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Hydrogeological Study in Support of Site Plan
108, 116 & 122 Harvie Road

ASA Development Inc.
Barrie, Ontario

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Hydrogeological Study in Support of Site Plan
108, 116 & 122 Harvie Road

ASA Development Inc.
Barrie, Ontario

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Guelph ON N1H 1C4 CANADA

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-	June 4, 2021	Initial Submission to ASA Development Inc.

R.J. Burnside & Associates Limited

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1.0 Introduction

R.J. Burnside & Associates Limited (Burnside) was retained by ASA Development Inc. to complete a hydrogeological study report in support of a Site Plan application for a proposed residential development located in Barrie, Ontario. The location of the subject property (herein referred to as the subject lands) is shown in Figure 1. The subject lands are located at 108, 116 and 122 Harvie Road in Barrie, Ontario (Figure 2). The proposed development for the subject lands includes a change from the current single residential lots to a concept that includes single detached homes, townhouses and amenity lands. The subject lands are within the City of Barrie and within the jurisdiction of the Lake Simcoe Region Conservation Authority (LSRCA). The requirements for hydrogeological studies in these jurisdictions are outlined in the document "Hydrogeological Assessment Submissions - Conservation Authority Guidelines for Development Applications (2013)" and the "Hydrogeological Study Terms of Reference (2021) from the City of Barrie.

2.0 Site Conditions

2.1 Topography and Drainage

The topography of the subject lands slopes gently towards the east with elevations ranging from 308 meters above sea level (masl) near the western property boundary to 305 masl on the eastern property boundary (Figure 3).

The subject lands are located in the Barrie Creeks catchment of the Severn River subwatershed and are within the jurisdiction of the Lake Simcoe Region Conservation Authority (LSRCA). There are no watercourses on the subject lands. Drainage on the subject lands is to the east and northeast (Figure 3). Watercourses associated with the Severn River subwatershed are observed to the south and east of the subject lands and drains in an easterly direction towards Kempenfelt Bay.

2.2 Geology

The subject lands are located in the physiographic region known as the Peterborough Drumlin Field. The region is characterized as a rolling drumlinized till plain. The drumlins through the region are comprised of highly calcareous till (Chapman & Putnam, 1984).

The overburden was deposited during a series of advances and retreats of the Simcoe glacial ice lobe. This has resulted in drumlinized sheets of glacial till (Newmarket till), stratified glaciolacustrine deposits of sand and gravel, littoral-foreshore deposits and massive-well laminated deposits of sand and gravel. A review of the quaternary geology mapping for the area (OGS, 2003) indicates that the overburden sediments of the subject lands consist primarily of silty to sandy glacial till with glaciofluvial ice contact stratified sediments of sand and gravel east and west of the subject lands (Figure 4).

The bedrock underlying the subject lands is mapped as the Lindsay Formation of the Simcoe Group, which consists of limestone and claystone (OGS, 2007).

2.3 Local Stratigraphy

A geotechnical investigation on the subject lands was completed by Peto MacCallum Ltd. (Peto) in January 2021. The investigation included the drilling of 10 boreholes with five of them completed as monitoring wells. The borehole logs are provided in Appendix A and locations are shown on Figure 5. The boreholes ranged in depths from 4.8 m to 11.2 m and indicated that the subject lands are underlain by a layer of fill of about 1.4 m. Under the fill was generally a sand deposit with some local surficial layers of silty sand, silty sand till and silty clay overlying the sand.

To illustrate the shallow stratigraphy of the subject lands, schematic geologic cross-sections have been prepared by Burnside (Figures 6 and 7) using the MECP well records (Appendix B) and the soils information collected during drilling of boreholes and monitoring wells (Appendix A). The locations of the cross-sections are illustrated on Figure 5 along with the locations of water wells and boreholes used in the construction of the cross-sections. The cross-sections illustrate that the subject lands to be underlain by a sand layer that is 15 to 20 m thick. Some lenses of silty sand, silty clay and silty sand till are encountered within the sand layer.

2.4 Hydraulic Conductivity

Hydraulic conductivity is a measure of the rate of groundwater transmission in sediments. Higher hydraulic conductivity rates indicate a strong potential for groundwater movement. There are various methods that can be used to assess soil hydraulic conductivity and determine the potential for groundwater movement. Grainsize data and soil characteristics collected during a geotechnical investigation can be used to provide a general estimate of hydraulic conductivity. The estimated hydraulic conductivity values may then be used to estimate infiltration rates based on their approximate relationship (as presented in the TRCA Stormwater Management Criteria, 2012).

2.4.1 Estimates from Soil Grainsize Analysis

During the geotechnical investigation completed by Peto (2021), four representative soil samples were analyzed for grainsize distribution (Appendix C). A summary of the hydraulic conductivity values estimated from the grainsize analyses utilizing the Hazen correlation methods is provided below in Table 1. The Hazen method is designed to approximate the hydraulic conductivity of more permeable sediments; however, it is still considered useful in finer grained sediments to provide a general indication of the low range of the hydraulic conductivity.

Table 1: Estimated Hydraulic Conductivity and Infiltration Rates

Location	Soil Description	Soil Depth (mbgs)	Hydraulic Conductivity (cm/sec) Hazen Estimation	Estimated Infiltration Rate* (mm/hr)
BH1-SS3	Clayey Silt	1.4	n/a	<12
BH7-SS4	Sand and Silt Till	2.3	6.3×10^{-6}	12 - 30
BH8-SS4	Silty Sand Till	2.3	2.5×10^{-3}	75 -150
BH3-SS4	Sand	2.3	2.8×10^{-3}	75 -150

*From Table C2 in Appendix C: Toronto and Region Conservation Authority Stormwater Management Criteria, 2012.

Based on the results of the grainsize analyses, the estimated hydraulic conductivities and infiltration rates for various soil types identified across the subject lands have been summarized in Table 1. The table indicates that infiltration rates will vary based on soils encountered but that the silty sand till and sands prevalent in the boreholes (see Appendix A) will have infiltration rates between 75 to 150 mm/hour. Site-specific infiltration rates and design values should be refined once the final locations of LID measures are identified during development design.

2.5 Local Groundwater Use

The City of Barrie obtains its water from a combination of groundwater and surface water based supplies. Municipal servicing is assumed to be available for lands within the municipal city boundary including the subject lands. The water supply wells for the City of Barrie obtain water from deep formations that are significantly below the shallow excavations that are expected in the current development and the wells themselves are located in an area that is north and west of the subject lands and over 3 km away.

Water well records for private supply wells are filed with the MECP and are available for review via the MECP online water well record database. A review of the online MECP water well records indicated that there are approximately 49 water well records within 500 m of the study area. Of the 49 well records, 30 of them were water supply well records, 9 were abandonment records, 9 were monitoring wells and one was a dewatering well. Based on the well records and interpreted hydrostratigraphy, most of these water supply wells are completed in the surficial (local) aquifer with depths ranging from 8 m to 75 m. The well records reviewed are provided in Appendix B and the locations of the MECP water well records are shown on Figure 8.

2.6 Groundwater Levels

Five monitoring wells were completed during the geotechnical investigation in December 2020. Groundwater levels were measured by Peto in January 2021 and Burnside on May 5, 2021. The locations of the monitoring wells are shown on Figure 2 and the water levels are provided in Table D-1, Appendix D.

The water level monitoring completed on the subject lands indicates that groundwater was only observed in MW7A while all the remaining monitoring wells were dry. The groundwater levels at MW7A were 8.60 mbgs in January 2021 and 8.56 mbgs in May 2021. It is interpreted that groundwater was below the screened intervals at all the other monitor wells and therefore generally over 5 m below grade and may be as much a s 8.6 m (based on the observed water table measurements and the depth of monitoring wells). Shallow wells in southern Ontario typically show a pattern of groundwater fluctuations that is related to seasonal variations in precipitation and infiltration where the highest groundwater levels occur in the spring, levels decline throughout the summer and early fall and then rise again in the late fall/early winter. Seasonal variability for groundwater in sand soils such as at the subject lands is generally less than 1 m. The groundwater levels collected in May 2021 can be therefore interpreted as seasonal high groundwater levels.

3.0 Source Water Protection

3.1 Wellhead Protection Areas

Wellhead Protection Areas (WHPAs) are zones around municipal water supply wells where land uses must be carefully planned and restricted to protect the quality and quantity of the water supply. The City of Barrie municipal water supply wells are located on the west and northern sides of the City and the closest municipal well is about 3 km north of the subject lands.

The subject lands are located in the Lakes Simcoe and Couchiching/Black River Source Protection Area. A review of available source protection mapping indicates that the subject lands do not fall within any wellhead protection areas or intake protection (Figure 9) for water quality but are located within a wellhead protection area for quantity (WHPA-Q1 and WHPA-Q2). Within a WHPA-Q2 reduction in recharge is a concern and the LSRCA has policies regarding the reduction of recharge as a result of development. As such, it is important that low impact development (LID) measures are implemented during site development to ensure that recharge is maintained in the post-development scenario to the greatest extent feasible. A water balance for the subject lands is presented and discussed below in Section 4.0.

3.2 Significant Groundwater Recharge Areas

Significant Groundwater Recharge Areas (SGRAs) can be described as areas that can effectively move water from the surface through the unsaturated soil zone to replenish available groundwater resources (LSRCA, 2012). SGRAs were mapped by the Source Water Protection Assessment Report (LSRCA, 2012) as a requirement of the Clean Water Act, 2006 and based on guidance provided by the MECP. The delineation of these areas was completed using numerical models and analyses that included the evaluations of numerous factors including precipitation, temperature and other climate data along with land use, soil type, topography and vegetation to predict groundwater recharge, runoff and evapotranspiration. SGRAs represent areas where the annual recharge rate is greater than 115% of the average recharge of 164 mm/year across the Lake Simcoe watershed (or greater than the threshold recharge rate of 189 mm/year) (LSRCA, 2012). Mapping from the LSRCA indicates that the subject lands are not located in a significant groundwater recharge area (SGRA).

3.3 Aquifer Vulnerability

Aquifer vulnerability refers to the susceptibility of an aquifer to potential contamination. Some degree of protection for groundwater quality from natural and human impacts is provided by the soil above the water table. The degree of protection is dependent upon the depth to the water table (for unconfined aquifers) or the depth of the aquifer (for confined aquifers) and the type of soil above the water table of aquifer. As these two properties vary over any given area, the degree of protection or vulnerability of the groundwater to contamination also varies.

The aquifer vulnerability for aquifers serving municipal wells was mapped in the Lake Simcoe and Couchiching-Black River SPA Part 1 Approved Assessment Report, Lake Simcoe Region Conservation Authority, 2015. The approach used by the LSRCA to create a regional vulnerability map was the aquifer vulnerability index (AVI) method. Using water well records for the area to determine the soil types and depths to aquifer an AVI was calculated for each delineated aquifer to produce a map of regional groundwater vulnerability. Based on the AVI scores aquifers were divided into High Medium and Low vulnerability to contamination. Areas classified as High are referred to as Highly Vulnerable Aquifers (HVA). Highly Vulnerable Aquifer mapping for the subject lands shows a small portion of subject lands near Harvie Road is mapped as HVA (Figure 10).

The classification of a small portion of the subject lands as high aquifer vulnerability does not restrict the proposed residential development of the subject lands. The classification is restrictive for potentially contaminating land uses that involve industrial land uses, for example the generation or storage of hazardous and industrial wastes.

4.0 Water Balance

4.1 Water Balance Components

A water balance is an accounting of the water resources within a given area. For the current assessment the water balance was conducted for the entire subject lands. As a concept, the water balance is relatively simple and may be estimated from the following equation:

$$P = S + ET + R + I$$

Where:

Where:	P	=	precipitation
	S	=	change in groundwater storage
	ET	=	evapotranspiration/evaporation
	R	=	surface water runoff
	I	=	infiltration

The components of the water balance vary in space and time and depend on climatic conditions as well as the soil and land cover conditions (i.e., rainfall intensity, land slope, soil hydraulic conductivity and vegetation). Runoff, for example, occurs particularly during periods of snowmelt when the ground is frozen, or during intense rainfall events.

Precise measurement of the water balance components is difficult and as such, approximations and simplifications are made to characterize the water balance of a site. Field observations of the drainage conditions, land cover and soil types, groundwater levels and local climatic records are important input considerations for the water balance calculations. For the following assessment the water balance was computed based on the soil moisture approach that was outlined by Thornthwaite and Mather (1957). The groundwater balance components for the Subject lands are discussed below:

Precipitation (P)

The long-term average annual precipitation for the area is 933 mm based on data from the Environment Canada Barrie WPCC (Station 6110557, 44°22'33.012" N, 79°41'23.010" W, elevation 221.0 masl) for the period between 1981 and 2010. The climate station is located 3.3 km northeast of the subject lands. Average monthly records of precipitation and temperature from this station have been used for the water balance calculations in this study (Appendix E).

Storage (S)

Although there are groundwater storage gains and losses on a short-term basis, the net change in groundwater storage on a long-term basis is assumed to be zero so this term is dropped from the equation.

Evapotranspiration (ET)/Evaporation (E)

Evapotranspiration and evaporation components vary based on the characteristics of the land surface cover (i.e., type of vegetation, soil moisture conditions, perviousness of surfaces, etc.). Potential evapotranspiration (PET) refers to the water loss from a vegetated surface to the atmosphere under conditions of an unlimited water supply. The actual rate of evapotranspiration (AET) is generally less than the PET under dry conditions (i.e., during the summer when there is a soil moisture deficit). The mean annual ET has been calculated for this study using a monthly soil-moisture balance approach considering the local climate conditions.

