applicable boxes)

☐ Regulation 153/04
Table (Indicate One) ☐ Ind/Com ☐ Res/Park ☐ Agriculture
Soil Texture (Check One) ☑ Coarse ☐ Fine

☑ Sewer Use
☑ Sanitary
☑ Storm
Region: Durham (Indicate One)

☐ Regulation 558
☐ CCME
☑ Prov. Water Quality Objectives (PWQO)
☐ Other
(Indicate One)

Is this submission for a **Record of Site Condition?** ☐ Yes ☐ No

Report Guideline on *Certificate of Analysis* ☐ Yes ☐ No

Turnaround Time (TAT) Required:

Regular TAT ☑ 5 to 7 Business Days

Rush TAT (Rush Surcharges Apply)

☐ 3 Business Days ☐ 2 Business Days ☐ Next Business Day

OR Date Required (Rush Surcharges May Apply):

*TAT is exclusive of weekends and statutory holidays

For 'Same Day' analysis, please contact your AGAT CPM

Project Information:

Project: 60551059
Site Location:
Sampled By:
AGAT Quote #: PO:
Please note: If quotation number is not provided, client will be billed full price for analysis.

Invoice Information:

Bill To Same: Yes ☑ No ☐

Company: AECOM Canada Ltd.
Contact: Accounts Payable
Address: 105 Commerce Valley Drive West, Markham, ON L3T 7W3
Email: CANSSC.E-billing@aecom.com/

Sample Matrix Legend

B	Biota
GW	Ground Water
O	Oil
P	Paint
S	Soil
SD	Sediment
SW	Surface Water

Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Field Filtered - Metals, Hg, CrVI (Y/N)	O. Reg 153: Metals and Inorganics	All Metals ☐ 153 Metals (excl. Hydrides)	Hydride Metals	ORPs: ☐ B-HWS ☐ Cl⁻ ☐ CN⁻ ☐ Cr⁶⁺ ☐ EC ☐ FOC ☑ Hg ☐ pH ☐ SAR	Full Metals Scan	Regulation/Custom Metals	Nutrients: ☐ TP ☐ NH_3 ☐ TKN ☐ NO_3 ☐ NO_2 ☐ NO_3+NO_2	Volatiles: ☑ VOC ☐ BTEX ☐ THM	CCME Fractions 1 to 4	ABNs	PAHs	PCBs: ☐ Total ☐ Aroclors	Organochlorine Pesticides	TCLP: ☐ M&I ☐ VOCs ☐ ABNs ☐ B(a)P ☐ PCBs	Sewer Use Durham Reg	GW WOA	SW PWQO WOA
MW3	Oct 12/17	15:00	2	GW		Y															✓	✓	✓
MW9	Oct 12/17	16:00	2	GW		Y															✓	✓	✓

Samples Relinquished By (Print Name and Sign): Kelly Ali Kelly Ali — Date: Oct 13/17 — Time: 9:30 — Samples Received By (Print Name and Sign): — Date: 2017/10/13 — Time: 1:55

Samples Relinquished By (Print Name and Sign): — Date: 2017/10/13 — Time: 4:20 — Samples Received By (Print Name and Sign): — Date: — Time:

Samples Relinquished By (Print Name and Sign): — Date: — Time: — Samples Received By (Print Name and Sign): — Date: — Time:

Page 1 of 1

N°:

AGAT Laboratories

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MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: AECOM CANADA LTD
105 COMMERCE VALLEY DR.W 7TH FLOOR
MARKHAM, ON L3T7W3
(905) 886-7022

ATTENTION TO: Kelly Ali

PROJECT: 60551059

AGAT WORK ORDER: 17T271541

WATER ANALYSIS REVIEWED BY: Mike Muneswar, BSc (Chem), Senior Inorganic Analyst

DATE REPORTED: Oct 20, 2017

PAGES (INCLUDING COVER): 8

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

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http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 17T271541

PROJECT: 60551059

CLIENT NAME: AECOM CANADA LTD

ATTENTION TO: Kelly Ali

SAMPLING SITE:

SAMPLED BY:

Water Quality Assessment - Surface Water Sample - PWQO

DATE RECEIVED: 2017-10-13

DATE REPORTED: 2017-10-20

		SAMPLE DESCRIPTION:		Brook - 1017
		SAMPLE TYPE:		Water
		DATE SAMPLED:		2017-10-12
Parameter	Unit	G / S	RDL	8816718
Electrical Conductivity	uS/cm		2	475
pH	pH Units	6.5-8.5	NA	8.24
Saturation pH				7.17
Langelier Index				1.07
Total Hardness (as CaCO3)	mg/L		0.5	233
Total Dissolved Solids	mg/L		20	284
Alkalinity (as CaCO3)	mg/L		5	196
Bicarbonate (as CaCO3)	mg/L		5	196
Carbonate (as CaCO3)	mg/L		5	<5
Hydroxide (as CaCO3)	mg/L		5	<5
Fluoride	mg/L		0.05	<0.05
Chloride	mg/L		0.10	29.8
Nitrate as N	mg/L		0.05	0.68
Nitrite as N	mg/L		0.05	<0.05
Bromide	mg/L		0.05	<0.05
Sulphate	mg/L		0.10	18.9
Ortho Phosphate as P	mg/L		0.10	<0.10
Reactive Silica	mg/L		0.05	13.0
Ammonia as N	mg/L		0.02	0.06
Total Phosphorus	mg/L	0.03	0.01	0.02
Total Organic Carbon	mg/L		0.5	3.8
Colour	TCU		5	14
Turbidity	NTU		0.5	3.3
Calcium	mg/L		0.05	72.5
Magnesium	mg/L		0.05	12.6
Sodium	mg/L		0.05	15.4
Potassium	mg/L		0.05	1.42
Aluminum (dissolved)	mg/L	0.075	0.004	0.006
Antimony	mg/L	0.020	0.003	<0.003
Arsenic	mg/L	0.1	0.003	<0.003

