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A REPORT TO
BROCK ROAD DUFFINS FOREST INC.

HYDROGEOLOGICAL ASSESSMENT

PROPOSED RESIDENTIAL DEVELOPMENT
2055 BROCK ROAD

CITY OF PICKERING

REFERENCE NO. 1909-W140

MARCH 2020

DISTRIBUTION

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1.0 EXECUTIVE SUMMARY

Soil Engineers Ltd. (SEL) has completed a Hydrogeological Assessment for a proposed development site, located at 2055 Brock Road, in the City of Pickering.

The subject site is located within the Physiographic Region of Southern Ontario known as the Iroquois plain, where sand plain is the predominant physiographic feature. The native surface geological soil unit consists of silty glaciolacustrine deposits, consisting predominantly of silt and clay with minor sand indicative of a basin and quiet water depositional environment.

A review of the topography shows that the site is slightly hilly, with the area descending gently to the southeast, towards West Duffins Creek.

The proposed development site is located within the Duffins Creek Watershed and West Duffins Creek Subwatershed. Records review shows that much of the southern portion of the property is wooded with the West Duffins Creek being located immediately south of the site's southern boundary. The closest wetland feature can be found approximately 225 m northwest of the site. This wetland has not been evaluated as being Provincially Significant under the Ontario Wetland Evaluation System (OWES). The closest Provincially Significant wetlands are located approximately 1,500 m southeast of the subject site.

This study has revealed that beneath the topsoil and/or earth fill layers, the site is underlain by silty clay, overlying glacial till, having occasional sand layers.

The groundwater monitoring program indicates that the average shallow groundwater levels range from El. 82.78 to 85.70 masl. The interpreted shallow groundwater flow pattern suggests that it flows east/southeasterly, towards West Duffins Creek.

Based on the hydraulic conductivity (K) testing, interpreted from the Single Well response tests (SWRT), the estimates for K ranges from 1.8×10^{-8} to 8.5×10^{-7} m/sec for the silty clay and glacial till deposits, indicating that low to moderated groundwater seepage rates can be expected within open excavations below the water table.

The estimated dewatering flow rates are expected reach daily rates of 34,864.0 L/day and 31,864.3 L/day for construction of the proposed 2-level and 1-level underground parking structures respectively; by considering a 3x safety factor, this rate could reach approximate daily maximums of 104,592.1 L/day and 95,592.8 L/day. As such, approval for any construction related groundwater taking would be through an Environmental Activity and

Sector Registry (EASR) and its filing with Ministry of the Environment, Conservation and Parks (MECP).

The estimated zone of influence for construction dewatering could reach a maximum of 11.4 m away from the conceptual dewatering arrays, considered for the construction of the proposed underground parking structures. No water supply wells, bodies of water, watercourses, wetlands or any natural features are present within the conceptual zone of influences for the construction dewatering arrays. Given that the southern and eastern portions of the site are heavily forested with no development anticipated within these portions of the site, it is likely that the West Duffins Creek and its associated natural features will be located outside the conceptual zone of influence for construction dewatering. However, existing residential buildings, and a nearby cultural centre are located north of the site, along with Brock Road, located west of the site which may be situated within the conceptual zones of influence for construction dewatering.

For the proposed 2-level underground parking structure located beneath the western portion of the site, the estimated long-term foundation seepage drainage rate to the Mira perimeter drainage network for a conventionally shored excavation is 2,159.44 L/day. The long-term, average seepage drainage rate to the under-slab basement floor drainage network is 100.6 L/day. The combined, long-term seepage drainage rate to both the Mira Drain, perimeter system for the shore walls, and from the under-slab drainage networks is estimated at 2,260.04 L/day. By applying a safety factor of three (3), the combined seepage drainage rate is estimated at 6,780.11 L/day.

The base elevation for the proposed 1-Level underground parking structure is at an elevation of approximately 83.78 masl, which was considered for the long-term foundation drainage estimation. Review of the measured groundwater levels for the east portion of the site indicates that the highest shallow groundwater level was at an elevation of 82.97 masl at BH/MW 10. As such, the base for the proposed underground structure will be established above the measured shallow groundwater level. As such, there are no concerns associated with any long-term foundation drainage needs for the proposed 1-level underground parking structure. The foundation drainage may come to fruition on a short-term basis, following heavy rainfall events, or following snow melt and during spring season thaw.

2.0 INTRODUCTION

2.1 Project Description

In accordance with authorization from Ms. Alison Lin of Brock Road Duffins Forest Inc., we have carried out a hydrogeological study for a development property at 2055 Brock Road, which is located approximately 300 m north of the intersection of Finch Avenue and Brock Road in the City of Pickering. The location of the site is shown on Drawing No. 1.

The subject site currently consists of vacant land. The surrounding land use consists of an institutional property (Pickering Islamic Centre) and residential properties to the north, wooded areas to the east, the West Duffins Creek and residential properties to the south along with Brock Road, and residential properties and a park to the west.

This Hydrogeological Study summarizes findings of a field study and the associated groundwater monitoring and testing programs, and provides a description and characterization for the site's hydrogeological setting. The current study provides preliminary recommendations for construction dewatering needs and for any need to acquire an Environmental Activity and Sector Registry (EASR), or a Permit-To-Take Water (PTTW) as approvals to facilitate a construction dewatering program. A pre- and post-development water balance was previously prepared for the subject site under a separate cover.

2.2 Project Objectives

The major objectives of this Hydrogeological Study Report are as follows:

1. Establish the local and regional hydrogeological setting for the subject site and local surrounding areas;
2. Interpret shallow groundwater flow patterns;
3. Identify zones of higher groundwater yield as potential sources for on-going shallow groundwater seepage from the site's subsoil strata;
4. Characterize the hydraulic conductivity (K) for groundwater-bearing subsoil strata;
5. Prepare interpreted hydrogeostratigraphic cross-sections across the subject site;
6. Estimate the anticipated dewatering flows that may be required to lower the groundwater table to facilitate earthworks and construction;
7. Estimate the anticipated zones of influence associated with any construction dewatering, if required, and to provide any mitigation recommendations to safeguard nearby groundwater receptors, if required;

8. Provide comments regarding any need to file an Environmental Activity and Sector Registry (EASR), or to acquire a Permit-To-Take Water (PTTW) as approvals to facilitate a construction dewatering program.

2.3 **Scope of Work**

The scope of work for the Hydrogeological Study is summarized below:

1. Borehole drilling and installation of five (5) monitoring wells within the site's development footprint
2. Monitoring well development and groundwater level monitoring and measurements at the monitoring wells;
3. Monitoring well development and performance of Single Well Response Tests (SWRTs) at the monitoring wells to estimate the hydraulic conductivity (K) for groundwater-bearing subsoil strata at the depths of the well screens;
4. Reviewing plotting and mapping of Ministry of the Environment, Conservation and Parks (MECP) water well records within 500 m of the development site (study area);
5. Describing the geological and hydrogeological setting for the subject site and nearby surrounding areas;
6. Review of the findings from the concurrent geotechnical investigation;
7. Review of the available engineering development plans and profiles; assessing the preliminary dewatering needs to estimate the anticipated dewatering flows necessary to lower groundwater levels for earthworks and construction;
8. Review of groundwater receptors in the vicinity of the development site, and providing of preliminary recommendations for any monitoring, mitigation and discharge management to safeguard potential groundwater receptors from potential adverse impacts associated with any construction dewatering;
9. Providing comments regarding any need to register an Environmental Activity and Sector Registry (EASR) approval or to apply for and obtain a Permit-To-Take Water (PTTW) to facilitate any construction dewatering program or for any anticipated long-term foundation drainage.

3.0 METHODOLOGY

3.1 Borehole Advancement and Monitoring Well Installation

The field work for borehole drilling and monitoring well construction was performed on October 11, 15, 17, 18 and 21, 2019. It consisted of ten (10) drilled boreholes (BH) and the installation of five (5) monitoring wells (MW), one in each of five selected boreholes at the time of drilling at the locations shown on Drawing No. 2. The boreholes were drilled using solid stem flight-augers. The drilling and monitoring well construction were completed by a licensed well contractor, DBW Drilling Limited, under the full-time supervision of a geotechnical technician from SEL, who also logged the subsoil strata encountered during borehole advancement and collected representative soil samples. The Borehole and Monitoring Well Logs are enclosed as Figures 1 to 10, inclusive.

The monitoring wells, consisting of 50 mm diameter PVC riser pipes and screen sections, were installed in the boreholes in accordance with Ontario Regulation (O. Reg.) 903. All of the wells were equipped with above-ground monument-type, steel protective casings. The well construction details are shown on the Borehole/Monitoring Well Logs with the construction details summarized in Table 3-1.

The UTM coordinates and ground surface elevations at the borehole and monitoring well locations, together with the monitoring well construction details, are provided in Table 3-1.

Table 3-1 - Monitoring Well Installation Details

Well ID	Installation Date	UTM Coordinates		Ground El. (masl)	Borehole Depth (mbgs)	Screen Interval (mbgs)	Casing Dia. (mm)
		East (m)	North (m)				
BH/MW 1	October 15, 2019	654606.4	4857344.6	91.0	12.3	9.2-12.2	50
BH/MW 4	October 15, 2019	654649.5	4857308.0	90.3	12.5	9.2-12.2	50
BH/MW 8	October 21, 2019	654739.3	4857371.0	88.7	12.3	9.2-12.2	50
BH/MW 9	October 18, 2019	654762.1	4857401.6	87.3	12.3	9.2-12.2	50
BH/MW 10	October 18, 2019	654787.5	4857370.4	85.9	12.3	9.2-12.2	50

mbgs -- metres below ground surface masl -- metres above sea level

3.2 Groundwater Monitoring

The groundwater levels in the monitoring wells were measured by our representative on November 14, November 21 and December 4, 2019.

3.3 **Mapping of Ontario Water Well Records**

SEL reviewed the MECP Water Well Records (WWRs) for the registered wells on the subject site and within 500 m from the site boundaries (study area). The well records indicate that twenty-seven (27) wells are located within the 500 m study area. A summary of the Ontario WWRs reviewed for this study is provided in Appendix 'A' with the locations of the well records shown on Drawing 3.

3.4 **Monitoring Well Development and Single Well Response Tests**

The monitoring wells underwent well development to prepare them for SWRTs to estimate the hydraulic conductivity (K) values for saturated aquifer subsoils at the well screen depths. The well development involved purging and removing several casing volumes of groundwater from each well to remove remnants of clay, silt and other debris introduced into the monitoring wells during construction, and to induce the flow of fresh formation groundwater through the well screens, thereby improving the transmissivity of the water bearing formation at the well screens intervals.

The K values provide an indication of the yield (seepage) capacity for the groundwater-bearing strata and can be used to estimate the flow of groundwater through the water-bearing soil strata.

The SWRT involves the placement of a slug of known volume into the well, below the water table, to displace the groundwater level upward. The rate at which the water level recovers to static conditions (falling head) is tracked using a data logger/pressure transducer, and/or manually using a water level tape, with the recovery rate being used to estimate the K value for the water-bearing subsoil formation at the well screen depth. All of the BH/MWs underwent a SWRT (Falling Head Tests) on November 21, 2019. The results of the SWRTs are provided in Appendix 'B'.

3.5 **Review of Concurrent Report**

The following concurrent geotechnical report was reviewed for the preparation of this hydrogeological study:

A Report to Brock Road Duffins Forest Inc., A Geotechnical Investigation for Proposed Residential Development, 2055 Brock Road, City of Pickering, SEL Reference No. 1905-S140, dated December 2019.

4.0 REGIONAL AND LOCAL SETTING

4.1 Regional Geology

The subject site lies within the Physiographic Region of Southern Ontario known as the Iroquois Plain, where a sand plain is the predominant physiographic feature. The Iroquois Plain occupies the north shore of Lake Ontario, where it extends from Scarborough to Trenton and is considered an area of considerable complexity, not easily divisible into well-marked geological units. Highland Creek and the Rouge River deposited sand into a former glacial lake to build the present-day sand plain in the southeast corner of the City of Toronto (Scarborough) and within the adjacent portions of the City of Pickering, and Towns of Ajax and Whitby. Across the Regional Municipality of Durham, the Iroquois plain has a fairly consistent pattern (Chapman and Putnam, 1984).

Based on a review of a surface geological map of Ontario, the subject site is located on glaciolacustrine deposits (silty), consisting predominantly of silt and clay, with minor sand, indicative of a quiet lacustrine depositional environment. Drawing No. 4, reproduced from Ontario Geological Survey mapping, illustrates the quaternary surface soil geology for the subject site and surrounding areas.

The bedrock surface lies approximately at El. 68.0 masl (Bedrock Topography of the Markham Area, Southern Ontario, 1992) and consists of Upper Ordovician aged shale, limestone, dolostone and siltstone of the Georgian Bay Formation, the Blue Mountain Formation, the Billings Formation, the Collingwood Member and the Eastview Member (Ontario Ministry of Northern Department and Mines, 1991). These sedimentary rock formations and members have been overlain by a sequence of about 60 m of overburden soil deposits.

4.2 Physical Topography

A review of the topographic map for the site and surrounding area shows that it is slightly hilly, with the area descending gently to the southeast, towards West Duffins Creek. The topographic relief across the subject site is approximately 5 m. Drawing No. 4 shows the mapped topographic contours for the subject site and surrounding areas.

4.3 **Watershed Setting**

The subject site is located within the Duffins Creek Watershed and the West Duffins Creek Subwatershed, as shown, mapped, on Drawing No. 6. The majority of the Duffins Creek watershed is located in the Regional Municipality of Durham, but smaller portions also fall within the Regional Municipality of York. From its headwaters to Lake Ontario, this watercourse links the communities of Whitchurch-Stouffville, Markham, Uxbridge, Pickering, and Ajax. Duffins Creek has a number of significant tributaries including; Reesor Creek, Stouffville Creek, Wixon Creek, Whitevale Creek, Major Creek, Mitchell Creek, Urfe Creek, Brougham Creek, Ganatsekiagon Creek, and Millers Creek. The headwaters for Duffins Creek rise on the Oak Ridges Moraine, from the Oak Ridges Moraine, Duffins Creek winds its way downstream across the Halton Till Plain, the Lake Iroquois Shoreline, and the Lake Iroquois Plain (Toronto and Region Conservation Authority, 2003) towards Lake Ontario.

4.4 **Local Surface Water and Natural Features**

Records show that much of the southern portion of the property is wooded with West Duffins Creek being located immediately south of the site's southern boundary. The intersection of Ganatsekiagon Creek and Urfe Creek are located approximately 825 m north of the subject site.

The closest wetland feature can be found approximately 225 m northwest of the subject site. This wetland has not been evaluated as being Provincially Significant under the Ontario Wetland Evaluation System (OWES). The closest Provincially Significant wetlands are located approximately 1,500 m southeast of the subject site.

Drawing No. 7 shows the locations of the above-mentioned natural features relative to the subject site.

