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Hydrogeological Assessment and Water Balance Avenia - Lisgar, City of Mississauga

Avenia Construction Inc.
(Mississauga)

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1.0 Introduction

R.J. Burnside & Associates Limited (Burnside) was retained by Avenia Construction Inc. (Mississauga) to complete a hydrogeological study of the Avenia - Lisgar property (herein referred to as the subject lands). The subject lands currently consist of vacant land that is proposed for residential development. The subject lands are approximately 6.66 ha in size and is roughly bounded by Lisgar Fields Community Park to the north, Lisgar Fields to the east, existing residential homes along Doug Leavens Boulevard to the south and existing residential homes and Lisgar Drive to the west (Figure 1). The subject lands are located within the jurisdiction of Conservation Halton (CH).

The purpose of the hydrogeological assessment is to provide site-specific soil and groundwater information for the subject lands in support of draft plan approval. The hydrogeological assessment was designed to characterize the geological and hydrogeological conditions on the subject lands, identify potential development impacts on local surface water and groundwater resources, and recommend mitigation measures to address potential impacts. As part of the assessment, water balance calculations have been completed to determine the pre-development water balance components, determine potential changes to the water balance as a result of the proposed development concept, and to provide appropriate infiltration targets as input to Low Impact Development (LID) strategies and stormwater management plans for the subject lands. Additionally, groundwater related constraints for the residential development regarding the depth to groundwater table, the potential need for construction dewatering and obtaining permissions required for construction dewatering (i.e., registration on the Environmental Activity and Sector Registry (EASR) or applying for a Permit to Take Water (PTTW)) are addressed herein.

1.1 Scope of Work

The scope of work for the hydrogeological study included the completion of the following tasks.

1. Review of the Ministry of Environment, Conservation and Parks (MECP) well records: A list of the available MECP water well records are provided in Appendix A, and the well locations are shown on Figure 5. It is noted that well locations listed in the MECP well records are approximations only and may not accurately reflect well locations in the field.

2. Review of published geological and hydrogeological information: A review of existing mapping and reports for the area was completed. These included provincial and surficial geology mapping and recharge mapping prepared by CH.

A review of applicable legislation including the Clean Water Act (Source Water Protection) was also completed for the subject lands.

3. Review of existing borehole logs for the subject lands: Soil Engineers Ltd. (Soil Eng.) drilled boreholes at six locations across the subject lands in February 2023. The borehole and monitoring well locations are shown on Figure 5 and borehole logs are provided in Appendix B.

4. Installation of monitoring wells: Burnside installed four monitoring wells (MW1 to MW4) on the subject lands in August 2023. The monitoring well locations are shown on Figure 5 and borehole logs are provided in Appendix B.

5. Review of laboratory grainsize distribution testing: Analyses were completed by the geotechnical consultant (Soil Eng.) and Burnside on representative soil samples obtained during the drilling programs. These data were reviewed to characterize the surficial sediments and estimate the hydraulic conductivity of the soils encountered. Copies of the soil grainsize analyses are provided in Appendix C.

6. In situ hydraulic conductivity testing: Single well response tests were completed in all four groundwater monitoring wells to assess the in situ hydraulic conductivity of the shallow soils on the subject lands. The hydraulic conductivity field testing results are provided in Appendix D.

7. Groundwater level monitoring: Monitoring has been completed to measure the depth to the water table and assess the horizontal and vertical groundwater flow conditions. Groundwater level measurements commenced in August 2023 and are monitored on a quarterly interval. Automatic water level recorders (dataloggers) are installed in all of the monitoring wells in order to record continuous water level fluctuations. The groundwater monitoring data collected to date and hydrographs are provided in Appendix E.

8. Water quality testing: Two groundwater samples were collected from one monitoring well (MW4) to characterize the baseline water quality underlying the subject lands. A groundwater sample was submitted for analysis to assess if the groundwater meets the Mississauga storm sewer discharge criteria for purposes of construction dewatering. A second sample was collected to characterize the general water quality indicators (e.g., pH, hardness, and conductivity), basic ions (including chloride and nitrate) and selected metals. The water samples were submitted to a qualified laboratory for analysis and the testing results are provided in Appendix F.

9. Water balance calculations: Pre-development and post-development water balance calculations were completed to document existing conditions, evaluate post-development conditions, establish an infiltration target, and assess the potential effectiveness of the proposed LID measures to mitigate the changes land development may have on the local groundwater infiltration volumes. The local climate data and detailed water balance calculations are provided in Appendix G.

10. Dewatering calculations: Based on the proposed servicing depths, as well as the soil and groundwater conditions on the subject lands, dewatering calculations were completed to determine the expected dewatering rates during construction. The dewatering calculations are provided in Appendix H.

2.0 Physical Setting

2.1 Physiography and Topography

The subject lands are located within a physiographic region known as the Peel Plain (Chapman and Putnam, 1984). The Peel Plain consists of clay till soils which have a flat to rolling topography with generally more incised slopes in the vicinity of watercourses.

The subject lands are mapped as bevelled till plains, that are generally flat reworked till plains. The subject lands have a topographic relief of approximately 3 m, with maximum elevation of 196 metres above sea level (masl) located along the northern boundary to a low elevation of 193 masl located along the southern boundary (Figure 3). It is noted that the topography has been influenced from previous earthworks with the presence of fill material noted in borehole logs across the subject lands (Section 2.3.1, Appendix B).

2.2 Drainage

The subject lands are located within the East Lisgar Branch subwatershed of the Sixteen Mile Creek watershed and is under the jurisdiction of Conservation Halton. Runoff from the subject lands drains to the south. There are no watercourses, wetlands or drainage features on the subject lands (Figure 3). A tributary of Sixteen Mile Creek is mapped east of Lisgar Fields, however no runoff from the subject lands is directed towards the east.

2.3 Geology

2.3.1 Surficial Geology

Surficial geology mapping published by the Ontario Geological Survey (2010) shows that the subject lands are covered by low permeability fine-textured silt and clay glaciolacustrine soils. Low permeability clayey glacial till (Halton till) is mapped west of the subject lands and modern alluvial deposits are mapped east of the subject lands (Figure 4).

The geotechnical investigation completed on the subject lands by Soil Eng. (2023) included the drilling of six boreholes, up to depths of 6.6 m. Four additional boreholes were drilled by Burnside in August 2023, to depths of 8.3 m completed as monitoring wells. Borehole locations are shown on Figure 5, and borehole logs are provided in Appendix B. The results of these investigations show that fill material has been deposited across the subject lands. Underlying the fill is the native clayey silt till/silty clay till/clay and silt till. The results of the drilling investigations suggest that the silty to clayey till soils are indicative of glacial till, corresponding to Halton till. It is interpreted that the till extends east and encompasses the subject lands.

2.3.2 Bedrock Geology

Underlying the till across the subject lands is the shale bedrock of the Queenston Formation. The bedrock surface regionally slopes from the north to south, with the lowest bedrock areas underlying nearby watercourse valleys (i.e., the topography in the area generally reflects the bedrock topography).

One of the drilling locations (MW1) encountered bedrock at about 8.2 metres below ground surface (mbgs). Nearby MECP well records, west of the subject lands, found shale at depths ranging from 5.4 mbgs to 9.7 mbgs. The shale is comprised of red mudstone with green siltstone bands, as well as thinly bedded layers of grey limestone/dolostone. The shale is heavily weathered at the overburden/bedrock contact and becomes more competent with depth.

2.3.3 Local Stratigraphy

Based on the geological data from site-specific geological information obtained from the boreholes drilled on the subject lands (Appendix B), two schematic cross-sections through the subject lands have been prepared to illustrate the subsurface conditions. On these cross-sections, an interpretation of the main stratigraphic layers has been made based on the overall sediment characteristics. The cross-section locations are shown on Figure 5 and the interpreted cross-sections are shown on Figure 6 and Figure 7.

The cross-sections show that the subject lands are covered by a moderate layer of fill, approximately 2 m thick. The fill is underlain by a native fine textured till layer about 8 m thick. Shale bedrock is interpreted to be below the till layer at an elevation of approximately 185.5 masl.

2.3.4 Soil Hydraulic Conductivity

Various methods can be used to evaluate soil hydraulic conductivity (K), i.e., the ease with which water can move through soil. Soil characteristics and grainsize data provide a general estimate of bulk hydraulic conductivity, whereas single well response tests are used to assess in situ conditions at specific locations. Both methods were used to estimate the K of the soils on the subject lands.

2.3.4.1 Grainsize Estimates of Hydraulic Conductivity

A summary of the hydraulic conductivity values estimated from the individual grainsize analyses and soil type using the Hazen approximation method is presented below in Table 1. The Hazen method is most reliable when used to approximate the hydraulic conductivity of coarse-grained sediments; however, it is still considered useful for providing a general indication of the hydraulic conductivity of finer grained sediments. The grainsize analyses are provided in Appendix C.

Table 1: Hydraulic Conductivity Estimates based on Grainsize Analyses

Sample Description	Sample Depth (m)	Test Location	D_{10} (mm)	Hydraulic Conductivity (cm/s) Hazen Estimation
Silty Clay Till	2.3 – 2.8	BH4, SS4	<0.001	$<1 \times 10^{-6}$
Silt and Clay Till	3.0 – 3.6	MW1, SS5	<0.001	$<1 \times 10^{-6}$
Clayey Silt Till	2.3 – 2.8	MW2, SS4	<0.001	$<1 \times 10^{-6}$
	6.1 – 6.7	MW4, SS7	<0.001	$<1 \times 10^{-6}$

Based on grainsize results, the estimated K of the soils tested across the subject lands are considered low and generally correspond to till and silty/clayey soils.

2.3.4.2 In Situ Estimates of Hydraulic Conductivity

To assess the in situ hydraulic conductivity of the shallow soils across the subject lands, bail-down tests were completed in MW1 to MW4 (refer to Figure 5 for monitoring well locations and Appendix B for borehole logs). The test results are provided in Appendix D and show the following:

- The bail-down tests completed at monitoring wells MW1 to MW3 are screened in sandy silt till and resulted in hydraulic conductivity (K) values ranging between 1.6×10^{-6} cm/s to 4.7×10^{-6} cm/s. The hydraulic conductivity rates are relatively low and typical for very dense till.

- The bail-down test completed at monitoring well MW4, screened in clayey silt till, and resulted in a hydraulic conductivity value of 1.3 x 10^{-5} cm/s. This is somewhat higher than expected for these till soils and may be due to the presence of thin sand seams that were identified in the till deposits in the borehole log.

2.3.4.3 Summary of Hydraulic Conductivity Results

Based on the results of the grainsize analyses and in situ well test described above, the estimated hydraulic conductivities and infiltration rates for various soil types identified across the subject lands have been summarized in Table 2. Hydraulic conductivity rates in the order of 10^{-6} cm/s are considered low and generally correspond to silty/clayey soils.

The values obtained from grainsize hydraulic conductivity are lower than the results of the in situ hydraulic conductivity tests. This may be a result of sand seams/layers not being captured during the grainsize analyses. Additionally, as noted in Section 2.3.4.1, the Hazen method is designed more for permeable soils and is a general estimation for fine grained soils.

Table 2: Summary of Hydraulic Conductivity

Soil Type	Hydraulic Conductivity (cm/s) Hazen Estimation	Hydraulic Conductivity (cm/s) In Situ Bail Test
Silty Clay Till	10^{-6}	–
Silt and Clay Till	10^{-6}	–
Clayey Silt Till	10^{-6}	1.3 x 10^{-5}
Sandy Silt Till	–	1.6 x 10^{-6} – 4.7 x 10^{-6}

3.0 Hydrogeology

3.1 Local Groundwater Use

The adjacent residential development is serviced by municipal water and sewer, and the proposed development will also be municipally serviced. There is no proposed on-site groundwater taking planned for the new development. It is possible the rural residential/agricultural properties located west of the subject lands may be serviced by private wells or cisterns, and septic systems.