Certified By:

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Certificate of Analysis

AGAT WORK ORDER: 17T271541

PROJECT: 60551059

CLIENT NAME: AECOM CANADA LTD

ATTENTION TO: Kelly Ali

SAMPLING SITE:

SAMPLED BY:

Water Quality Assessment - Surface Water Sample - PWQO

DATE RECEIVED: 2017-10-13

DATE REPORTED: 2017-10-20

		SAMPLE DESCRIPTION:		Brook - 1017
		SAMPLE TYPE:		Water
		DATE SAMPLED:		2017-10-12
Parameter	Unit	G / S	RDL	8816718
Barium	mg/L		0.002	0.069
Beryllium	mg/L	0.011	0.001	<0.001
Boron	mg/L	0.20	0.010	0.011
Cadmium	mg/L	0.0002	0.0001	<0.0001
Chromium	mg/L		0.003	<0.003
Cobalt	mg/L	0.0009	0.0005	<0.0005
Copper	mg/L	0.005	0.001	<0.001
Iron	mg/L	0.3	0.01	0.14
Lead	mg/L	0.005	0.001	<0.001
Manganese	mg/L		0.002	0.025
Dissolved Mercury	mg/L	0.0002	0.0001	<0.0001
Molybdenum	mg/L	0.04	0.002	<0.002
Nickel	mg/L	0.025	0.003	<0.003
Selenium	mg/L	0.1	0.004	<0.004
Silver	mg/L	0.0001	0.0001	<0.0001
Strontium	mg/L		0.005	0.163
Thallium	mg/L	0.0003	0.0003	<0.0003
Tin	mg/L		0.002	<0.002
Titanium	mg/L		0.002	<0.002
Tungsten	mg/L	0.03	0.010	<0.010
Uranium	mg/L	0.005	0.002	<0.002
Vanadium	mg/L	0.006	0.002	<0.002
Zinc	mg/L	0.02	0.005	<0.005
Zirconium	mg/L	0.004	0.004	<0.004
Cation Sum	meq/L		NA	5.37
Anion Sum	meq/L			5.20
% Difference/ Ion Balance	%		NA	1.56

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to PWQO (mg/L)
Guideline values are for general reference only. The guidelines provided may or may not be relevant for the intended use. Refer directly to the applicable standard for regulatory interpretation.

Certified By:

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http://www.agatlabs.com

Quality Assurance

CLIENT NAME: AECOM CANADA LTD

AGAT WORK ORDER: 17T271541

PROJECT: 60551059

ATTENTION TO: Kelly Ali

SAMPLING SITE:

SAMPLED BY:

Water Analysis

RPT Date: Oct 20, 2017

PARAMETER	Batch	Sample Id	DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
			Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Water Quality Assessment - Surface Water Sample - PWQO															
Electrical Conductivity	8813757		1460	1460	0.0%	< 2	100%	80%	120%						
pH	8813757		8.06	8.10	0.5%	NA	101%	90%	110%						
Total Dissolved Solids	8819960		456	440	3.6%	< 20	98%	80%	120%						
Alkalinity (as CaCO3)	8813757		197	199	0.9%	< 5	95%	80%	120%						
Bicarbonate (as CaCO3)	8813757		197	199	0.9%	< 5	NA								
Carbonate (as CaCO3)	8813757		<5	<5	NA	< 5	NA								
Hydroxide (as CaCO3)	8813757		<5	<5	NA	< 5	NA								
Fluoride	8820144		<0.25	<0.25	NA	< 0.05	107%	90%	110%	105%	90%	110%	107%	80%	120%
Chloride	8820144		38.4	38.6	0.6%	< 0.10	95%	90%	110%	107%	90%	110%	111%	80%	120%
Nitrate as N	8820144		<0.25	<0.25	NA	< 0.05	96%	90%	110%	102%	90%	110%	103%	80%	120%
Nitrite as N	8820144		<0.25	<0.25	NA	< 0.05	NA	90%	110%	104%	90%	110%	107%	80%	120%
Bromide	8820144		<0.25	<0.25	NA	< 0.05	100%	90%	110%	102%	90%	110%	103%	80%	120%
Sulphate	8820144		11.3	11.0	2.6%	< 0.10	99%	90%	110%	104%	90%	110%	105%	80%	120%
Ortho Phosphate as P	8820144		<0.50	<0.50	NA	< 0.10	107%	90%	110%	101%	90%	110%	106%	80%	120%
Reactive Silica	8809027		14.3	14.3	0.4%	< 0.05	95%	90%	110%	99%	90%	110%	97%	80%	120%
Ammonia as N	8815988		0.99	0.99	0.1%	< 0.02	95%	90%	110%	101%	90%	110%	NA	80%	120%
Total Phosphorus	8814525		0.12	0.13	1.3%	< 0.01	94%	90%	110%	94%	90%	110%	NA	70%	130%
Total Organic Carbon	8816718	8816718	3.8	3.8	0.3%	< 0.5	110%	90%	110%	NA	90%	110%	102%	80%	120%
Colour	8830531		35	35	0.0%	< 5	107%	90%	110%						
Turbidity	8816718	8816718	3.3	3.3	0.6%	< 0.5	101%	90%	110%						
Calcium	8821253		83.4	83.8	0.4%	< 0.05	100%	90%	110%	100%	90%	110%	102%	70%	130%
Magnesium	8821253		18.5	18.9	2.1%	< 0.05	102%	90%	110%	101%	90%	110%	104%	70%	130%
Sodium	8821253		13.0	12.9	0.3%	< 0.05	101%	90%	110%	101%	90%	110%	104%	70%	130%
Potassium	8821253		10.1	10.3	2.7%	< 0.05	103%	90%	110%	103%	90%	110%	104%	70%	130%
Aluminum (dissolved)	8816718	8816718	0.006	0.006	NA	< 0.004	102%	90%	110%	101%	90%	110%	98%	70%	130%
Antimony	8816718	8816718	<0.003	<0.003	NA	< 0.003	100%	90%	110%	100%	90%	110%	100%	70%	130%
Arsenic	8816718	8816718	<0.003	<0.003	NA	< 0.003	101%	90%	110%	103%	90%	110%	106%	70%	130%
Barium	8816718	8816718	0.069	0.068	0.7%	< 0.002	103%	90%	110%	102%	90%	110%	99%	70%	130%
Beryllium	8816718	8816718	<0.001	<0.001	NA	< 0.001	107%	90%	110%	110%	90%	110%	96%	70%	130%
Boron	8816718	8816718	0.011	0.010	NA	< 0.010	107%	90%	110%	104%	90%	110%	99%	70%	130%
Cadmium	8816718	8816718	<0.0001	<0.0001	NA	< 0.0001	99%	90%	110%	105%	90%	110%	107%	70%	130%
Chromium	8816718	8816718	<0.003	<0.003	NA	< 0.003	103%	90%	110%	104%	90%	110%	103%	70%	130%
Cobalt	8816718	8816718	<0.0005	<0.0005	NA	< 0.0005	100%	90%	110%	100%	90%	110%	101%	70%	130%
Copper	8816718	8816718	<0.001	<0.001	NA	< 0.001	105%	90%	110%	107%	90%	110%	108%	70%	130%
Iron	8816718	8816718	0.14	0.14	1.8%	< 0.01	103%	90%	110%	97%	90%	110%	102%	70%	130%
Lead	8816718	8816718	<0.001	<0.001	NA	< 0.001	100%	90%	110%	104%	90%	110%	102%	70%	130%
Manganese	8816718	8816718	0.025	0.025	0.4%	< 0.002	95%	90%	110%	96%	90%	110%	97%	70%	130%
Dissolved Mercury	8818538		<0.0001	<0.0001	NA	< 0.0001	102%	90%	110%	98%	90%	110%	96%	70%	130%
Molybdenum	8816718	8816718	<0.002	<0.002	NA	< 0.002	101%	90%	110%	98%	90%	110%	96%	70%	130%