Water Surplus (R + I)

The difference between the mean annual P and the mean annual ET is referred to as the water surplus. Part of the water surplus travels across the surface of the soil as surface or overland runoff (R) and the remainder infiltrates the surficial soil (I). The infiltration is comprised of two end member components: one component that moves vertically downward to the groundwater table (referred to as recharge) and a second component that moves laterally through the topsoil profile or shallow soils as interflow that re-emerges locally to surface (i.e., as runoff) at some short time following cessation of precipitation. As opposed to the “direct” component of surface runoff that occurs during precipitation or snowmelt events, interflow becomes an “indirect” component of runoff. The interflow component of surface runoff is not accounted for in the water balance equation cited above since it is often difficult to distinguish between interflow and direct (overland) runoff, however both interflow and direct runoff together form the total surface water runoff component.

4.2 Approach and Methodology

The analytical approach to calculate the water balance that was used for this assessment involves monthly soil-moisture balance calculations to determine the pre-development (based on pre-development land use) infiltration volumes. A soil-moisture balance approach assumes that soils do not release water as potential recharge while a soil moisture deficit exists. During wetter periods, any excess of precipitation over evapotranspiration first goes to restore soil moisture. Once the soil moisture deficit is overcome, any further excess water can then pass through the soil as infiltration and either become interflow (indirect runoff) or recharge (deep infiltration).

Existing vegetation on the subject lands consists of single residential houses, urban lawn and mature trees. A soil moisture storage capacity of 75 mm was selected as a representative value for areas of urban lawn in sandy loam soils (Table E-1, Appendix E). A soil moisture storage capacity of 300 mm was used to represent areas with mature trees (Table E-2, Appendix E). Tables E-1 and E-2 in Appendix E details the monthly potential evapotranspiration calculations accounting for latitude and climate, and then calculate the actual evapotranspiration and water surplus components of the water balance based on the monthly precipitation and soil moisture conditions.

The MECP SWM Planning and Design Manual (2003) methodology for calculating total infiltration based on topography, soil type and land cover was used and a corresponding runoff component was calculated for the soil moisture storage conditions. The calculated water balance components from this table are then used to assess the pre-development and post development volumes for runoff and infiltration as presented on Table E-3 in Appendix E.

4.3 Water Balance Component Values

The detailed monthly calculations of the water balance components are provided in Table E-1 and Table E-2 in Appendix E. For these calculations, it has been assumed that sandy loam soils are representative for the subject lands for estimating the soil infiltration factor. The calculations show that a water surplus is generally available from November to May (see Figure E-1). The monthly water balance calculations illustrate how infiltration occurs during periods when there is sufficient water available to overcome the soil moisture storage requirements. The monthly calculations are summed to provide estimates of the annual water balance component values (Table E-1 and Table E-2, Appendix E). A summary of these values is provided in Table 2.

Table 2: Water Balance Component Values

Water Balance Component	Urban Lawn	Mature Trees
Average Precipitation	933 mm/year	933 mm/year
Actual Evapotranspiration	555 mm/year	593 mm/year
Water Surplus	378 mm/year	340 mm/year
Infiltration	265 mm/year	272 mm/year
Runoff	113 mm/year	68 mm/year

The calculations show that a water surplus is generally available from November to May and the period of surplus is illustrated in Figure E-1. The monthly water balance calculations illustrate how infiltration occurs during periods when there is sufficient water available to overcome the soil moisture storage requirements. The monthly calculations are summed to provide estimates of the annual water balance component values (Table E-1 and Table E-2, Appendix E).

4.4 Pre-Development Water Balance (Existing Conditions)

The pre-development water balance calculations are presented in Table E-3 in Appendix E. As summarized on Table E-3, the total area of the subject lands is about 2.48 ha. The water balance component values from Table E-1 and Table E-2 were used to calculate the average annual volume of infiltration across the subject lands. Based on these component values, the pre-development infiltration volume for the subject lands is calculated to be about 6,137 m^3/year (Table E-3, Appendix E).

4.5 Potential Urban Development Impacts to Water Balance

Development of an area affects the natural water balance. The most significant difference is the addition of impervious surfaces as a type of surface cover (i.e., roads, parking lots, driveways, and rooftops). Impervious surfaces prevent infiltration of water into the soils and the removal of the vegetation removes the evapotranspiration component of the natural water balance. The evaporation component from impervious surfaces is relatively minor (estimated to be 10% to 20% of precipitation) compared to the evapotranspiration component that occurs with vegetation in this area (about 64% of precipitation in the study area). So, the net effect of the construction of impervious surfaces is that most of the precipitation that falls onto impervious surfaces becomes surplus water and direct runoff. The natural infiltration components (interflow and deep recharge) are reduced.

A water balance calculation of the potential water surplus for impervious areas is shown at the bottom of Table E-1 in Appendix E. There is an evaporation component from impervious surfaces and this is typically estimated to be between about 10% and 20% of the total precipitation. For the purposes of the calculations in this study, the evaporation has been estimated to be 15% of precipitation. The remaining 85% of the precipitation that falls on impervious surfaces is assumed to become runoff. Therefore, assuming an evaporation/loss from impervious surfaces of 15% of the precipitation, there is a potential water surplus from impervious areas of 793 mm/year.

It is noted that the proposed development will be serviced by municipal water supply and wastewater services. Therefore, there will be no impact on the water balance and local groundwater or surface water quantity and quality conditions related to any on-site groundwater supply pumping or disposal of septic effluent.

4.6 Post-Development Water Balance with No Mitigation

To assess potential development impacts on infiltration, the post-development infiltration volumes for the subject lands have been calculated in Table E-3 in Appendix E. The total areas for the proposed land uses were provided by Jones Consulting Group Ltd and the associated percentage impervious factors were assumed.

The infiltration and runoff components for the post-development land uses have been calculated using the MECP SWM Planning and Design Manual (2003) methodology based on topography, soil type and land cover as shown on Table E-1 in Appendix E. It should be noted that no mitigation has been applied to the results shown in this table and that they therefore represent the water balance under post-development conditions with no mitigation applied. The average calculated post-development infiltration volume (without mitigation) for the subject lands is about 2,337 m^3/year.

Comparing the pre- and post-development infiltration volumes, shows that development has the potential to reduce the infiltration on the subject lands from 6,137 m^3/year to 2,337 m^3/year, i.e., a reduction of about 3,800 m^3/year or 62%. These calculations assume no LID measures for stormwater management are in place. If mitigation were to be applied, it is anticipated that a reduction in the deficit could be achieved.

4.7 Mitigation Strategies for Infiltration

In order to minimize the potential impacts of development on the water balance, the use of Low Impact Development (LID) measures for stormwater management are generally recommended. LID is based on the premise of trying to manage stormwater to minimize the surface water runoff and increase the potential for infiltration where possible. There are, as outlined in the MECP SWMP Design Manual (2003) and Low Impact Development (LID) Stormwater Management Planning and Design Guide published by the CVC and TRCA (2010), a number of best management practices and mitigation techniques that can be used to increase the potential for post-development infiltration and mitigate the reductions in infiltration that occur with residential land development.

Techniques to maximize the water availability in pervious areas such as designing grades to direct roof runoff towards lawns, side and rear yard swales, boulevards, parks, and other open space areas throughout the development where possible can increase infiltration and reduce the volume of runoff directed to stormwater management facilities. Increasing the topsoil thickness is a method to increase the soil water storage area and potentially increase recharge volumes. Other LID practices that may be considered to control stormwater runoff for residential development areas include, but are not limited to, the use of vegetated buffer strips, rain gardens, construction of bioretention cells or bioswales, tree pits, cisterns and the use of porous pavers.

Where feasible, measures to minimize development impacts on the water balance will be incorporated into the development design. Based on the water balance calculations presented above, the difference between the pre- and post-development recharge volumes is estimated to be about 3,800 m^3/year (Table E-3, Appendix E), and can be considered as an infiltration target for the design of stormwater management and LID measures for the subject lands.

5.0 Development Considerations

5.1 Construction Below the Water Table

Based on groundwater level data collected as part of this study the water table on the subject lands is about 8.6 m below ground surface. At these depths, groundwater may occur below the expected elevation of servicing to be installed.

Should the proposed servicing be required to be blow the water table, the construction of buried services below the water table has the potential to capture and redirect groundwater flow through more permeable fill materials typically placed in the base of excavations. Groundwater may also infiltrate into joints in storm sewers and manholes. Over the long-term, these impacts can lower the groundwater table across the development area. To mitigate this effect, services to be installed below the water table should be constructed to prevent redirection of groundwater flow. This will involve the use of anti-seepage collars or clay plugs surrounding the pipes to provide barriers to flow and prevent groundwater flow along granular bedding material and erosion of the backfill materials.

Should excavations during construction of servicing extend below the water table the local soils may need to be dewatered. The undertaking of dewatering according to industry standards and in accordance with a MECP processes will ensure that adequate attention is paid to potential adverse impacts to the environment. Currently the MECP allows for construction dewatering of less than 400,000 L/d to proceed under the Environmental Activity Sector Registry (EASR) process. If dewatering is to be above this threshold, then the standard Permit to Take Water (PTTW) process applies. In both cases, a scientific study is required in support of EASR registration or PTTW application. This scientific study must review the potential for environmental impacts and provide mitigation and monitoring measures to the satisfaction of the MECP or other review agency. The requirements for construction dewatering will be confirmed by geotechnical/hydrogeological investigations completed in support of detailed design.

5.2 Well Decommissioning

Prior to or during construction, it is necessary to ensure that all inactive wells within the development footprint have been located and properly decommissioned by a licensed water well contractor according to Ontario Regulation 903. This regulation applies private domestic wells and to the groundwater observation wells installed for this study unless they are maintained throughout the construction for monitoring purposes. While it is anticipated that private domestic wells in the area may have already been decommissioned, it will be necessary to decommission any monitoring wells that are not required for construction monitoring.

6.0 Conclusions and Recommendations

- The subject lands are underlain by a thick sandy layer that may be up to 20 m thick.

- Groundwater level data indicate that the water table is greater than 5 m below ground across the subject lands and approximately 8.6 m at the southern part of the site.

- The subject lands are not located in an SGRA and only partially in an HVA. No restrictions on development from a Source Protection perspective are present.

- The water balance completed for the subject lands indicates that if no LID measures are utilized there will be a post-development infiltration deficit of approximately 3,800 m^3/year.

7.0 References

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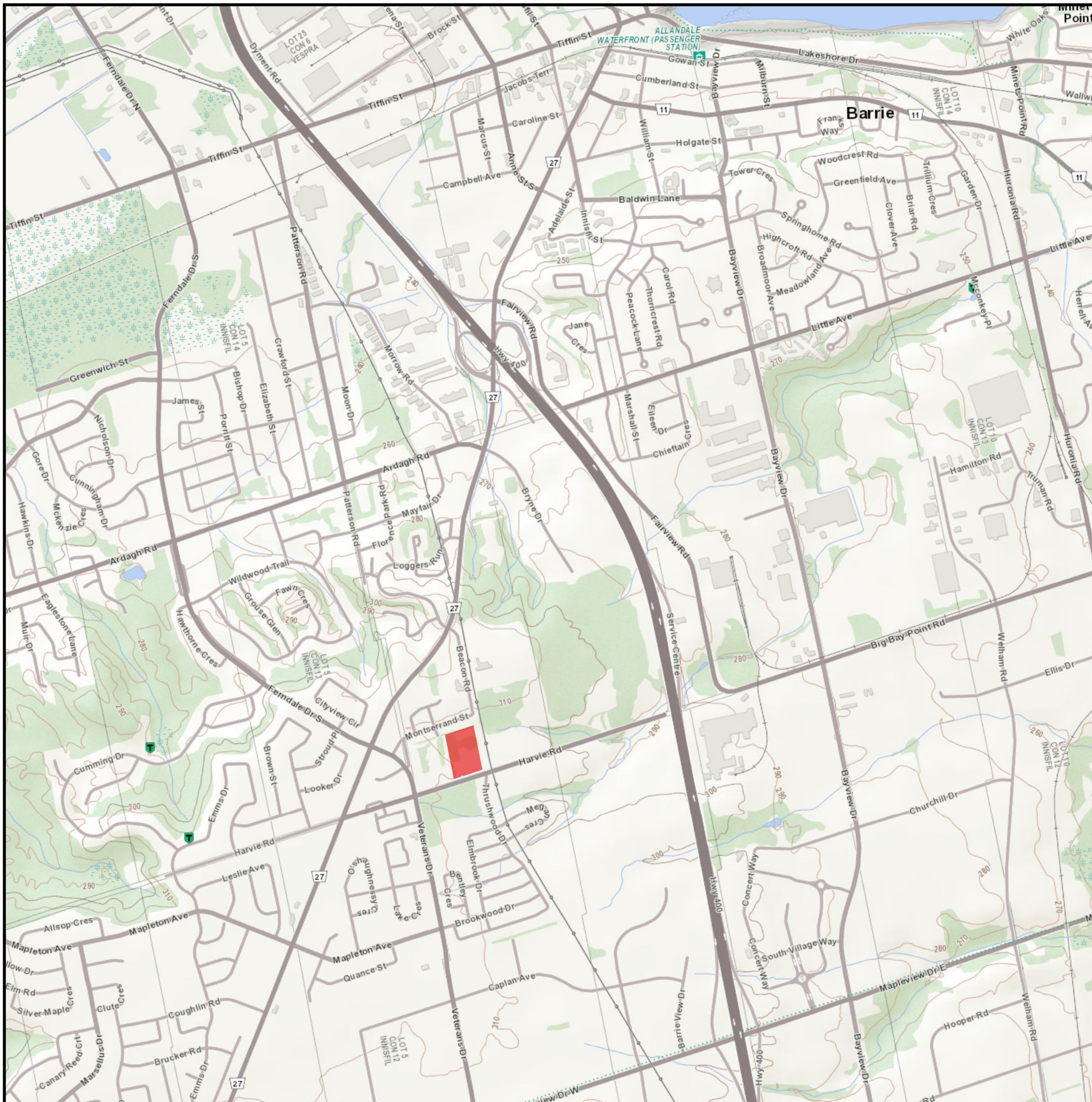
Figures



LEGEND

SUBJECT LANDS

0 250 500 1,000 1,500 2,000

MetRES

N

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ASA DEVELOPMENT INC.
BARRIE, ONTARIO

HYDROGEOLOGICAL STUDY

Figure Title:

SITE LOCATION

Drawn	Checked	Date	Figure No.
SK	SC	JUNE 2021	1
Scale		Project No.	
1:25,000		300053318	

File Path: Nigel/Shared Work Areas/053318 Harvie Rd/06_GIS/053318 Site Location.mxd

LEGEND

SUBJECT LANDS

MONITORING WELL (PETO MacCALLUM, 2021)

0 30 60 90 120

Metres

N

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HYDROGEOLOGICAL STUDY

Figure Title

MONITORING LOCATIONS

Drawn	Checked	Date	Figure No.
SK	SC	JUNE 2021	2
Scale		Project No.	
1:1,500		300053318	

File Name: Nigel/Shared Work Areas/053318 Harvie Road/02_Production/053318 HG Study Drawing Set.dwg Date Plotted: May 27, 2021 - 11:12 AM

Sources:

1. Ministry of Natural Resources and Forestry, © Queen's Printer for Ontario
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3. Contours derived from Provincial Digital Elevation model, 2013.