5.0 SOIL LITHOLOGY

This study has revealed that beneath a layer of topsoil and/or earth fill horizon, the native soils underlying the subject site consists of sand, silty clay, and glacial till (sandy silt till/silty sand till). A Key Plan, and the interpreted geological cross-sections along west-to-east, and southwest-to- northeast transects are presented on Drawing Nos. 8-1 and 8-2, respectively.

5.1 **Topsoil** (BHs 2 and 7, and BH/MW 10)

Topsoil was found at the surface at BHs 2 and 7, as well as at BH/MW 10. The thickness of topsoil ranges from 20 to 25 cm.

5.2 **Earth Fill** (BHs 3, 5 and 6, and BH/MWs 1, 4, 9 and 10)

Earth fill was encountered at the surface, or beneath the topsoil horizon at BHs 3, 5 and 6, and at BH/MWs 1, 4, 9 and 10. The earth fill layer generally consists of silty sand beneath sandy silt beneath the western portion of the site and by silty clay beneath the eastern portion of the site. It ranges in thickness from 1.0 to 2.4 m.

5.3 **Sand** (BHs 2, 6 and 7, and BH/MW 8)

Sand was observed at BHs 2, 6 and 7 and at BH/MW 8 at the surface, and beneath the topsoil horizon or beneath the earth fill layer. It is generally brown in colour and the thickness of the layer ranges from 0.6 to 1.3 m. At BH 7, sand was encountered at two different depths. The upper layer was encountered at a depth of 0.3 m, and the lower layer was encountered at a depth of 11.6 m. The moisture contents for the retrieved subsoil samples ranged from 4-18%, indicating damp to very moist conditions.

5.4 **Silty Clay** (All BH and BH/MW locations)

Silty clay till was encountered beneath the sand or earth fill layers at all of the BH and BH/MW locations. It is brown to grey in colour and the thickness of the layer ranges from 3.1 to 8.0 m. The moisture content for the retrieved samples ranges from 10-39%, indicating moist to saturated conditions. The estimated permeability for this layer at depths of 3.3 mbgs and 4.8 mbgs is 10^{-7} m/sec. Grain size analyses were performed on two (2) samples, with the gradations being plotted on Figure 11.

5.5 **Glacial Till (Sandy Silt Till/Silty Sand Till)** (All BH and BH/MW locations)

Glacial till, consisting of sandy silt or sandy silt till to silty sand till, was observed beneath the silty clay at all of the BH and BH/MW locations. It is grey in colour and the thickness of the layer ranges from 3.3 to 7.7 m. The moisture content for the retrieved subsoil samples ranges from 6-15%, indicating damp to moist conditions. The estimated permeability for this layer, at a depth of 7.8 mbgs is between 10^{-6} and 10^{-5} m/sec. Grain size analyses were performed on three (3) samples, with the gradations being plotted on Figures 12 and 13.

6.0 GROUNDWATER STUDY

6.1 Review Summary of Previous Report

A review of the findings from the concurrent geotechnical investigation report (SEL Reference No. 1909-S140) has revealed that beneath the topsoil and/or earth fill layer, the site is underlain by silty clay, overlying glacial till, having occasional sand layers. Groundwater seepage and cave-in was encountered at depths of 8.5 to 9.5 m (El. 80.0 to 82.5 m) and saturated sand was encountered at a depth of 11.6 m at BH 7 upon completion of the drilling program.

6.2 Review of Ontario Water Well Records

The Ministry of the Environment, Conservation and Parks (MECP) water well records (WWRs) for the site and for the properties within a 500 m radius of the boundaries of the subject site were reviewed.

The records indicate that twenty-seven (27) wells are located within the 500 m study area relative to the subject site. The locations of these wells, based on the UTM coordinates provided by the records, are shown on Drawing No 3. A detailed summary of the MECP WWRs that were reviewed is provided in Appendix ‘A’.

A review of the final status of the wells within the study area reveals that thirteen (13) are registered as water supply wells, six (6) are registered as abandoned – other wells, two (2) are registered as test hole wells, one (1) is an observation well, and five (5) wells have unidentified statuses.

A review of the first status of the wells shows that, twelve (12) are registered as domestic wells, four (4) are not being used, two (2) are monitoring wells, one (1) is a monitoring and test hole well, one (1) is a public supply well, and seven (7) wells have unidentified statuses.

The records indicate that there is one (1) well located on the subject site. This well is registered as a test hole well, having a depth of 8.38 m and a 1.5 m length screen. Groundwater was found at a depth of 2.44 m at this well, however this well could not be located upon our site visits. It has likely been destroyed or decommissioned. There are no records for any water supply wells located within the subject site.

6.3 **Groundwater Monitoring**

Groundwater levels were measured in all of the installed monitoring wells to record the fluctuation of the groundwater table beneath the site on November 14, 21 and December 4, 2019. The water level measurements and their corresponding elevations are summarized in Table 6-1.

Table 6-1 - Water Level Measurements

Well ID		Nov. 14, 2019	Nov. 21, 2019	December 4, 2019	Average
BH/MW 1	mbgs	5.33	5.28	5.28	5.30
	masl	85.67	85.72	85.72	85.70
BH/MW 4	mbgs	6.61	6.53	6.40	6.51
	masl	83.69	83.77	83.90	83.79
BH/MW 8	mbgs	5.87	5.85	5.80	5.84
	masl	82.83	82.85	82.90	82.86
BH/MW 9	mbgs	4.66	4.48	4.41	4.52
	masl	82.64	82.82	82.89	82.78
BH/MW 10	mbgs	3.08	3.00	2.93	3.00
	masl	82.82	82.90	82.97	82.90

Notes: mbgs -- metres below ground surface masl -- metres above sea level

As shown above, the groundwater levels increased or rose at all of the BH/MW locations over the monitoring period. The highest shallow groundwater level fluctuation was recorded at BH/MW 9, which exhibited a 0.25 m increase in groundwater level during the study.

6.4 **Single Well Response Test Analysis**

All of the BH/MWs underwent Falling Head Tests (SWRT's) to assess the hydraulic conductivity (K) for saturated aquifer soils at the well screen depths. The results of the SWRT analysis are presented in Appendix 'B', with a summary of the findings shown in Table 6-2.

Table 6-2 - Summary of SWRT Results

Well ID	Ground El. (masl)	Monitoring Well Depth (mbgs)	Borehole Depth (mbgs)	Screen Interval (mbgs)	Screened Soil Strata	Hydraulic Conductivity (K) (m/sec)
BH/MW 1	91.0	12.2	12.3	9.2-12.2	Sandy Silt Till/Silty Sand Till	1.9×10^{-7}
BH/MW 4	90.3	12.2	12.5	9.2-12.2	Sandy Silt Till/Silty Sand Till	8.5×10^{-7}
BH/MW 8	88.7	12.2	12.3	9.2-12.2	Sandy Silt Till/Silty Sand Till	1.8×10^{-7}
BH/MW 9	87.3	12.2	12.3	9.2-12.2	Sandy Silt Till/Silty Sand Till	8.4×10^{-7}
BH/MW 10	85.9	12.2	12.3	9.2-12.2	Sandy Silt Till/Silty Sand Till	6.6×10^{-7}

The SWRT results provide an indication of the yield capacity for the groundwater-bearing subsoil strata at the depths of the well screens. The results of the field investigation and SWRTs indicate low to moderate anticipated seepage rates associated with the saturated subsoils at the depths of the monitoring well screens.

6.5 **Shallow Groundwater Flow Pattern**

The average of the groundwater levels measured at the monitoring wells were used to interpret the shallow groundwater flow pattern across the subject site. The interpretation indicates that shallow groundwater flows in east/southeasterly directions, towards West Duffins Creek. The interpreted groundwater flow pattern for the study site is illustrated on Drawing No. 9.

7.0 GROUNDWATER CONTROL DURING CONSTRUCTION

The estimated hydraulic conductivity (K) for the screened subsoil strata suggests that groundwater seepage rates into open excavations below the groundwater table will be low to moderate. To provide safe, dry and stable conditions from earthworks and excavations for the construction of the proposed underground parking structure, the groundwater table may need to be lowered in advance of, or during construction. The preliminary estimates for construction dewatering flows required to locally lower the shallow groundwater table, based on the K test results, are discussed in the following sections.

7.1 Groundwater Construction Dewatering Rates

The proposed development will consist of the construction of two stacked townhouse blocks, one street townhouse block, and one, 20-storey high rise residential building with one or two-levels of underground parking structure. Based on the shallow groundwater level elevations, temporary construction dewatering is anticipated for the earthworks portion of the underground structures and for underground services construction. The construction dewatering flow rate assessments are discussed below:

Dewatering Flow Rate Estimates for West Portion (with Proposed 2-Level Underground Parking Structure)

The Level P1 and P2 Floor Plan, and the Overall Site Sections, prepared by Kohn Partnership Architects Inc, Drawing Nos. A2 00 and A4 10, dated November 21, 2019, were reviewed for this assessment. The overall site statistics indicate that the base for the 2-Level underground parking structure will be at an elevation of 80.78 masl. To facilitate excavation and construction in dry and stable subsoil conditions, it is proposed that the groundwater table be lowered to an elevation of 79.78 masl, which is about 1.0 m below the lowest proposed excavation depth. The highest shallow groundwater level measured beneath the western portion of the site was at El. 85.72 masl at BH/MW 1. The subsoil profile consists predominantly of silty clay and glacial till (sandy silt till/silty sand till), extending to the maximum anticipated excavation depth. As such, the estimated construction dewatering flow rates are anticipated to reach rates of 34,864.0 L/day for the proposed 2-level underground parking structure; by considering a 3x safety factor, this rate could reach an approximate daily maximum of 104,592.1 L/day. It should be noted that a rectangular excavation footprint, having a length of 99.41 m and width of 63.22 m was considered for this, dewatering needs assessment.

Dewatering Flow Rate Estimates for East Portion (with Proposed 1-Level Underground Parking Structure)

The Level P1 and P2 Floor Plan, and the Overall Site Sections, prepared by Kohn Partnership Architects Inc, Drawing Nos. A2 00 and A4 10, dated November 21, 2019, were reviewed for this assessment. The overall site statistics indicate that the base for the 1-Level underground parking structure will be at an elevation of 83.78 masl. To facilitate excavation and construction in dry and stable subsoil conditions, it is proposed that the groundwater table be lowered to an elevation of 82.78 masl, which is about 1.0 m below the lowest proposed excavation depth. The highest shallow groundwater level measured beneath the eastern portion of the site was at El. 82.97 masl at BH/MW 10. The subsoil profile consists, predominantly of silty clay and glacial till (sandy silt till/silty sand till), extending to the maximum anticipated excavation depth. As such, the estimated construction dewatering flow rate is anticipated to reach 31,864.3 L/day for the proposed 1-level underground parking structure; by considering a 3x safety factor, this rate could reach an approximate daily maximum of 95,592.8 L/day. It should be noted that a rectangular excavation footprint having a length of 93.16 m and width of 52.58 m was considered for this, dewatering needs assessment.

In accordance with the current policy of the Ministry of the Environment, Conservation and Parks (MECP), where the dewatering flow rate is between 50,000 L/day and 400,000 L/day, the registering for proposed groundwater-taking for construction is by means of the filing an Environmental Activity and Sector Registry (EASR) with the MECP. Since the estimated dewatering flow rate exceeds 50,000 L/day, where it is expected to reach a maximum daily rate of 104,592.1 L/day, the registering for any proposed groundwater-taking for construction would be through an EASR, and its filing with the MECP. It is recommended that the EASR should be filed for the maximum allowable construction dewatering flow rate of 400,000 L/day to also account for the management and removal of any accumulated runoff volumes within the construction excavations following high rainfall events.

It should be noted that shallow groundwater levels were monitored over the fall season and it is anticipated that they will increase over the high precipitation, spring season. As such, it is recommended that shallow groundwater levels be monitored again, over the spring season, if the excavation and construction are planned for this season.

7.2 Groundwater Control Methodology

Low to moderate groundwater seepage rates which may be encountered in open excavations below the water table can likely be controlled by occasional pumping from sumps. Well points can be employed to lower water table if wet subsoil is unstable and seepage cannot be controlled via sump pumping. The final design for the temporary dewatering system will be the responsibility of the construction contractors.

7.3 Mitigation of Potential Impacts Associated with Dewatering

The zone of influence for construction dewatering could reach a maximum of 11.4 m away from the conceptual dewatering arrays considered for construction of the proposed underground structure. No water supply wells, bodies of water, watercourses, wetlands or any natural features are present within the conceptual zone of influences for the construction dewatering arrays. Given that the southern and eastern portions of the site are heavily forested with no development anticipated within these portions of the site, it is likely that West Duffins Creek and its associated natural features will be located outside the conceptual zone of influence for temporary construction dewatering. However, residential buildings and the nearby cultural centre located north of the site, and Brock Road, is located west of the site may be situated within the conceptual zones of influence for construction dewatering.

7.4 Long-Term Foundation Drainage Estimation

The proposed development plans indicate that two stacked townhouse blocks, one street townhouse block and a 20-storey high rise building, with associated 2-level underground parking will be constructed at the site. A base elevation of 80.78 masl was considered to accommodate the proposed 2 level underground parking structure. As such, the highest recorded shallow groundwater level elevation is about 4.94 m above the base for the proposed 2-level underground parking structure.

Given the low to moderate anticipated groundwater seepage rate estimates for long-term foundation drainage, a conventionally shored excavation, using pile and lagging methods can be designed and completed for the construction of the proposed underground parking level structure. A standard Mira drainage network can be included with the design of a conventionally shored excavation, along with a simple basement under-slab drainage network to address any long-term seepage to the excavation and completed underground structure. These systems can be drained to separate sump pits. The drainage network should be

designed by a qualified mechanical engineer, having experience with the designs for under-slab and Mira drainage networks.

The drainage networks should have separate connections to the proposed sump pits, with one pit connected to the Mira drainage network for the shored excavation walls, and a second pit connected to the under-slab basement floor drainage network.

In order to estimate the long-term foundation drainage needs for the Mira perimeter foundation drainage network and to the under-slab floor basement drainage systems at the constructed site, Darcy's Equation was used. The estimates are provided for the 2-Level and 1-Level underground parking structures separately as follows:

West Portion (with Proposed 2-Level Underground Parking Structure)

$$Q = KiA$$

Where:

- Q = Estimated foundation drainage rate (m^3/day)
- K = 8.5×10^{-7} m/sec (highest hydraulic conductivity (K) assessed for the screened subsoil units encountered beneath the site)
- A = 1,606.8 m^2 for the Mira Drain foundation walls area and 39.70 m^2 for the total under-slab floor drainage network which is the approximate total surface areas for weeper tiles used to estimate groundwater seepage to the basement under-slab drainage network, below the water table (cross-sectional area of flow) (m^2)
- iv = 0.0345 [unitless], Vertical Hydraulic Gradient for groundwater considered for the under-slab floor drainage network
- ih = 0.0183 [unitless], Horizontal Hydraulic Gradient for groundwater considered for the Mira Drain perimeter foundation drainage system.