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http://www.agatlabs.com

Quality Assurance

CLIENT NAME: AECOM CANADA LTD

AGAT WORK ORDER: 17T271541

PROJECT: 60551059

ATTENTION TO: Kelly Ali

SAMPLING SITE:

SAMPLED BY:

Water Analysis (Continued)

RPT Date: Oct 20, 2017			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Nickel	8816718	8816718	<0.003	<0.003	NA	< 0.003	102%	90%	110%	103%	90%	110%	102%	70%	130%
Selenium	8816718	8816718	<0.004	<0.004	NA	< 0.004	100%	90%	110%	102%	90%	110%	106%	70%	130%
Silver	8816718	8816718	<0.0001	<0.0001	NA	< 0.0001	102%	90%	110%	110%	90%	110%	113%	70%	130%
Strontium	8816718	8816718	0.163	0.166	1.7%	< 0.005	97%	90%	110%	97%	90%	110%	99%	70%	130%
Thallium	8816718	8816718	<0.0003	<0.0003	NA	< 0.0003	101%	90%	110%	105%	90%	110%	102%	70%	130%
Tin	8816718	8816718	<0.002	<0.002	NA	< 0.002	102%	90%	110%	99%	90%	110%	100%	70%	130%
Titanium	8816718	8816718	<0.002	<0.002	NA	< 0.002	96%	90%	110%	96%	90%	110%	92%	70%	130%
Tungsten	8816718	8816718	<0.010	<0.010	NA	< 0.010	106%	90%	110%	100%	90%	110%	88%	70%	130%
Uranium	8816718	8816718	<0.002	<0.002	NA	< 0.002	102%	90%	110%	105%	90%	110%	101%	70%	130%
Vanadium	8816718	8816718	<0.002	<0.002	NA	< 0.002	96%	90%	110%	96%	90%	110%	95%	70%	130%
Zinc	8816718	8816718	<0.005	<0.005	NA	< 0.005	102%	90%	110%	106%	90%	110%	106%	70%	130%
Zirconium	8816718	8816718	<0.004	<0.004	NA	< 0.004	102%	90%	110%	98%	90%	110%	107%	70%	130%

Comments: NA signifies Not Applicable.
Duplicate Qualifier: As the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Certified By:

AGAT Laboratories

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MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
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Method Summary

CLIENT NAME: AECOM CANADA LTD

AGAT WORK ORDER: 17T271541

PROJECT: 60551059

ATTENTION TO: Kelly Ali

SAMPLING SITE:

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Water Analysis			
Electrical Conductivity	INOR-93-6000	SM 2510 B	PC TITRATE
pH	INOR-93-6000	SM 4500-H+ B	PC TITRATE
Saturation pH			CALCULATION
Langelier Index		SM 2330B	CALCULATION
Total Hardness (as CaCO3)	MET-93-6105	EPA SW-846 6010C & 200.7	ICP/OES
Total Dissolved Solids	INOR-93-6028	SM 2540 C	BALANCE
Alkalinity (as CaCO3)	INOR-93-6000	SM 2320 B	PC TITRATE
Bicarbonate (as CaCO3)	INOR-93-6000	SM 2320 B	PC TITRATE
Carbonate (as CaCO3)	INOR-93-6000	SM 2320 B	PC TITRATE
Hydroxide (as CaCO3)	INOR-93-6000	SM 2320 B	PC TITRATE
Fluoride	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Chloride	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Nitrate as N	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Nitrite as N	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Bromide	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Sulphate	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Ortho Phosphate as P	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Reactive Silica	INOR-93-6047	SmartChem Method SIL-001-A & SM 4500 Si-F 18 &19th	DISCRETE ANALYZER
Ammonia as N	INOR-93-6059	QuikChem 10-107-06-1-J & SM 4500 NH3-F	LACHAT FIA
Total Phosphorus	INOR-93-6022	SM 4500-P B&E	SPECTROPHOTOMETER
Total Organic Carbon	INOR-93-6049	EPA 415.1 & SM 5310 B	SHIMADZU CARBON ANALYZER
Colour	INOR-93-6046	SM 2120 B	SPECTROPHOTOMETER
Turbidity	INOR-93-6044	SM 2130 B	NEPHELOMETER
Calcium	MET-93-6105	EPA SW-846 6010C & 200.7	ICP/OES
Magnesium	MET-93-6105	EPA SW-846 6010C & 200.7	ICP/OES
Sodium	MET-93-6105	EPA SW-846 6010C & 200.7	ICP/OES
Potassium	MET-93-6105	EPA SW-846 6010C & 200.7	ICP/OES
Aluminum (dissolved)	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Antimony	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Arsenic	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Barium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Beryllium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Boron	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Cadmium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Chromium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Cobalt	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Copper	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Iron	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Lead	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Manganese	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Dissolved Mercury	MET-93-6100	EPA SW 846 7470 & 245.1	CVAAS
Molybdenum	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Nickel	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Selenium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Silver	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Strontium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Thallium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Method Summary

CLIENT NAME: AECOM CANADA LTD

AGAT WORK ORDER: 17T271541

PROJECT: 60551059

ATTENTION TO: Kelly Ali

SAMPLING SITE:

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Tin	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Titanium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Tungsten	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Uranium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Vanadium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Zinc	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Zirconium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Cation Sum		SM 1030 E	CALCULATION
Anion Sum		SM 1030 E	CALCULATION
% Difference/ Ion Balance		SM 1030 E	CALCULATION

AGAT Laboratories

5835 Coopers Avenue
Mississauga, Ontario L4Z 1Y2
Ph: 905.712.5100 Fax: 905.712.5122
webearth.agatlabs.com

Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water intended for human consumption)

Laboratory Use Only

Work Order #: 17T271541

Cooler Quantity: Smeel

Arrival Temperatures: 3.9 | 3.7 | 4
3.3 | 3.1 | 2-8

Custody Seal Intact: ☐Yes ☐No ☐N/A

Notes:

Report Information:

Company: AECOM Canada Ltd.
Contact: Kelly Ali
Address: 105 Commerce Valley Drive West
Markham, Ontario, L3T 7W3
Phone: 905-747-7598 Fax:
Reports to be sent to:
1. Email: Kelly.Ali@aecom.com
2. Email:

Regulatory Requirements: ☐ No Regulatory Requirement

(Please check all applicable boxes)

☐ Regulation 153/04
Table (Indicate One) ☐ Ind/Com ☐ Res/Park ☐ Agriculture
Soil Texture *(Check One)* ☑ Coarse ☐ Fine

☑ Sewer Use
☑ Sanitary
☑ Storm
Region: Durham (Indicate One)

☐ Regulation 558
☐ CCME
☑ Prov. Water Quality Objectives (PWQO)
☐ Other
(Indicate One)

Is this submission for a **Record of Site Condition?** ☐ Yes ☐ No

Report Guideline on *Certificate of Analysis* ☐ Yes ☐ No

Turnaround Time (TAT) Required:

Regular TAT ☑ 5 to 7 Business Days

Rush TAT (Rush Surcharges Apply)

☐ 3 Business Days ☐ 2 Business Days ☐ Next Business Day

OR Date Required (Rush Surcharges May Apply):

**TAT is exclusive of weekends and statutory holidays*

For 'Same Day' analysis, please contact your AGAT CPM

Project Information:

Project: 60551059
Site Location:
Sampled By:
AGAT Quote #: PO:
Please note: If quotation number is not provided, client will be billed full price for analysis.

Invoice Information:

Bill To Same: Yes ☑ No ☐

Company: AECOM Canada Ltd.
Contact: Accounts Payable
Address: 105 Commerce Valley Drive West, Markham, ON L3T 7W3
Email: CANSSC.E-billing@aecom.com/

Sample Matrix Legend

B	Biota
GW	Ground Water
O	Oil
P	Paint
S	Soil
SD	Sediment
SW	Surface Water

Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Y/N
Book - 1017	Oct 12/17	15:30	7	SW		N

Field Filtered - Metals, Hg, CrVI: Y/N

O. Reg 153

Metals and Inorganics: ☐ All Metals ☐ 153 Metals (excl. Hydrides) ☐ Hydride Metals

ORPs: ☐ B-HWS ☐ Cl ☐ CN ☐ Cr^{6+} ☐ EC ☐ FOC ☑ Hg ☐ pH ☐ SAR

Full Metals Scan

Regulation/Custom Metals

Nutrients: ☐ TP ☐ NH_3 ☐ TKN ☐ NO_3 ☐ NO_2 ☐ NO_3+NO_2

Volatiles: ☑ VOC ☐ BTEX ☐ THM

CCME Fractions 1 to 4

ABNs

PAHs

PCBs: ☐ Total ☐ Aroclors

Organochlorine Pesticides

TCLP: ☐ M&I ☐ VOCs ☐ ABNs ☐ B(a)P ☐ PCBs

Sewer Use

GW WOA

SW PWQO WOA ✓

Samples Relinquished By (Print Name and Sign)	Date	Time	Samples Received By (Print Name and Sign)	Date	Time
Kelly Ali	Oct 13/17	9:15			
	2017/10/13	4:30		2017/10/13	17:54

Page 1 of 1

N:

AECOM Imagine it. Delivered.