A review of the MECP well records within a 500 m radius of the subject lands indicates a total of 20 well records. Of the 20 water well records, five are monitoring/test holes, six are abandonment records, two records indicating unknown and the remaining seven records indicate the wells are/were used for water supply for commercial (one) and domestic (six) purposes. Copies of the well records are included in Appendix A. Stratigraphic information shows that two of the water supply wells are installed in the overburden (7.5 mbgs to 9.1 mbgs), and the remaining water supply wells are installed in the shale and range in depths from 6.1 mbgs to 12.2 mbgs.

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. Based on our review of WHPA mapping available from Source Water Protection Information Atlas compiled by the MECP, the subject lands are not located in a WHPA for water quality or a WHPA-Q zone for water quantity.

3.2 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 or aquifer. As these two properties vary over any given area, the degree of protection or vulnerability of the groundwater to contamination also varies. Some land use restrictions may apply to areas of high aquifer vulnerability, which pose a risk of contaminating the underlying aquifers. Residential land uses are not considered ‘high risk’ in terms of potential aquifer contamination.

Review of the Aquifer Vulnerability mapping available from Source Water Protection Information Atlas compiled by the MECP shows that the subject lands are not mapped within an area of high aquifer vulnerability.

3.3 Groundwater Levels

Four monitoring wells (MW1 to MW4) were installed in August 2023 by Burnside to facilitate measurement of the groundwater levels across the subject lands. Refer to Figure 5 for well locations and Appendix B for borehole logs. Dataloggers were installed in each monitoring well to record continuous groundwater levels. It is noted that the groundwater levels collected to date are preliminary and may not represent seasonally high groundwater conditions. The groundwater monitoring data tables and hydrographs are provided in Appendix E.

The groundwater monitoring data recorded in the monitoring wells to date show the following:

- Preliminary groundwater level highs were recorded on August 29, 2023, across the subject lands. Groundwater levels range from approximately 1.4 mbgs (MW2, Figure E-2) to 2.1 mbgs (MW3, Figure E-3).

- Datalogger data suggests groundwater levels in all monitoring wells quickly reached static conditions following installation and show minimal response to precipitation.

- Groundwater levels across all monitoring wells generally decreased between the beginning of August to the beginning of September under seasonally drier conditions. Monitoring well MW4 (Figure E-4) had the largest decrease of approximately 0.2 m.

3.4 Groundwater Flow Conditions

Groundwater elevation data from August 2023 are shown on Figure 8 with the interpreted groundwater elevation contours and shallow groundwater flow directions. It is interpreted that the shallow water table will generally reflect the surface topography and that the shallow groundwater flow patterns will mimic the surface water flow patterns. As shown on Figure 8, groundwater is interpreted to flow moving from the northwest to the southeast across the subject lands.

3.5 Significant Groundwater Recharge Areas

Areas where water from precipitation percolates or infiltrates into the ground and moves downward from the water table are known as recharge areas and occur as a result of regional and/or local flow systems. Significant Groundwater Recharge Areas (SGRAs) are areas where precipitation more readily recharges aquifers. As such, they can be sensitive to land use changes that impact infiltration from precipitation sources. Review of mapping available from Source Water Protection Information Atlas compiled by the MECP shows that the subject lands are not located within an SGRA.

3.6 Groundwater Quality

Two groundwater samples were collected from monitoring well MW4 on the subject lands and were submitted to AGAT Laboratories. One sample was submitted for analysis to assess if the groundwater meets the Mississauga Storm Sewer Bylaw (0046-2022) discharge criteria such that groundwater can be discharged to the storm sewer during construction dewatering (refer to Table F-1 and Table F-2; in Appendix F, for results). A second sample was collected to characterize the general water quality indicators (e.g., pH, hardness, and conductivity), basic ions (including chloride and nitrate) and selected metals and are compared to Ontario Drinking Water Quality Standards (ODWQS) with results presented in Table F-3 in Appendix F. The groundwater testing results from the analytical laboratory show the following:

- The groundwater meets the City of Mississauga Storm Sewer Bylaw (0046-2022) discharge criteria. No inorganic or organic exceedances were noted.

- The general groundwater quality results compared to the ODWQS noted the following:
  - The groundwater is hard, with a reported hardness of 2910 mg/L as $CaCO_3$ compared to the ODWQS of 80 to 100 mg/L as $CaCO_3$. Hardness is typical for shallow groundwater conditions in the area and is related to the overburden sediment chemistry in Southern Ontario.
  - The groundwater quality shows that the manganese concentration (0.345 mg/L) exceeded the ODWQS of 0.05 mg/L. Elevated concentrations of manganese are commonly found in groundwater as a result of naturally occurring dissolution of mineral deposits in chemically reducing underground conditions.
  - Sulphate concentrations (1170 mg/L) were reported above the ODWQS aesthetic objective of 500 mg/L. Sources of sulphate in groundwater include mineral dissolution or anthropogenic sources such as fertilizer application.
  - The groundwater quality results show that the shallow groundwater conditions may have been impacted by road de-icing agents. The sodium concentration at MW4 (1310 mg/L) are reported above the ODWQS aesthetic objective of 200 mg/L. Additionally, the chloride concentration at MW4 (3070 mg/L) are reported above the ODWQS aesthetic objective of 250 mg/L.
  - The groundwater was also reported to have high total dissolved solids (TDS) concentration of 7600 mg/L, compared to the ODWQS of 500 mg/L. TDS is influenced by the dissolution of minerals within the groundwater (e.g., manganese, calcium, chloride, sulfates, etc.).

The groundwater quality sampling results indicate exceedances in parameters compared to the ODWQS that include hardness, TDS, manganese and sulphate. The concentrations measured in these parameters reflect the local geology and groundwater chemistry. Local users generally treat the groundwater using water softeners, filters, UV, etc. prior to use.

4.0 Water Balance

To assess potential land development impacts on the local groundwater conditions, a detailed water balance analysis has been completed to determine the pre-development infiltration volumes (based on existing land use conditions) and the post-development infiltration volumes that would be expected based on the proposed land use plan. The water balance calculations are provided in Appendix G and discussed below.

Water Balance Components

A water balance is an accounting of the water resources within a given area. As a concept, the water balance is relatively simple and may be estimated from the following equation:

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

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, soil, and land cover conditions (i.e., rainfall intensity, land slope, soil hydraulic conductivity and vegetation). Accurate measurement of the water balance components is difficult; consequently, approximations and simplifications are made to characterize the study area. Field observations of the drainage conditions, land cover and soil types, groundwater levels, and local climate records are important inputs to the water balance calculations. The groundwater balance components for the subject lands are discussed below.

Precipitation (P)

The long-term average annual precipitation for the area is 786 mm based on data from the Environment Canada Toronto Lester B. Pearson International Airport climate station (Station 6158733 - 43°40’38.000” N, 79°37’50.000” W, elevation 173.40 masl) for the period between 1981 and 2010. Average monthly records of precipitation and temperature from this station have been used for the water balance component calculations in this study (Table G-1, Appendix G).

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 often less than the PET under dry conditions (i.e., during the summer when there is a soil moisture deficit). In this report, the monthly PET and AET have been calculated based on a soil-moisture balance approach using average temperature data and climate information adjusted to the local latitude (refer to Table G-1 in Appendix G).

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 and the remainder infiltrates the surficial soil.

Infiltrating precipitation either moves vertically downward to the groundwater table or laterally through the shallow soils as interflow that re-emerges locally to surface (i.e., as runoff). Compared to the “direct” component of surface runoff that occurs as overland flow, shallow interflow becomes an “indirect” component of runoff. The interflow component of surface water runoff is not accounted for separately in the water balance equation cited above since it is difficult to distinguish between interflow and direct (overland) runoff. Both interflow and direct runoff contribute to the overall surface water runoff component.

4.1 Approach and Methodology

The analytical approach to calculate a water balance for the subject lands involved monthly soil-moisture balance calculations to determine the pre-development (based on existing land use conditions) and post-development (based on the proposed development concept plan) infiltration volumes. A soil-moisture balance approach assumes that soils do not release water as “potential infiltration” 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, excess water can then pass through the soil as infiltration and either become interflow (indirect runoff) or recharge (deeper infiltration).

The 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. Considering the clay till and silt till soils in the area, a soil moisture storage capacity of 250 mm was used for the vacant land (pasture/shrubs) in pre-development calculations. Table G-1 (Appendix G) details the monthly potential evapotranspiration calculations accounting for latitude and climate, and the actual evapotranspiration and water surplus components of the water balance based on the monthly precipitation and soil moisture conditions.

The calculated water balance components are used to assess the pre-development infiltration volumes based on the existing land use and a post-development water balance is calculated for the subject lands based on the proposed land development plan.

4.2 Component Values

The detailed monthly calculations show that a water surplus is generally available from January to April (Table G-1, Appendix G). Infiltration occurs during periods when there is sufficient water available to overcome the soil moisture storage requirements. In winter climates, frozen conditions affect when the actual infiltration will occur; however, the monthly balance calculations show the potential volumes available for these water balance components.

The monthly calculations are summed to provide estimates of the annual water balance component values (Table G-1, Appendix G). A summary of these values for existing conditions is provided in Table 3.

Table 3: Existing Conditions Water Balance Components

Water Balance Component	Vacant Land (Pasture/Shrubs in Silt Till)
Average Precipitation	786 mm/year
Actual Evapotranspiration	617 mm/year
Water Surplus	169 mm/year
Infiltration	85 mm/year
Runoff	85 mm/year

4.3 Pre-Development Infiltration (Existing Conditions)

Using the water balance component values calculated for the subject lands, and the existing land use area, the pre-development water balance calculations were completed for the subject lands and are presented in Table G-3 in Appendix G. In summary, from Table G-3 (Appendix G), the total calculated pre-development infiltration volume is about 5,600 m^3/year. It is acknowledged that infiltration rates depend on the hydraulic conductivity of soils and that hydraulic conductivity may naturally vary over several orders of magnitude, so the margins of error on the calculations are high. As such the calculated volumes are considered as general estimates only.

4.4 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 a healthy vegetation cover (about 70% of precipitation in the study area). So, the net effect of the development of the lands is expected to be an increase in the water surplus resulting in a decrease in infiltration and an increase in runoff.

The calculated potential water surplus for impervious areas is shown at the bottom of Table G-1 in Appendix G. For the purposes of the calculations in this study, the evaporation from impervious surfaces 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 would be a potential water surplus from impervious areas of 668 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 taking or from septic effluent.

4.5 Post-Development Water Balance With No Mitigation

To assess the potential development impact on infiltration, the post-development infiltration volume was calculated for the subject lands based on the proposed development plan. The calculations provided in Table G-3 assume no mitigation is in place, resulting in quantification of an infiltration target for the design of a LID strategy for stormwater management.

The total areas for the proposed land uses have been estimated based on the proposed development concept and the infiltration and runoff components for the post-development land uses have been calculated using the SWM Planning and Design Manual (2003) methodology based on topography, soil type and land cover as shown on Table G-2 (Appendix G). The total calculated post-development infiltration volume (without mitigation) is about 2,000 m^3/year.

Comparison of the pre-development and post-development infiltration volumes from the water balance calculations shows that development has the potential to reduce the natural infiltration on the subject lands by 64%. Again, it is noted that with the assumptive nature of the input values and the wide margins of error associated with this type of analysis, the estimated infiltration deficit volume is simply considered as a reasonable estimate and may not reflect the actual volume of water that may infiltrate on the subject lands.

4.6 Water Balance Mitigation Strategies

The basic premise for low impact development is to try to manage stormwater to minimize the runoff of rainfall and increase the potential for infiltration. As outlined in the SWMP Design Manual (2003) and Low Impact Development Stormwater Management Planning and Design Guide (2010), there are a wide variety of mitigation techniques that can be used to try to reduce the increases in direct runoff that occur with land development and increase the potential for post-development infiltration.

Techniques to maximize the water availability in pervious areas such as designing grades to direct roof runoff towards lawns, side and rear yard swales, and other pervious areas throughout the development where possible can considerably increase the volume of infiltration in developed areas. These types of surface LID techniques promote natural infiltration simply by providing additional water volumes in the pervious areas (i.e., these areas would receive precipitation as well as extra water from roof runoff). This may be particularly effective in the summer months, when natural infiltration would not generally occur because the additional water overcomes the natural soil moisture deficit.