For the proposed 2-level underground parking structure, the long-term foundation seepage drainage rate to the Mira perimeter drainage network for a conventionally shored excavation is 2,159.44 L/day. The long-term, average seepage drainage rate to the under-slab basement floor drainage network is 100.6 L/day. The combined, long-term seepage drainage rate to both the Mira Drain, perimeter system for the shore walls, and from the under-slab drainage networks is estimated at 2,260.04 L/day. By applying a safety factor of three (3), the combined seepage drainage rate is estimated at 6,780.11 L/day.

East Portion (with Proposed 1-Level Underground Parking Structure)

The base elevation for the proposed 1-Level underground parking structure is at an elevation of approximately 83.78 masl, which was considered for the long-term foundation drainage needs estimation. Review of the highest measured groundwater level for the east portion of the site indicates that the highest shallow groundwater level was at an elevation of 82.97 masl at BH/MW 10. As such, there are no concerns associated with any long-term foundation drainage needs for the proposed 1-level underground parking structure. Foundation drainage may come to fruition on a short-term basis, following heavy rainfall events or following snow melt, during spring thaw.

7.5 Groundwater Function for the Subject Site

The subject site is located within an existing residential neighborhood. The proposed 1-level underground parking structure beneath the east portion of the development area will be constructed above the shallow groundwater level. However, the proposed 2-level underground parking structure will be below the shallow groundwater level beneath the west portion of the development area. Shallow groundwater flows in an east/southeasterly direction, towards the existing watercourse (West Duffins Creek) located adjacent to the south limits of the subject site. As such, potential impacts to shallow groundwater flow patterns may result from the proposed underground structures being below the shallow groundwater table. Since the subject site is underlain by soils of low permeability, any impact to the shallow groundwater function of the site from any temporary dewatering for underground structures construction is anticipated to be minor to negligible, with no long-term impacts anticipated. In addition, given that the southern and eastern portions of the site are heavily forested with no development anticipated within these portions, it is likely that West Duffins Creek will be located outside the conceptual zone of influence for construction dewatering.

7.6 Ground Settlement

Potential ground settlement associated with construction dewatering should be assessed by a geotechnical engineer prior to construction.

8.0 CONCLUSIONS

1. The subject site is located within the Physiographic Region of Southern Ontario known as the Iroquois plain, where sand plain is the predominant physiographic feature.
2. The native surface geological soil unit consists of silty glaciolacustrine deposits, which consists, predominantly of silt and clay with minor sand indicative of a basin and quiet lacustrine depositional environments.
3. A review of the site topography shows that it is slightly hilly, with the area descending, gently to the southeast, towards West Duffins Creek.
4. The proposed development site is located within the Duffins Creek Watershed and West Duffins Creek Subwatershed. Records review shows that much of the southern portion of the property is wooded with West Duffins Creek being located immediately south of the southern boundary. The closest wetland feature can be found approximately 225 m northwest of the subject site. This wetland has not been evaluated as being Provincially Significant under the Ontario Wetland Evaluation System (OWES). The closest Provincially Significant wetlands are located approximately 1,500 m southeast of the subject site.
5. This study has revealed that beneath the topsoil and/or earth fill layers, the site is underlain by silty clay, overlying glacial till, having occasional sand layers.
6. The groundwater monitoring program indicates that the average shallow groundwater level ranged from El. 82.78 to 85.70 masl. The interpreted shallow groundwater flow pattern suggests that it flows east/southeasterly, towards West Duffins Creek.
7. Based on the hydraulic conductivity (K) testing from the Single Well response tests (SWRT), the estimates for K ranges from 1.8×10^{-8} to 8.5×10^{-7} m/sec for the silty clay and glacial till deposits, indicating that low to moderated groundwater seepage rates can be expected within open excavations below the water table.
8. The estimated construction dewatering flow rates for expected reach daily rates of 34,864.0 L/day and 31,864.3 L/day for the proposed 2-level and 1-level underground parking structure respectively; by considering a 3x safety factor, these rates could reach approximate daily maximums of 104,592.1 L/day and 95,592.8 L/day. As such, approval for any construction related groundwater taking would be through an Environmental Activity and Sector Registry (EASR) and its filing with Ministry of the Environment, Conservation and Parks (MECP), which is recommended prior to commencing earthworks.
9. The estimated zone of influence for construction dewatering could reach a maximum of 11.4 m away from the conceptual dewatering arrays considered for construction of the proposed underground parking structure. No water supply wells, bodies of water, watercourses, wetlands or any natural features are present within the conceptual zone of

influences for the construction dewatering arrays. Given that the southern and eastern portions of the site are heavily forested, with no development being anticipated for these portions of the site, it is likely that West Duffins Creek and its associated natural features will be located outside the conceptual zone of influence for construction dewatering. However, residential buildings and a nearby cultural centre, located north of the site, and Brock Road, are located west of the site which may be situated within the conceptual zones of influence for construction dewatering.

10. For the proposed 2-level underground parking structure located beneath the western portion of the site, the long-term foundation seepage drainage rate to the Mira perimeter drainage network for a conventionally shored excavation is 2,159.44 L/day. The long-term, average seepage drainage rate to the under-slab basement floor drainage network is 100.6 L/day. The combined, long-term seepage drainage rate to both the Mira Drain, perimeter system for the shore walls, and from the under-slab drainage networks is estimated at 2,260.04 L/day. By applying a safety factor of three (3), the combined seepage drainage rate is estimated at 6,780.11 L/day.
11. The base elevation for the proposed 1-Level underground parking structure is at an elevation of approximately 83.78 masl, which was considered for the long-term foundation drainage estimation. Review of the highest measured groundwater level for the east portion of the site indicates that the highest shallow groundwater level was at an elevation of 82.97 masl at BH/MW 10. As such, the base for the proposed 1 level underground parking structure will be established at an elevation being above the measured shallow groundwater level and, as such, there are no concerns associated with any long-term foundation drainage needs for the proposed 1-level underground parking structure. Foundation drainage may come to fruition on a short-term basis, following heavy rainfall events or following snow melt and during spring thaw.

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10.0 **REFERENCES**

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2. A Watershed Plan for Duffins Creek and Carruthers Creek, Toronto and Region Conservation Authority, 2003

3. Bedrock Topography of the Markham Area, Southern Ontario, 1992, Open File Map 196, Mines and Minerals Division, Ontario Geological Survey

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FIGURES 1 to 13

BOREHOLE LOGS AND GRAIN SIZE DISTRIBUTION GRAPHS

REFERENCE NO. 1909-W140

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:

SAMPLE TYPES

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

PENETRATION RESISTANCE

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 '○'

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

SOIL DESCRIPTION

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

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

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

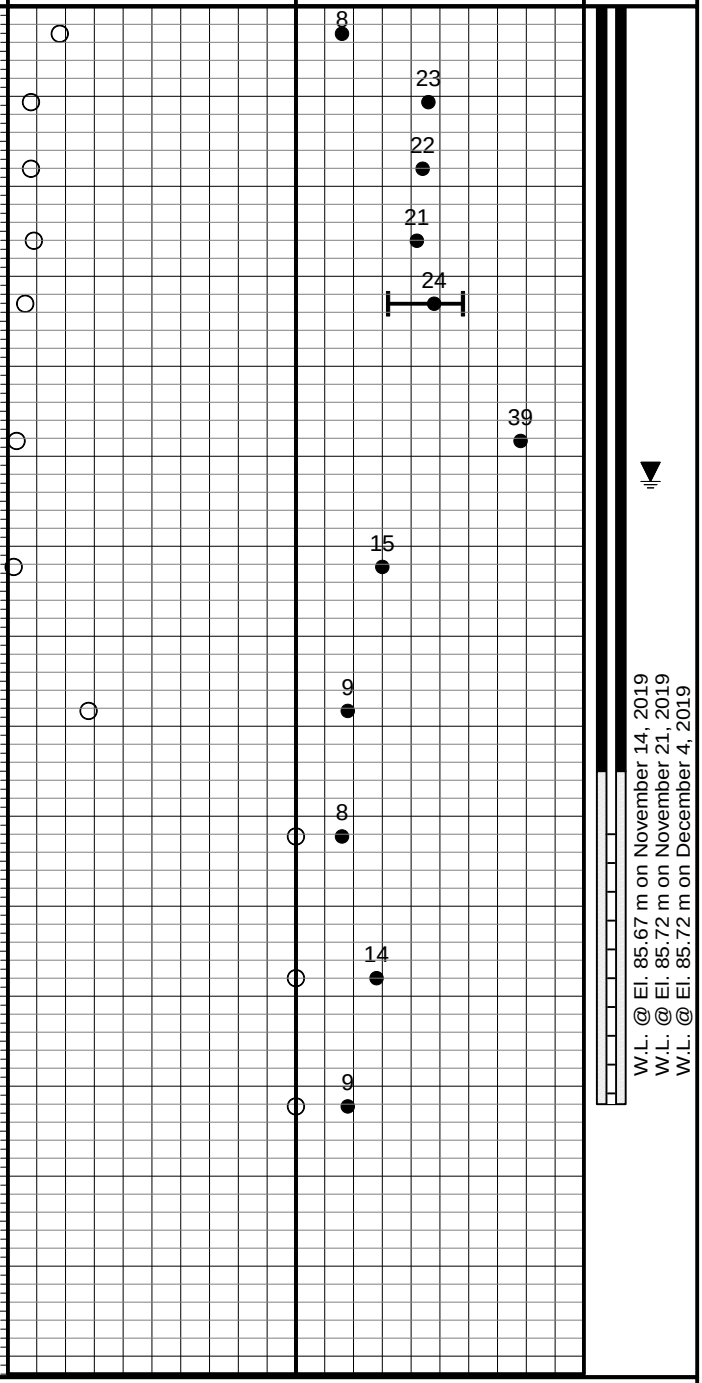
1 ft = 0.3048 metres
1lb = 0.454 kg
1 inch = 25.4 mm
1ksf = 47.88 kPa

JOB NO.: 1909-W140 # LOG OF BOREHOLE NO.: BH/MW 1 **FIGURE NO.:** 1

PROJECT DESCRIPTION: Proposed Residential Development **METHOD OF BORING:** Flight-Auger

PROJECT LOCATION: 2055 Brock Road, City of Pickering **DRILLING DATE:** October 15, 2019

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)
91.0	Ground Surface				
0.0	Dark brown **EARTH FILL** silty sand to sandy silt occ. topsoil pockets	1	DO	18	0
		2	DO	8	1
89.3					
1.7	Soft to stiff	3	DO	8	2
		4	DO	9	
		5	DO	6	3
	SILTY CLAY — brown / grey				4
		6	DO	3	5
	a trace of sand occ. silt seams and layers				
		7	DO	2	6
84.0					7
7.0	Grey, compact to very dense				
		8	DO	28	8
	GLACIAL TILL	9	DO	50/10	9
	sandy silt to silty sand till traces to some clay and gravel occ. cobbles and boulders	10	DO	50/5	10
78.7		11	DO	55/15	11
12.3	**END OF BOREHOLE**				12
	Installed 50 mm Ø monitoring well to 12.2 m 3.0 m screen from 9.2 to 12.2 m Sand backfill from 8.5 m to 12.2 m Bentonite seal from 0.0 m to 8.5 m Provided with a steel casing.				13
					14
					15



Soil Engineers Ltd.

JOB NO.: 1909-W140 # LOG OF BOREHOLE NO.: BH 2 **FIGURE NO.:** 2

PROJECT DESCRIPTION: Proposed Residential Development **METHOD OF BORING:** Flight-Auger

PROJECT LOCATION: 2055 Brock Road, City of Pickering **DRILLING DATE:** October 15 and 17, 2019

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)
90.0	Ground Surface				
0.0	**23 cm TOPSOIL**	1A	DO	6	0
0.2	Brown, compact, weathered	1B			
	SAND fine-grained, some silt to silty	2A 2B	DO	11	1
88.5					
1.5	Brown, firm to stiff	3	DO	10	2
	SILTY CLAY	4	DO	6	
	a trace of sand occ. sand seams and layers	5	DO	6	3
85.4					4
4.6	Grey, dense to very dense	6	DO	45	5
		7	DO	50/15	6
	GLACIAL TILL	8	DO	65	7
		9	DO	50/13	8
	sandy silt till to silty sand till traces to some clay and gravel occ. cobbles and boulders	10	DO	60/15	9
					10
					11
77.7		11	DO	50/10	12
12.3	**END OF BOREHOLE**				13
					14
					15

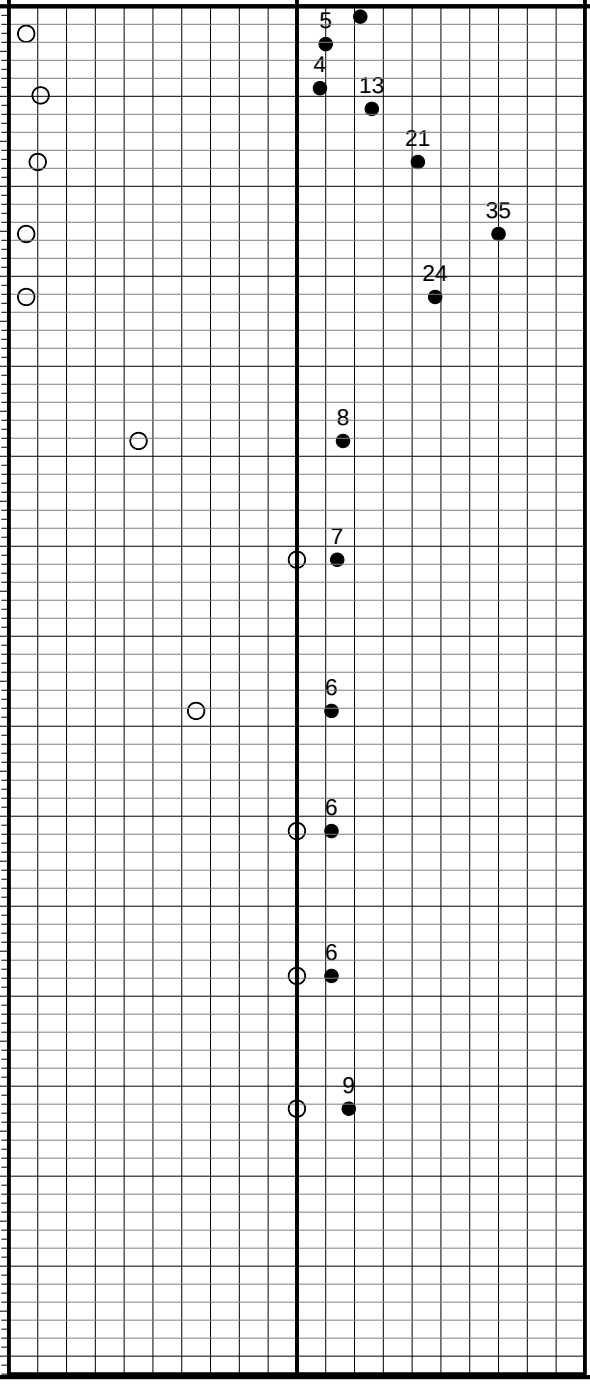
Dynamic Cone (blows/30 cm) 10 30 50 70 90

Shear Strength (kN/m²) 50 100 150 200

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

Atterberg Limits PL LL

Moisture Content (%) 10 20 30 40



WATER LEVEL: Dry on completion

Soil Engineers Ltd.