Appendix F

Dewatering Calculations and Assumptions

Radius of Influence (R_o) and Groundwater Inflow Rate (Q) Calculations - Unconfined Surficial Granular Aquifer

Project Name: Proposed Twin Cluvert (Uxbridge, ON)
Client: The Township of Uxbridge
AECOM Project No.: 60551059

STAGE #1 NORTH AREA

.1 RADIUS OF INFLUENCE (R_o)				
Sichardt's Empirical Relationship:	$R_o = r_s+C(H-h)(K^{0.5})$			
Radial Flow to Pumped Wells:	C = 3,000			
Line Flow to Trenches or Line of Wellpoints:	C = 1,500 to 2,000			
Radius of Influence (line source)	R_o =	30.9	m	
Coefficient:	C =	1,750	unitless	
Highest Water Level:		264.8	m	**BH8-17**
Target Water Level:		257.4	m	
Approximate Aquifer Bottom:		256.0	m	
Saturated Thickness before Dewatering:	H =	8.8	m	
Saturated Thickness after Dewatering:	h =	1.4	m	
Hydraulic Conductivity:	K =	3.3E-06	m/s	

.2 EXCAVATION LENGTH TO WIDTH RATIO (x/a)				
Equation:	x/a =	10.0		

.3 EQUVALENT RADIUS OF INFLUENCE FOR LONG NARROW EXCAVATIONS (r_s)				
Validity: For long narrow excavations (i.e., x/a >1.5), r_s is approximated as the distance wellpoints are from the centreline of the excavation.				
Equivalent Radius of Influence:	r_s =	7.5	m	
Excavation Slope Angle:	A =	1V:1H		
Maximum Excavation Depth:	H =	7.4	m	(at VC location)
Horizontal Distance from Bottom to Top of Excavation:	x =	0	m	(shored excavation)
Wellpoint Setback from Top of Excavation Slope:	y =	2	m	(assumed)

.4 GROUNDWATER SEEPAGE RATE (Q)				
Equation:	$Q = [(\pi K(H^2-h^2))/\ln(R_o/r_s)]+ 2[(xK(H^2-h^2))/2L]$			
* Based on Jacob's modified non-equilibrium equation for long, narrow systems in an unconfined aquifer.				
Radius of Influence:	R_o =	30.9	m	
Equivalent Radius of Infleunce:	r_s =	7.5	m	(long, narrow)
Saturated Thickness before Dewatering:	H =	8.8	m	
Saturated Thickness after Dewatering:	h =	1.4	m	
Hydraulic Conductivity:	K =	3.3E-06	m/s	
Length of Trench:	x =	110.0	m	
Line Source Distance:	L =	55.0	m	
Pi:	π =	3.1416		
Groundwater Inflow Rate:	Q =	1.0E-03	m3/s	
	Q =	89,713	L/day	
	Q_3 =	**269,138**	**L/day**	(with 3x Fs)

.5 SHORING EFFECTIVENESS				
60% Effectiveness	**Q_3 =**	107,655		
80% Effectiveness	**Q_3 =**	53,828		

REFERENCES:

Powers, J.P, Corwin, A.B., Schmall, P.C., Kaeck, W.E., and Herridge, C.J., 2007. Construction Dewatering and Groundwater Control: New Methods and Applications, 3rd Ed. John Wiley and Sons Inc

Sichart, W. and Kyrieleis, W., 1930. Grundwasser Absekungen bei Fundierungsarbeiten. Berlin, Germany.

L is taken to be the average of the maximum and minimum distance from the nearest portion of Uxbridge Brook not contained in the culvert.

Radius of Influence (R_o) and Groundwater Inflow Rate (Q) Calculations - Unconfined Surficial Granular Aquifer

Project Name: Proposed Twin Cluvert (Uxbridge, ON)
Client: Region of Durham
AECOM Project No.: 60551059

STAGE #2 SOUTH AREA

.1 RADIUS OF INFLUENCE (R_O)				
Sichardt's Empirical Relationship:	$R_o = r_s+C(H-h)(K^{0.5})$			
Radial Flow to Pumped Wells:	C = 3,000			
Line Flow to Trenches or Line of Wellpoints:	C = 1,500 to 2,000			
Radius of Influence (line source)	R_o =	24.9	m	
Coefficient:	C =	1,750	unitless	
Highest Water Level:		263.5	m	**BH2-17**
Target Water Level:		258.0	m	
Approximate Aquifer Bottom:		256.0	m	
Saturated Thickness before Dewatering:	H =	7.5	m	
Saturated Thickness after Dewatering:	h =	2.0	m	
Hydraulic Conductivity:	K =	3.3E-06	m/s	

.2 EXCAVATION LENGTH TO WIDTH RATIO (x/a)				
Equation:	x/a =	6.4		

.3 EQUVALENT RADIUS OF INFLUENCE FOR LONG NARROW EXCAVATIONS (r_s)				
Validity: For long narrow excavations (i.e., x/a >1.5), r_s is approximated as the distance wellpoints are from the centreline of the excavation.				
Equivalent Radius of Influence:	r_s =	7.5	m	
Excavation Slope Angle:	A =	1V:1H		
Maximum Excavation Depth:	H =	6.8	m	(at VC location)
Horizontal Distance from Bottom to Top of Excavation:	x =	0	m	(shored excavation)
Wellpoint Setback from Top of Excavation Slope:	y =	2	m	(assumed)

.4 GROUNDWATER SEEPAGE RATE (Q)				
Equation: $Q = [(\pi K(H^2-h^2))/\ln(R_o/r_s)]+ 2[(xK(H^2-h^2))/2L]$ * Based on Jacob's modified non-equilibrium equation for long, narrow systems in an unconfined aquifer.				
Radius of Influence:	R_o =	24.9	m	
Equivalent Radius of Infleunce:	r_s =	7.5	m	(long, narrow)
Saturated Thickness before Dewatering:	H =	7.5	m	
Saturated Thickness after Dewatering:	h =	2.0	m	
Hydraulic Conductivity:	K =	3.3E-06	m/s	
Length of Trench:	x =	70.0	m	
Line Source Distance:	L =	35.0	m	
Pi:	π =	3.1416		
Groundwater Inflow Rate:	Q =	7.9E-04	m3/s	
	Q =	67,992	L/day	
	Q_3 =	**203,975**	**L/day**	(with 3x Fs)