Other mitigation techniques that can be considered to mitigate increases in runoff and reductions in infiltration include such measures as: permeable pavements, rain gardens, rain barrels, bioswales, subsurface infiltration trenches, galleries and pervious pipe systems. Subsurface methods should only be considered in areas where there is sufficient depth to water table to accommodate the systems within the unsaturated zone and sufficient soil hydraulic conductivity to function effectively. The 2003 SWM Manual recommends that subsurface galleries or trenches should generally be about 1 m above the seasonally high water table.

4.7 Post-Development With LID Measures in Place

The City of Mississauga has requested that the first 27 mm of runoff from storm events from impervious areas be retained on site as part of the SWM strategy. To calculate the annual 27 mm runoff volume required to be retained on the subject lands, the Toronto Wet Weather Flow Management Guidelines (City of Toronto, 2006) was used to correlate the storm event size to a percentage of the average annual rainfall depth, which was then applied to the impervious areas. It is reported in these Guidelines, based on the review of rainfall data from 16 rainfall stations across Toronto, the 27 mm storm event accounts for approximately 95% of the annual rainfall volume (~87% of annual precipitation).

As presented in the Functional Servicing Report prepared by Urbantech (October 2023), the proposed SWM strategy includes the following LID measures:

- Increased topsoil depth across all lots. The intention with increased topsoil depth is to aid retention of runoff through increased soil storage and promote more infiltration in these areas. Typically, topsoil is increased to about 300 mm. It is noted that the additional topsoil has not been considered in the water balance calculations.

- Rear roof areas will be discharged to pre-cast splash pads and directed to rear/side pervious areas. The TRCA and CVC Stormwater Management Criteria (2010) indicates that a conservative estimate for the reduction in runoff due to roof leader disconnection is 25% for silt to clayey soils.

- Runoff from rear roof and rear yard areas to be directed to rear yard infiltration trenches designed to accommodate the 27 mm storm event.

- Runoff from front roof areas is to be directly piped to front yard infiltration galleries designed to accommodate the 27 mm storm event.

- Runoff from front roof areas fronting Lisgar Drive is to be directly piped to front yard soakaway pits designed to accommodate the 27 mm storm event.

As discussed in Sections 2.3.4 and 3.3 herein, the surficial soils have low hydraulic conductivity and the groundwater level across the subject lands are estimated to range from about 1.4 mbgs to 2.1 mbgs. The proposed grading plan provides limited areas of cut and fill. Seasonal high groundwater levels will be monitored through the spring to assess the potential for subsurface infiltration opportunities as part of the SWM strategy.

Quantification of these surficial LID techniques is challenging and there are no widely accepted quantification standards. To assess the potential effectiveness of the recommended LID measures for groundwater infiltration and runoff reduction for the subject lands, the water balance component values were recalculated (Table G-2, Appendix G). In the residential areas where select roofs areas are directed to pervious areas (rear/side yards), it has been assumed in the calculations that 25% of the roof runoff will infiltrate, as per the estimation provided in the Low Impact Development Stormwater Management Planning and Design Guide (CVC and TRCA, 2010).

Recalculation of the water balance for the subject lands with these LID measures in place suggests that infiltration volumes would be 241% of pre-development volumes (Table G-4, Appendix G). This shows the significant benefit of the proposed LID strategy in increasing recharge volumes in the developed area.

5.0 Construction Considerations

5.1 Construction Below Water Table

The construction of buried services below the water table, particularly in lower hydraulic conductivity soils, has the potential to capture and redirect groundwater flow through permeable fill materials typically placed in the base of excavated trenches. Over the long-term, these impacts can lower the local groundwater table. To mitigate this effect, services to be installed below the water table should use appropriate best management techniques to prevent redirection of groundwater flow (e.g., the use of cut-off collars and/or trench plugs in service trenches).

5.2 Dewatering Requirements

As noted in Section 3.3, groundwater data collected to date indicates the water table ranges from approximately 1.4 mbgs to 2.1 mbgs across the subject lands. Excavations for installation of municipal services may extend into the groundwater requiring dewatering. The volume of water required for dewatering depends on the size and depth of the excavation with respect to the water table and the hydraulic conductivity of the soils. Sandy soil layers may produce significant volumes of groundwater and require more active dewatering, whereas excavations into the silt and till deposits may encounter less groundwater inflow that may be controlled by localized pumping from sumps.

In addition, water may accumulate in excavations during and immediately after rain events. In all cases, water will have to be pumped from the work area to allow for construction to occur in the “dry”.

The total dewatering volume is anticipated to comprise of the following components:

- Groundwater seepage
- Precipitation and runoff

Preliminary dewatering volumes have been calculated for the subject lands using a conservative approach based on deepest excavation inverts, highest water levels and highest hydraulic conductivity values being used to estimate groundwater seepage. Calculations are provided in Appendix H.

5.2.1 Groundwater Seepage

The extent of groundwater dewatering required in the excavations can be estimated using the following formulae as presented in Groundwater Lowering in Construction - A Practical Guide to Dewatering, 2nd Edition” (Cashman & Preen, 2013).

The following equation is suitable for maintenance holes or short excavation lengths which groundwater infiltration is approximated as flow to an equivalent well:

$$Q = \pi K(H^2-h^2)/(\ln R_o/r_s)$$

The following equation is appropriate for long narrow trenches (pipe trenches):

$$Q = [\pi K(H^2-h^2)/(\ln R_o/r_s)] + 2[xK(H^2-h^2)/2L]$$

Where:

Q = Discharge (m^3/s)
K = Hydraulic Conductivity (m/s)
H = Initial water level relative to datum (m)
h = Final water level relative to the datum required for dewatering (m)
R_0 = Radius of influence of dewatering (m)
r_s = Equivalent radius of dewatering well (m)
π = 3.1416
x = length of trench (m)
L = distance from line source (m)

The required drawdown has been estimated using available water table elevation information and the proposed depths of the excavations. Based on information provided by the site's engineers (Urbantech), installation of municipal services will occur at depths up to 4.0 m below ground existing grade requiring drawdowns of more than 2.6 m in some areas.

The amount of groundwater seepage into the open excavations that will be encountered is controlled by the hydraulic conductivity of the sediments that make up the subsurface deposits, as well as the local hydraulic gradients. Conditions such as the degree of weathering and fracturing, as well as the amount of silt and sand or gravel and layering, may affect the overall effective hydraulic conductivity of the overburden deposits.

As described in Section 2.3, the subject lands are underlain by a layer of finer-grained soils (glaciolacustrine silt and clay and glacial till deposits). To determine a potential dewatering volume for the servicing trenches which extend across the subject lands the highest hydraulic conductivity determined through in situ testing of monitoring wells on the subject lands (1.3×10^{-5} cm/s) was used.

The dewatering calculations are presented in Table H-1, Appendix H and summarized in Table 5 below.

Table 4: Estimated Groundwater Seepage

Source	Groundwater Volume (L/day)	Maximum Groundwater Volume (L/day)
Servicing Trenches (per 100 m)	15,000	22,500

For the servicing trenches it has been assumed that a maximum of 100 m of trench will be open at any given time during construction. To calculate the maximum volume, a safety factor of about 50% was applied. These volumes can be considered maximum takings since they are based on worst-case scenario parameters.

5.2.2 Precipitation and Runoff

It is noted that precipitation events occurring when excavations are open are likely to increase the volume of water requiring removal. It is anticipated that during and after rainfall events the volume of taking may have to be temporarily increased to control volume of runoff and seepage into open excavations. In the event of precipitation, water falling directly on the construction area will likely pool in excavation areas. In order for work to continue, the pooled water will need to be pumped. The volume of water associated with the proposed excavations has been estimated based on a 5 mm rainfall event as summarized below in Table 6 (refer to Table H-2, Appendix H).

Table 5: Estimated Runoff Volume

Source	Width of Excavation (m)	Length of Excavation (m)	Runoff Volume for 5 mm Rainfall Event (L)
Trench Excavations (per 100 m)	4	100	2,000

5.2.3 Total Taking

The total taking required has been calculated using both the groundwater seepage and the estimated surface water runoff and is provided in Table 7 (refer to Table H-3, Appendix H).

Table 6: Total Estimated Water Takings

Source	Max Groundwater Seepage (L/day)	Surface Water Runoff (L/day)	Total (L/day)	Total (L/min)
Trench Excavations (per 100 m)	22,500	2,000	24,500	17

The removal of subsurface water (dewatering) to facilitate construction is regulated by the MECP. Water taking in excess of 50,000 L/day but less than 400,000 L/day is regulated via an Environmental Sector Activity Registry (EASR) process. For takings in excess of 400,000 L/day, a Permit to Take Water (PTTW) will be required in accordance with provincial regulations prior to dewatering activities. Detailed groundwater impact assessment and monitoring plans are required to support EASR and PTTW applications. Based on the preliminary calculations completed, no permissions or permits will be required to manage the water taking.

It is noted, however, that permissions are required to discharge the water to municipal services as discussed in Section 3.6.

5.3 Private Water Wells

The proposed development will be municipally serviced. However, as discussed in Section 3.1, several surrounding properties may still use private water supply wells. It is important that groundwater control during construction does not adversely affect these local groundwater supplies.

In review of the dewatering calculations, the radius of influence caused as a result of the construction dewatering is estimated to be about 2.0 m. As such, impacts to any private water supply wells are not anticipated.

5.4 Well Decommissioning

In accordance with the Ontario Water Resource Act, Regulation 903 as amended (Wells Regulation), all monitoring wells on the subject lands must be located and properly decommissioned by a licensed water well contractor, once they are no longer needed.

At least four monitoring wells are located within the subject lands. The monitoring wells should be maintained as long as possible for use throughout construction. Once construction is complete, all monitoring wells that are no longer required must be decommissioned in accordance with the Wells Regulation and best management practices.

6.0 References

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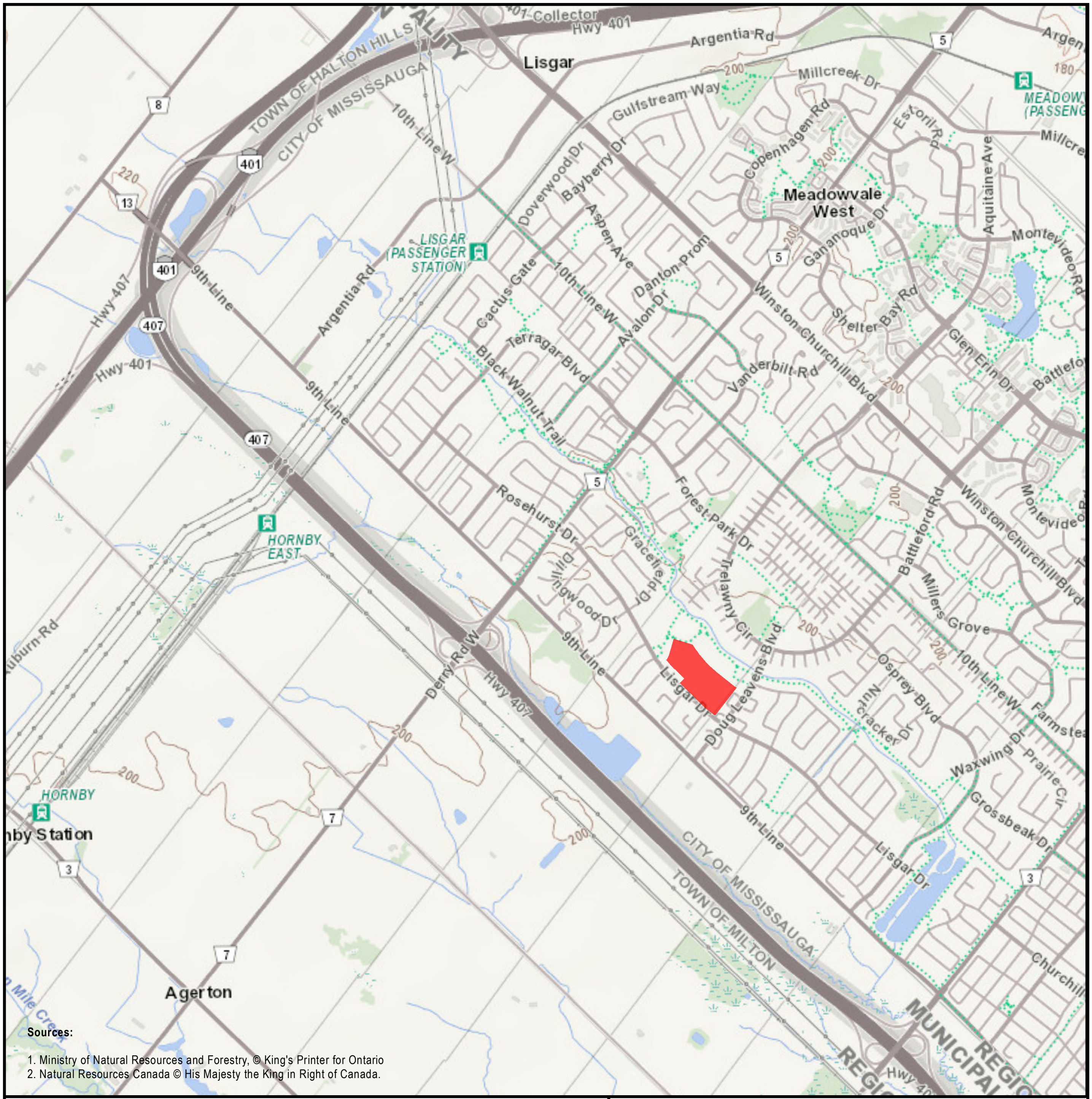
Figures