JOB NO.: 1909-W140 # LOG OF BOREHOLE NO.: BH 3 **FIGURE NO.:** 3

PROJECT DESCRIPTION: Proposed Residential Development **METHOD OF BORING:** Flight-Auger

PROJECT LOCATION: 2055 Brock Road, City of Pickering **DRILLING DATE:** October 17, 2019

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)
91.0	Ground Surface				
0.0	Brown to grey	1	DO	20	0
	EARTH FILL	2	DO	14	1
	silty sand to sandy silt	3	DO	11	2
88.6					
2.4	Soft to stiff	4	DO	7	
		5	DO	7	3
	SILTY CLAY				4
	a trace of sand occ. sand seams and layers brown / grey	6	DO	6	5
		7	DO	0	6
84.0					
7.0	Grey, compact to very dense				7
		8	DO	21	8
	GLACIAL TILL	9	DO	85	9
	sandy silt till to silty sand till traces to some clay and gravel occ. cobbles and boulders	10	DO	50/13	10
78.7		11	DO	60/15	11
12.3	**END OF BOREHOLE**				12
					13
					14
					15

Dynamic Cone (blows/30 cm) 10 30 50 70 90

Shear Strength (kN/m²) 50 100 150 200

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

Atterberg Limits PL LL

Moisture Content (%) 10 20 30 40

WATER LEVEL

W.L. @ El. 82.5 m on completion

Moisture Content values: 8, 9, 16, 24, 23, 27, 19, 10, 7, 9, 9

Soil Engineers Ltd.

JOB NO.: 1909-W140 **LOG OF BOREHOLE NO.: BH/MW 4** **FIGURE NO.:** 4

PROJECT DESCRIPTION: Proposed Residential Development **METHOD OF BORING:** Flight-Auger

PROJECT LOCATION: 2055 Brock Road, City of Pickering **DRILLING DATE:** October 15, 2019

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)	Dynamic Cone (blows/30 cm) 10 30 50 70 90 / Shear Strength (kN/m²) 50 100 150 200 / Penetration Resistance (blows/30 cm) 10 30 50 70 90	Atterberg Limits PL LL / Moisture Content (%) 10 20 30 40	WATER LEVEL
90.3	Ground Surface							
0.0	Brown **EARTH FILL** silty sand with topsoil layers	1	DO	8	0		6	
		2	DO	13	1		16	
88.6		3	DO	6	2		25	
1.7	Soft to stiff	4	DO	7			23	
		5	DO	7	3		23	
	brown / grey				4			
	SILTY CLAY	6	DO	3	5		33	
		7	DO	0	6		27	
	a trace of sand occ. sand seams and layers	8	DO	4	7		13	
81.3					8			
9.0	Grey, dense to very dense **GLACIAL TILL** sandy silt to silty sand till traces to some clay and gravel occ. cobbles and boulders	9	DO	48	9		9	
		10	DO	50/15	10		10	
77.8		11	DO	50/15	11		14	
12.5	**END OF BOREHOLE** Installed 50 mm Ø monitoring well to 12.2 m 3.0 m screen from 9.2 to 12.2 m Sand backfill from 8.5 m to 12.2 m Bentonite seal from 0.0 m to 8.5 m Provided with a steel casing.				12			
					13			
					14			
					15			

W.L. @ El. 83.69 m on November 14, 2019
W.L. @ El. 83.77 m on November 21, 2019
W.L. @ El. 83.90 m on December 4, 2019

Soil Engineers Ltd.

JOB NO.: 1909-W140 # LOG OF BOREHOLE NO.: BH 5 **FIGURE NO.:** 5

PROJECT DESCRIPTION: Proposed Residential Development **METHOD OF BORING:** Flight-Auger

PROJECT LOCATION: 2055 Brock Road, City of Pickering **DRILLING DATE:** October 11, 2019

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)	Dynamic Cone (blows/30 cm) 10 30 50 70 90 / Shear Strength (kN/m²) 50 100 150 200 / Penetration Resistance (blows/30 cm) 10 30 50 70 90	Atterberg Limits PL LL / Moisture Content (%) 10 20 30 40	WATER LEVEL
90.9	Ground Surface							
0.0	Dark brown	1	DO	33	0		9	
	EARTH FILL	2	DO	13	1		11	
	silty clay with rootlets and topsoil pockets	3	DO	7	2		19	
88.5								
2.4	Brown, stiff to very stiff	4	DO	13			21	
		5	DO	10	3		26	
	SILTY CLAY				4			
	a trace of sand occ. sand seams and layers	6	DO	16	5		22	
84.9								
6.0	Grey, dense to very dense	7	DO	46	6		8	
		8	DO	43	7		8	
	GLACIAL TILL	9	DO	67	8		13	
	sandy silt till to silty sand till traces to some clay and gravel occ. cobbles and boulders	10	DO	60/15	9			
78.4		11	DO	65/15	10		13	
12.5	**END OF BOREHOLE**				11			
					12			
					13			
					14			
					15			

W.L. @ El. 82.1 m on completion

Cave-in @ El. 80.5 m on completion

Soil Engineers Ltd.

JOB NO.: 1909-W140 # LOG OF BOREHOLE NO.: BH 6 **FIGURE NO.:** 6

PROJECT DESCRIPTION: Proposed Residential Development **METHOD OF BORING:** Flight-Auger

PROJECT LOCATION: 2055 Brock Road, City of Pickering **DRILLING DATE:** October 17, 2019

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)	Dynamic Cone (blows/30 cm) 10 30 50 70 90 / Shear Strength (kN/m²) 50 100 150 200 / Penetration Resistance (blows/30 cm) 10 30 50 70 90	Atterberg Limits PL LL / Moisture Content (%) 10 20 30 40	WATER LEVEL
91.8	Ground Surface							
0.0	Brown	1	DO	13	0		11	
	EARTH FILL silty clay with gravel occ. sand layers, topsoil layers and pockets	2	DO	12	1		11	
90.3								
1.5	Brown, loose, weathered **SAND** fine-grained	3	DO	6	2		18	
89.5								
2.3	with clay layer Stiff to very soft	4	DO	11			21	
		5	DO	12	3		22	
	SILTY CLAY				4			
	a trace of sand occ. sand seams and layers	6	DO	2	5		35	
		7	DO	1	6		24	
84.2					7			
7.6	Grey, very dense	8	DO	70	8		8	
	GLACIAL TILL	9	DO	52	9		8	
	sandy silt till to silty sand till traces to some clay and gravel occ. cobbles and boulders	10	DO	50/8	10		7	
79.8					11			
12.0	**END OF BOREHOLE** Refusal to augering, inferred boulder				12			
					13			
					14			
					15			

W.L. @ El. 84.8 m on completion

Soil Engineers Ltd.

JOB NO.: 1909-W140 # LOG OF BOREHOLE NO.: BH 7 **FIGURE NO.:** 7

PROJECT DESCRIPTION: Proposed Residential Development **METHOD OF BORING:** Flight-Auger

PROJECT LOCATION: 2055 Brock Road, City of Pickering **DRILLING DATE:** October 21, 2019

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)	Dynamic Cone (blows/30 cm) 10 30 50 70 90 / Shear Strength (kN/m²) 50 100 150 200 / Penetration Resistance (blows/30 cm) 10 30 50 70 90	Atterberg Limits PL LL / Moisture Content (%) 10 20 30 40	WATER LEVEL
89.5	Ground Surface							
0.0	**25 cm TOPSOIL**	1A	DO	5	0		15	
0.3	Brown, loose, weathered **SAND** fine-grained, some silt to silty	1B						
88.6 / 0.9	Brown, stiff to very soft	2	DO	6	1		24	
		3	DO	16	2		21	
	SILTY CLAY	4	DO	4			26	
	brown / grey	5	DO	2	3		36	
	a trace of sand occ. sand seams and layers	6	DO	0	4 5		31	
83.5 / 6.0	Grey, dense to very dense	7	DO	36	6		7	W.L. @ El. 80.0 m on completion
		8	DO	56	7 8		7	Cave-in @ El. 78.2 m on completion
	GLACIAL TILL	9	DO	55/15	9		6	
	sandy silt till to silty sand till traces to some clay and gravel occ. cobbles and boulders	10	DO	50/15	10 11		6	
77.9 / 11.6	Grey, very dense **SAND** fine-grained				12			
76.8	occ. silt seams	11	DO	52			17	
12.7	**END OF BOREHOLE**				13 14 15			

Soil Engineers Ltd.

JOB NO.: 1909-W140 # LOG OF BOREHOLE NO.: BH/MW 8 **FIGURE NO.:** 8

PROJECT DESCRIPTION: Proposed Residential Development **METHOD OF BORING:** Flight-Auger

PROJECT LOCATION: 2055 Brock Road, City of Pickering **DRILLING DATE:** October 21, 2019

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)	Dynamic Cone (blows/30 cm) 10 30 50 70 90 / Shear Strength (kN/m²) 50 100 150 200 / Penetration Resistance (blows/30 cm) 10 30 50 70 90	Atterberg Limits PL LL / Moisture Content (%) 10 20 30 40	WATER LEVEL
88.7	Ground Surface							
0.0	Brown, very loose, weathered **SAND** fine-grained, some silt to silty	1	DO	2	0		8	
87.7		2A	DO	3	1		15	
1.0	Brown, stiff to very soft	2B					23	
		3	DO	8	2		23	
		4	DO	6			25	
	brown / grey	5	DO	3	3		24	
	SILTY CLAY							
	a trace of sand occ. sand seams and layers	6	DO	0	5		27	
		7	DO	1	6		32	
81.1					7			
7.6	Grey, very dense	8	DO	50/8	8		10	
	GLACIAL TILL	9	DO	60/15	9		9	
	sandy silt till to silty sand till traces to some clay and gravel occ. cobbles, boulders and shale fragments	10	DO	50/8	10		10	
76.4		11	DO	55/15	11			
12.3	**END OF BOREHOLE**				12		8	
	Installed 50 mm Ø monitoring well to 11.7 m 3.0 m screen from 9.2 to 12.2 m Sand backfill from 8.0 m to 11.7 m Bentonite seal from 0.0 m to 8.0 m Provided with a steel casing.				13			
					14			
					15			

W.L. @ El. 82.83 m on November 14, 2019
W.L. @ El. 82.85 m on November 21, 2019
W.L. @ El. 82.90 m on December 4, 2019

Soil Engineers Ltd.

JOB NO.: 1909-W140 # LOG OF BOREHOLE NO.: BH/MW 9 **FIGURE NO.:** 9

PROJECT DESCRIPTION: Proposed Residential Development **METHOD OF BORING:** Flight-Auger

PROJECT LOCATION: 2055 Brock Road, City of Pickering **DRILLING DATE:** October 18, 2019

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)	Dynamic Cone (blows/30 cm) 10 30 50 70 90 / Shear Strength (kN/m²) 50 100 150 200 / Penetration Resistance (blows/30 cm) 10 30 50 70 90	Atterberg Limits PL LL / Moisture Content (%) 10 20 30 40	WATER LEVEL
87.3	Ground Surface							
0.0	Brown **EARTH FILL** sand with clay layers	1	DO	4	0		12	
86.3 1.0	Brown, very soft to stiff	2	DO	9	1		24	
		3	DO	5	2		22	
	brown / grey	4	DO	4			24	
		5	DO	0	3		28	
	SILTY CLAY				4			
		6	DO	0	5		35	
	traces of sand and gravel occ. sand seams and layers	7	DO	0	6		31	
					7			
		8	DO	8	8		10	
78.3 9.0	Grey, very dense	9A 9B	DO	52	9		9 15	
	sand layer **GLACIAL TILL**				10			
	sandy silt till to silty sand till traces to some clay and gravel occ. cobbles, boulders and shale fragments	10	DO	50/8	11		11	
75.0 12.3	**END OF BOREHOLE**	11	DO	50/10	12		9	
	Installed 50 mm Ø monitoring well to 12.2 m 3.0 m screen from 9.2 to 12.2 m Sand backfill from 8.5 m to 12.2 m Bentonite seal from 0.0 m to 8.5 m Provided with a steel casing.				13			
					14			
					15			

W.L. @ El. 82.64 m on November 14, 2019
W.L. @ El. 82.82 m on November 21, 2019
W.L. @ El. 82.89 m on December 4, 2019

Soil Engineers Ltd.