.5 SHORING EFFECTIVENESS				
60% Effectiveness	**Q_3 =**	81,590		
80% Effectiveness	**Q_3 =**	40,795		

REFERENCES:

Powers, J.P, Corwin, A.B., Schmall, P.C., Kaeck, W.E., and Herridge, C.J., 2007. Construction Dewatering and Groundwater Control: New Methods and Applications, 3rd Ed. John Wiley and Sons Inc

Sichart, W. and Kyrieleis, W., 1930. Grundwasser Absekungen bei Fundierungsarbeiten. Berlin, Germany.

L is taken to be the average of the maximum and minimum distance from the nearest portion of Uxbridge Brook not contained in the culvert.

Radius of Influence (R_o) and Groundwater Inflow Rate (Q) Calculations - Unconfined Surficial Granular Aquifer

Project Name: Proposed Twin Cluvert (Uxbridge, ON)
Client: Region of Durham
AECOM Project No.: 60551059

STAGE #1 SOUTH AREA (A)

.1 RADIUS OF INFLUENCE (R_o)				
Sichardt's Empirical Relationship:	$R_o = r_s+C(H-h)(K^{0.5})$			
Radial Flow to Pumped Wells:	C = 3,000			
Line Flow to Trenches or Line of Wellpoints:	C = 1,500 to 2,000			
Radius of Influence (line source)	R_o =	15.4	m	
Coefficient:	C =	1,750	unitless	
Highest Water Level:		263.5	m	**BH2-17**
Target Water Level:		261.0	m	
Approximate Aquifer Bottom:		256.0	m	
Saturated Thickness before Dewatering:	H =	7.5	m	
Saturated Thickness after Dewatering:	h =	5.0	m	
Hydraulic Conductivity:	K =	3.3E-06	m/s	

.2 EXCAVATION LENGTH TO WIDTH RATIO (x/a)				
Equation:	x/a =	3.6		

.3 EQUVALENT RADIUS OF INFLUENCE FOR LONG NARROW EXCAVATIONS (r_s)				
Validity: For long narrow excavations (i.e., x/a >1.5), r_s is approximated as the distance wellpoints are from the centreline of the excavation.				
Equivalent Radius of Influence:	r_s =	7.5	m	
Excavation Slope Angle:	A =	1V:1H		
Maximum Excavation Depth:	H =	3.8	m	(at VC location)
Horizontal Distance from Bottom to Top of Excavation:	x =	0	m	(shored excavation)
Wellpoint Setback from Top of Excavation Slope:	y =	2	m	(assumed)

.4 GROUNDWATER SEEPAGE RATE (Q)				
Equation:	$Q = [(\pi K(H^2-h^2))/\ln(R_o/r_s)]+ 2[(xK(H^2-h^2))/2L]$			
* Based on Jacob's modified non-equilibrium equation for long, narrow systems in an unconfined aquifer.				
Radius of Influence:	R_o =	15.4	m	
Equivalent Radius of Infleunce:	r_s =	7.5	m	(long, narrow)
Saturated Thickness before Dewatering:	H =	7.5	m	
Saturated Thickness after Dewatering:	h =	5.0	m	
Hydraulic Conductivity:	K =	3.3E-06	m/s	
Length of Trench:	x =	40.0	m	
Line Source Distance:	L =	50.0	m	
Pi:	π =	3.1416		
Groundwater Inflow Rate:	Q =	5.3E-04	m3/s	
	Q =	45,479	L/day	
	Q_3 =	**136,436**	**L/day**	(with 3x Fs)

.5 SHORING EFFECTIVENESS				
60% Effectiveness	**Q_3 =**	54,574		
80% Effectiveness	**Q_3 =**	27,287		

REFERENCES:

Powers, J.P, Corwin, A.B., Schmall, P.C., Kaeck, W.E., and Herridge, C.J., 2007. Construction Dewatering and Groundwater Control: New Methods and Applications, 3rd Ed. John Wiley and Sons Inc

Sichart, W. and Kyrieleis, W., 1930. Grundwasser Absekungen bei Fundierungsarbeiten. Berlin, Germany.

L is taken to be the average of the maximum and minimum distance from the nearest portion of Uxbridge Brook not contained in the culvert.

Overburden Storage - With Effective Cut-Off Measures

Project Name: Proposed Twin Cluvert (Uxbridge, ON)
Client: The Township of Uxbridge
AECOM Project No.: 60551059

STAGE #1 NORTH AREA

.1 Alluvial UC Seepage			
Equation: $V_s = (xy)*(H-h)*n$			
Effective Porosity:	n =	0.4	
Saturated Excavation Length:	x =	110	m
Saturated Excavation Width:	y =	11.0	m
Depth of Dewatering:	H-h =	7.4	m
Overburden Storage:	V_s =	3,582	m^3
		3,581,600	L

STAGE #2 SOUTH AREA

.1 Alluvial UC Seepage			
Equation: $V_s = (xy)*(H-h)*n$			
Effective Porosity:	n =	0.4	
Saturated Excavation Length:	x =	70	m
Saturated Excavation Width:	y =	11.0	m
Depth of Dewatering:	H-h =	5.5	m
Overburden Storage:	V_s =	1,694	m^3
		1,694,000	L

STAGE #2 SOUTH AREA (A)

.1 Alluvial UC Seepage			
Equation: $V_s = (xy)*(H-h)*n$			
Effective Porosity:	n =	0.4	
Saturated Excavation Length:	x =	40	m
Saturated Excavation Width:	y =	11.0	m
Depth of Dewatering:	H-h =	2.5	m
Overburden Storage:	V_s =	440	m^3
		440,000	L