Sources:

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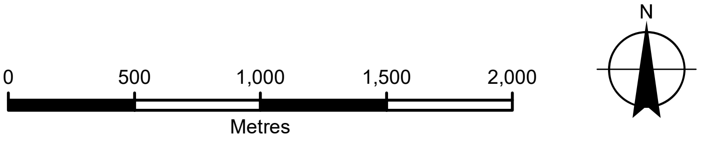
LEGEND

🟥 SUBJECT LANDS



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Client / Report

AVENIA CONSTRUCTION INC.
MISSISSAUGA, ONTARIO

HYDROGEOLOGICAL ASSESSMENT
AND WATER BALANCE

Figure Title:

SITE LOCATION

Drawn SK	Checked MM	Date OCTOBER 2023	Figure No. 1
Scale 1:30,000		Project No. 300057229	

Path:Nigel/Shared Work Areas/ \\NIGEL\Shared Work Areas\057229 Avenia Lisgar\06_GIS\057229 Site Location.mxd Date Saved: Tuesday, October 03, 2023

LEGEND

🟥 SUBJECT LANDS

— PROPOSED ROADS AND RESIDENTIAL LOTS

0 50 100 150 200
Metres

N

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AVENIA CONSTRUCTION INC.
MISSISSAUGA, ONTARIO
HYDROGEOLOGICAL ASSESSMENT
AND WATER BALANCE

Figure Title

SITE PLAN

Drawn	Checked	Date	Figure No.
SK	MM	OCTOBER 2023	2
Scale		Project No.	
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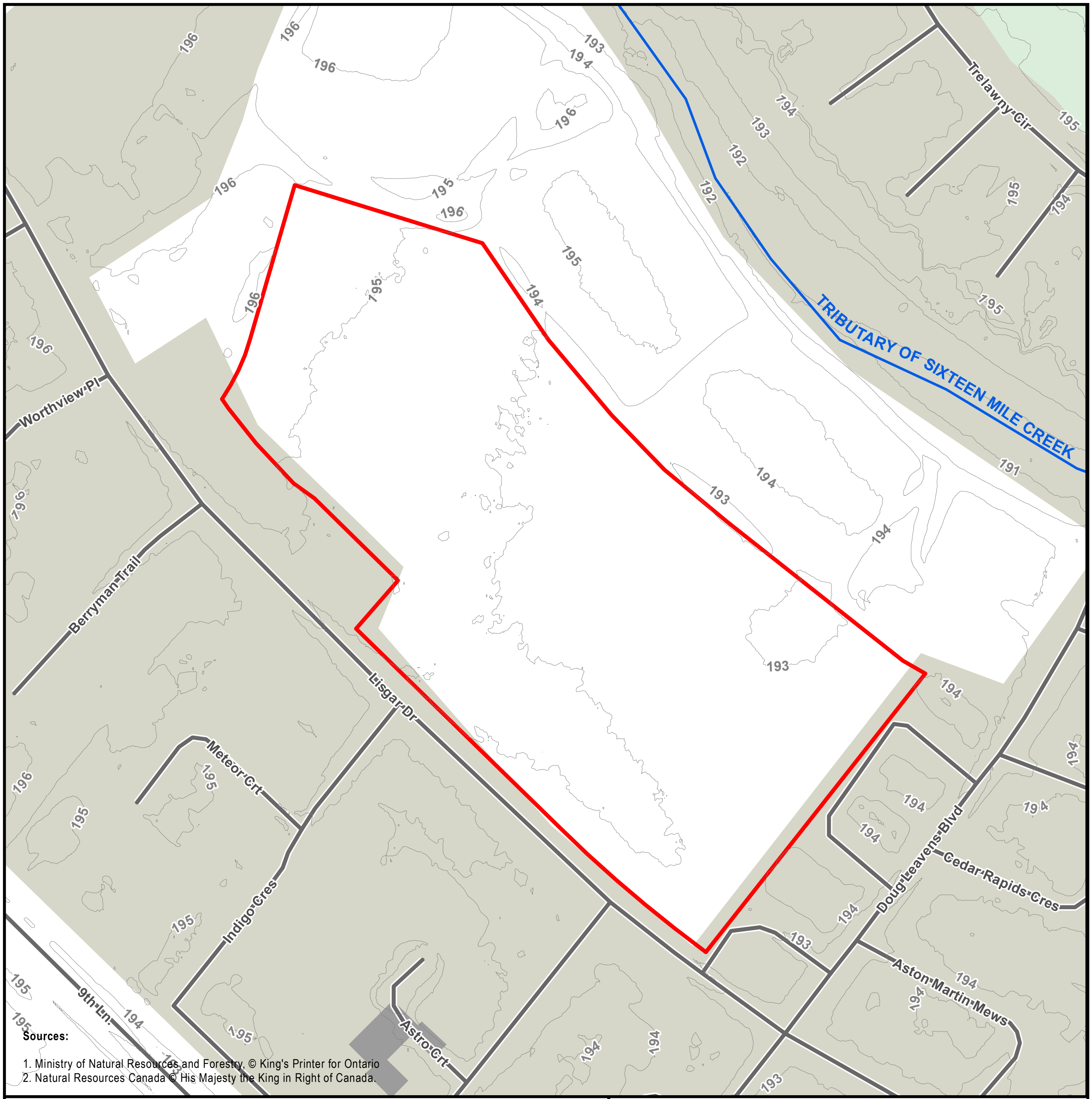

Sources:

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LEGEND

▭	SUBJECT LANDS
—	CONTOUR (1m intervals - masl)
—	ROADWAY
—	WATERCOURSE
■	BUILDING
▨	WOODED AREA
▨	BUILT-UP AREA: IMPERVIOUS
▨	BUILT-UP AREA: PERVIOUS

0 50 100 150 200

Metres

N

BURNSIDE

Client / Report

AVENIA CONSTRUCTION INC.
MISSISSUAGA, ONTARIO

HYDROGEOLOGICAL ASSESSMENT AND WATER BALANCE

Figure Title:

TOPOGRAPHY AND DRAINAGE

Drawn	Checked	Date	Figure No.
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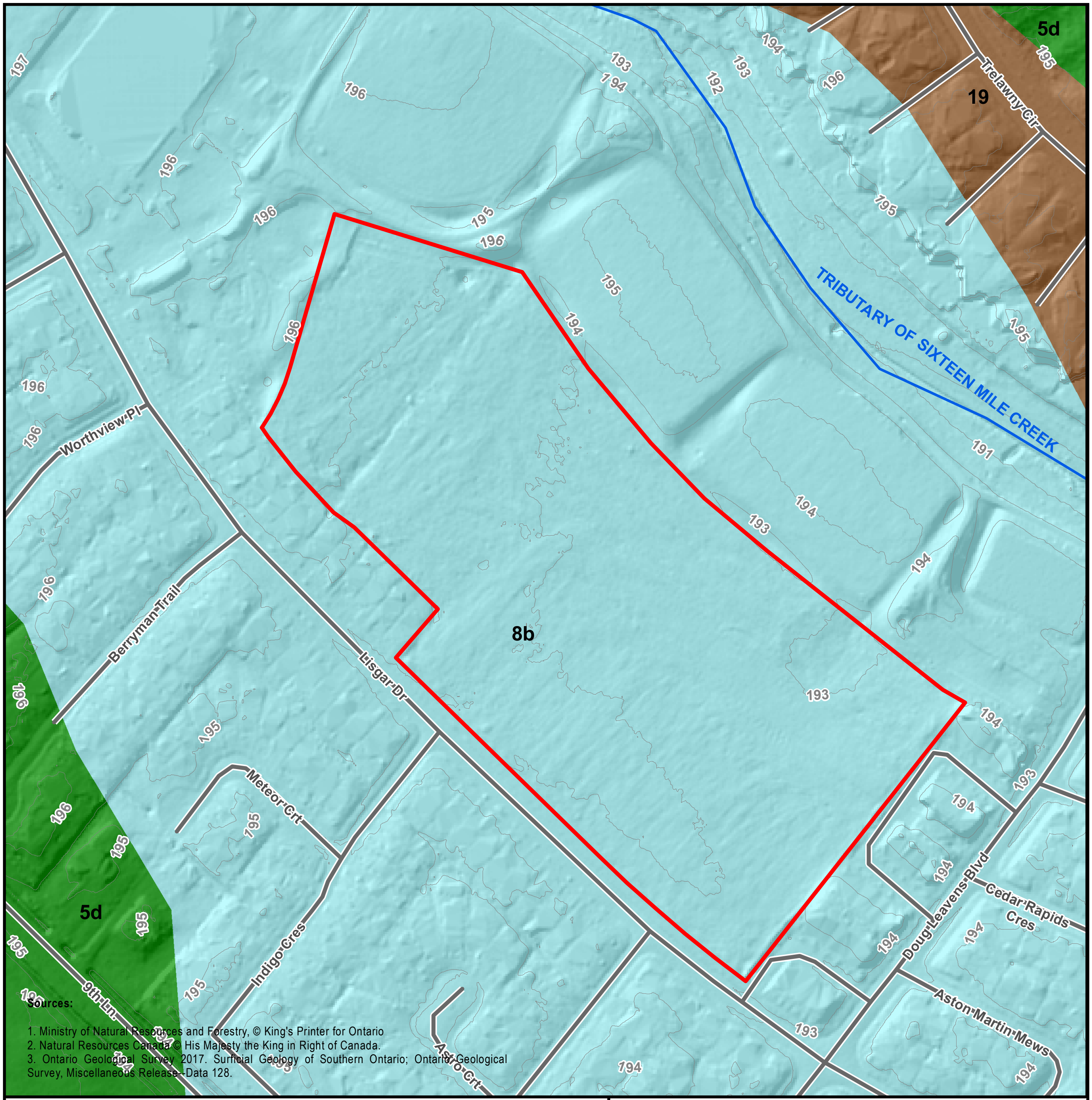

Sources:

1. Ministry of Natural Resources and Forestry, © King's Printer for Ontario
2. Natural Resources Canada © His Majesty the King in Right of Canada.
3. Ontario Geological Survey 2017. Surficial Geology of Southern Ontario; Ontario Geological Survey, Miscellaneous Release--Data 128.