JOB NO.: 1909-W140 # LOG OF BOREHOLE NO.: BH/MW 10 **FIGURE NO.:** 10

PROJECT DESCRIPTION: Proposed Residential Development **METHOD OF BORING:** Flight-Auger

PROJECT LOCATION: 2055 Brock Road, City of Pickering **DRILLING DATE:** October 18, 2019

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)	Dynamic Cone (blows/30 cm) / Shear Strength (kN/m²) / Penetration Resistance (blows/30 cm)	Atterberg Limits PL LL / Moisture Content (%)	WATER LEVEL
85.9	Ground Surface							
0.0	**20 cm TOPSOIL**				0			
0.2	Brown	1	DO	7			12	
	EARTH FILL silty clay with topsoil seams	2	DO	11	1		15	
84.4								
1.5	Brown, firm to very soft	3	DO	5	2		32	
		4	DO	5			25	
	SILTY CLAY	5	DO	5	3		35	
	traces of sand and gravel occ. sand seams and layers	6	DO	2	4		25	
79.9					5			
6.0	Grey, dense to very dense	7	DO	46	6		10	
		8	DO	35	7		8	
	GLACIAL TILL	9	DO	50/15	8			
	sandy silt till to silty sand till traces to some clay and gravel occ. cobbles, boulders and shale fragments	10	DO	50/15	9		6	
					10		10	
73.6		11	DO	50/15	11			
12.3	**END OF BOREHOLE**				12		7	
	Installed 50 mm Ø monitoring well to 12.2 m 3.0 m screen from 9.2 to 12.2 m Sand backfill from 8.5 m to 12.2 m Bentonite seal from 0.0 m to 8.5 m Provided with a steel casing.				13			
					14			
					15			

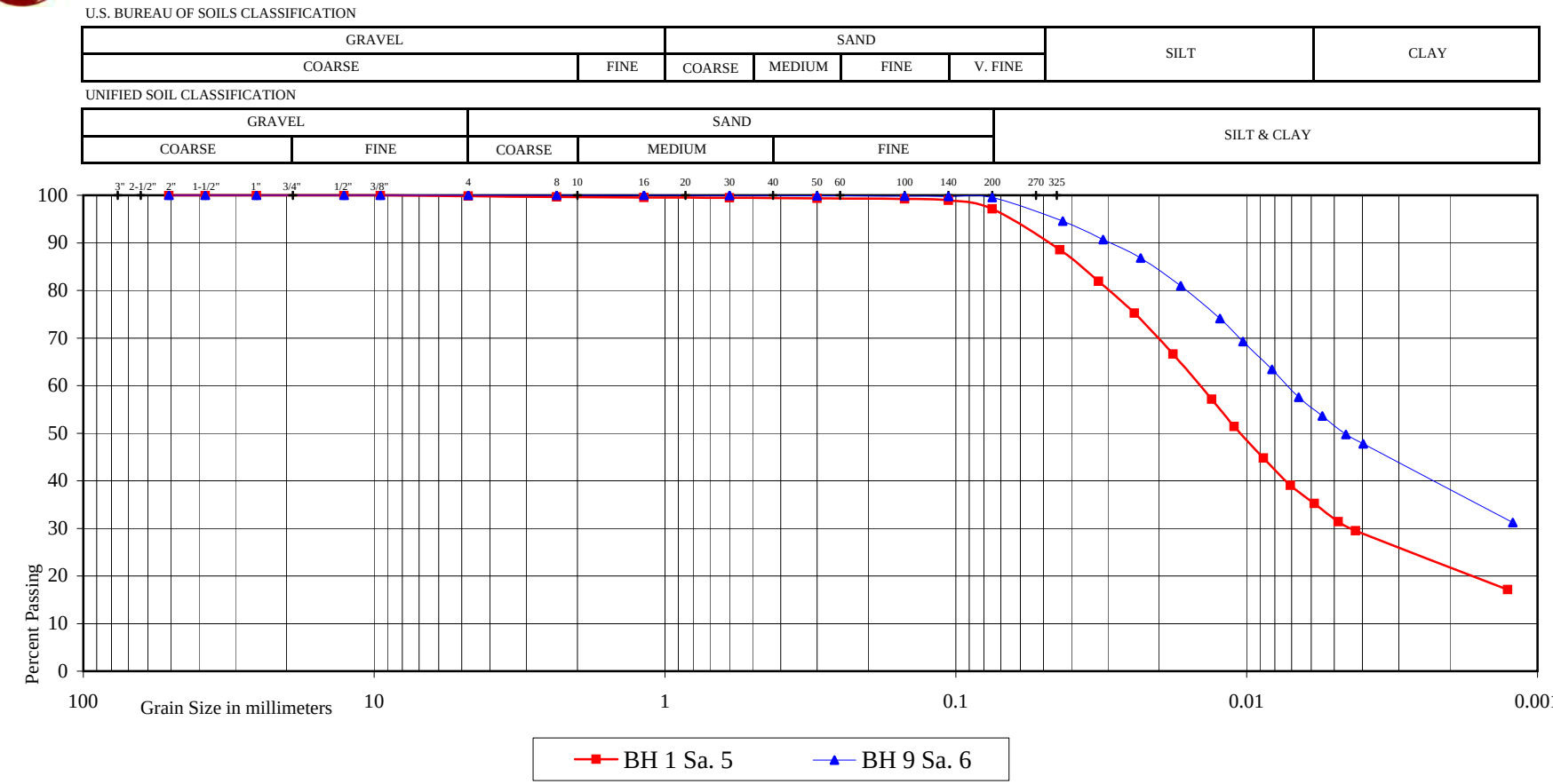
W.L. @ El. 82.82 m on November 14, 2019
W.L. @ El. 82.90 m on November 21, 2019
W.L. @ El. 82.97 m on December 4, 2019

Soil Engineers Ltd.

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

Reference No: 1909-W140



Project: Proposed Residential Development

Location: 2055 Brock Rd, City of Pickering

Borehole No:	1	9
Sample No:	5	6
Depth (m):	3.3	4.8
Elevation (m):	87.7	82.5

BH 1 Sa. 5 (cm./sec.) = 10^{-7}

BH 9 Sa. 6 (cm./sec.) = 10^{-7}

Classification of Sample [& Group Symbol]: SILTY CLAY

a trace of fine sand

Figure: 11

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

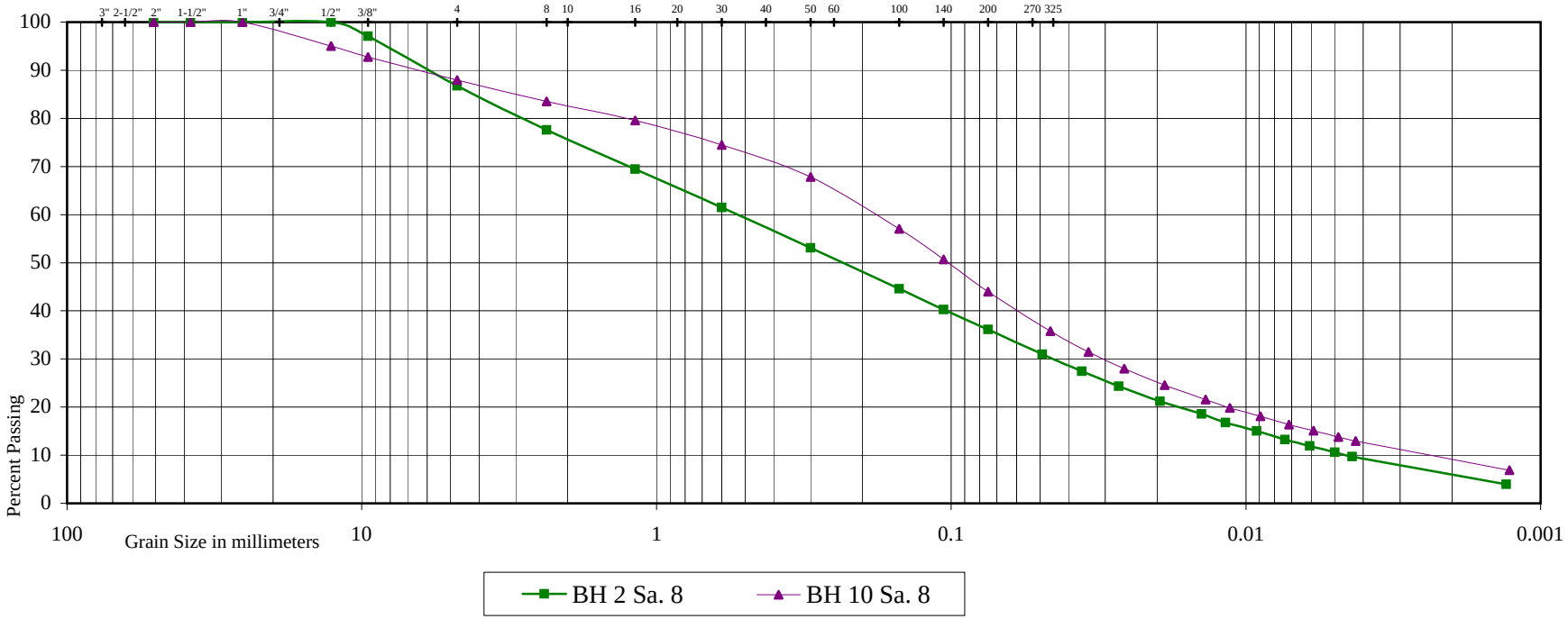
Reference No: 1909-W140

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 Residential Development

Location: 2055 Brock Road, City of Pickering

Borehole No:	2	10
Sample No:	8	8
Depth (m):	7.8	7.8
Elevation (m):	82.2	78.1

BH 2 Sa. 8 Estimated Permeability (cm./sec.) = 10^{-5}

BH 10 Sa 8 Estimated Permeability (cm./sec.) = 10^{-5}

Classification of Sample [& Group Symbol]: SILTY SAND, TILL

some gravel, a trace of clay

Figure: 12

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

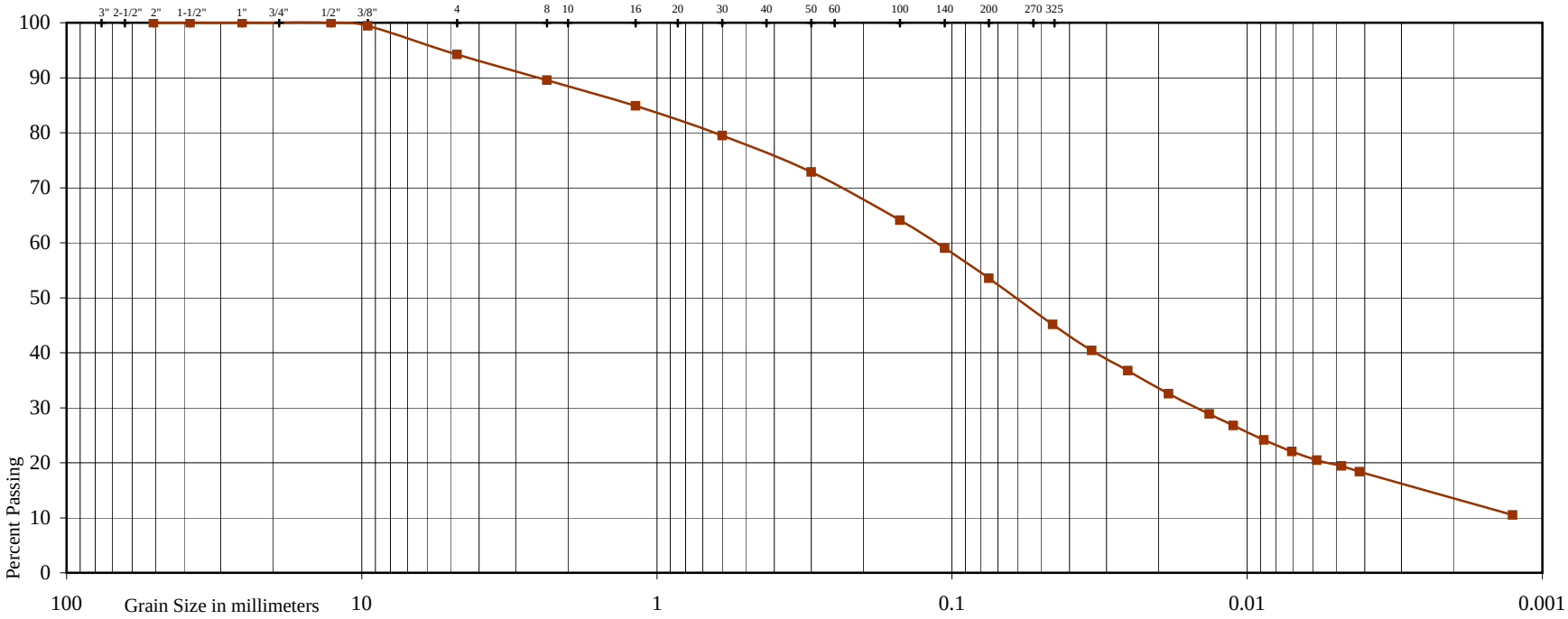
Reference No: 1909-W140

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 Residential Development

Location: 2055 Brock Rd, City of Pickering

Borehole No: 6

Sample No: 8

Depth (m): 7.8

Elevation (m): 84.0

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

Classification of Sample [& Group Symbol]: SANDY SILT, TILL

some clay, a trace of gravel

Figure: 13

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FAX: (705) 721-7864	FAX: (905) 542-2769	FAX: (905) 725-1315	FAX: (905) 881-8335	FAX: (705) 684-8522	FAX: (905) 542-2769

DRAWINGS 1 to 9

REFERENCE NO. 1909-W140

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Source: Ministry of Natural Resources and Forestry
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N

Approximate Boundary of Subject Site
Waterbody
Watercourse
Major Road
Local Road

Soil Engineers Ltd.

Title: Site Location Plan

Project:

Hydrogeological Assessment
Proposed Residential Development
2055 Brock Road
City of Pickering

Reference No. 1909-W140

Date: November 20, 2019

Scale:

0 35 70 140 210 280 350
Metres

Drawing No. 1

Source: Ministry of Natural Resources and Forestry
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N

Approximate Boundary of Subject Site

Borehole

Borehole with Monitoring Well

Watercourse

Major Road

Local Road

Soil Engineers Ltd.

Title: Borehole and Monitoring Well Location Plan

Project:

Hydrogeological Assessment
Proposed Residential Development
2055 Brock Road
City of Pickering

Reference No. 1909-W140

Date: November 20, 2019

Scale:

0 5 10 20 30 40 50
Metres

Drawing No. 2

Source: Ministry of Natural Resources and Forestry
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N

Approximate Boundary of Subject Site

500 metres from Subject Site Boundary

1 Well Location from MECP Well Records (see Appendix 'A')

Waterbody

Watercourse

Major Road

Local Road

Soil Engineers Ltd.

Title: MECP Well Location Plan

Project:

Hydrogeological Assessment
Proposed Residential Development
2055 Brock Road
City of Pickering

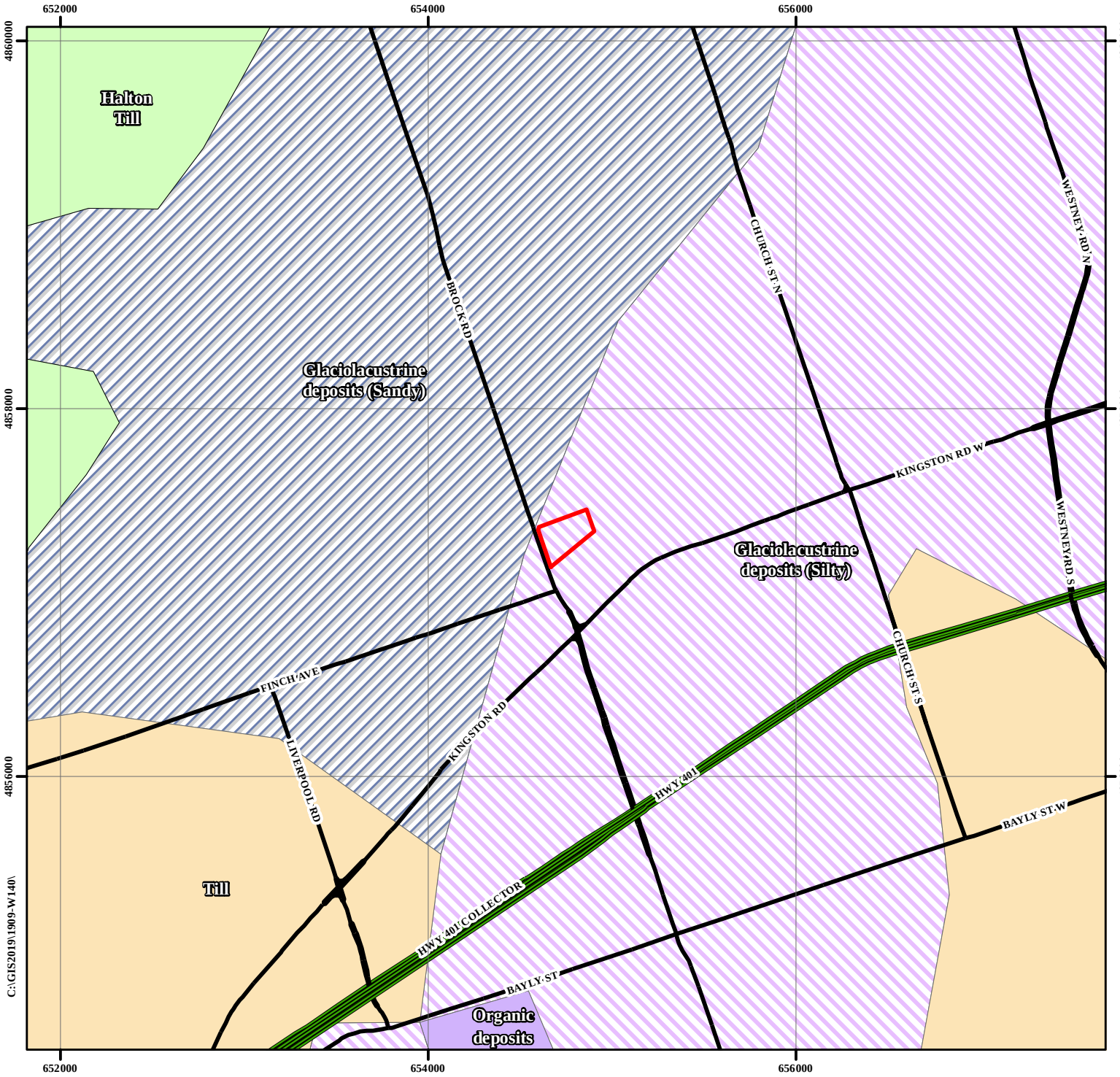
Reference No. 1909-W140

Date: November 20, 2019

Scale:

0 40 80 160 240 320 400
Metres

Drawing No. 3



N

Approximate Boundary of Subject Site

Glaciolacustrine deposits (Sandy)
Material: sand, gravelly sand and gravel, nearshore and beach deposits

Glaciolacustrine deposits (Silty)
Material: silt and clay, minor sand, basin and quiet water deposits

Halton Till
Material: predominantly silt to silty clay matrix, high in matrix carbonate content and clast poor

Organic deposits
material: peat, muck and marl

Till
Material: undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content

Expressway/Freeway

Major Road

Source:Ontario Geological Survey, 1997, Surface Geology of Ontario; Ontario Geological Survey, Miscellaneous Released-Data 0014

Soil Engineers Ltd.

Title: Quarternary and Surface Geology Map

Project:

Hydrogeological Assessment
Proposed Residential Development
2055 Brock Road
City of Pickering

Reference No. 1909-W140

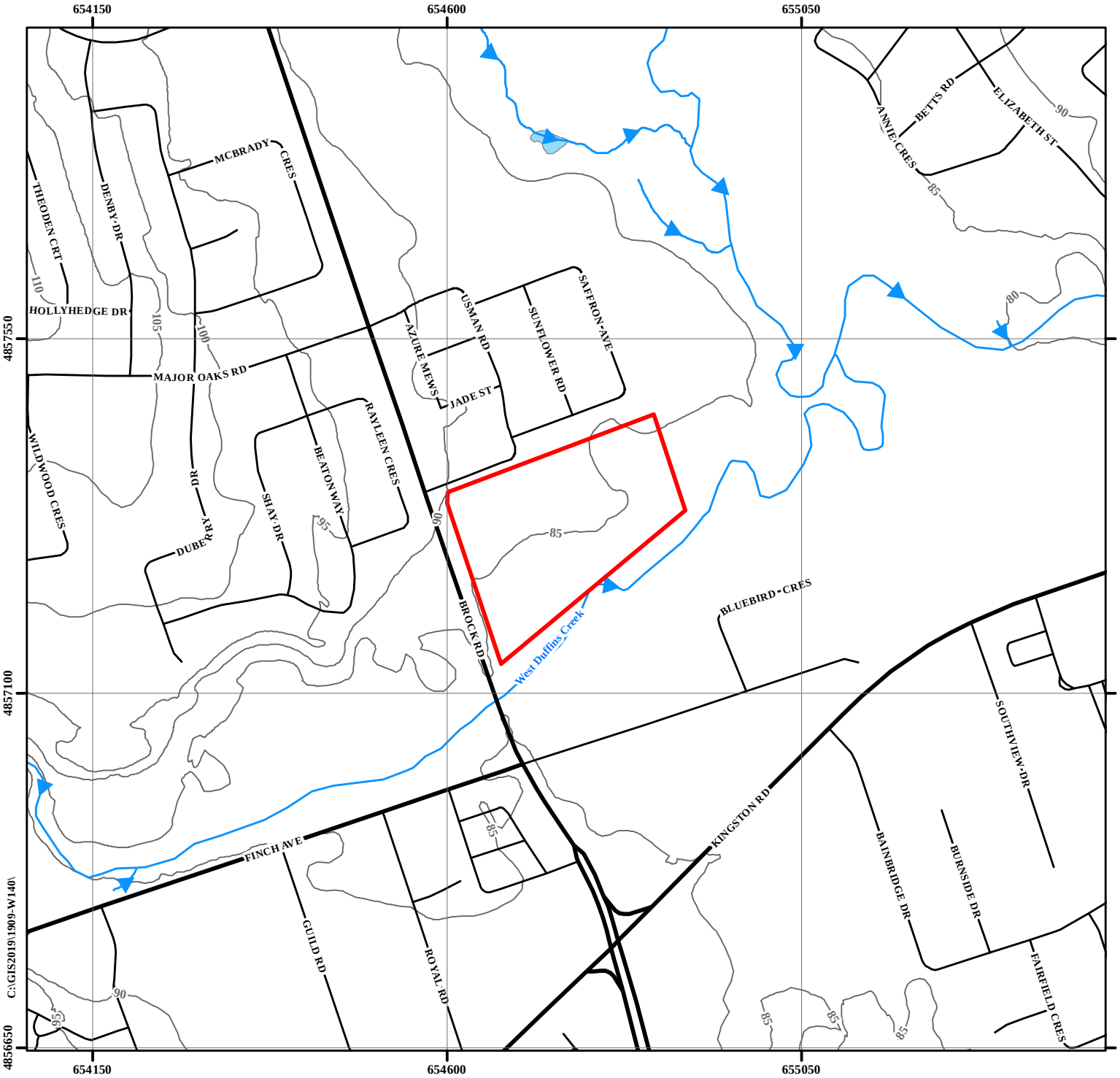
Date: November 20, 2019

Scale:

0 155 310 620 930 1,240 1,550

Metres

Drawing No. 4



N

Approximate Boundary of Subject Site

Waterbody

Watercourse

Major Road

Local Road

85 Topographic Contour (masl)

Soil Engineers Ltd.

Title: Topographic Map

Project:

Hydrogeological Assessment
Proposed Residential Development
2055 Brock Road
City of Pickering

Reference No. 1909-W140

Date: November 20, 2019

Scale:

0 35 70 140 210 280 350
Metres

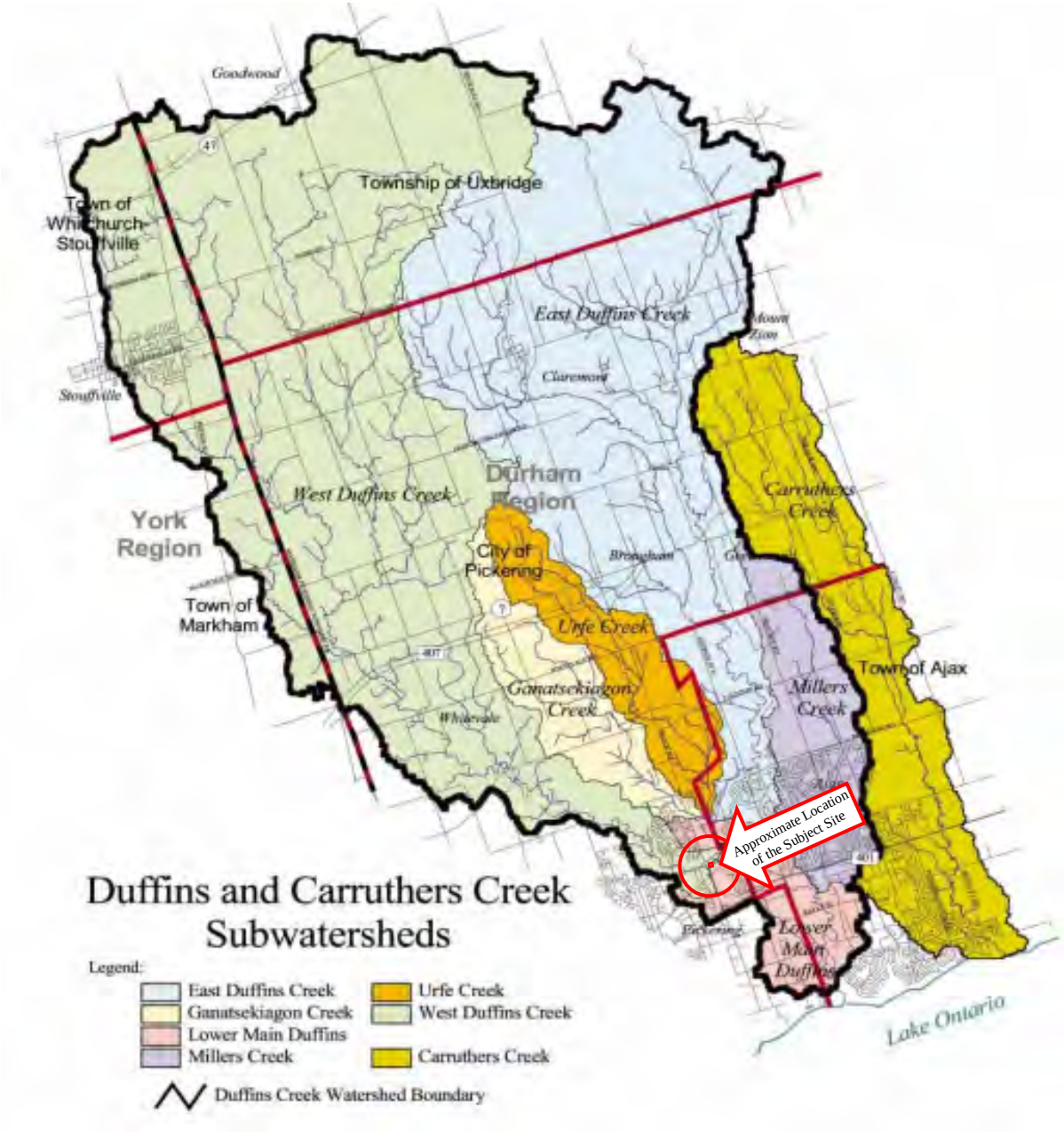
Drawing No. 5

C:\GIS2019\1909-W140\

Source: Contour, Ontario Ministry of Natural Resources and Forestry, 2015
©Queen's Printer for Ontario, 2015

Source: Water Body, Ontario Ministry of Natural Resources and Forestry, 2015
©Queen's Printer for Ontario, 2015

Source: Water Course, Ontario Ministry of Natural Resources and Forestry, 2015
©Queen's Printer for Ontario, 2015



Source: Toronto and Region Conservation Authority

N

Approximate Boundary of the Subject Site

Soil Engineers Ltd.

Title:

Watershed and Sbuwatershed Map

Project:

Proposed Residential Development
2055 Brock Street
City of Pickering

Date

November 20, 2019

Reference No.

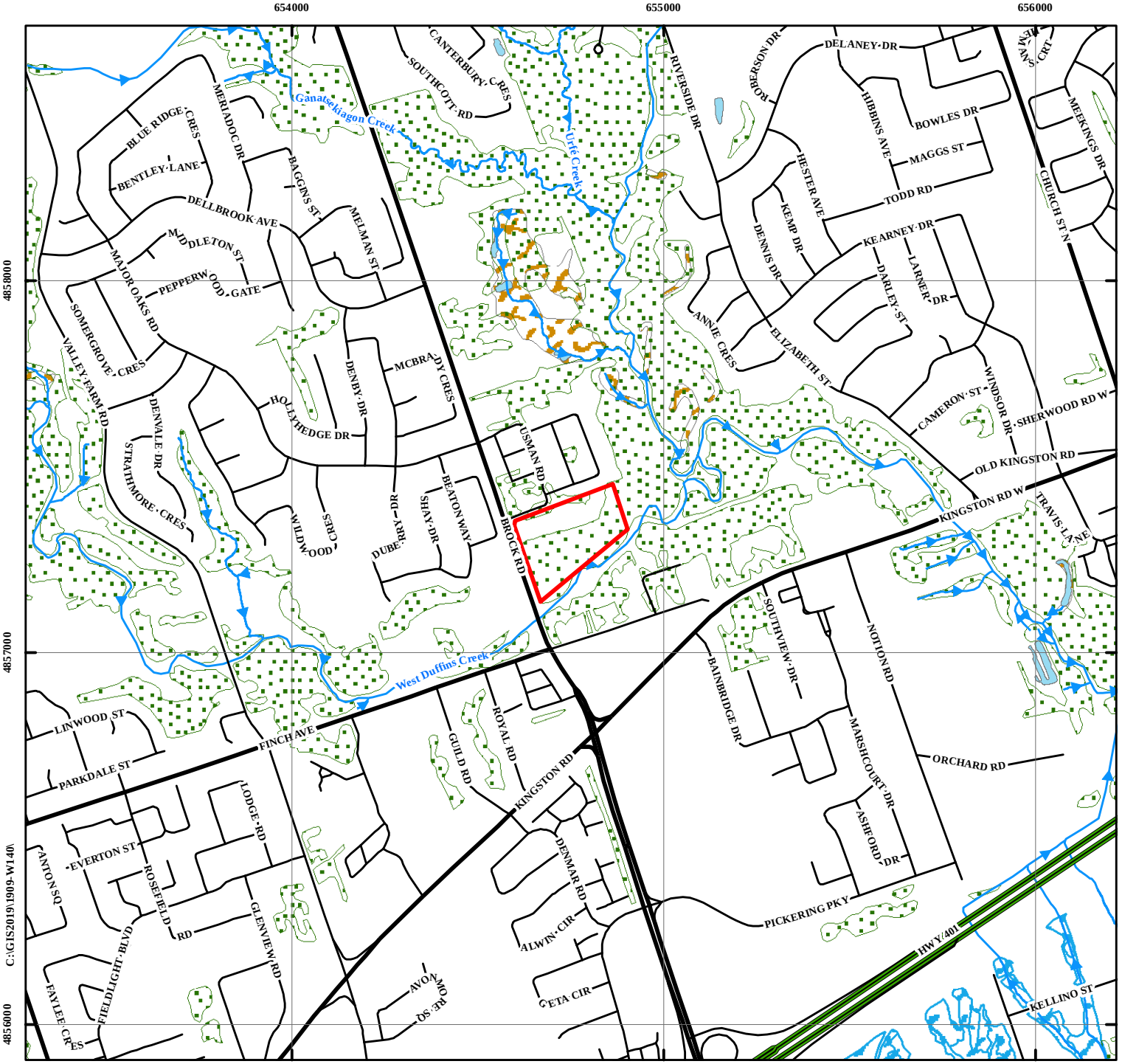
1909 – W140

Scale

N.T.S.