LEGEND

- CONTOUR (1m intervals - masl)
- SUBJECT LANDS
- WOODED AREA
- WATERCOURSE
- ROADWAY

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HYDROGEOLOGICAL STUDY

Figure Title:

TOPOGRAPHY AND DRAINAGE

Drawn	Checked	Date	Figure No.
SK	SC	JUNE 2021	3
Scale		Project No.	
1:3,000		300053318	

File Path: Nigel/Shared Work Areas/053318 Harvie Rd/06_GIS/053318 Topography & Drainage.mxd

Sources:

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3. Ontario Geological Survey 2010. Surficial geology of southern Ontario; Ontario Geological Survey, Miscellaneous Release—Data 128 – Revised.

LEGEND

- SUBJECT LANDS
- WATERCOURSE
- ROADWAY
- 5b: TILL: STONE-POOR, SANDY SILT TO SILTY SAND-TEXTURED TILL
- 6: ICE-CONTACT STRATIFIED DEPOSITS: SAND AND GRAVEL, MINOR SILT, CLAY AND TILL
- 8a: FINE-TEXTURED GLACIOLACUSTRINE DEPOSITS: SILT AND CLAY, MINOR SAND AND

0 25 50 100 150 200 250 300 350
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BARRIE, ONTARIO

HYDROGEOLOGICAL STUDY

Figure Title:

SURFICIAL GEOLOGY

Drawn	Checked	Date	Figure No.
SK	SC	JUNE 2021	4
Scale		Project No.	
1:5,000		300053318	

File Path: Nigel/Shared Work Areas/053318 Harvie Rd/06_GIS/053318 Surficial Geology.mxd

LEGEND

SUBJECT LANDS

MONITORING WELL (PETO MacCALLUM, 2021)

BOREHOLE (PETO MacCALLUM, 2021)

MECP WELL RECORD LOCATION

A A' CROSS-SECTION LOCATION KEY

0 30 60 90 120

Metres

N

BURNSIDE

Client / Report

ASA DEVELOPMENT INC.
BARRIE, ONTARIO

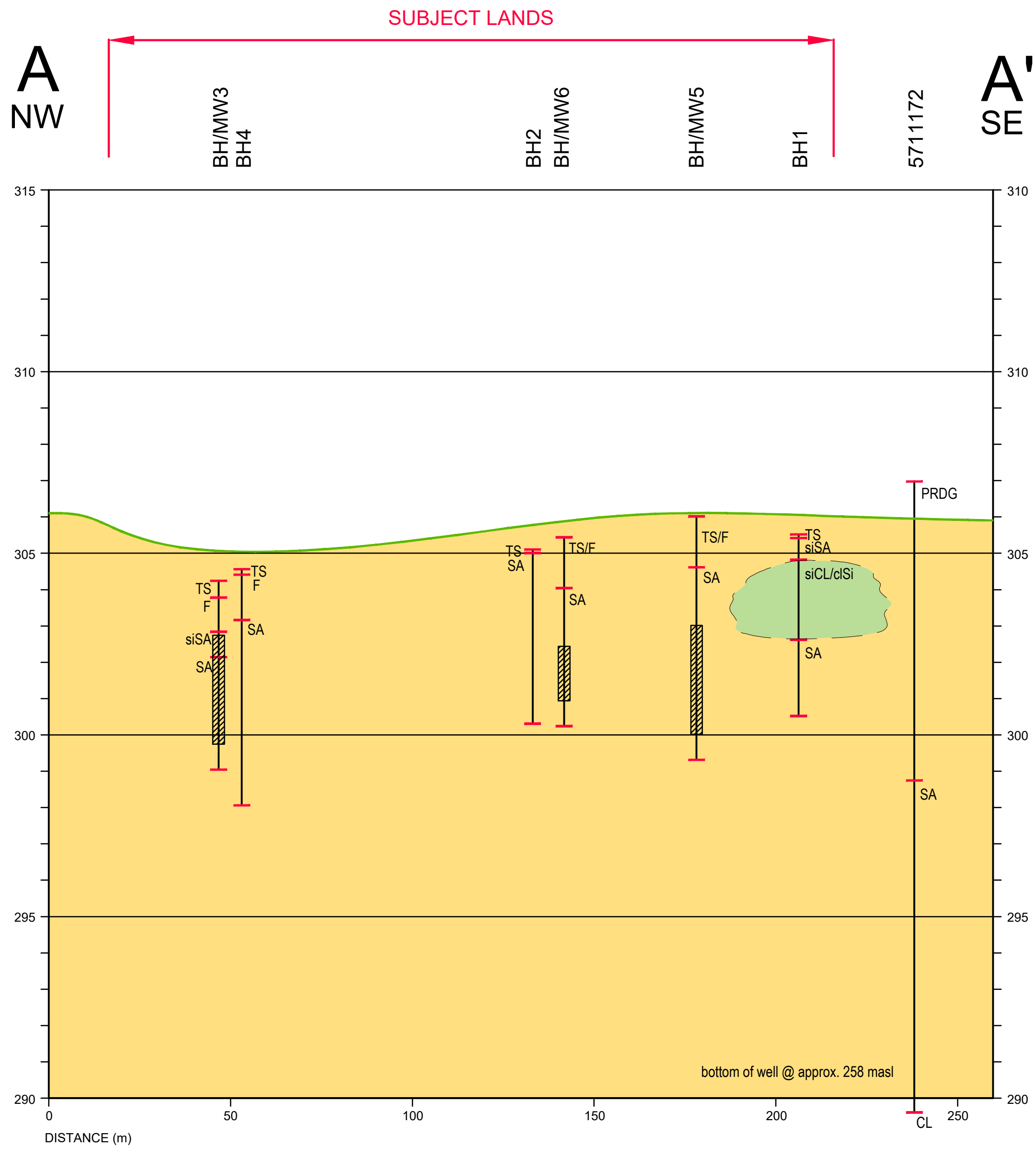
HYDROGEOLOGICAL STUDY

Figure Title

BOREHOLE, WELL ADN CROSS-SECTION LOCATIONS

Drawn	Checked	Date	Figure No.
SK	SC	JUNE 2021	5
Scale		Project No.	
1:1,500		300053318	

File Name: Nigel/Shared Work Areas/053318 Harvie Road/02_Production/053318 HG Study Drawing Set.dwg Date Plotted: May 27, 2021 - 11:01 AM



LEGEND

BH1	WELL NUMBER / ID
	EXISTING GROUND PROFILE
	GEOLOGICAL CONTACT
	MEASURED WATER LEVEL (APRIL 6, 2020)
	STATIC WATER LEVEL (MECP WELL RECORD)
	WELL SCREEN
	INTERPRETED STRATIGRAPHY

si	SILTY
sa	SANDY
cl	CLAYEY
TS	TOPSOIL
HPAN	HARD PAN
BLDR	BOULDERS
F	FILL
T	TILL
GR	GRAVEL
SA	SAND
Si	SILT
CL	CLAY
ST	STONES

SAND / SILT / GRAVEL

SILT CLAY TILL

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ASA DEVELOPMENT INC.
BARRIE, ONTARIO

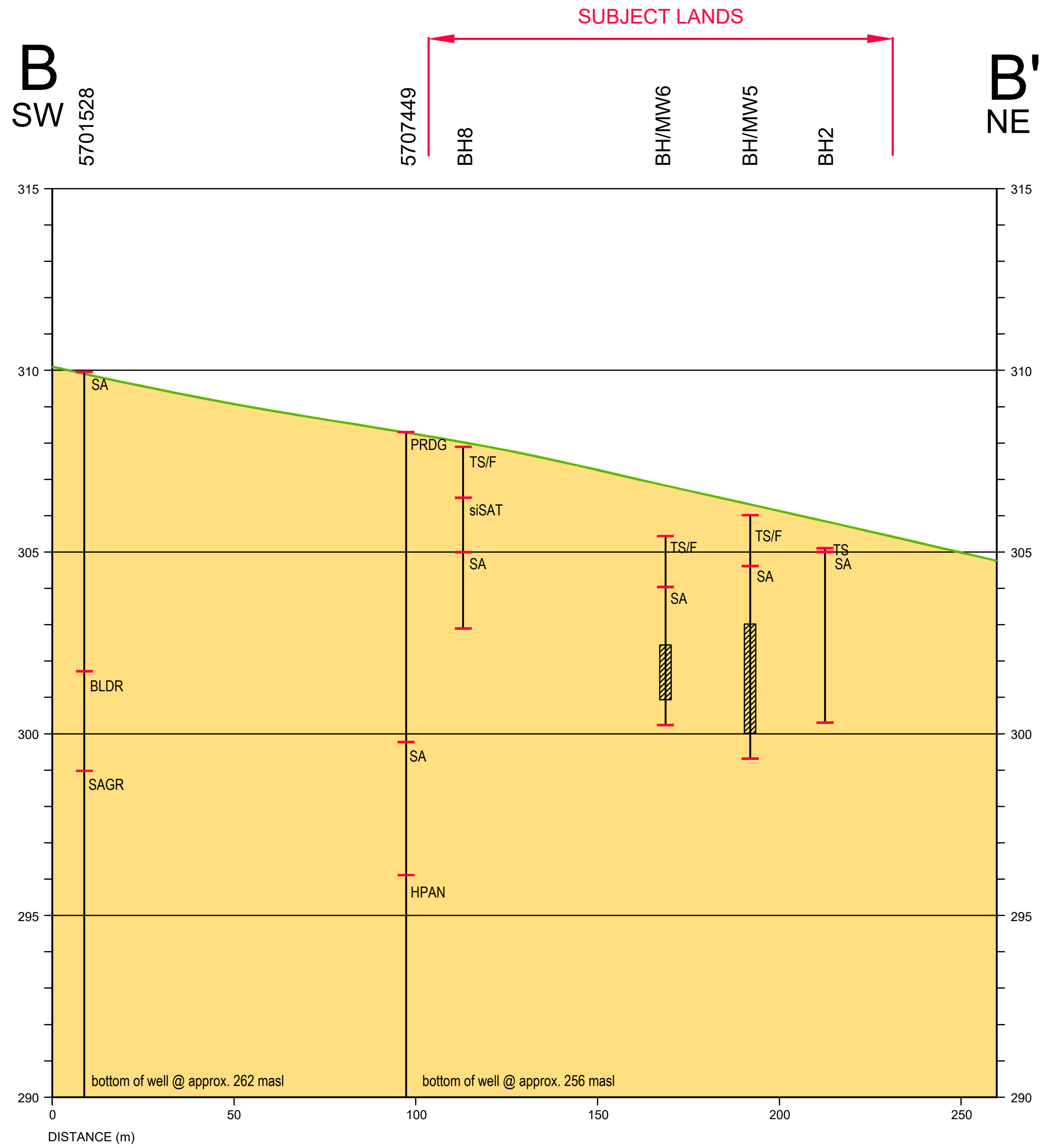
HYDROGEOLOGICAL STUDY

Figure Title

INTERPRETED GEOLOGICAL CROSS-SECTION A-A'

Drawn	Checked	Date	Figure No.
SK	SC	JUNE 2021	6
Scale		Project No.	
1:2,000		300053318	

File Name: Nigel/Shared Work Areas/053318 Harvie Road/02_Production/053318 HG Study Drawing Set.dwg Date Plotted: May 27, 2021 - 1:17 PM



LEGEND

BH1	WELL NUMBER / ID
	EXISTING GROUND PROFILE
	GEOLOGICAL CONTACT
	MEASURED WATER LEVEL (APRIL 6, 2020)
	STATIC WATER LEVEL (MECP WELL RECORD)
	WELL SCREEN
	INTERPRETED STRATIGRAPHY

si	SILTY
sa	SANDY
cl	CLAYEY
TS	TOPSOIL
HPAN	HARD PAN
BLDR	BOULDERS
F	FILL
T	TILL
GR	GRAVEL
SA	SAND
Si	SILT
CL	CLAY
ST	STONES

SAND / SILT / GRAVEL

SILT CLAY TILL

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ASA DEVELOPMENT INC.
BARRIE, ONTARIO