LEGEND

- 🟥 SUBJECT LANDS
- — CONTOUR (1m intervals - masl)
- — ROADWAY
- — WATERCOURSE
- 🟩 5d: Till: Glaciolacustrine-derived silty to clayey till
- 🟦 8b: Fine-textured glaciolacustrine deposits: Interbedded flow till, rainout deposits and silt and clay
- 🟫 19: Modern alluvial deposits

0 50 100 150 200

Metres

N

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AVENIA CONSTRUCTION INC.
MISSISSAUGA, ONTARIO

HYDROGEOLOGICAL ASSESSMENT AND WATER BALANCE

Figure Title:

SURFICIAL GEOLOGY

Drawn	Checked	Date	Figure No.
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Scale		Project No.	
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LEGEND

▭ SUBJECT LANDS

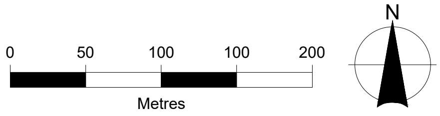
— WATERCOURSE

⊕ MONITORING WELL (RJB, 2023)

⊕ BOREHOLE (SOIL ENG., 2023)

● MECP WELL RECORD LOCATION

A A' CROSS-SECTION LOCATION KEY



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MISSISSAUGA, ONTARIO
HYDROGEOLOGICAL ASSESSMENT
AND WATER BALANCE

Figure Title

BOREHOLE, WELL AND CROSS-SECTION LOCATIONS

Drawn	Checked	Date	Figure No.
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Scale		Project No.	
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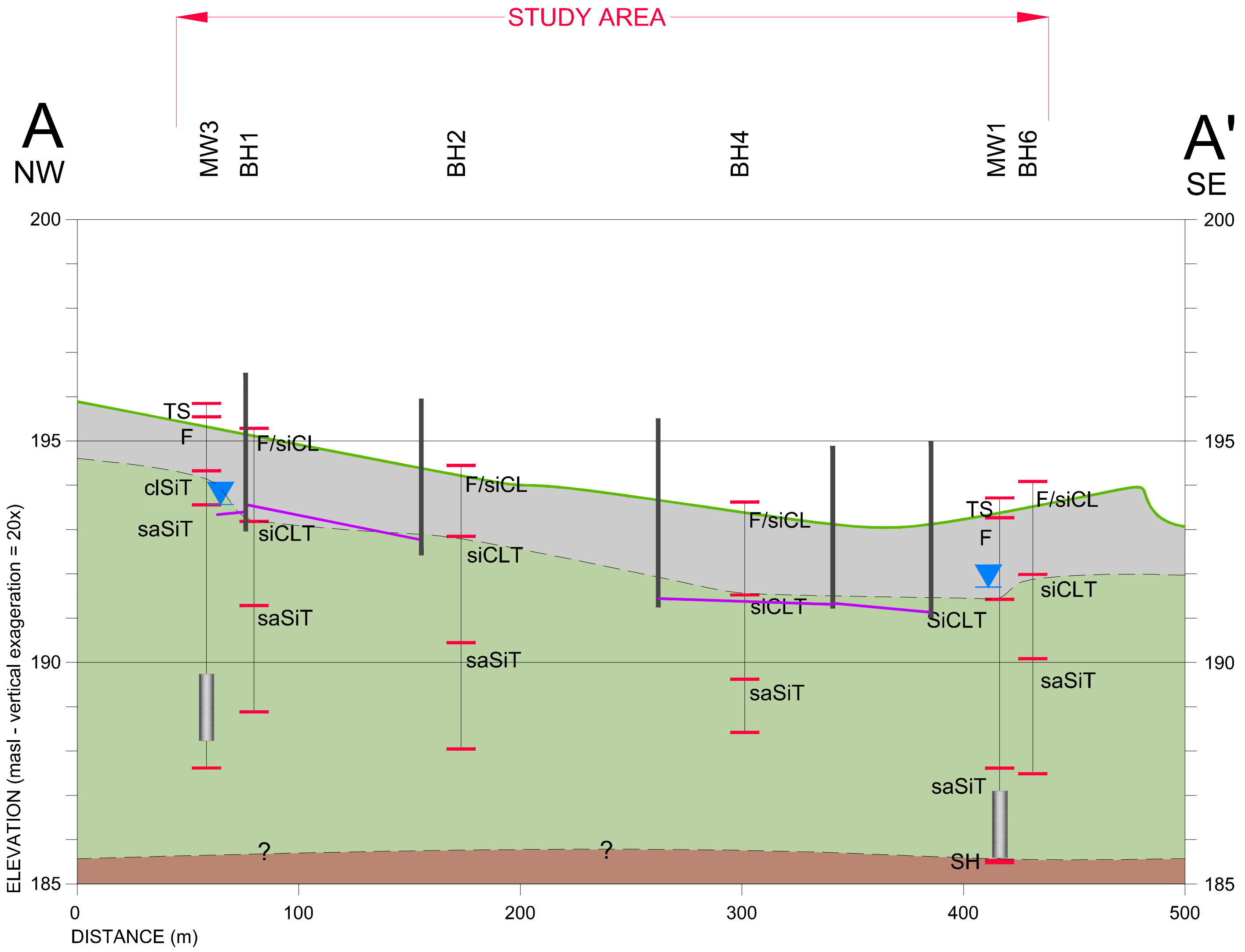

LEGEND

BH1 WELL NUMBER / ID

EXISTING GROUND PROFILE

GEOLOGICAL CONTACT

▼ MEASURED WATER LEVEL (AUGUST 29, 2023)

WELL SCREEN

- - - - INTERPRETED STRATIGRAPHY

▨ TOPSOIL / FILL

🟩 SILT / CLAY / TILL

🟫 BEDROCK / SHALE

si	SILTY
sa	SANDY
cl	CLAYEY
TS	TOPSOIL
F	FILL
T	TILL
GR	GRAVEL
SA	SAND
Si	SILT
CL	CLAY
ST	STONES
SH	SHALE

PROPOSED MANHOLE

PROPOSED SERVICING

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AVENIA CONSTRUCTION INC.
MISSISSAUGA, ONTARIO
HYDROGEOLOGICAL ASSESSMENT AND WATER BALANCE

Figure Title

INTERPRETED GEOLOGICAL CROSS-SECTION A-A'

Drawn	Checked	Date	Figure No.
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Scale		Project No.	
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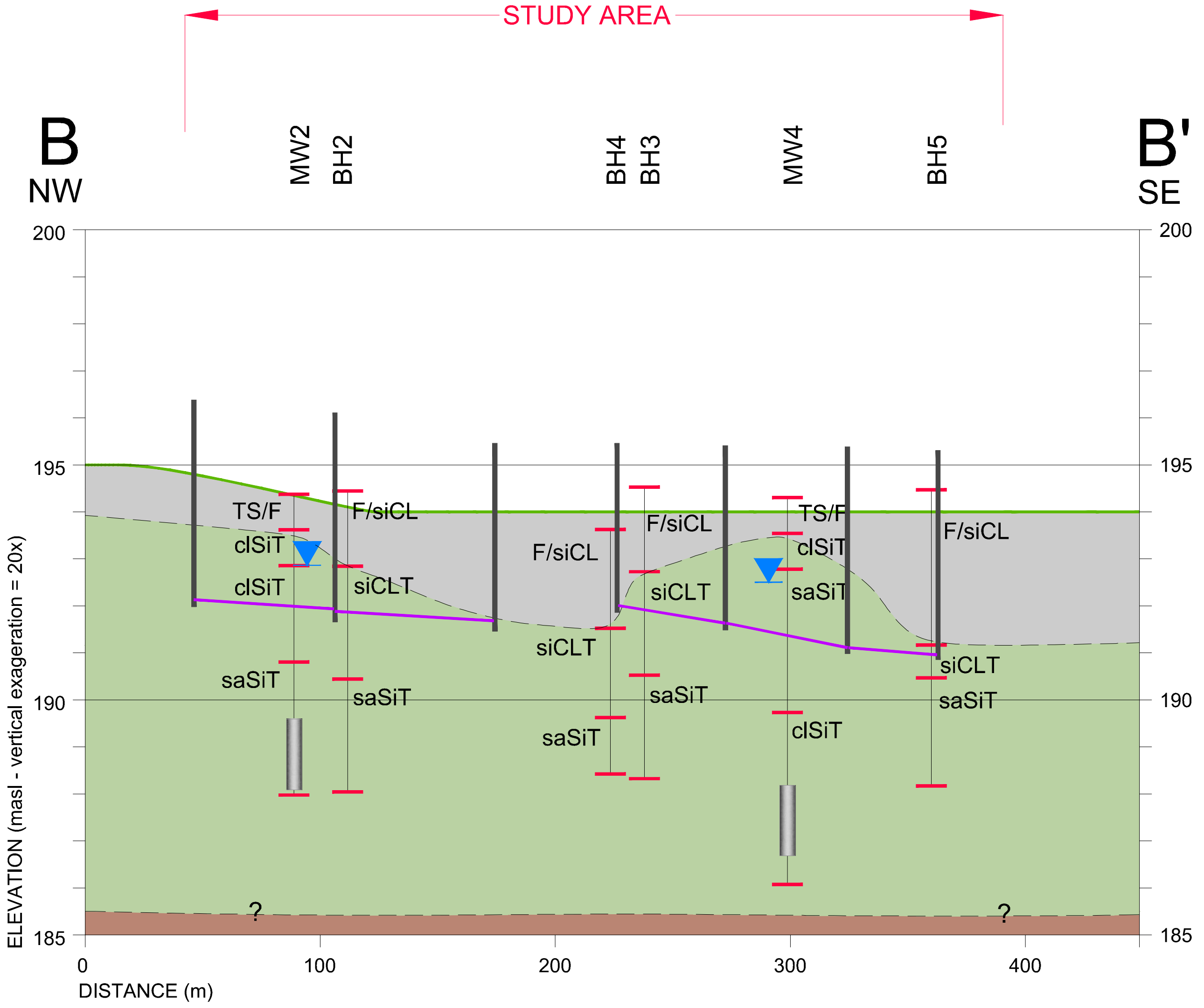

LEGEND

BH1	WELL NUMBER / ID
—	EXISTING GROUND PROFILE
┼	GEOLOGICAL CONTACT
▼	MEASURED WATER LEVEL (AUGUST 29, 2023)
▮	WELL SCREEN
- - - -	INTERPRETED STRATIGRAPHY
▨	TOPSOIL / FILL
🟩	SILT / CLAY / TILL
🟫	BEDROCK / SHALE

si	SILTY
sa	SANDY
cl	CLAYEY
TS	TOPSOIL
F	FILL
T	TILL
GR	GRAVEL
SA	SAND
Si	SILT
CL	CLAY
ST	STONES
SH	SHALE

▮	PROPOSED MANHOLE
—	PROPOSED SERVICING

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AVENIA CONSTRUCTION INC.
MISSISSAUGA, ONTARIO

HYDROGEOLOGICAL ASSESSMENT AND WATER BALANCE

Figure Title

INTERPRETED GEOLOGICAL CROSS-SECTION B-B'