Drawing No.

6



Approximate Boundary of Subject Site
Wetland (classified as Provincial)
Wetland (Not evaluated per OWES)
Wooded Area
Water Body
Watercourse
Expressway/Freeway
Major Road
Local Road

Soil Engineers Ltd.

Title: Natural Features and Protection Area Plan

Project:

Hydrogeological Assessment
Proposed Residential Development
2055 Brock Road
City of Pickering

Reference No. 1909-W140

Date: November 20, 2019

Scale:
0 75 150 300 450 600 750
Metres

Drawing No. 7

Source: Ministry of Natural Resources and Forestry
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N

Approximate Boundary of Subject Site
Borehole
Borehole with Monitoring Well
Watercourse
Major Road
Local Road
A A' Cross-Section Direction
85 Topographic Contour (masl)

Soil Engineers Ltd.

Title: Cross-Section Key Plan

Project:

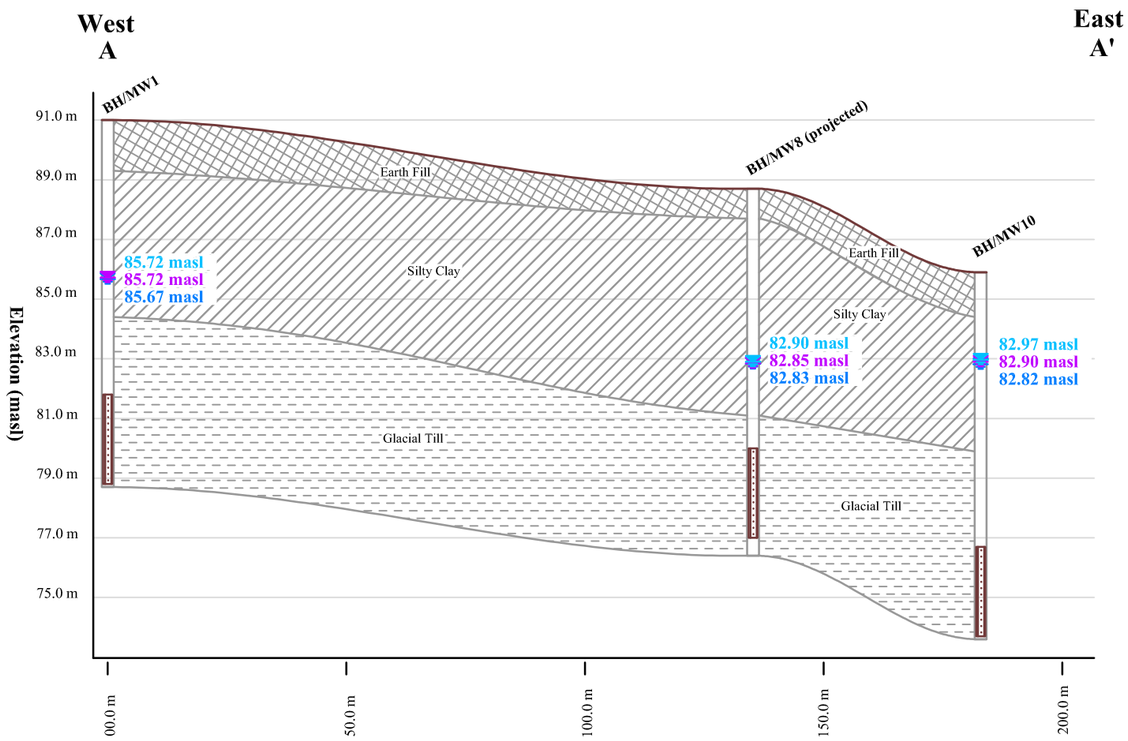
Hydrogeological Assessment
Proposed Residential Development
2055 Brock Road
City of Pickering

Reference No. 1909-W140

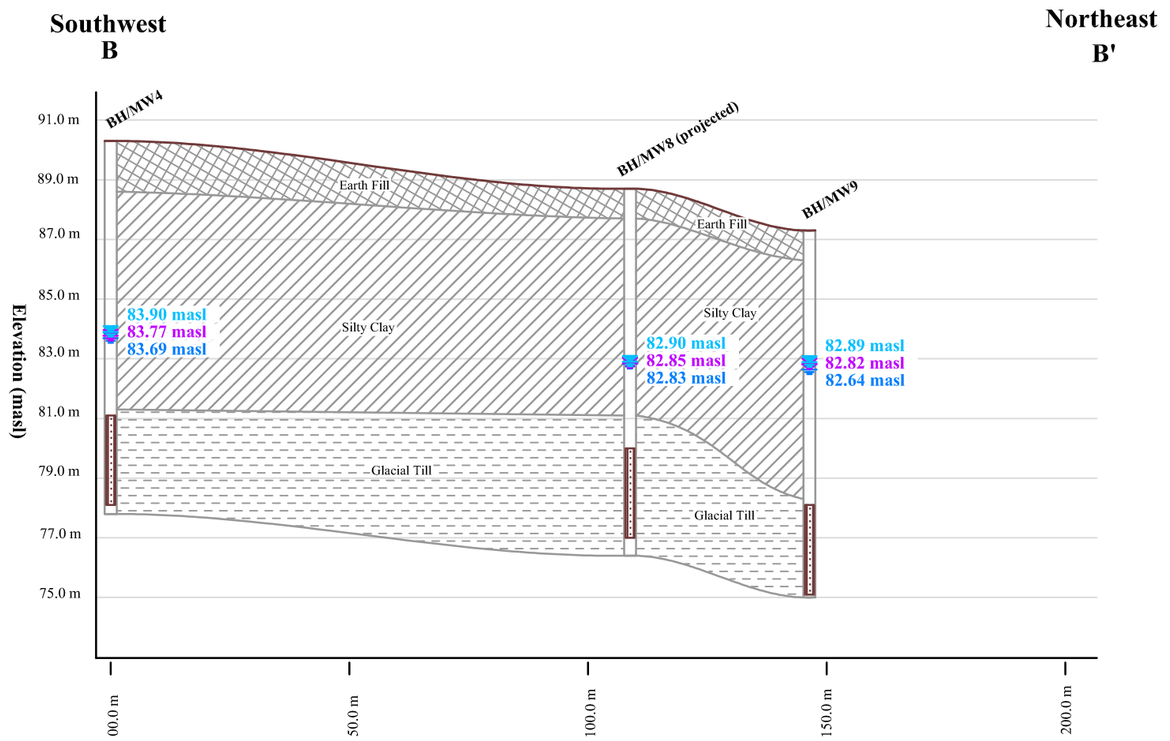
Date: December 5, 2019

Scale:
0 5 10 20 30 40 50
Metres

Drawing No. 8-1



Section A-A'



Section B-B'

C:Projects/2019 Jobs/1909-W140

Earth Fill

Silty Clay

Glacial Till

3.0 m Screen

Water Table on November 14, 2019

Water Table on November 21, 2019

Water Table on December 4, 2019

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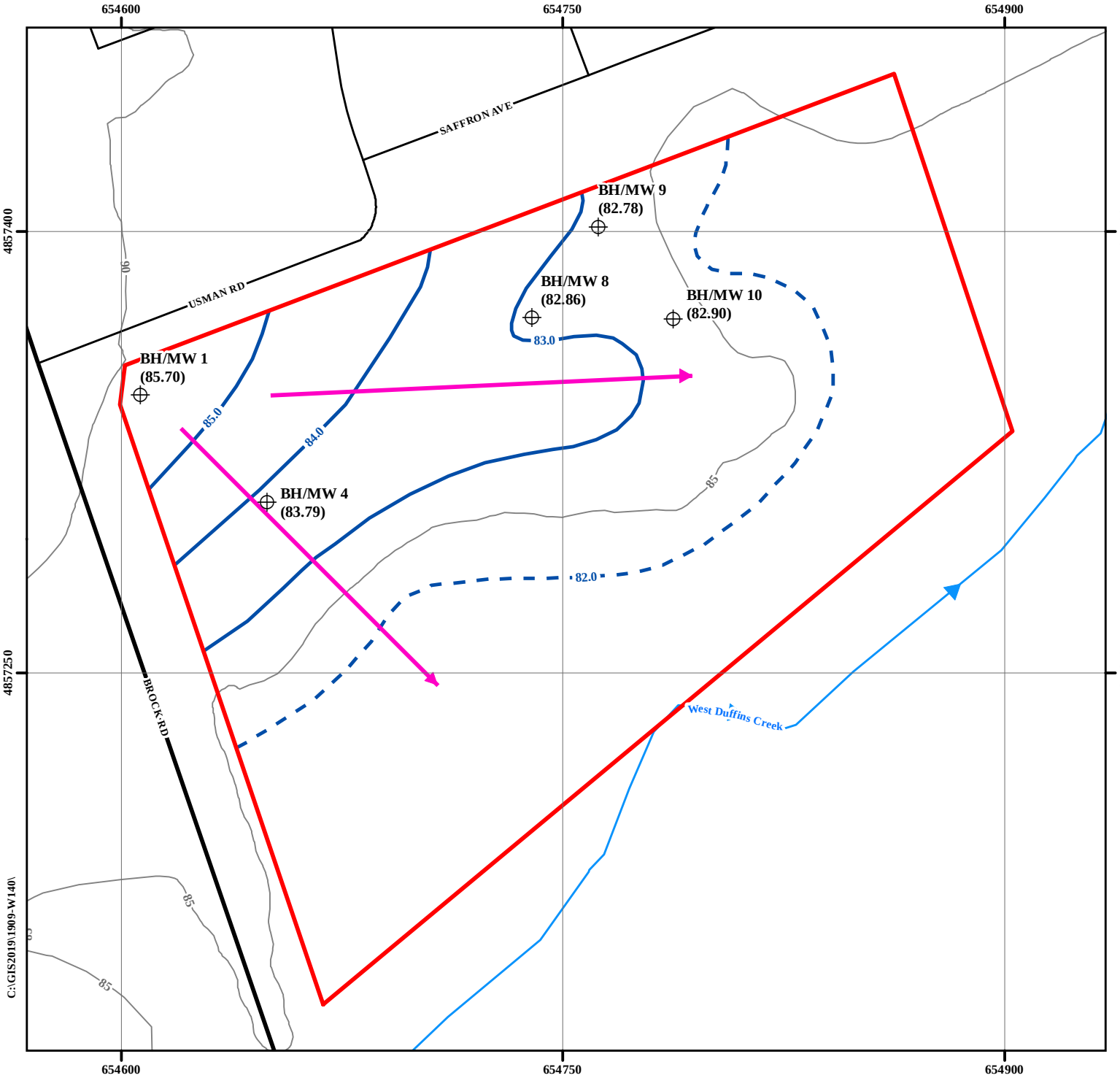
Title: Geological Cross-Sections (A-A' and B-B')

Project: Hydrogeological Assessment
Proposed Residential Development
2055 Brock Road, City of Pickering

Reference No:	Date:	Scale: V	Scale: H	Drawing No.
1909-W140	December, 2019	1:200	1:1000	8-2



Source: Ministry of Natural Resources and Forestry
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N

Approximate Boundary of Subject Site

Borehole with Monitoring Well

Interpreted Shallow Groundwater Flow Direction

Interpreted Shallow Groundwater Level Elevation (masl)

Inferred Shallow Groundwater Level Elevation (masl)

Watercourse

Major Road

Local Road

85 Topographic Contour (masl)

251.25 Average Shallow Groundwater Level Elevation (masl)

Soil Engineers Ltd.

Title: Shallow Groundwater Flow Pattern Plan

Project:

Hydrogeological Assessment
Proposed Residential Development
2055 Brock Road
City of Pickering

Reference No. 1909-W140

Date: December 5, 2019

Scale:

0 5 10 20 30 40 50
Metres

Drawing No. 9

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APPENDIX 'A'

MECP WATER WELL RECORDS SUMMARY

REFERENCE NO. 1909-W140

Ontario Water Well Records

WELL ID	MECP WWR ID	Construction Method	Well Depth (m)**	Well Usage		Water Found (m)**	Static Water Level (m)**	Top of Screen Depth (m)**	Bottom of Screen Depth (m)**
				Final Status	First Use				
1	1907166	Boring	11.13	Water Supply	Domestic	8.23	-	-	-
2	4605707	Cable Tool	14.33	Water Supply	Domestic	13.41	7.32	-	-
3	4605706	Cable Tool	13.72	Water Supply	Domestic	13.41	7.62	-	-
4	4605705	Cable Tool	13.11	Water Supply	Domestic	12.50	7.32	-	-
5	1905246	Boring	10.97	Water Supply	Domestic	9.14	3.05	-	-
6	7176506	Other Method	7.92	Abandoned-Other	Not Used	-	3.66	-	-
7	7279404	-	3.35	Abandoned-Other	-	-	3.05	-	-
8	4601165	Boring	6.55	Water Supply	Domestic	5.94	1.52	5.94	6.55
9	7228644	Boring	6.10	-	-	3.05	-	-	-
10	7101063	Other Method	7.60	Test Hole	Monitoring	4.80	-	4.50	7.60
11	7228646	Boring	6.10	-	-	3.66	-	-	-
12	7048172	Other Method	6.10	Observation Wells	Monitoring	-	-	-	-
13	7188280	Rotary (Convent.)	8.38	Test Hole	Monitoring and Test Hole	2.44	-	6.86	8.38
14	7208501	-	-	-	-	-	-	-	-
15	1911659	Not Known	-	Abandoned-Other	-	-	-	-	-
16	7228645	Boring	5.94	-	-	3.05	-	2.90	5.94
17	4604388	Boring	7.01	Water Supply	Domestic	3.05	3.05	-	-
18	4601300	Boring	4.57	Water Supply	Domestic	3.05	1.86	-	-
19	4601163	Boring	6.10	Water Supply	Public	4.88	1.52	-	-
20	4601162	Boring	10.67	Water Supply	Domestic	8.23	2.44	8.23	10.67
21	7228647	Boring	6.10	-	-	3.66	-	3.05	6.10
22	1914143	Digging	3.05	Abandoned-Other	Not Used	-	-	-	-
23	4601298	Boring	2.29	Water Supply	Domestic	1.22	0.76	0.76	2.29
24	6928837	Other Method	-	Abandoned-Other	Not Used	-	-	-	-
25	6928838	Other Method	-	Abandoned-Other	Not Used	-	-	-	-
26	4604352	Boring	5.49	Water Supply	Domestic	2.13	2.13	-	-
27	4601158	Boring	3.35	Water Supply	Domestic	0.91	0.91	-	-

*MECP WWID: Ministry of Environment, Conservation, and Parks - Water Well Records Identification