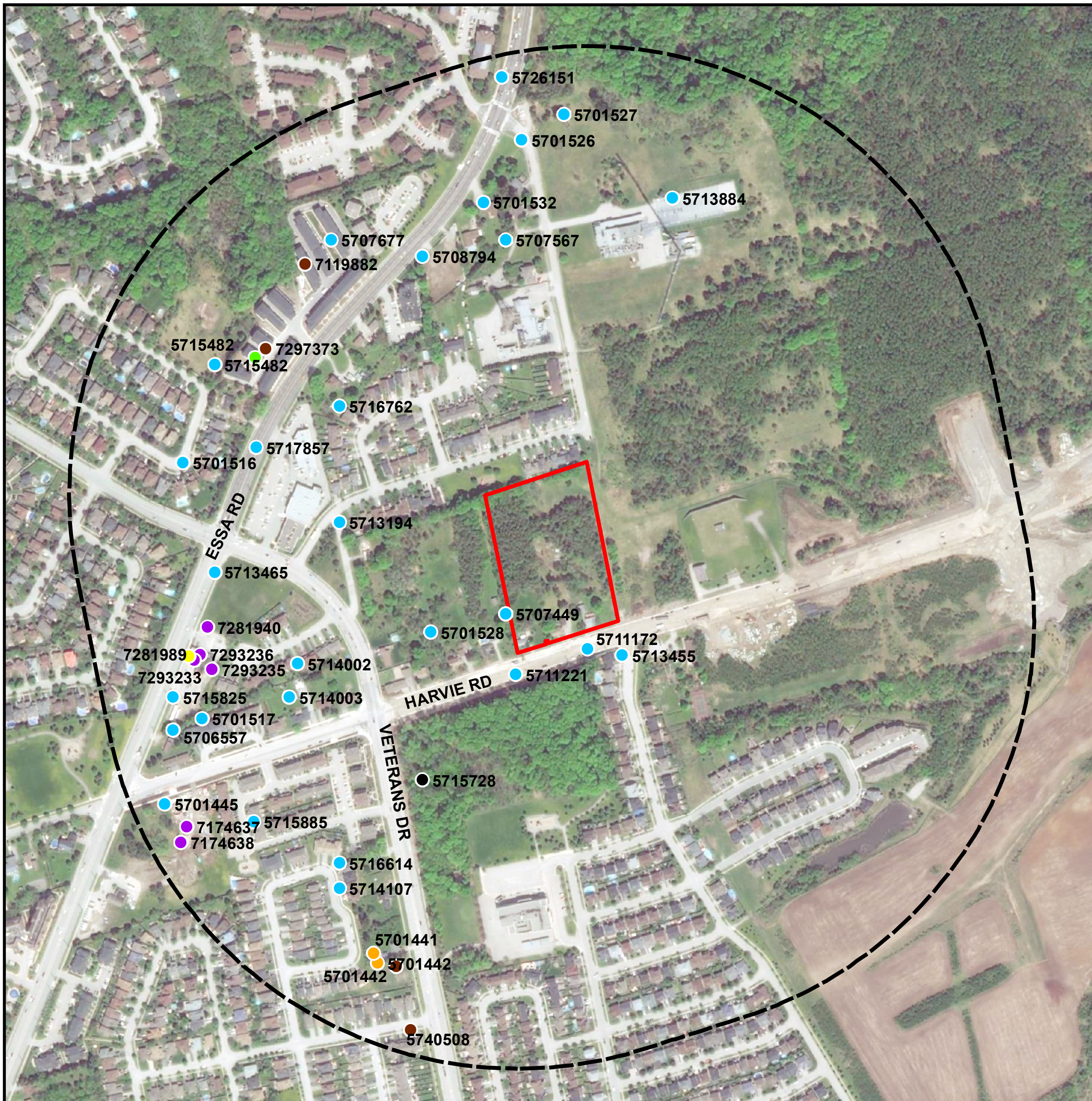
HYDROGEOLOGICAL STUDY

Figure Title

INTERPRETED GEOLOGICAL CROSS-SECTION B-B'

Drawn	Checked	Date	Figure No.
SK	SC	JUNE 2021	7
Scale		Project No.	
1:2,000		300053318	

File Name: Nigel/Shared Work Areas/053318 Harvie Road/02_Production/053318 HG Study Drawing Set.dwg Date Plotted: May 27, 2021 - 1:28 PM



LEGEND

SUBJECT LANDS

BUFFER (500m)

WELL USE:

- WATER SUPPLY
- OBSERVATION
- MONITORING AND TEST
- RECHARGE WELL
- TEST HOLE
- ABANDONED - SUPPLY
- ABANDONED - OTHER

0 25 50 100 150 200 250 300 350 400 450 500

MetRES

N

BURNSIDE

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ASA DEVELOPMENT INC.
BARRIE, ONTARIO

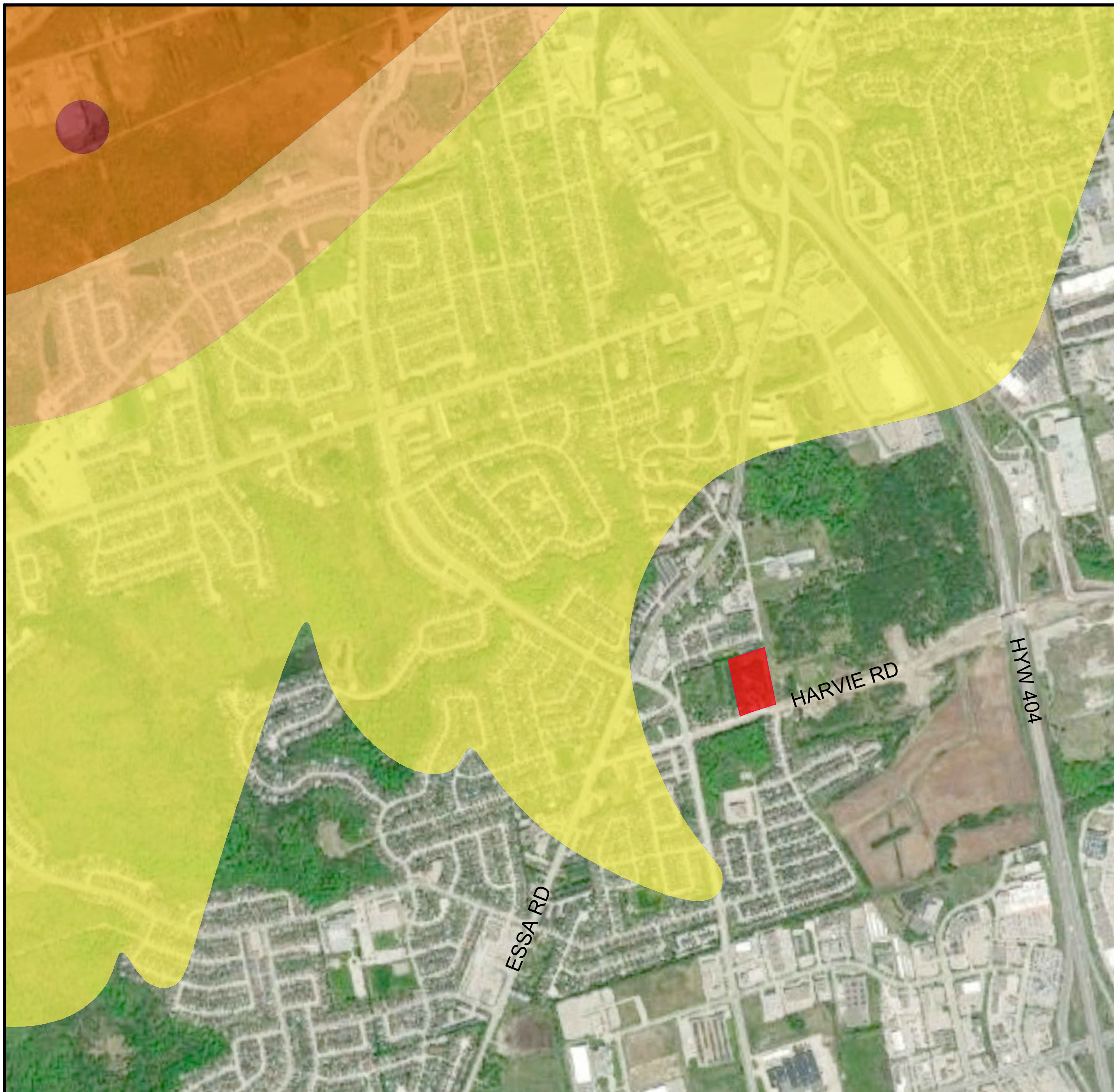
HYDROGEOLOGICAL STUDY

Figure Title:

MECP WELL RECORD LOCATIONS

Drawn	Checked	Date	Figure No.
SK	SC	JUNE 2021	8
Scale		Project No.	
1:7,000		300053318	

File Path: Nigel/Shared Work Areas/053318 Harvie Rd/06_GIS/053318 MECP Well Locations.mxd



LEGEND

- SUBJECT LANDS
- WHPA A (100m RADIUS)
- WHPA B (2 YEAR TIME OF TRAVEL)
- WHPA C (5 YEAR TIME OF TRAVEL)
- WHPA D (25 YEAR TIME OF TRAVEL)

0 400 800 1,200 1,600
Metres

N

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ASA DEVELOPMENT INC.
BARRIE, ONTARIO

HYDROGEOLOGICAL STUDY

Figure Title

WELLHEAD PROTECTION AREAS

Drawn	Checked	Date	Figure No.
SK	SC	JUNE 2021	9
Scale		Project No.	
1:20,000		300053318	

File Name: Nigel/Shared Work Areas/053318 Harvie Road/02_Production/053318 HG Study Drawing Set.dwg Date Plotted: May 27, 2021 - 1:34 PM

LEGEND

SUBJECT LANDS

HIGHLY VULNERABLE AQUIFER

0 100 200 400

MetRES

N

BURNSIDE

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ASA DEVELOPMENT INC.
BARRIE, ONTARIO

HYDROGEOLOGICAL STUDY

Figure Title:

AQUIFER VULNERABILITY

Drawn	Checked	Date	Figure No.
SK	SC	JUNE 2021	10
Scale		Project No.	
1:5,000		300053318	

File Path: Nigel/Shared Work Areas/053318 Harvie Rd/06_GIS/053318 Aquifer Vulnerability.mxd

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Appendix A

Borehole Logs

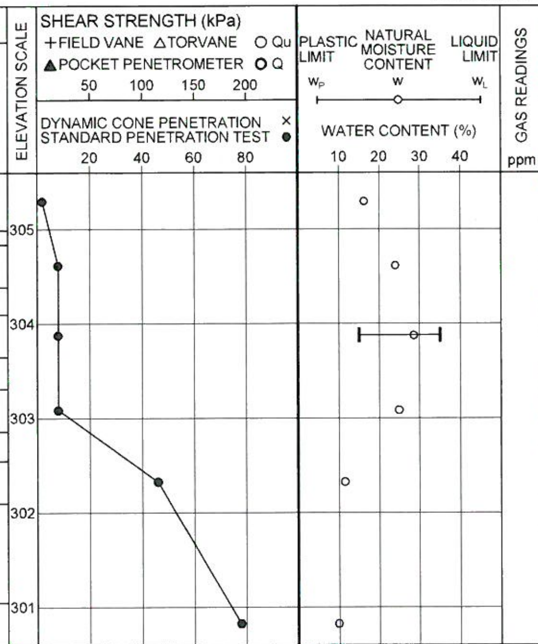
Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 1

17T 603735E 4911115N

PROJECT Proposed Residential Subdivision
LOCATION 108, 116, 122 Harvie Road, Barrie Ontario
BORING METHOD Continuous Flight Solid Stem Augers
BORING DATE December 18, 2020
PML REF. 20BF059
ENGINEER GW
TECHNICIAN SB

DEPTH / ELEV (metres)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER OBSERVATIONS AND REMARKS
	SURFACE ELEVATION 305.60				
0.08 / 305.52	TOPSOIL: Black, silty sand, trace organics, frozen	1	SS	2	
0.70 / 304.90	SILTY SAND: Very loose, brown, silty sand, trace organics, frozen				
	LAYERED SILTY CLAY/CLAYEY SILT: Firm, brown, silty clay to clayey silt, trace sand, sand seam, APL to WTPL	2	SS	8	
		3	SS	8	First water strike at 1.8 m
		4	SS	8	
2.9 / 302.7	SAND: Dense to very dense, light brown, sand, trace to some silt, silt seams, moist	5	SS	46	
		6	SS	78	
5.0 / 300.6	BOREHOLE TERMINATED AT 5.0 m				Upon completion of augering No water No cave



GRAIN SIZE DISTRIBUTION (%) GR SA SI&CL

Depth scale (m): 0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0

NOTES

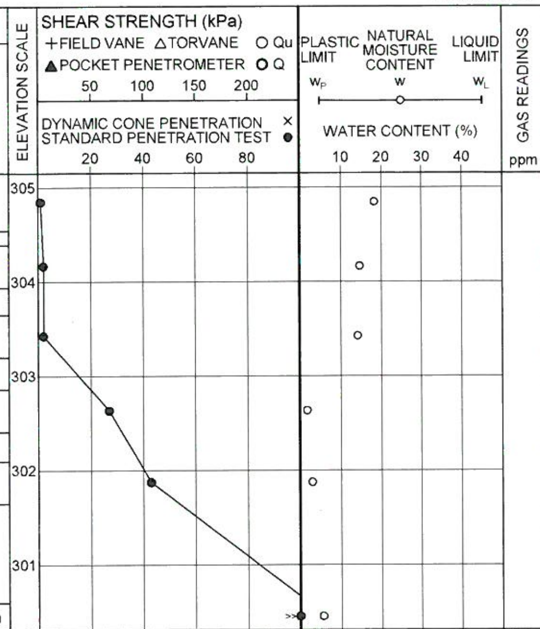
Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 2

17T 603707E 4911189N

PROJECT Proposed Residential Subdivision
LOCATION 108, 116, 122 Harvie Road, Barrie Ontario
BORING METHOD Continuous Flight Solid Stem Augers
BORING DATE December 21, 2020
PML REF. 20BF059
ENGINEER GW
TECHNICIAN SB

DEPTH / ELEV (metres)	SOIL PROFILE – DESCRIPTION	STRAT PLOT	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER OBSERVATIONS AND REMARKS
	SURFACE ELEVATION 305.15					
0.10 / 305.05	TOPSOIL: Black, silty sand, trace organics, frozen		1	SS	1	
	SAND: Very loose to very dense, brown to light brown, sand, trace to some silt, frozen to moist		2	SS	2	
			3	SS	2	
			4	SS	27	
			5	SS	43	
4.8 / 300.3			6	SS	83/290mm	
	BOREHOLE TERMINATED AT 4.8 m					Upon completion of augering No water No cave