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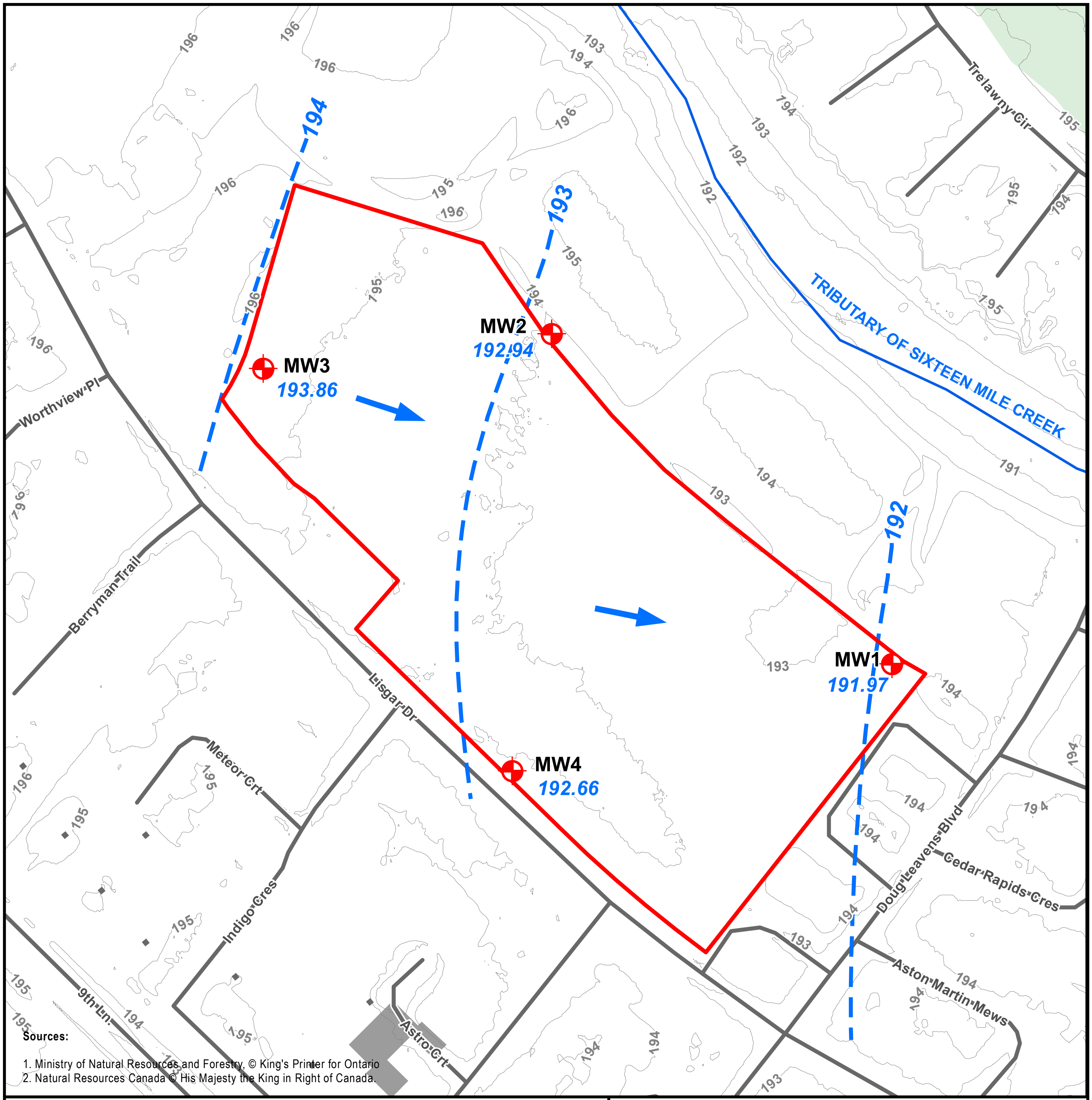

Sources:

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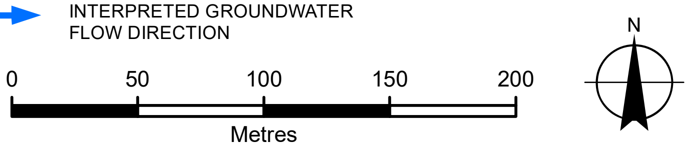
LEGEND

▭	SUBJECT LANDS
▬	ROADWAY
─	WATERCOURSE
▨	BUILDING
🟩	WOODED AREA
─	CONTOUR (1m intervals - masl)
⊕	MONITORING WELL (RJB, 2023)
– –	INTERPRETED GROUNDWATER CONTOUR (masl)
177.95	MEASURED WATER LEVEL (AUGUST 29, 2023)
→	INTERPRETED GROUNDWATER FLOW DIRECTION



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AVENIA CONSTRUCTION INC.
MISSISSUAGA, ONTARIO

HYDROGEOLOGICAL ASSESSMENT AND WATER BALANCE

Figure Title:

INTERPRETED GROUNDWATER FLOW

Drawn	Checked	Date	Figure No.
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Scale		Project No.	
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Path:Nigel/Shared Work Areas/ \\NIGEL\Shared Work Areas\057229 Avenia Lisgar\06_GIS\057229 Groundwater Flow.mxd Date Saved: Tuesday, October 10, 2023

LEGEND

▭	SUBJECT LANDS
—	WATERCOURSE
—	CONTOUR (1m intervals - masl)
⊕	MONITORING WELL (RJB, 2023)
191.97	MEASURED WATER LEVEL (AUGUST 29, 2023)

DEPTH TO GROUNDWATER:

🟧	1.0 TO 1.5m BELOW GRADE
🟨	1.5 TO 2.0m BELOW GRADE
🟦	2.0 TO 2.5m BELOW GRADE

0 50 100 150 200

Metres

N

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AVENIA CONSTRUCTION INC.
MISSISSAUGA, ONTARIO
HYDROGEOLOGICAL ASSESSMENT
AND WATER BALANCE

Figure Title

INTERPRETED DEPTH TO GROUNDWATER FROM EXISTING GRADE

Drawn	Checked	Date	Figure No.
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Appendix A

MECP Water Well Records

Water Well Records

Tuesday, September 26, 2023

10:29:49 AM

TOWNSHIP CON LOT	UTM	DATE CNTR	CASING DIA	WATER	PUMP TEST	WELL USE	SCREEN	WELL	FORMATION
MILTON TOWN (TRAFALG	17 598338 4824612 W	2012/05 6607						7189722 (C17967) A126305 P	
MILTON TOWN (TRAFALG	17 598621 4824650 W	2016/03 7241	2				0015 10	7261911 (Z207344) A174660 A	
MILTON TOWN (TRAFALG	17 598937 4824275 W	2016/03 7241	2			MT	0020 5	7261805 (Z207345) A181667	BLCK LOAM SOFT 0001 BRWN TILL SILT HARD 0025
MILTON TOWN (TRAFALG	17 598448 4824602 W	2016/03 7241	2			MT	0009 5	7261804 (Z207335) A181666	BLCK LOAM SILT SOFT 0001 BRWN FSND SILT SOFT 0014
MILTON TOWN (TRAFALG	17 598817 4824312 W	2016/04 7241	0.49			MT	0016 16	7261912 (Z231326) A164972	BRWN SILT CLAY TILL 0026 GREY CLAY SILT 0030 BRWN CLAY STNS 0033
MILTON TOWN (TRAFALG NS 09 009	17 598445 4824593 W	1968/09 1307	30	FR 0025	///:	DO		2802771 ()	BRWN CLAY MSND 0012 CSND 0025
MILTON TOWN (TRAFALG NS 09 009	17 598515 4824683 W	1972/08 3637	30	FR 0041	11/43//2:0	DO		2804135 ()	BRWN LOAM 0001 BRWN CLAY PCKD 0032 RED SHLE 0043
MILTON TOWN (TRAFALG NS 09 009	17 598455 4824703 W	1980/11 3637		FR 0012 FR 0025	10//14/1:0	DO		2805664 ()	BRWN LOAM 0001 BRWN CLAY STNS HARD 0010 BRWN MSND 0012 RED SAND CLAY STNS 0018 RED SHLE HARD 0030
MILTON TOWN (TRAFALG NS 09 009	17 598403 4824634 W	1998/03 4868				DO		2808814 (186029) A	UNKN 0030
MILTON TOWN (TRAFALG NS 09 010	17 598335 4824826 W	1990/11 4868	30	FR 0016	12/25/10/1:0	CO		2807698 (74522)	BRWN LOAM FSND 0002 BRWN CLAY HARD 0007 GREY CLAY STNY HARD 0011 BRWN SAND 0016 BRWN SAND SOFT 0030
MISSISSAUGA CITY	17 598338 4824993 W	2010/03 6032				MO		7144763 (Z108986) A083982	BRWN SILT SAND SILT 0015
MISSISSAUGA CITY (TR	17 598301 4825039 W	2013/05 7268						7218332 (Z141742) A	
MISSISSAUGA CITY (TR	17 598322 4824998 W	2013/05 7268						7218333 (Z141740) A	
MISSISSAUGA CITY (TR	17 598651 4824661 W	2014/11 7241	2			MT	0005 15	7235268 (Z201259) A174660	BRWN LOAM GRVL 0005 RED SHLE 0020
MISSISSAUGA CITY (TR	17 598315 4824995 W	2013/05 7268						7218331 (Z141741) A	

TOWNSHIP CON LOT	UTM	DATE CNTR	CASING DIA	WATER	PUMP TEST	WELL USE	SCREEN	WELL	FORMATION
MISSISSAUGA CITY (TR NS 10 009	17 598649 4824637 W	1964/07 1307	30	FR 0020	10//10/:	DO		2802711 ()	BRWN LOAM CLAY 0010 RED SHLE 0020
MISSISSAUGA CITY (TR NS 10 009	17 598607 4824735 W	2014/09 7219	1					7235870 (Z185087) A161465	
MISSISSAUGA CITY (TR NS 10 009	17 598564 4824739 W	2014/09 7219	6		21///:			7235871 (Z185084) A161463 A	
MISSISSAUGA CITY (TR NS 10 009	17 598649 4824725 W	2014/09 7219	6		35///:	NU		7235872 (Z185088) A161465 A	
MISSISSAUGA CITY (TR NS 10 010	17 598345 4824983 W	1979/07 3317	6 6	FR 0021	9/19/7/1:0	DO		4905605 ()	CLAY 0012 RED SHLE 0031

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 B

Borehole and Monitoring Well Logs

R.J. Burnside & Associates Limited
292 Speedvale Avenue West, Unit 20, Guelph, Ontario, N1H 1C4
telephone (519) 823-4995 fax (519) 836-5447

LOG OF DRILLING OPERATIONS

MW1

Page 1 of 1

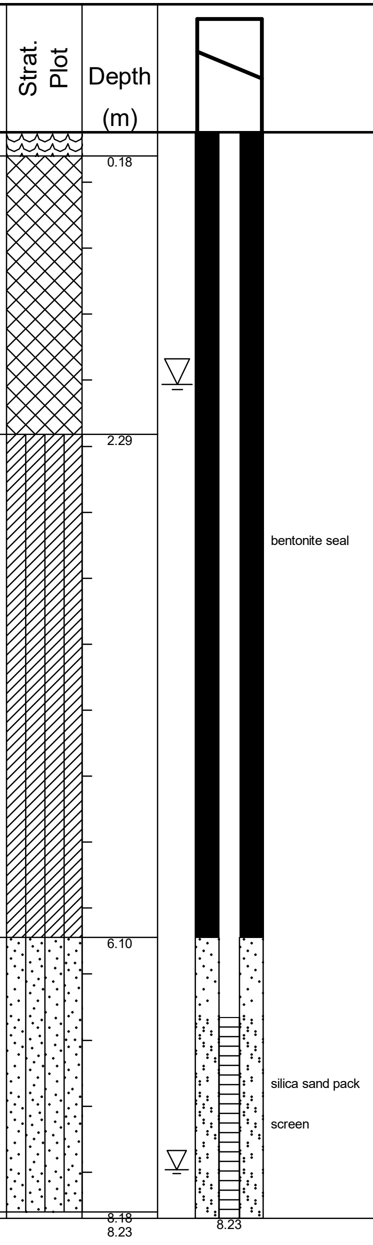
Client: **Avenia Construction Inc.**	Project Name: **Avenia - Lisgar Drive**	Logged by: **M.Morris**
Project No.: **300057229**	Location: **Lisgar Drive, Mississauga ON**	Ground (m amsl): **193.88**
Drilling Co.: **Geo-Environmental**	Date Started: **7/31/2023**	Static Water Level Depth (m): **1.91**
Drilling Method: **Hollow Stem Auger**	Date Completed: **7/31/2023**	Sand Pack Depth (m) : **6.10 - 8.23**

Depth Scale (ft) (m)

Stratigraphic Description

Surface Elevation (m): **193.88**

Stratigraphic Description	Depth (m)
TOPSOIL dark brown, moist, rootlets	0.18
FILL clayey silt, some sand, some gravel, brown, moist, stiff to medium, non-uniform, oxidized, mottled, low plasticity	2.29
SILT and CLAY Till trace sand, trace gravel, brown, moist, medium to stiff, non-uniform, oxidized, low plasticity at 4.8 m rock obstruction	6.10
SANDY SILT Till trace clay, trace gravel, brown-red, moist, very dense, fine grained sand, non-uniform, friable at 7.6 m 20 cm seam of wet silty sand	8.18
SHALE grey	8.23



SAMPLE

Num.	Type	Int.	N.Val.
1	SS	☒	7
2	SS	☒	13
3	SS	☒	5
4	SS	☒	6
5	SS	☒	13
6	SS	☒	109
7	SS	☒	98
8	SS	☒	56