** Volume contained within sheet pile wall. Wall bottom assumed keyed into the lower till to a depth >1.0m below the lowermost excavation depth within each project stage.*

POROSITY VALUES

Source: Freeze & Cherry (1979), Table 2.4	
Value:	**n (%)**
Unconsolidated deposits	
Gravel	25–40
Sand	25–50
Silt	35–50
Clay	40–70
Rocks	
Fractured basalt	5–50
Karst limestone	5–50
Sandstone	5–30
Limestone, dolomite	0–20
Shale	0–10
Fractured crystalline rock	0–10
Dense crystalline rock	0–5

Overburden Storage - With Ineffective Cut-Off Measures

Project Name: Proposed Twin Cluvert (Uxbridge, ON)
Client: The Township of Uxbridge
AECOM Project No.: 60551059

STAGE #1 NORTH AREA

.1 Alluvial UC Seepage			
Equation: $V_s = (xy+R_ox+(\pi R_o^2/3))*(H-h)*n$			
Effective Porosity:	n =	0.4	
Saturated Excavation Length:	x =	110	m
Saturated Excavation Width:	y =	11.0	m
Radius of Influence:	R_o =	30.9	
Depth of Dewatering:	H-h =	7.4	m
Overburden Storage:	V_s =	16,591	m^3
		16,591,377	L

STAGE #2 SOUTH AREA

.1 Alluvial UC Seepage			
Equation: $V_s = (xy+R_ox+(\pi R_o^2/3))*(H-h)*n$			
Effective Porosity:	n =	0.4	
Saturated Excavation Length:	x =	70	m
Saturated Excavation Width:	y =	11.0	m
Radius of Influence:	R_o =	24.9	
Depth of Dewatering:	H-h =	5.5	m
Overburden Storage:	V_s =	6,950	m^3
		6,950,471	L

STAGE #2 SOUTH AREA (A)

.1 Alluvial UC Seepage			
Equation: $V_s = (xy+R_ox+(\pi R_o^2/3))*(H-h)*n$			
Effective Porosity:	n =	0.4	
Saturated Excavation Length:	x =	40	m
Saturated Excavation Width:	y =	11.0	m
Radius of Influence:	R_o =	15.4	
Depth of Dewatering:	H-h =	2.5	m
Overburden Storage:	V_s =	1,304	m^3
		1,304,175	L

** Volume contained within sheet pile wall. Wall bottom assumed keyed into the lower till to a depth >1.0m below the lowermost excavation depth within each project stage.*

POROSITY VALUES

Source: Freeze & Cherry (1979), Table 2.4

Value:	n (%)
Unconsolidated deposits	
Gravel	25–40
Sand	25–50
Silt	35–50
Clay	40–70
Rocks	
Fractured basalt	5–50
Karst limestone	5–50
Sandstone	5–30
Limestone, dolomite	0–20
Shale	0–10
Fractured crystalline rock	0–10
Dense crystalline rock	0–5

Vertical Seepage

Project Name: Proposed Twin Cluvert (Uxbridge, ON)
Client: The Township of Uxbridge
AECOM Project No.: 60551059

STAGE #1 NORTH AREA

.1 Alluvial UC Seepage				
Equation:	Q = KiA			
Hydraulic Conductivity:	K =	3.3E-06	m/s	
		2.8E-01	m/day	
Hydraulic Gradient:	i =	1.0	unitless	
Area of Excavation:	A =	1210.0	m^2	
Vertical Seepage Volume:	V_s =	340.81	m^3/day	
		340,813	L/day	
	Q_3 =	**1,022,440**	**L/day**	(with 3x Fs)

STAGE #2 SOUTH AREA

.1 Alluvial UC Seepage				
Equation:	Q = KiA			
Hydraulic Conductivity:	K =	3.3E-06	m/s	
		2.8E-01	m/day	
Hydraulic Gradient:	i =	1.0	unitless	
Area of Excavation:	A =	770.0	m^2	
Vertical Seepage Volume:	V_s =	216.88	m^3/day	
		216,881	L/day	
	Q_3 =	**650,644**	**L/day**	(with 3x Fs)

STAGE #2 SOUTH AREA (A)

.1 Alluvial UC Seepage				
Equation:	Q = KiA			
Hydraulic Conductivity:	K =	3.3E-06	m/s	
		2.8E-01	m/day	
Hydraulic Gradient:	i =	1.0	unitless	
Area of Excavation:	A =	51.0	m^2	
Vertical Seepage Volume:	V_s =	14.36	m^3/day	
		14,365	L/day	
	Q_3 =	**43,095**	**L/day**	(with 3x Fs)

Total Dewatering

Project Name: Proposed Twin Cluvert (Uxbridge, ON)
Client: The Township of Uxbridge
AECOM Project No.: 60551059

STAGE #1 NORTH AREA + SOUTH AREA (A)

.1 Ineffective Cut-Off (60% Effective) - North Are		***Q***	***Q3***	
Unconfined Aquifer:	Q =	35,885	107,655	L/day
Vertical Seepage:	Q =	340,813	1,022,440	L/day
Overburden Storage*:	V_s =	2,212,184	2,212,184	L
.1 Ineffective Cut-Off (60% Effective) - South Area (a)				
Unconfined Aquifer:	Q =	18,191	54,574	L/day
Vertical Seepage:	Q =	14,365	43,095	L/day
Overburden Storage*:	V_s =	173,890	173,890	L
Total Dewatering Volume:	**Q_T =**	**2,795,328**	**3,613,838**	L/day