Depth scale (m): 0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0, 11.0, 12.0, 13.0, 14.0, 15.0

NOTES

[illegible]

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE/MONITORING WELL NO. 3

17T 603692E 4911266N

PROJECT Proposed Residential Subdivision
LOCATION 108, 116, 122 Harvie Road, Barrie Ontario
BORING METHOD Continuous Flight Solid Stem Augers
BORING DATE December 21, 2020
PML REF. 20BF059
ENGINEER GW
TECHNICIAN SB

SURFACE ELEVATION 304.20

DEPTH / ELEV (metres)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT	GAS READINGS (ppm)	GROUND WATER OBSERVATIONS AND REMARKS
0.46 / 303.74	TOPSOIL: Black, silty sand, trace organics, frozen	1	SS	2		0	Stick-up casing; Concrete; Bentonite seal
1.4 / 302.8	FILL: Dark brown, silty sand, frozen	2	SS	1		0	
2.1 / 302.1	SILTY SAND: Loose, brown, silty sand, trace clay, moist	3	SS	5		30	
5.2 / 299.0	SAND: Loose to compact, light brown, sand, trace to some silt, moist	4	SS	4		20	50 mm slotted pipe; Filter sand
		5	SS	13		10	
		6	SS	29		0	
	BOREHOLE TERMINATED AT 5.2 m						Upon completion of augering No water No cave Water Level Readings: Date / Depth / Elev. 2020-01-07 / Dry / -

Legend: SHEAR STRENGTH (kPa): + FIELD VANE, △ TORVANE, ○ Qu, ▲ POCKET PENETROMETER, ● Q (50, 100, 150, 200); DYNAMIC CONE PENETRATION ×; STANDARD PENETRATION TEST ● (20, 40, 60, 80); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT W_L; WATER CONTENT (%) (10, 20, 30, 40); GRAIN SIZE DISTRIBUTION (%) GR SA SI&CL.

NOTES

Peto MacCallum Ltd.
CONSULTING ENGINEERS

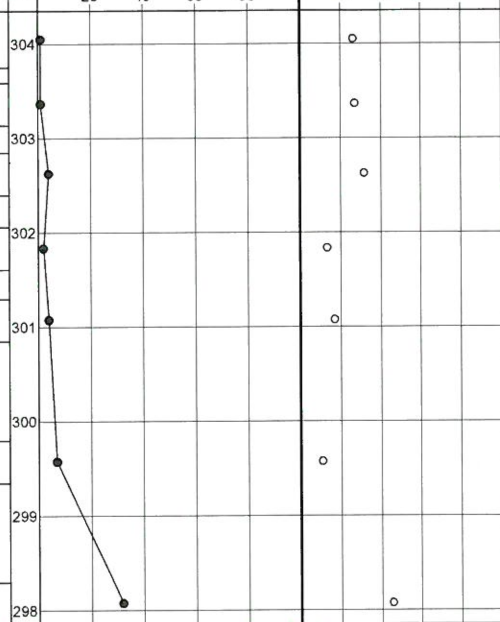
LOG OF BOREHOLE NO. 4

17T 603664E 4911262N

PROJECT Proposed Residential Subdivision
LOCATION 108, 116, 122 Harvie Road, Barrie Ontario
BORING METHOD Continuous Flight Solid Stem Augers
BORING DATE December 21, 2020
PML REF. 20BF059
ENGINEER GW
TECHNICIAN SB

SURFACE ELEVATION 304.35

DEPTH / ELEV (metres)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%) (approx.)	GROUND WATER OBSERVATIONS AND REMARKS
0.15 / 304.20	TOPSOIL: Black, sand, trace silt, frozen					
	FILL: Dark brown, sandy silt to silty sand, frozen to moist	1	SS	1		
		2	SS	1		First water strike at 0.9 m
1.4 / 303.0	SAND: Very loose to dense, brown, sand, trace to some silt, moist	3	SS	4		
		4	SS	2		
		5	SS	4		
		6	SS	7		
		7	SS	32		
6.5 / 297.9	BOREHOLE TERMINATED AT 6.5 m					Upon completion of augering No water No cave



NOTES

Peto MacCallum Ltd. CONSULTING ENGINEERS

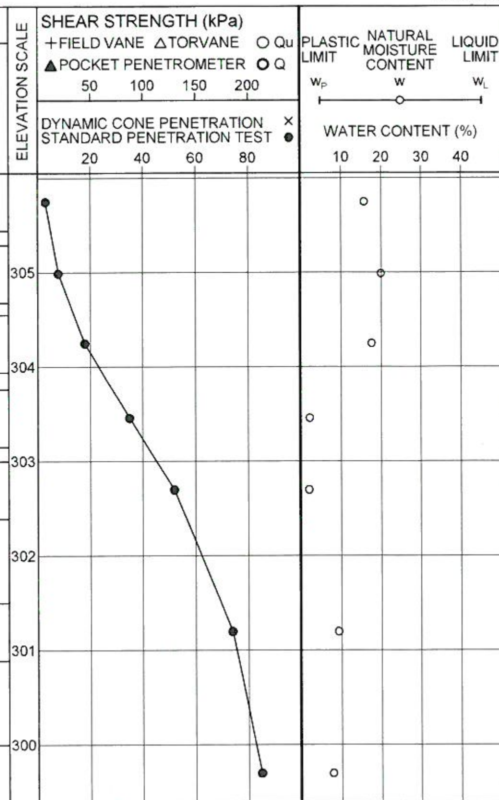
LOG OF BOREHOLE/MONITORING WELL NO. 5

17T 603709E 4911142N

PROJECT Proposed Residential Subdivision
LOCATION 108, 116, 122 Harvie Road, Barrie Ontario
BORING METHOD Continuous Flight Solid Stem Augers
BORING DATE December 21, 2020
PML REF. 20BF059
ENGINEER GW
TECHNICIAN SB

SURFACE ELEVATION 306.05

DEPTH / ELEV (metres)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GAS READINGS (ppm)	GROUND WATER OBSERVATIONS AND REMARKS
0.10 / 305.95	TOPSOIL: Black, silty sand, trace organics, frozen	1	SS	3	35	Stick-up casing; Concrete
	FILL: Dark brown to grey, silty clay, frozen	2[1]	SS	8	5	Bentonite seal
1.4 / 304.7	SAND: Compact to very dense, light brown, sand, trace to some silt, moist	3	SS	18	15	
		4	SS	35	15	
		5	SS	52	20	
		6	SS	74	10	50 mm slotted pipe; Filter sand
		7[1]	SS	85	0	
6.7 / 299.4	BOREHOLE TERMINATED AT 6.7 m					Upon completion of augering No water No cave Water Level Readings: Date Depth Elev. 2020-01-07 Dry -



NOTES 1. Sample submitted for chemical testing

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE/MONITORING WELL NO. 6

17T 603671E 4911177N

PROJECT Proposed Residential Subdivision
LOCATION 108, 116, 122 Harvie Road, Barrie Ontario
BORING METHOD Continuous Flight Solid Stem Augers
BORING DATE December 21, 2020
PML REF. 20BF059
ENGINEER GW
TECHNICIAN SB

DEPTH / ELEV (metres)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	NATURAL MOISTURE CONTENT (%)	GAS READINGS (ppm)	GROUND WATER OBSERVATIONS AND REMARKS
	SURFACE ELEVATION 305.50						
0.05 / 305.45	TOPSOIL: Black, silty sand, trace organics, frozen	1	SS	14	~16	20	Stick-up casing; Concrete
	FILL: Brown, sand, trace silt, frozen	2[1]	SS	18	~5	5	Bentonite seal
1.4 / 304.1	SAND: Compact to very dense, brown, sand, trace to some silt, moist with wet seam	3	SS	26	~6	15	
		4	SS	37	~6	15	
		5	SS	53	~5	15	50 mm slotted pipe; Filter sand
		6[1]	SS	54	~6	0	
5.2 / 300.3	BOREHOLE TERMINATED AT 5.2 m						Upon completion of augering: No water; No cave

Water Level Readings:

Date	Depth	Elev.
2020-01-07	Dry	-

NOTES 1. Sample submitted for chemical testing

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE/MONITORING WELL NO. 7

17T 603654E 4911091N

PROJECT Proposed Residential Subdivision
LOCATION 108, 116, 122 Harvie Road, Barrie Ontario
BORING METHOD Continuous Flight Solid Stem Augers
BORING DATE December 22, 2020
PML REF. 20BF059
ENGINEER GW
TECHNICIAN SB

SURFACE ELEVATION 307.70

DEPTH / ELEV (metres)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	NATURAL MOISTURE CONTENT (approx. %)	GAS READINGS (ppm)	GROUND WATER OBSERVATIONS AND REMARKS
0.15 / 307.55	TOPSOIL: Brown, silty sand, trace organics, frozen	1	SS	2		30	Stick-up casing; Concrete; Bentonite seal
	FILL: Light brown, sandy silt, trace gravel, frozen to moist	2	SS	10		25	
		3	SS	21		25	
2.1 / 305.6	SAND AND SILT TILL: Very dense, light brown, sand and silt, trace gravel, trace clay, cobbles and boulders, moist	4	SS	55		25	
		5	SS	50/290mm		35	50 mm slotted pipe; Filter sand
		6	SS	69		15	
5.2 / 302.5	BOREHOLE TERMINATED AT 5.2 m						Upon completion of augering: No water; No cave

Water Level Readings:

Date	Depth	Elev.
2021-01-07	Dry	-

SHEAR STRENGTH (kPa): +FIELD VANE △TORVANE ○ Qu ▲POCKET PENETROMETER ● Q — 50 100 150 200
DYNAMIC CONE PENETRATION × STANDARD PENETRATION TEST ● — 20 40 60 80
PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L — WATER CONTENT (%) 10 20 30 40
GRAIN SIZE DISTRIBUTION (%) GR SA SI&CL

NOTES

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE/MONITORING WELL NO. 7A

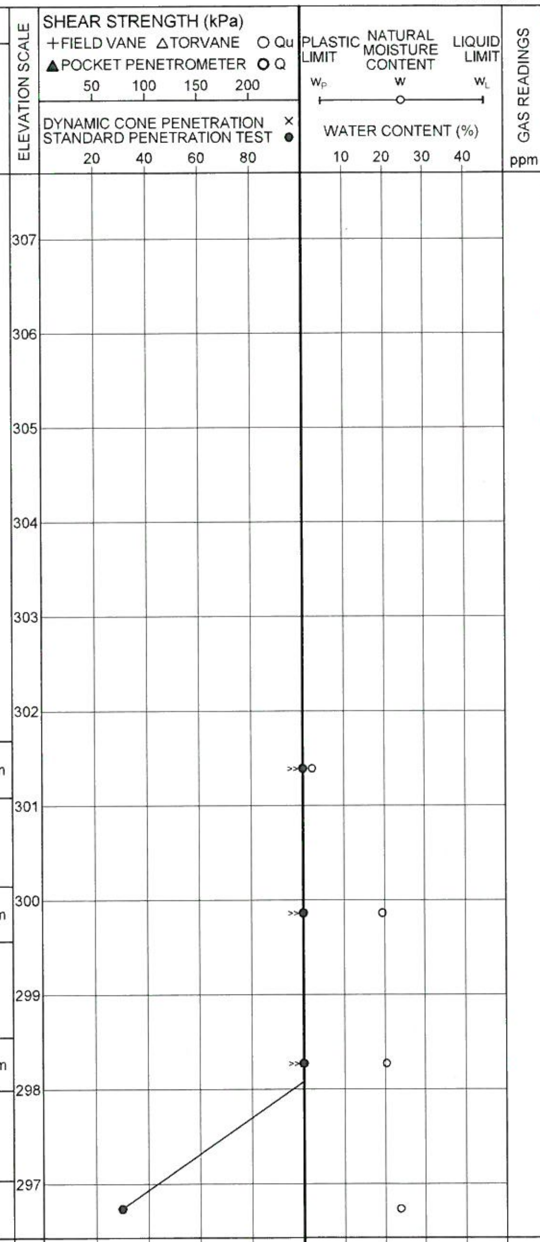
17T 603654E 4911091N

PROJECT Proposed Residential Subdivision
LOCATION 108, 116, 122 Harvie Road, Barrie Ontario
BORING METHOD Continuous Flight Hollow Stem Augers
BORING DATE January 12, 2021
PML REF. 20BF059
ENGINEER GW
TECHNICIAN SB

DEPTH / ELEV (metres)	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER OBSERVATIONS AND REMARKS
	SURFACE ELEVATION 307.70				Stick-up casing; Concrete
	Unsampled to 6.0 m. Drilled 1 m North from BH/MW7 (see BH/MW7)				Bentonite seal
6.0 / 301.7	SAND: Very dense to dense, light brown to brown sand, trace to some silt, moist to wet	7	SS	85/595 mm	
		8	SS	89/580 mm	
		9	SS	73/560 mm	50 mm slotted pipe; Filter sand; First ground water strike at 9.2 m
		10	SS	30	
11.3 / 296.4	BOREHOLE TERMINATED AT 11.3 m				Upon completion of augering Water at 8.6 m; No cave

Water Level Readings:

Date	Depth	Elev.
2021-01-20	8.6	299.1



NOTES

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 8

17T 603628E 4911135N

PROJECT Proposed Residential Subdivision

LOCATION 108, 116, 122 Harvie Road, Barrie Ontario

BORING METHOD Continuous Flight Solid Stem Augers

BORING DATE December 22, 2020

PML REF. 20BF059

ENGINEER GW

TECHNICIAN SB

SURFACE ELEVATION 307.90

DEPTH / ELEV (metres)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT
0.15 / 307.75	TOPSOIL: Black, silty sand, trace organics, frozen				
	FILL: Dark brown, sand, some silt, trace gravel, frozen to moist	1	SS	3	
		2	SS	6	
1.4 / 306.5	SILTY SAND TILL: Compact to dense, brown, silty sand, trace clay, trace gravel, cobbles and boulders, moist	3	SS	14	
		4	SS	37	
2.9 / 305.0	SAND: Very dense, brown, sand, trace to some silt, moist	5	SS	65	
		6	SS	59	
5.0 / 302.9	BOREHOLE TERMINATED AT 5.0 m				

GROUND WATER OBSERVATIONS AND REMARKS

Upon completion of augering
No water
No cave

NOTES

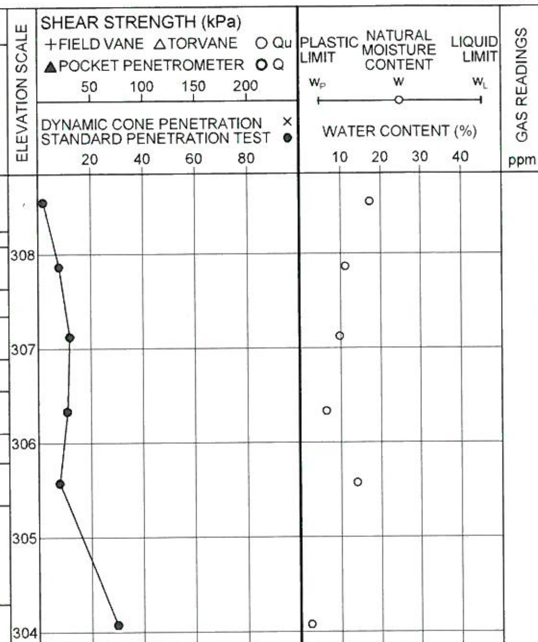
Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 9

17T 603645E 4911241N

PROJECT Proposed Residential Subdivision
LOCATION 108, 116, 122 Harvie Road, Barrie Ontario
BORING METHOD Continuous Flight Solid Stem Augers
BORING DATE December 21, 2020
PML REF. 20BF059
ENGINEER GW
TECHNICIAN SB

DEPTH / ELEV (metres)	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER OBSERVATIONS AND REMARKS
	SURFACE ELEVATION 308.85				
0.15 / 308.70	TOPSOIL: Black, sand, trace silt, trace organics, frozen	1	SS	2	
	FILL: Dark brown, sand, trace silt, frozen to moist	2	SS	8	First water strike at 0.9 m
1.4 / 307.5	SILTY SAND TILL: Compact, brown, silty sand, trace clay, trace gravel, cobbles and boulders, moist	3	SS	12	
2.1 / 306.8	SAND: Loose to compact, light brown, sand, trace to some silt, moist	4	SS	11	
		5	SS	8	
		6	SS	30	
5.0 / 303.9	BOREHOLE TERMINATED AT 5.0 m				Upon completion of augering No water No cave



NOTES

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Appendix B

MECP Water Well Records

Appendix B

TOWNSHIP CON LOT	UTM	DATE CNTR	CASING DIA	WATER	PUMP TEST	WELL USE	SCREEN	WELL	FORMATION
BARRIE CITY	17 603423 4911554 W	2008/06 2514	36			OT		7118645 (Z54586) A048117 A	0056
BARRIE CITY	17 603373 4911544 W	2008/06 2514	36					7119882 (Z54587) A048118 A	0051
BARRIE CITY (INNISFI	17 603267 4911105 W	2017/10 6946						7304389 (C33355) A203404 P	
INNISFIL TOWNSHIP	17 603256 4911107 W	2017/01 7241	1.5			TH MO	0005 10	7281940 (Z251037) A195298	BRWN GRVL SAND DNSE 0001 GREY SILT FSND SOFT 0015
INNISFIL TOWNSHIP	17 603231 4910867 W	2011/11 7241	1.5			MT	0010 10	7174637 (Z143415) A126470	BRWN FILL 0010 GREY SILT CLAY TILL 0020
INNISFIL TOWNSHIP	17 603313 4911431 W	2015/03 7190	0.75			MT	0012	7240101 (Z202347) A177433	BRWN LOAM 0006 BRWN SAND SILT GRVL 0020
INNISFIL TOWNSHIP	17 603500 4910622 W	2005/07 3108				NU		5740507 (Z30595) A	PRDG 0025
INNISFIL TOWNSHIP	17 603233 4911072 W	2017/01 7241	1.5			MN DE	0005 10	7281989 (Z251042) A195299	BRWN GRVL SAND DNSE 0001 GREY SILT FSND SOFT 0015
INNISFIL TOWNSHIP	17 603236 4911060 W	2017/06 7241	1.25			TH MO	0004 10	7293233 (Z254097) A208806	BRWN SILT CLAY 0005 GREY SILT SAND 0014
INNISFIL TOWNSHIP	17 603240 4911067 W	2017/06 7241	1.25			TH MO	0004 10	7293234 (Z261005) A208805	BRWN SILT SAND 0005 GREY SILT SAND 0014
INNISFIL TOWNSHIP	17 603247 4911074 W	2017/06 7241	1.25			TH MO	0005 10	7293236 (Z261006) A208803	BRWN SILT SAND 0005 GREY SILT SAND 0015
INNISFIL TOWNSHIP	17 603224 4910848 W	2011/11 7241	1.5			MT	0010 10	7174638 (Z143414) A126471	BRWN FILL 0010 GREY SILT CLAY TILL 0020
INNISFIL TOWNSHIP CON 12 005	17 603509 4910438 W	1966/01 2514	6	FR 0161	139/155/10/1:0	DO	0161 3	5701446 ()	PRDG 0033 MSND 0063 BLUE CLAY 0068 BRWN CLAY GRVL 0086 YLLW MSND 0164 FSND SILT 0171
INNISFIL TOWNSHIP CON 12 005	17 603414 4910793 W	1977/03 3660	5	FR 0153	140/145/6/1:0	DO	0161 3	5714107 ()	RED SAND 0015 GREY CLAY GRVL 0040 BRWN FSND CLAY 0050 BLUE CLAY 0092 BRWN SAND CLAY 0153 GREY MSND 0158 BRWN MSND 0164

TOWNSHIP CON LOT	UTM	DATE CNTR	CASING DIA	WATER	PUMP TEST	WELL USE	SCREEN	WELL	FORMATION
INNISFIL TOWNSHIP CON 12 005	17 603455 4910715 W	1960/10 3512	4					5701441 () A	FSND 0100 BLUE CLAY 0120
INNISFIL TOWNSHIP CON 12 005	17 603311 4910873 W	1978/12 3135	5	UK 0155	155/165/10/2:0	CO DO	0181 4	5715885 ()	BRWN LOAM 0001 BRWN SAND CLAY 0032 GREY CLAY 0040 BRWN SAND DRY 0155 BRWN SAND 0185
INNISFIL TOWNSHIP CON 12 005	17 603414 4910823 W	1980/03 3660	5	FR 0153	147/155/5/1:0	DO	0165 3	5716614 ()	BLCK LOAM 0001 BRWN CLAY 0030 BRWN SAND 0070 BLUE CLAY 0080 BRWN SAND CLAY 0105 BRWN SAND DRY 0153 GREY FSND WBRG 0165 BRWN MSND WBRG 0168
INNISFIL TOWNSHIP CON 12 005	17 603204 4910894 W	1964/10 2514	6	FR 0077	48/70/10/2:0	ST DO	0077 3	5701445 ()	LOAM 0001 FILL 0005 BRWN CLAY BLDR 0015 BLUE CLAY BLDR 0040 MSND 0080
INNISFIL TOWNSHIP CON 12 005	17 603483 4910699 W	2005/07 3108				NU		5740511 (Z30600) A	PRDG 0032
INNISFIL TOWNSHIP CON 12 005	17 603460 4910703 W	1960/11 3512	5					5701442 () A	FSND 0100 BLUE CLAY 0150 FSND 0250 BLUE CLAY 0350 FSND 0430 BLUE CLAY 0450 FSND 0477
INNISFIL TOWNSHIP CON 12 005	17 603491 4910612 W	2005/07 3108						5740508 (Z30593) A	PRDG 0031
INNISFIL TOWNSHIP CON 12 006	17 603514 4910923 W	1978/09 2801				MN		5715728 ()	BRWN CLAY BLDR GRVL 0015 GREY CLAY STKY 0028 GREY SILT CLAY SOFT 0064 GREY CLAY 0083 BRWN SAND GRVL PCKD 0186 BRWN SAND SILT GRVL 0224 GREY CLAY 0334 GREY CLAY SOFT 0386 GREY CLAY HARD 0462 GREY CLAY SILT SAND 0514 GREY CLAY HARD 0516
INNISFIL TOWNSHIP CON 12 006	17 603754 4911073 W	1975/06 3203	5	FR 0105	105/130/5/2:0	DO	0143 3	5713455 ()	BRWN CLAY SAND 0008 BRWN SAND 0036 BRWN CLAY 0037 GREY CLAY 0078 BRWN SAND 0146
INNISFIL TOWNSHIP CON 13	17 603326 4911442 W	2017/04 1851	6.25					7297373 (Z242509) A	
INNISFIL TOWNSHIP CON 13 005	17 603226 4911305 W	1951/10 5510	4	FR 0065	57/57/4/0:30	ST DO	0063 12	5701516 ()	LOAM MSND 0002 MSND CLAY STNS 0019 CLAY MSND 0043 MSND 0075
INNISFIL TOWNSHIP CON 13 005	17 603249 4910997 W	1951/09 5510	4	FR 0067	51/56/4/0:30	PS	0060 10	5701517 ()	LOAM 0002 BRWN CLAY MSND STNS 0028 BLUE CLAY STNS GRVL 0042 MSND 0046 FSND 0088
INNISFIL TOWNSHIP CON 13 005	17 603264 4911173 W	1975/09 3203	5	FR 0050	45/58/4/2:0	DO	0069 4	5713465 ()	BLCK LOAM 0001 BRWN CLAY 0022 BRWN SAND 0073
INNISFIL TOWNSHIP CON 13 005	17 603214 4910983 W	1969/08 4608	30	FR 0042 FR 0052	42/48//1:0	DO		5706557 ()	BRWN CLAY STNS 0015 GREY CLAY 0035 GREY MSND 0052
INNISFIL TOWNSHIP CON 13 005	17 603214 4911023 W	1978/07 4608	30	FR 0055	10///:	DO		5715825 ()	GREY CLAY HARD STNY 0055 SAND 0065
INNISFIL TOWNSHIP CON 13 005	17 603261 4911056 W	2017/06 7241	1.25			TH MO	0004 10	7293235 (Z261007) A208804	BRWN SILT SAND 0005 GREY SILT SAND 0014
INNISFIL TOWNSHIP CON 13 005	17 603354 4911023 W	1976/12 3742	30	FR 0008	6/20/3/4:0	DO		5714003 ()	BRWN CLAY 0005 BLUE CLAY 0026

TOWNSHIP CON LOT	UTM	DATE CNTR	CASING DIA	WATER	PUMP TEST	WELL USE	SCREEN	WELL	FORMATION
INNISFIL TOWNSHIP CON 13 005	17 603314 4911323 W	1981/12 2514	6	FR 0060	40/65/6/1:0	DO	0065 5	5717857 ()	PRDG 0021 BRWN SAND SILT CLAY 0045 GREN FSND 0070
INNISFIL TOWNSHIP CON 13 005	17 603364 4911063 W	1976/12 3742	30 24	FR 0008	6/30/3/4:0	DO		5714002 ()	BRWN CLAY 0005 BLUE CLAY 0037
INNISFIL TOWNSHIP CON 13 005	17 603264 4911423 W	1978/08 1204	5	FR	150/160/8/1:0	ST DO	0175 5	5715482 ()	PRDG 0007 GREY CLAY SAND HARD 0041 BRWN SAND SOFT 0070 GREY SILT 0078 GREY CLAY SILT LYRD 0097 BRWN SAND GRVL HARD 0170 BRWN FSND 0180
INNISFIL TOWNSHIP CON 13 006	17 603609 4911769 L	1989/09 3203		FR 0168	158/162/7/:	DO		5727766 (66197)	LOAM 0001 BRWN CLAY 0063 BRWN CLAY SAND 0085 BRWN CLAY 0089 BRWN SAND DRY 0161 BRWN SAND CLAY 0168 BRWN SAND 0183
INNISFIL TOWNSHIP CON 13 006	17 603609 4911769 L	1989/12 4919	30 30	UK 0032	32/45/10/1:0	DO		5726151 (62554)	BRWN SAND PCKD 0052
INNISFIL TOWNSHIP CON 13 006	17 603414 4911373 W	1980/06 3203	6	FR 0068	37/58/10/2:0	DO	0068 4	5716762 ()	BRWN SAND 0012 BRWN CLAY GRVL STNS 0029 GREY CLAY 0033 BRWN SAND CLAY 0063 BRWN SAND SLTY 0068 BRWN SAND CLN 0072 BRWN SAND CLAY 0072
INNISFIL TOWNSHIP CON 13 006	17 603633 4911693 W	1955/04 5510	4	FR 0177	138/143/5/1:0	DO		5701526 ()	LOAM MSND 0002 MSND GRVL 0048 GRVL 0053 MSND GRVL 0161 MSND 0177
INNISFIL TOWNSHIP CON 13 006	17 603684 4911724 W	1955/06 1637	4	FR 0074	74/86/2/1:0	DO	0087 5	5701527 ()	CSND STNS 0074 FSND 0085 CSND 0092
INNISFIL TOWNSHIP CON 13 006	17 603587 4911618 W	1964/04 2514	6	FR 0175	147/178/6/3:0	CO	0175 4	5701532 ()	LOAM 0001 BRWN CLAY MSND GRVL 0049 FSND 0170 MSND 0179
INNISFIL TOWNSHIP CON 13 006	17 603614 4911123 W	1970/08 1510	4	FR 0170	140/150/5/2:0	DO	0165 5	5707449 ()	PRDG 0028 GREY FSND 0040 GREY HPAN STNS 0150 MSND 0170
INNISFIL TOWNSHIP CON 13 006	17 603614 4911573 W	1970/10 4608	30	FR 0036 FR 0046	36/44/6/1:0	DO		5707567 ()	GREY MSND 0003 GREY GRVL STNS 0008 BRWN CLAY MSND 0036 GREY FSND 0046
INNISFIL TOWNSHIP CON 13 006	17 603404 4911573 W	1970/11 4608	30	FR 0028 FR 0040	28/36/6/1:15	DO		5707677 ()	BRWN CLAY 0025 GREY CLAY 0028 GREY MSND 0040
INNISFIL TOWNSHIP CON 13 006	17 603514 4911553 W	1972/05 4608	30	FR 0018	18/26/2/1:0	DO		5708794 ()	BRWN CLAY 0014 GREY GRVL 0030
INNISFIL TOWNSHIP CON 13 006	17 603614 4911123 W	1976/06 3203	5	FR 0120	120/145/6/1:10	DO	0158 3	5714186 ()	BRWN CLAY 0017 BRWN SAND CLAY 0048 GREY CLAY 0052 BRWN SAND 0158
INNISFIL TOWNSHIP CON 13 006	17 603814 4911623 W	1976/10 4816	6	FR 0210	144/175/8/2:0	CO DO	0201 5	5713884 ()	SAND 0009 CLAY GRVL 0032 FSND 0071 CLAY GRVL 0080 CSND 0140 MSND 0168 FSND 0185 MSND 0215 FSND 0230 CLAY SILT 0245
INNISFIL TOWNSHIP CON 13 006	17 603524 4911101 W	1956/11 1637	4	FR 0132	132/145/0/2:0	DO	0151 5	5701528 ()	CSND 0027 BLDR 0036 MSND GRVL 0156