Depth Scale (ft) (m): 5.0, 10.0, 15.0, 20.0, 25.0 (ft); 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0 (m)

Prepared By: **M.Morris** Checked By: **T.Mikel** Date Prepared: **8/17/2023**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND
▼ Water found @ time of drilling
▽ Static Water Level - 8/29/2023

MONITORING WELL DATA
Pipe: **51 mm dia. PVC**
Screen: **51 mm dia. PVC #10 slot**

SAMPLE TYPE					
AC	◧	Auger Cutting	SS	☒	Split Spoon
CS	☐	Continuous	AR	☐	Air Rotary
RC	☐	Rock Core	WC	☐	Wash Cuttings

BURNSIDE
R.J. Burnside & Associates Limited
292 Speedvale Avenue West, Unit 20, Guelph, Ontario, N1H 1C4
telephone (519) 823-4995 fax (519) 836-5447

LOG OF DRILLING OPERATIONS

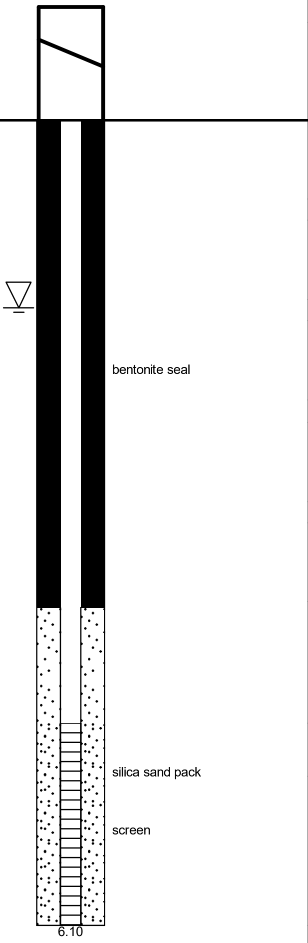
MW2

Page 1 of 1

Client: **Avenia Construction Inc.**	Project Name: **Avenia - Lisgar Drive**	Logged by: **M.Morris**
Project No.: **300057229**	Location: **Lisgar Drive, Mississauga ON**	Ground (m amsl): **194.36**
Drilling Co.: **Geo-Environmental**	Date Started: **8/1/2023**	Static Water Level Depth (m): **1.42**
Drilling Method: **Hollow Stem Auger**	Date Completed: **8/1/2023**	Sand Pack Depth (m) : **3.69 - 6.10**

Surface Elevation (m): **194.36**

Stratigraphic Description	Depth (m)
TOPSOIL dark brown, moist, rootlets	0.30
FILL sandy silt, some clay, trace gravel, brown, dry, stiff	0.76
CLAYEY SILT Till some sand, trace gravel, brown, dry, very stiff, non-uniform, oxidized, mottled	1.52
CLAYEY SILT Till some sand to sandy, trace gravel, brown, moist, very stiff, oxidized, friable at 3.1m turns grey	3.57
SANDY SILT Till trace clay, trace gravel, grey, moist, very dense, non-uniform, friable at 6.1m turns reddish-grey	6.40



SAMPLE Num.	Type	Int.	N.Val.
1	SS	☒	13
2	SS	☒	30
3	SS	☒	33
4	SS	☒	32
5	SS	☒	22
6	SS	☒	66
7	SS	☒	85

Prepared By: **M.Morris** Checked By: **T.Mikel** Date Prepared: **8/17/2023**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND
- ▼ Water found @ time of drilling
- ▽ Static Water Level - 8/29/2023

MONITORING WELL DATA
- Pipe: **51 mm dia. PVC**
- Screen: **51 mm dia. PVC #10 slot**

SAMPLE TYPE				
AC	Auger Cutting	SS	☒	Split Spoon
CS	Continuous	AR		Air Rotary
RC	Rock Core	WC		Wash Cuttings

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R.J. Burnside & Associates Limited
292 Speedvale Avenue West, Unit 20, Guelph, Ontario, N1H 1C4
telephone (519) 823-4995 fax (519) 836-5447

LOG OF DRILLING OPERATIONS

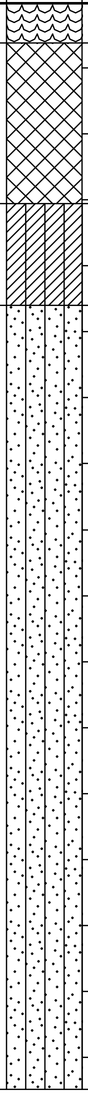
MW3

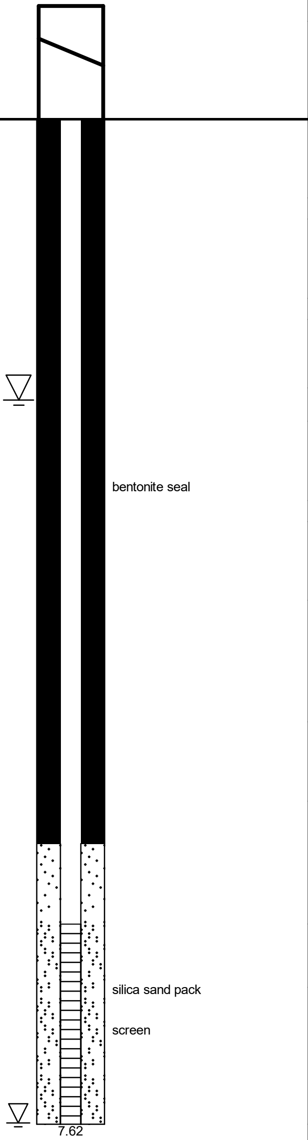
Page 1 of 1

Client: **Avenia Construction Inc.**	Project Name: **Avenia - Lisgar Drive**	Logged by: **M.Morris**
Project No.: **300057229**	Location: **Lisgar Drive, Mississauga ON**	Ground (m amsl): **195.99**
Drilling Co.: **Geo-Environmental**	Date Started: **8/1/2023**	Static Water Level Depth (m): **2.13**
Drilling Method: **Hollow Stem Auger**	Date Completed: **8/1/2023**	Sand Pack Depth (m) : **5.49 - 7.62**

Surface Elevation (m): **195.99**

Depth (m)	Stratigraphic Description
	TOPSOIL dark brown, moist, rootlets
0.30	FILL sandy silt, some clay, brown, moist, stiff, oxidized, friable
1.52	CLAYEY SILT Till trace sand, trace gravel, brownish-grey, moist, very stiff, non-uniform, oxidized, mottled, low plasticity
2.29	SANDY SILT Till some clay, trace gravel, brown, moist, medium dense to very dense, fine grained sand, non-uniform, friable at 6.1 m turns grey and wet
8.23	





Num.	Type	Int.	N.Val.
1	SS	☒	9
2	SS	☒	13
3	SS	☒	17
4	SS	☒	17
5	SS	☒	23
6	SS	☒	49
7	SS	☒	100
8	SS	☒	60

Depth Scale (ft): 5.0, 10.0, 15.0, 20.0, 25.0
Depth Scale (m): 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0

Prepared By: **M.Morris** Checked By: **T.Mikel** Date Prepared: **8/17/2023**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND	MONITORING WELL DATA	SAMPLE TYPE			
▼ Water found @ time of drilling	Pipe: **51 mm dia. PVC**	AC	Auger Cutting	SS ☒	Split Spoon
▽ Static Water Level - 8/29/2023	Screen: **51 mm dia. PVC #10 slot**	CS	Continuous	AR	Air Rotary
		RC	Rock Core	WC	Wash Cuttings

LOG OF DRILLING OPERATIONS

MW4

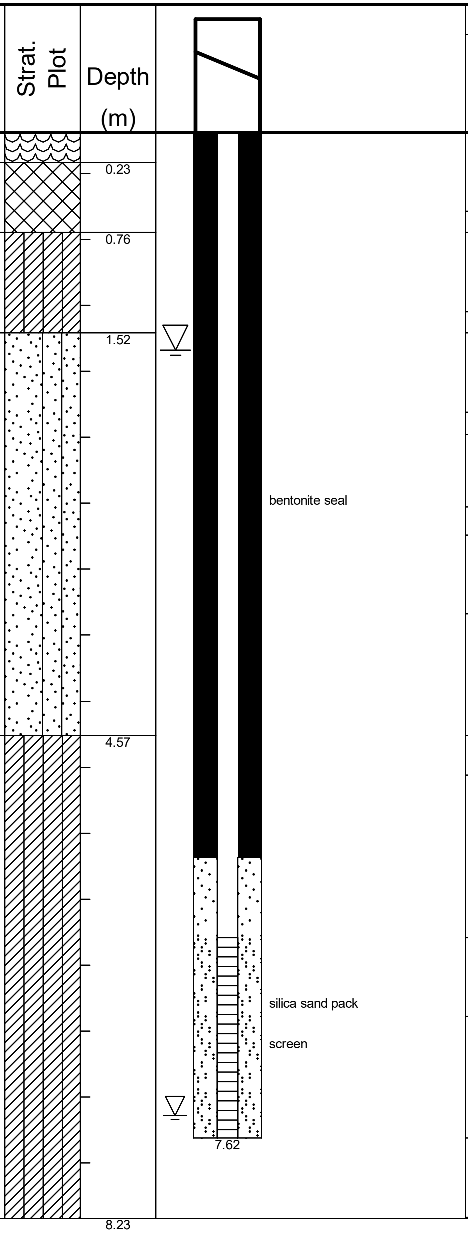
R.J. Burnside & Associates Limited
292 Speedvale Avenue West, Unit 20, Guelph, Ontario, N1H 1C4
telephone (519) 823-4995 fax (519) 836-5447

Page 1 of 1

Client: **Avenia Construction Inc.**	Project Name: **Avenia - Lisgar Drive**	Logged by: **M.Morris**
Project No.: **300057229**	Location: **Lisgar Drive, Mississauga ON**	Ground (m amsl): **194.31**
Drilling Co.: **Geo-Environmental**	Date Started: **7/31/2023**	Static Water Level Depth (m): **1.65**
Drilling Method: **Hollow Stem Auger**	Date Completed: **7/31/2023**	Sand Pack Depth (m) : **5.49 - 7.62**

Surface Elevation (m): **194.31**

Stratigraphic Description	Depth (m)
TOPSOIL dark brown, moist, rootlets	0.23
FILL sandy silt, some clay, trace gravel, brown, dry, stiff	0.76
CLAYEY SILT Till some sand, trace gravel, brown, dry, very stiff, non-uniform, oxidized, mottled	1.52
SANDY SILT Till some clay, trace gravel, brown, dry, very stiff to hard, oxidized, friable	4.57
CLAYEY SILT Till trace sand, trace gravel, brownish-grey, moist, very dense, non-uniform, friable at 6.1m turns reddish-brown, occasional wet seams	8.23



SAMPLE Num.	Type	Int.	N.Val.
1	SS	☒	11
2	SS	☒	17
3	SS	☒	24
4	SS	☒	49
5	SS	☒	46
6	SS	☒	>50
7	SS	☒	88
8	SS	☒	48

Prepared By: **M.Morris** Checked By: **T.Mikel** Date Prepared: **8/17/2023**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND
▼ Water found @ time of drilling
▽ Static Water Level - 8/29/2023

MONITORING WELL DATA
Pipe: **51 mm dia. PVC**
Screen: **51 mm dia. PVC #10 slot**

SAMPLE TYPE
AC Auger Cutting
CS Continuous
RC Rock Core
SS ☒ Split Spoon
AR Air Rotary
WC Wash Cuttings