**metres below ground surface

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FAX: (705) 721-7864	FAX: (905) 542-2769	FAX: (905) 725-1315	FAX: (905) 881-8335	FAX: (705) 684-8522	FAX: (905) 542-2769

APPENDIX 'B'

SINGLE WELL RESPONSE TEST RESULTS

REFERENCE NO. 1909-W140

Falling Head Test (Slug Test)

Test Date:		21-Nov-19	
Piezometer/Well No.:		BH/MW 1	
Ground level:		91.00	m
Screen top level:		81.80	m
Screen bottom level:		78.80	m
Test El. (at midpoint of screen):		80.3	m
Test depth (at midpoint of screen):		10.7	m
Screen length	L=	3.0	m
Diameter of undisturbed portion	2R=	0.22	m
Standpipe diameter	2r=	0.05	m
Initial unbalanced head	Ho=	-0.573	m
Initial water depth		5.28	m
Aquifer material:		**Sandy silt / Silty sand till**	

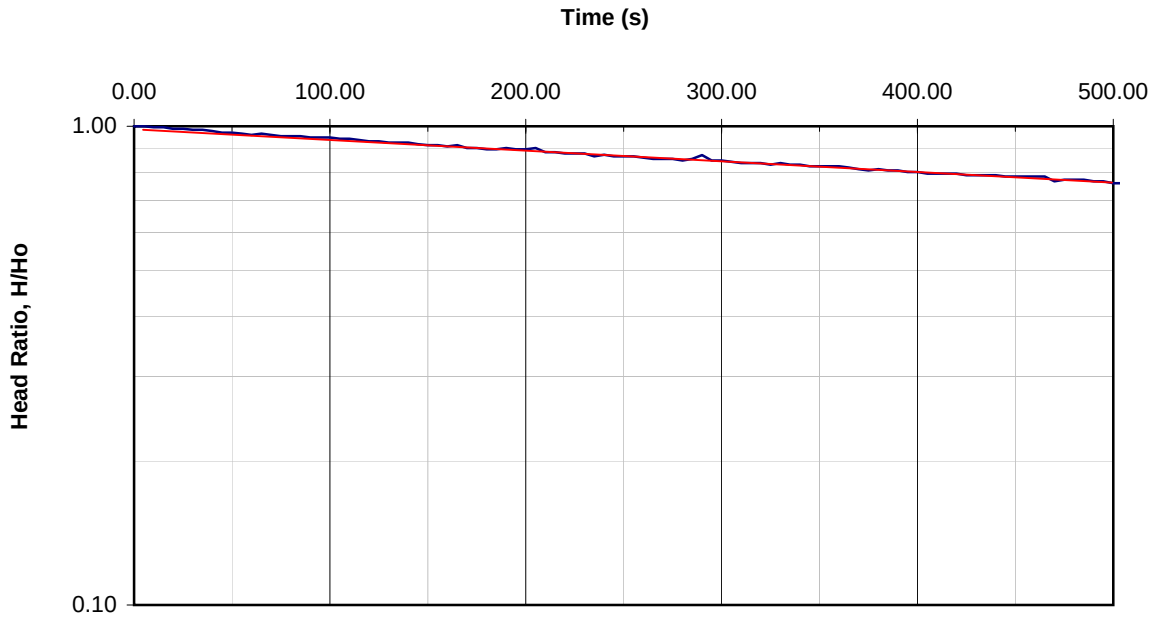
Shape factor $F = \frac{2 \times 3.14 \times L}{\ln(L/R)} = 5.701815$ m

Permeability $K = \frac{3.14 \times r2}{F \times (t2 - t1)} \times \ln(H1/H2)$ (Bouwer and Rice Method)

$\frac{\ln(H1/H2)}{(t2 - t1)} = 0.000537764$

K= **1.9E-05** cm/s

1.9E-07 m/s



Falling Head Test (Slug Test)

Test Date:		21-Nov-19	
Piezometer/Well No.:		BH/MW 4	
Ground level:		90.40	m
Screen top level:		81.20	m
Screen bottom level:		78.20	m
Test El. (at midpoint of screen):		79.70	m
Test depth (at midpoint of screen):		10.7	m
Screen length	L=	3.0	m
Diameter of undisturbed portion	2R=	0.22	m
Standpipe diameter	2r=	0.05	m
Initial unbalanced head	Ho=	-0.421	m
Initial water depth		3.35	m
Aquifer material:		**Sandy silt till / Silty sand till**	

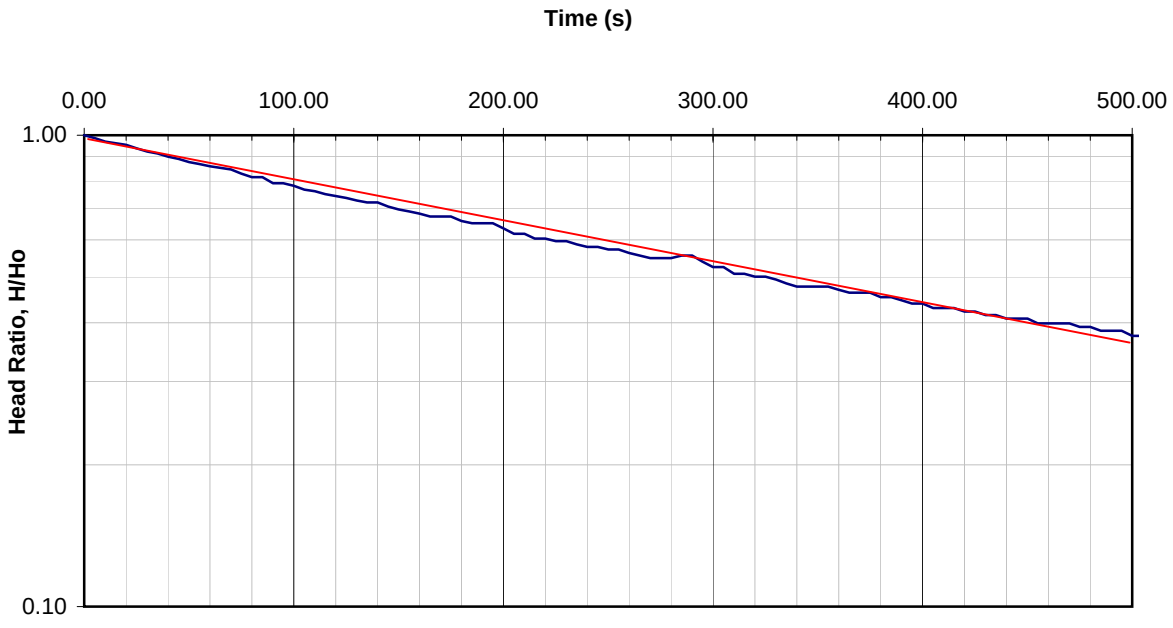
Shape factor $F = \frac{2 \times 3.14 \times L}{\ln(L/R)} = 5.701815$ m

Permeability $K = \frac{3.14 \times r2}{F \times (t2 - t1)} \times \ln(H1/H2)$ (Bouwer and Rice Method)

$\frac{\ln(H1/H2)}{(t2 - t1)} = 0.002465751$

K= **8.5E-05** cm/s

8.5E-07 m/s



Falling Head Test (Slug Test)

Test Date:		21-Nov-19	
Piezometer/Well No.:		BH/MW 8	
Ground level:		88.70	m
Screen top level:		80.00	m
Screen bottom level:		77.00	m
Test El. (at midpoint of screen):		78.50	m
Test depth (at midpoint of screen):		10.2	m
Screen length	L=	3.0	m
Diameter of undisturbed portion	2R=	0.22	m
Standpipe diameter	2r=	0.05	m
Initial unbalanced head	Ho=	-0.599	m
Initial water depth		3.35	m
Aquifer material:		**Sandy silt till / Silty sand till**	

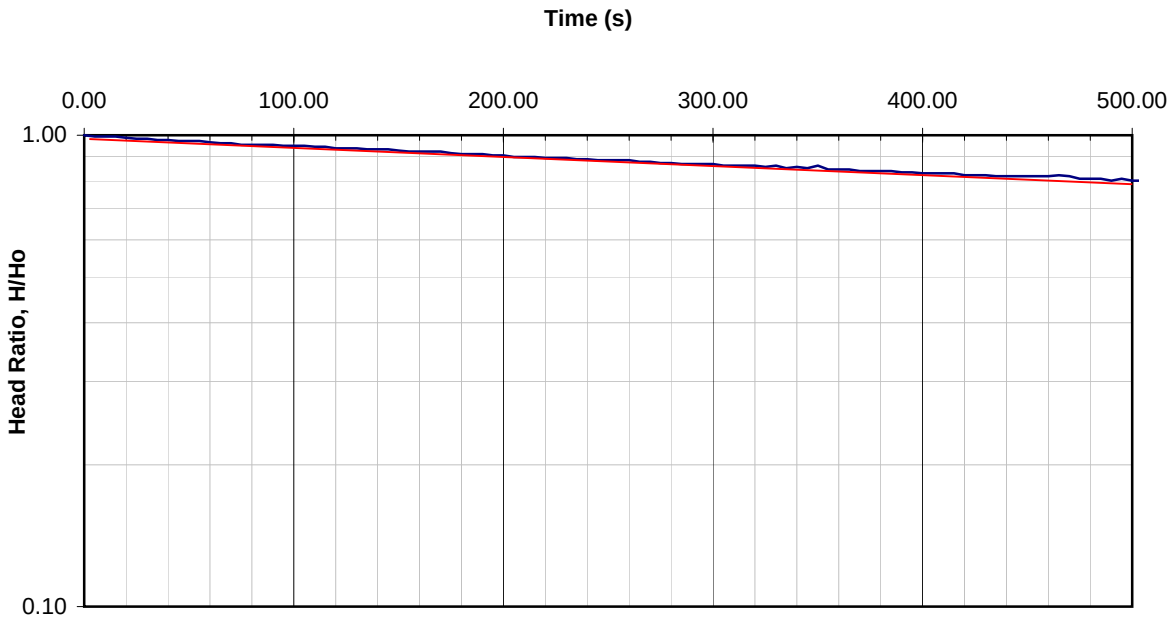
Shape factor $F = \frac{2 \times 3.14 \times L}{\ln(L/R)} = 5.701815$ m

Permeability $K = \frac{3.14 \times r2}{F \times (t2 - t1)} \times \ln(H1/H2)$ (Bouwer and Rice Method)

$\frac{\ln(H1/H2)}{(t2 - t1)} = 0.000513812$

K= **1.8E-05** cm/s

1.8E-07 m/s



Falling Head Test (Slug Test)

Test Date:		21-Nov-19	
Piezometer/Well No.:		BH/MW 9	
Ground level:		87.30	m
Screen top level:		78.10	m
Screen bottom level:		75.10	m
Test El. (at midpoint of screen):		76.60	m
Test depth (at midpoint of screen):		10.7	m
Screen length	L=	3.0	m
Diameter of undisturbed portion	2R=	0.22	m
Standpipe diameter	2r=	0.05	m
Initial unbalanced head	Ho=	-0.092	m
Initial water depth		3.35	m
Aquifer material:		**Sandy silt till / Silty sand till**	

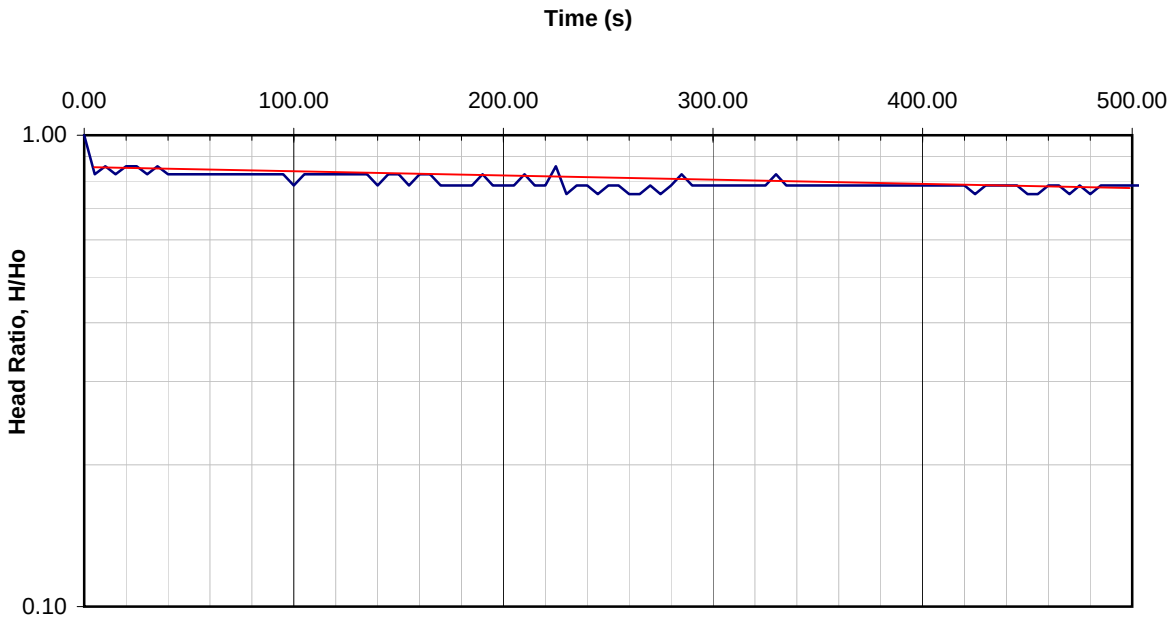
Shape factor $F = \frac{2 \times 3.14 \times L}{\ln(L/R)} = 5.701815$ m

Permeability $K = \frac{3.14 \times r2}{F \times (t2 - t1)} \times \ln(H1/H2)$ (Bouwer and Rice Method)

$\frac{\ln(H1/H2)}{(t2 - t1)} = 0.002451225$

K= **8.4E-05** cm/s

8.4E-07 m/s



Falling Head Test (Slug Test)

Test Date:		21-Nov-19	
Piezometer/Well No.:		BH/MW 10	
Ground level:		85.90	m
Screen top level:		76.70	m
Screen bottom level:		73.70	m
Test El. (at midpoint of screen):		75.20	m
Test depth (at midpoint of screen):		10.7	m
Screen length	L=	3.0	m
Diameter of undisturbed portion	2R=	0.22	m
Standpipe diameter	2r=	0.05	m
Initial unbalanced head	Ho=	-0.04	m
Initial water depth		3.35	m
Aquifer material:		**Sandy silt till / Silty sand till**	

Shape factor $F = \frac{2 \times 3.14 \times L}{\ln(L/R)} = 5.701815$ m

Permeability $K = \frac{3.14 \times r2}{F \times (t2 - t1)} \times \ln(H1/H2)$ (Bouwer and Rice Method)

$\frac{\ln(H1/H2)}{(t2 - t1)} = 0.001923719$

K= **6.6E-05** cm/s

6.6E-07 m/s