TOWNSHIP CON LOT	UTM	DATE CNTR	CASING DIA	WATER	PUMP TEST	WELL USE	SCREEN	WELL	FORMATION

Notes:
UTM: UTM in Zone, Easting, Northing and Datum is NAD83; L: UTM estimated from Centroid of Lot; W: UTM not from Lot Centroid
DATE CNTR: Date Work Completedand Well Contractor Licence Number
CASING DIA: .Casing diameter in inches
WATER: Unit of Depth in Fee. See Table 4 for Meaning of Code

PUMP TEST: Static Water Level in Feet / Water Level After Pumping in Feet / Pump Test Rate in GPM / Pump Test Duration in Hour : Minutes
WELL USE: See Table 3 for Meaning of Code
SCREEN: Screen Depth and Length in feet
WELL: WEL (AUDIT #) Well Tag . A: Abandonment; P: Partial Data Entry Only
FORMATION: See Table 1 and 2 for Meaning of Code

1. Core Material and Descriptive terms

Code	Description	Code	Description	Code	Description	Code	Description	Code	Description
BLDR	BOULDERS	FCRD	FRACTURED	IRFM	IRON FORMATION	PORS	POROUS	SOFT	SOFT
BSLT	BASALT	FGRD	FINE-GRAINED	LIMY	LIMY	PRDG	PREVIOUSLY DUG	SPST	SOAPSTONE
CGRD	COARSE-GRAINED	FGVL	FINE GRAVEL	LMSN	LIMESTONE	PRDR	PREV. DRILLED	STKY	STICKY
CGVL	COARSE GRAVEL	FILL	FILL	LOAM	TOPSOIL	QRTZ	QUARTZITE	STNS	STONES
CHRT	CHERT	FLDS	FELDSPAR	LOOS	LOOSE	QSND	QUICKSAND	STNY	STONEY
CLAY	CLAY	FLNT	FLINT	LTCL	LIGHT-COLOURED	QTZ	QUARTZ	THIK	THICK
CLN	CLEAN	FOSS	FOSILIFEROUS	LYRD	LAYERED	ROCK	ROCK	THIN	THIN
CLYY	CLAYEY	FSND	FINE SAND	MARL	MARL	SAND	SAND	TILL	TILL
CMTD	CEMENTED	GNIS	GNEISS	MGRD	MEDIUM-GRAINED	SHLE	SHALE	UNKN	UNKNOWN TYPE
CONG	CONGLOMERATE	GRNT	GRANITE	MGVL	MEDIUM GRAVEL	SHLY	SHALY	VERY	VERY
CRYS	CRYSTALLINE	GRSN	GREENSTONE	MRBL	MARBLE	SHRP	SHARP	WBRG	WATER-BEARING
CSND	COARSE SAND	GRVL	GRAVEL	MSND	MEDIUM SAND	SHST	SCHIST	WDFR	WOOD FRAGMENTS
DKCL	DARK-COLOURED	GRWK	GREYWACKE	MUCK	MUCK	SILT	SILT	WTHD	WEATHERED
DLMT	DOLOMITE	GVLY	GRAVELLY	OBDN	OVERBURDEN	SLTE	SLATE		
DNSE	DENSE	GYPS	GYPSUM	PCKD	PACKED	SLTY	SILTY		
DRTY	DIRTY	HARD	HARD	PEAT	PEAT	SNDS	SANDSTONE		
DRY	DRY	HPAN	HARDPAN	PGVL	PEA GRAVEL	SNDY	SANDYOAPSTONE		

2. Core Color

Code	Description
WHIT	WHITE
GREY	GREY
BLUE	BLUE
GREN	GREEN
YLLW	YELLOW
BRWN	BROWN
RED	RED
BLCK	BLACK
BLGY	BLUE-GREY

3. Well Use

Code	Description	Code	Description
DO	Domestic	OT	Other
ST	Livestock	TH	Test Hole
IR	Irrigation	DE	Dewatering
IN	Industrial	MO	Monitoring
CO	Commercial	MT	Monitoring TestHole
MN	Municipal		
PS	Public		
AC	Cooling And A/C		
NU	Not Used		

4. Water Detail

Code	Description	Code	Description
FR	Fresh	GS	Gas
SA	Salty	IR	Iron
SU	Sulphur		
MN	Mineral		
UK	Unknown		

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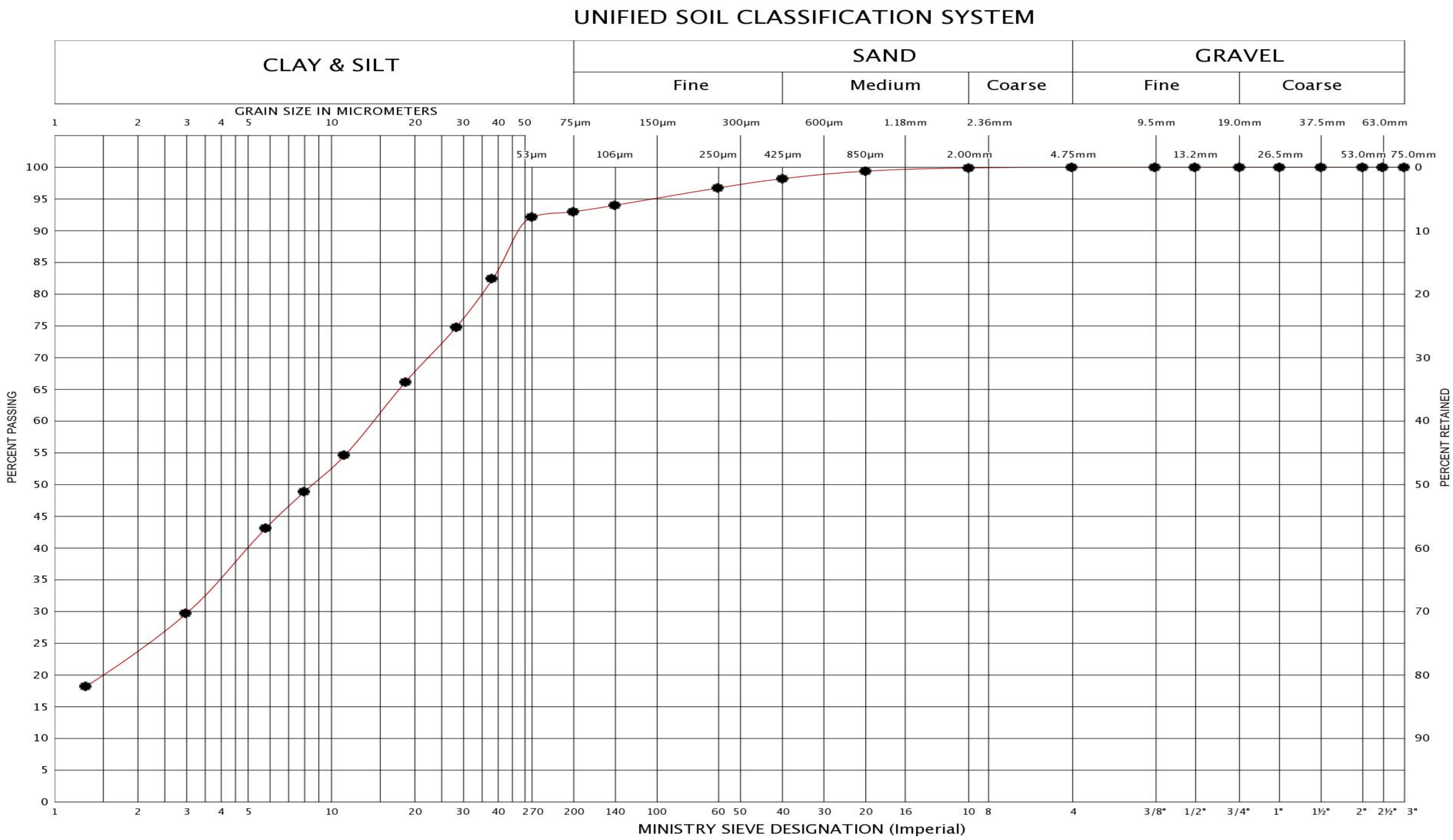
Appendix C

Grainsize Analysis



LEGEND		
	BH	1
	SAMPLE	3
	SYMBOL	⬢

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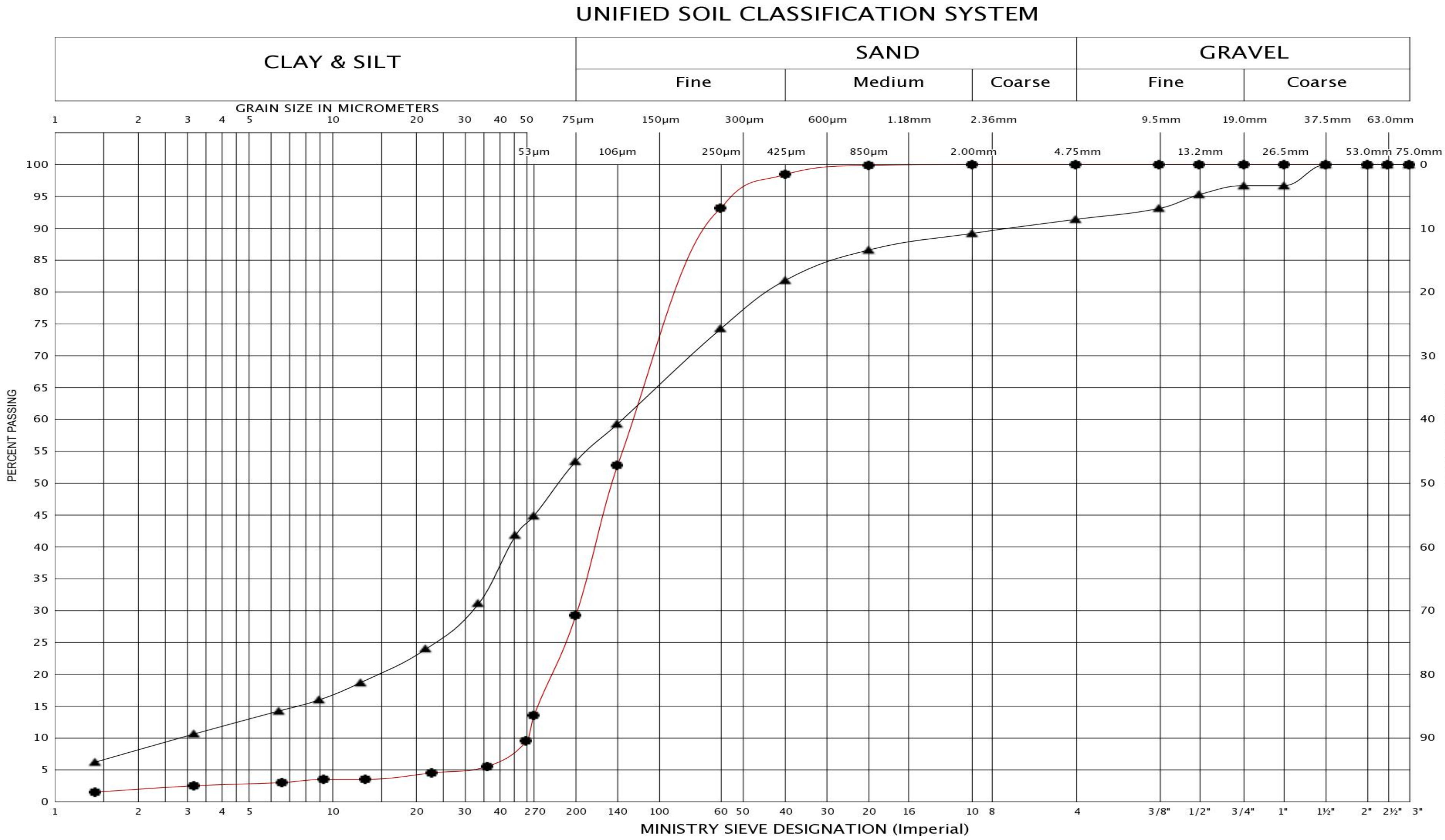
GRAIN SIZE DISTRIBUTION