.2 Effective Cut-Off (80% Effective) North Area				
Unconfined Aquifer:	Q =	17,943	53,828	L/day
Vertical Seepage:	Q =	340,813	1,022,440	L/day
Overburden Storage*:	V_s =	1,193,867	1,193,867	L
.2 Effective Cut-Off (80% Effective) - South Area (a)				
Unconfined Aquifer:	Q =	9,096	27,287	L/day
Vertical Seepage:	Q =	14,365	43,095	L/day
Overburden Storage*:	V_s =	146,667	146,667	L
Total Dewatering Volume:	**Q_T =**	**1,722,750**	**2,487,183**	L/day

** Overburden storage assumed to be removed over a pre-drainage period of 3 days (ie. $V_s/3$).*

STAGE #2 SOUTH AREA

.1 Ineffective Cut-Off (60% Effective)		***Q***	***Q3***	
Unconfined Aquifer:	Q =	27,197	81,590	L/day
Vertical Seepage:	Q =	216,881	650,644	L/day
Overburden Storage*:	V_s =	926,730	926,730	L
Total Dewatering Volume:	**Q_T =**	**1,170,808**	**1,658,964**	**L/day**

.2 Effective Cut-Off (80% Effective)		***Q***	***Q3***	
Unconfined Aquifer:	Q =	13,598	40,795	L/day
Vertical Seepage:	Q =	216,881	650,644	L/day
Overburden Storage*:	V_s =	564,667	564,667	L
Total Dewatering Volume:	**Q_T =**	**795,146**	**1,256,106**	L/day

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Appendix G

Confined Aquifer Basal Heave Assessment (V.A. Wood)

V. A. WOOD ASSOCIATES LIMITED
CONSULTING GEOTECHNICAL ENGINEERS
1080 TAPSCOTT ROAD, UNIT 24, SCARBOROUGH, ONTARIO M1X 1E7
TELEPHONE: (416) 292-2868 • FAX No: (416) 292-5375

Memorandum

To: *AECOM* ***Page:*** *1*

Subject: *Geotechnical Assessment of Possible Basal Heave on Proposed Uxbridge Culvert Excavation*

From: *Victor Wood, M.Eng, P.Eng.*

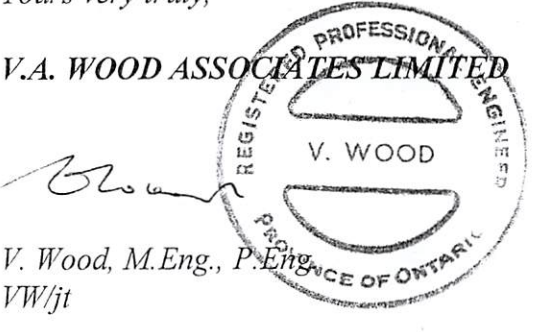
Date: *April 3, 2018* ***Project Number:*** *7171*

Basal heave is when the pore pressure at the base of an impermeable layer below the base of an excavation is more than 70% of the total stress at this point.

Reference to our Geotechnical Report Ref. No. 7171-17-6 indicates that there are two aquifers on this site, one is unconfined in the surficial deposit of fill and alluvium and this will be dewatered. The other is a confined aquifer, the surface of which ranges from Elev. 246 to 253 m. The proposed excavation grade is to be between Elev. 259.0 and 259.5. Assuming that the water level in the confined aquifer is at 262 ± m and the highest elevation of the top of the confined aquifer is 253, then the safety factor against basal heave will be 1.33 which we consider to be acceptable. It is noted that we consider this to be conservative since the dewatering of the excavation will tend to reduce the hydrostatic head in the confined aquifer.

Yours very truly,

V.A. WOOD ASSOCIATES LIMITED



V. Wood, M.Eng., P.Eng.
VW/jt

References

Geotechnical Investation
Culvert Reconstruction
Brock Street/Centennial Drive
Uxbridge, Ontario
Ref. No. 7171-17-6
September 2017

AECOM Imagine it. Delivered.

Appendix H

Ground Settlement Assessment (V.A. Wood)

V. A. WOOD ASSOCIATES LIMITED
CONSULTING GEOTECHNICAL ENGINEERS
1080 TAPSCOTT ROAD, UNIT 24, SCARBOROUGH, ONTARIO M1X 1E7
TELEPHONE: (416) 292-2868 • FAX No: (416) 292-5375

Memorandum

To: *AECOM* ***Page:*** *1*

Subject: *Geotechnical Assessment for Construction Dewatering Works*

From: *Victor Wood, P.Eng.*

Date: *April 3, 2018* ***Project Number:*** *7171*

This memorandum is a supplementary geotechnical assessment to support the proposed construction dewatering works at the site.

Ground Settlement Induced by Construction Dewatering

Based on our Geotechnical Report Ref. No. 7171-17-6 the highest ground water level is at Elev. 264.8 ± m and the excavation is to be dewatered to at least 0.5 m below the excavation grade i.e. to Elev. 259.5 ± m which is a drop of 5.3 ± m. This results in an average increase of stress of 25 kPa in the variable deposits of fill and alluvium. It is not possible to obtain an accurate estimate of the probable settlement but based on our experience it is likely to be less than 100 mm in the immediate vicinity of the excavation decreasing to zero at around Bescom Street to the east and Toronto Street N to the west. In view of the depth of fill and alluvium, it is likely that most of the buildings in the vicinity are founded on deep foundations. We would recommend however that a preconstruction survey be carried out on all buildings within 50 metres of the excavation.

The effect of any settlement on buried utilities will depend on existing condition of these utilities. It is recommended that the condition of any utilities within 50 metres of the excavation be inspected prior to any dewatering.

Yours very truly,

V.A. WOOD ASSOCIATES LIMITED

REGISTERED PROFESSIONAL ENGINEER
V. WOOD
PROVINCE OF ONTARIO

V. Wood, M.Eng., P.Eng.
VW/jt

References

Geotechnical Investation
Culvert Reconstruction
Brock Street/Centennial Drive
Uxbridge, Ontario
Ref. No. 7171-17-6
September 2017