CLAYEY SILT, Trace Sand

FIG No.: 2-1

Project No.: 20BF059



LEGEND	BH	BH/MW 7	8
	SAMPLE	4	4
	SYMBOL	▲	●

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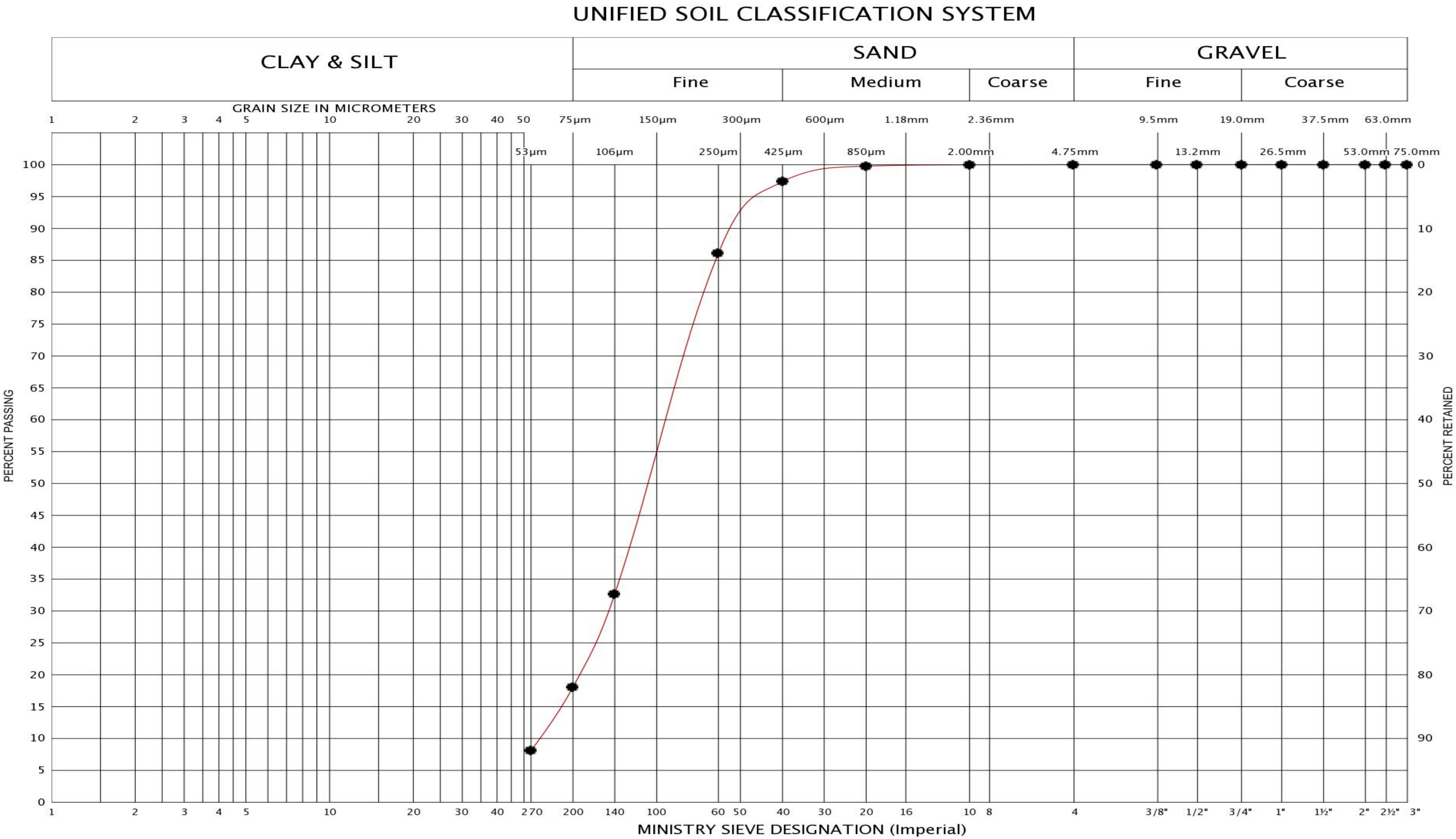
GRAIN SIZE DISTRIBUTION

TILL: Silt and Sand, Trace Gravel, Trace Clay / Silty Sand, Trace Clay

FIG No.: 2-3

Project No.: 20BF059



LEGEND	BH	BH/MW 3
	SAMPLE	4
	SYMBOL	⬢

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GRAIN SIZE DISTRIBUTION

SAND, Some Silt

FIG No.: 2-4

Project No.: 20BF059

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Appendix D

Groundwater Level Data

Appendix D

Table D-1: Groundwater Level Data

Well	Well Depth (mbgs)	Ground Surface Elevation (masl)	Dec 22, 2020 (Upon Completion of Well)		07-Jan-21		20-Jan-21		05-May-21	
			WL (mbgs)	Elevation	WL (mbgs)	Elevation	WL (mbgs)	Elevation	WL (mbgs)	Elevation
MW3	4.48	304.20	Dry	Dry	Dry	Dry	-	-	Dry	Dry
MW5	5.84	306.05	Dry	Dry	Dry	Dry	-	-	Dry	Dry
MW6	4.43	305.50	Dry	Dry	Dry	Dry	-	-	Dry	Dry
MW7	4.67	307.70	Dry	Dry	Dry	Dry	-	-	Dry	Dry
MW7A	10.62	307.70	-	-	-	-	8.60	299.10	8.56	299.14

"-" indicates data not available
mbgs - meters below ground surface
masl - meters above sea level
Ground elevations based on borehole logs.

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Appendix E

Appendix E

Water Balance Calculations

WATER BALANCE CALCULATIONS
ASA Development Inc.
108, 116 & 122 Harvie Road
Barrie, ON
PROJECT No.300053318

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TABLE E-1

Water Balance Components

Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 75 mm (urban lawn in sandy loam soils)

Precipitation data from Barrie WPCC Climate Station (1981 - 2010)

Potential Evapotranspiration Calculation	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Average Temperature (Degree C)	-7.7	-6.6	-2.1	5.6	12.3	17.9	20.8	19.7	15.3	8.7	2.7	-3.5	**6.9**
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.00	1.19	3.91	6.90	8.66	7.97	5.44	2.31	0.39	0.00	**36.8**
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	0.00	25.18	58.76	88.02	103.48	97.59	74.33	40.47	11.47	0.00	**499**
Adjusting Factor for U (Latitude 44^o 20' N)	0.81	0.82	1.02	1.13	1.27	1.29	1.3	1.2	1.04	0.95	0.8	0.76	
Adjusted Potential Evapotranspiration PET (mm)	0	0	0	28	75	114	135	117	77	38	9	0	**593**
WATER BALANCE COMPONENTS	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Precipitation (P)	83	62	58	62	82	85	77	90	94	78	89	74	**933**
Potential Evapotranspiration (PET)	0	0	0	28	75	114	135	117	77	38	9	0	**593**
P - PET	83	62	58	34	8	-29	-57	-27	17	39	80	74	**340**
Change in Soil Moisture Storage	0	0	0	0	0	-29	-46	0	17	39	19	0	**0**
Soil Moisture Storage max 75 mm	75	75	75	75	75	46	0	0	17	56	75	75	
Actual Evapotranspiration (AET)	0	0	0	28	75	114	123	90	77	38	9	0	**555**
Soil Moisture Deficit max 75 mm	0	0	0	0	0	29	75	75	58	19	0	0	
Water Surplus - available for infiltration or runoff	83	62	58	34	8	0	0	0	0	0	60	74	**378**
Potential Infiltration (based on MOE methodology*; independent of temperature)	58	43	41	24	5	0	0	0	0	0	42	52	**265**
Potential Direct Surface Water Runoff (independent of temperature)	25	19	17	10	2	0	0	0	0	0	18	22	**113**
IMPERVIOUS AREA WATER SURPLUS													
Precipitation (P)	933	mm/year											
Potential Evaporation (PE) from impervious areas (assume 15%)	140	mm/year											
P-PE (surplus available for runoff from impervious areas)	793	mm/year											

Assume January storage is 100% of Soil Moisture Storage
Soil Moisture Storage 75 mm <-- See "Water Holding Capacity" values in Table 3.1, MOE SWMPDM, 2003

*MOE SWM infiltration calculations

topography - rolling	0.2	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
soils - sandy loam	0.4	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
cover - urban lawn	0.1	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
Infiltration factor	**0.7**	

Latitude of site (or climate station) 44 ^{O} N.

WATER BALANCE CALCULATIONS
ASA Development Inc.
108, 116 & 122 Harvie Road
Barrie, ON
PROJECT No.300053318

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TABLE E-2

Water Balance Components

Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 300 mm (mature treess in sandy loam soils)

Precipitation data from Barrie WPCC Climate Station (1981 - 2010)

Potential Evapotranspiration Calculation	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Average Temperature (Degree C)	-7.7	-6.6	-2.1	5.6	12.3	17.9	20.8	19.7	15.3	8.7	2.7	-3.5	**6.9**
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.00	1.19	3.91	6.90	8.66	7.97	5.44	2.31	0.39	0.00	**36.8**
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	0.00	25.18	58.76	88.02	103.48	97.59	74.33	40.47	11.47	0.00	**499**
Adjusting Factor for U (Latitude 44^{o} 20' N)	0.81	0.82	1.02	1.13	1.27	1.29	1.3	1.2	1.04	0.95	0.8	0.76	
Adjusted Potential Evapotranspiration PET (mm)	0	0	0	28	75	114	135	117	77	38	9	0	**593**
WATER BALANCE COMPONENTS	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Precipitation (P)	83	62	58	62	82	85	77	90	94	78	89	74	**933**
Potential Evapotranspiration (PET)	0	0	0	28	75	114	135	117	77	38	9	0	**593**
P - PET	83	62	58	34	8	-29	-57	-27	17	39	80	74	**340**
Change in Soil Moisture Storage	0	0	0	0	0	-29	-57	-27	17	39	58	0	**0**
Soil Moisture Storage max 300 mm	300	300	300	300	300	271	214	187	203	242	300	300	
Actual Evapotranspiration (AET)	0	0	0	28	75	114	135	117	77	38	9	0	**593**
Soil Moisture Deficit max 300 mm	0	0	0	0	0	29	86	113	97	58	0	0	
Water Surplus - available for infiltration or runoff	83	62	58	34	8	0	0	0	0	0	22	74	**340**
Potential Infiltration (based on MOE metholodogy*; independent of temperature)	66	49	46	27	6	0	0	0	0	0	18	59	**272**
Potential Direct Surface Water Runoff (independent of temperature)	17	12	12	7	2	0	0	0	0	0	4	15	**68**
IMPERVIOUS AREA WATER SURPLUS													
Precipitation (P)	933	mm/year											
Potential Evaporation (PE) from impervious areas (assume 15%)	140	mm/year											
P-PE (surplus available for runoff from impervious areas)	793	mm/year											

Assume January storage is 100% of Soil Moisture Storage
Soil Moisture Storage 300 mm <-- See "Water Holding Capacity" values in Table 3.1, MOE SWMPDM, 2003

*MOE SWM infiltration calculations

topography - rolling land	0.2	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
soils - sandy loam	0.4	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
cover - woodlands	0.2	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
Infiltration factor	**0.8**	

Latitude of site (or climate station) 44^{O} N.

WATER BALANCE CALCULATIONS
ASA Development Inc.
108, 116 & 122 Harvie Road
Barrie, ON
PROJECT No.300053318

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TABLE E-3

Water Balance for Pre- and Post-Development Land Use Conditions (with no SWM/LID measures in place)

Land Use Description	Approx. Land Area* (m^2)	Estimated Impervious Fraction for Land Use	Estimated Impervious Area (m^2)	Runoff from Impervious Area** (m/a)	Runoff Volume from Impervious Area (m^3/a)	Estimated Pervious Area (m^2)	Runoff from Pervious Area** (m/a)	Runoff Volume from Pervious Area (m^3/a)	Infiltration from Pervious Area** (m/a)	Infiltration Volume from Pervious Area (m^3/a)	Total Runoff Volume (m^3/a)	Total Infiltration Volume (m^3/a)
Pre-Development Land Use												
Residential Impervious	2,130	1.00	2,130	0.793	1,689	0	0.113	0	0.265	0	1,689	0
Trees	19,350	0.00	0	0.793	0	19,350	0.068	1,315	0.272	5,259	1,315	5,259
Lawn/Open Space	3,320	0.00	0	0.793	0	3,320	0.113	376	0.265	878	376	878
TOTAL PRE-DEVELOPMENT	**24,800**		**2,130**		**1,689**	**22,670**		**1,691**		**6,137**	**3,380**	**6,137**
Post-Development Land Use (with no LID measures in place)												
Single Detached	3,366	0.60	2,020	0.793	1,601	1,346	0.113	153	0.265	356	1,754	356
Townhomes	17,800	0.59	10,502	0.793	8,328	7,298	0.113	828	0.265	1,931	9,155	1,931
Private Amenity	1,764	1.00	1,764	0.793	1,399	0	0.113	0	0.265	0	1,399	0
Parking and Roads and Road Widening	1,870	0.90	1,683	0.793	1,335	187	0.113	21	0.265	49	1,356	49
TOTAL POST-DEVELOPMENT	**24,800**		**15,969**		**12,663**	**8,831**		**1,001**		**2,337**	**13,664**	**2,337**
										% Change from Pre to Post	404	62
										Effect of development (with no mitigation)	4.0 times increase in runoff	62% reduction of infiltration

* data provided by Jones Consulting March 2021

** figures from Tables E-1 and E-2.

To balance pre- to post-,
the infiltration target (m^3/a)= **3,801**

Figure E-1
Pre-Development Monthly Site Water Balance

R.J. Burnside & Associates Limited