JOB NO.: 2302-S052

LOG OF BOREHOLE: 1

FIGURE NO.: 1

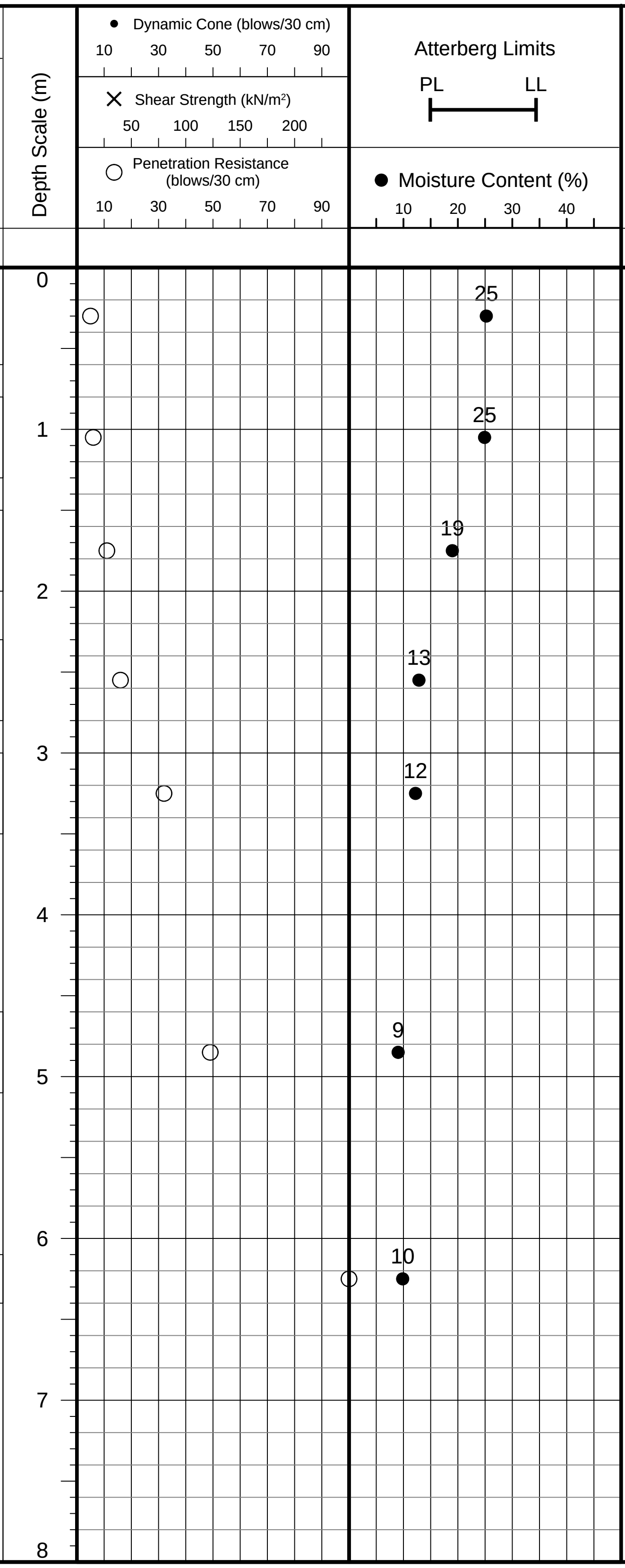
PROJECT DESCRIPTION: Due Diligence for Land Acquisition

METHOD OF BORING: Flight Auger (Solid Stem)

PROJECT LOCATION: North of Lisgar Drive and Doug Leavens Boulevard, City of Mississauga

DRILLING DATE: February 24, 2023

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
195.1	Ground Surface			
0.0	**8 cm of Topsoil** **EARTH FILL** Brown Silty Clay traces of gravel and sand occ. rootlets and wood fragments	1	DO	5
		2	DO	6
		3	DO	11
192.9 2.1	Brown, very stiff to hard **SILTY CLAY TILL** traces of gravel and sand	4	DO	16
		5	DO	32
191.0 4.0	Brown, dense to very dense **SANDY SILT TILL** traces of gravel and clay	6	DO	49
		7	DO	50/13
188.7 6.4	**END OF BOREHOLE**			



WATER LEVEL

W.L. @ El. 189.3 m upon completion

Soil Engineers Ltd.

JOB NO.: 2302-S052

LOG OF BOREHOLE: 2

FIGURE NO.: 2

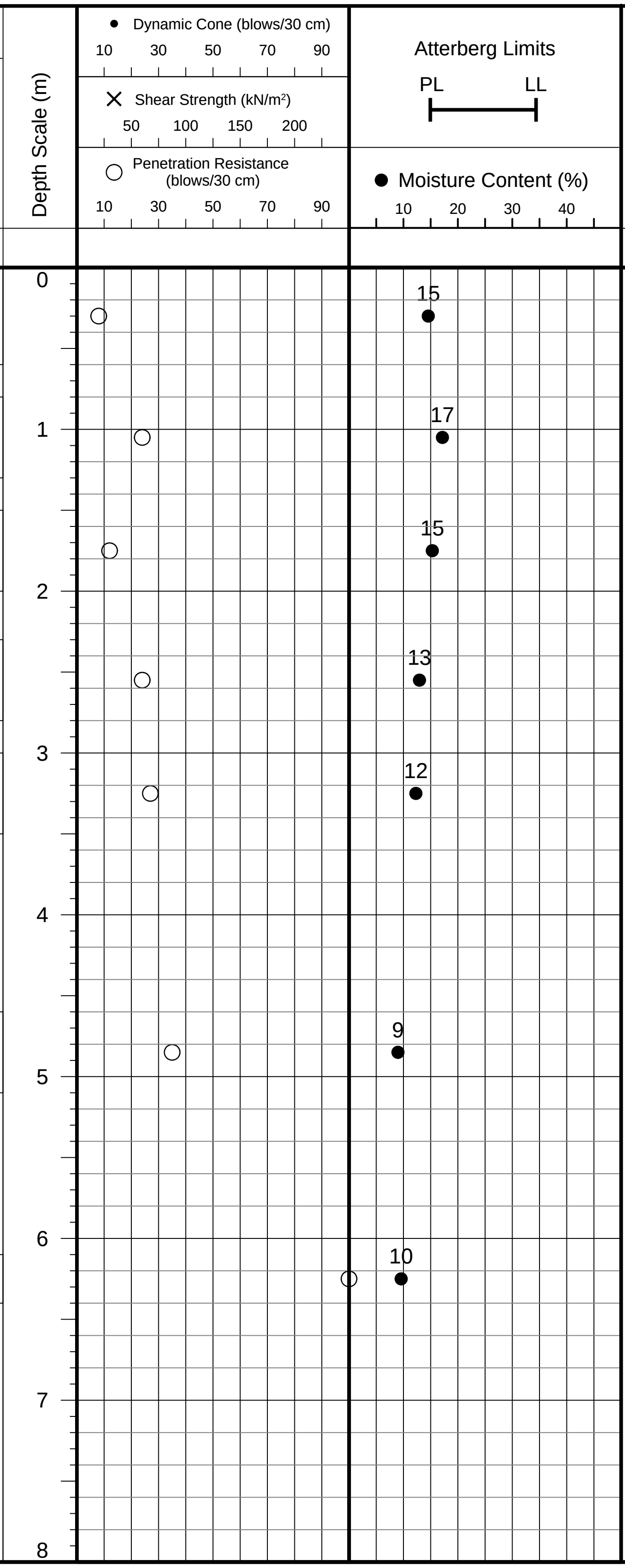
PROJECT DESCRIPTION: Due Diligence for Land Acquisition

METHOD OF BORING: Flight Auger
(Solid Stem)

PROJECT LOCATION: North of Lisgar Drive and Doug Leavens Boulevard,
City of Mississauga

DRILLING DATE: February 24, 2023

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
194.6	Ground Surface			
0.0	**10 cm of Topsoil** **EARTH FILL** Brown Silty Clay traces of gravel and sand occ. rootlets and wood fragments	1	DO	8
		2	DO	24
193.0 1.6	Brown, stiff to very stiff **SILTY CLAY TILL** traces of gravel and sand	3	DO	12
		4	DO	24
		5	DO	27
190.5 4.0	Brown, dense to very dense **SANDY SILT TILL** traces of gravel and clay	6	DO	35
		7	DO	50/13
188.2 6.4	**END OF BOREHOLE**			



WATER LEVEL

Dry upon Completion

Soil Engineers Ltd.

JOB NO.: 2302-S052

LOG OF BOREHOLE: 3

FIGURE NO.: 3

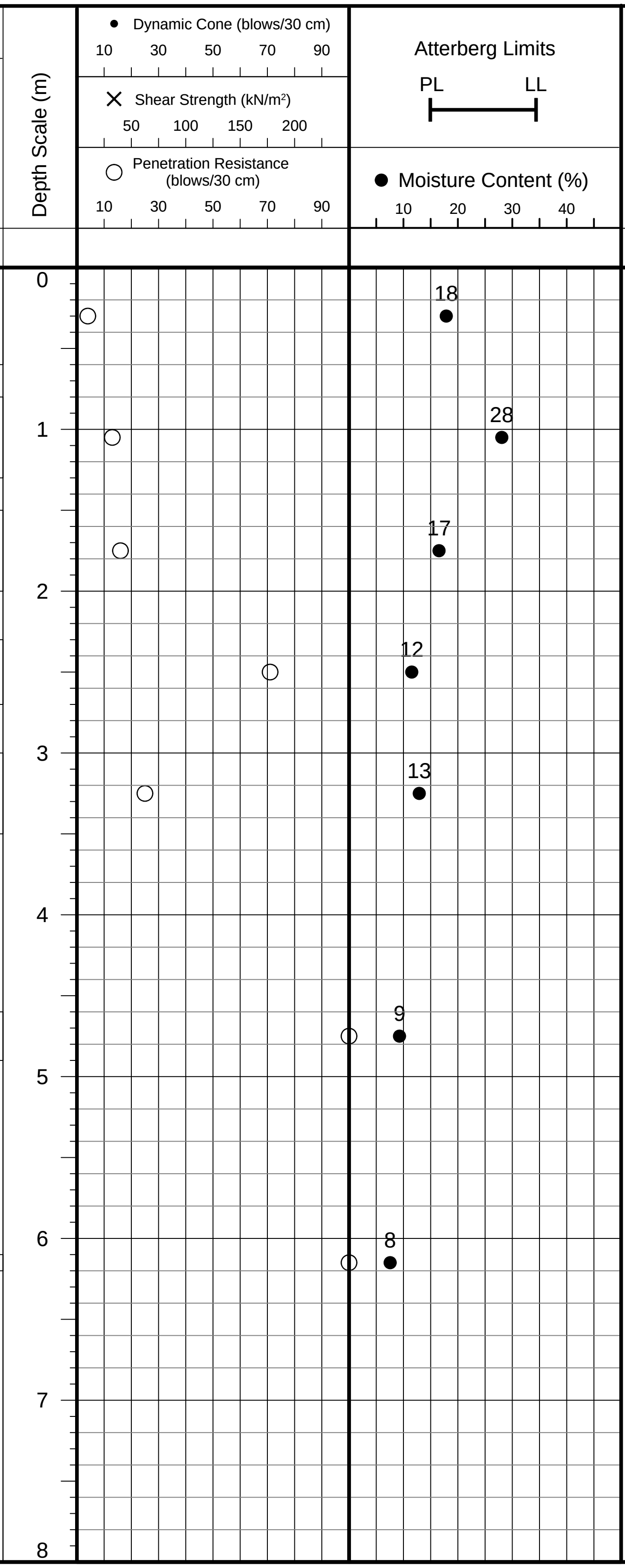
PROJECT DESCRIPTION: Due Diligence for Land Acquisition

METHOD OF BORING: Flight Auger
(Solid Stem)

PROJECT LOCATION: North of Lisgar Drive and Doug Leavens Boulevard,
City of Mississauga

DRILLING DATE: February 24, 2023

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES		
		Number	Type	N-Value
194.5	Ground Surface			
0.0	**10 cm of Topsoil** **EARTH FILL** Brown Silty Clay traces of gravel and sand occ. rootlets and wood fragments	1	DO	4
		2	DO	13
		3	DO	16
192.7 1.8	Brown, very stiff to hard **SILTY CLAY TILL** traces of gravel and sand			
		4	DO	71
		5	DO	25
190.4 4.0	Very dense **SANDY SILT TILL** traces of gravel and clay			
	brown grey	6	DO	50/15
		7	DO	50/13
188.3 6.2	**END OF BOREHOLE**			



WATER LEVEL

Cave-in @ El. 188.6 m upon completion

Soil Engineers Ltd.

Page: 1 of 1

JOB NO.: 2302-S052

LOG OF BOREHOLE: 4

FIGURE NO.: 4

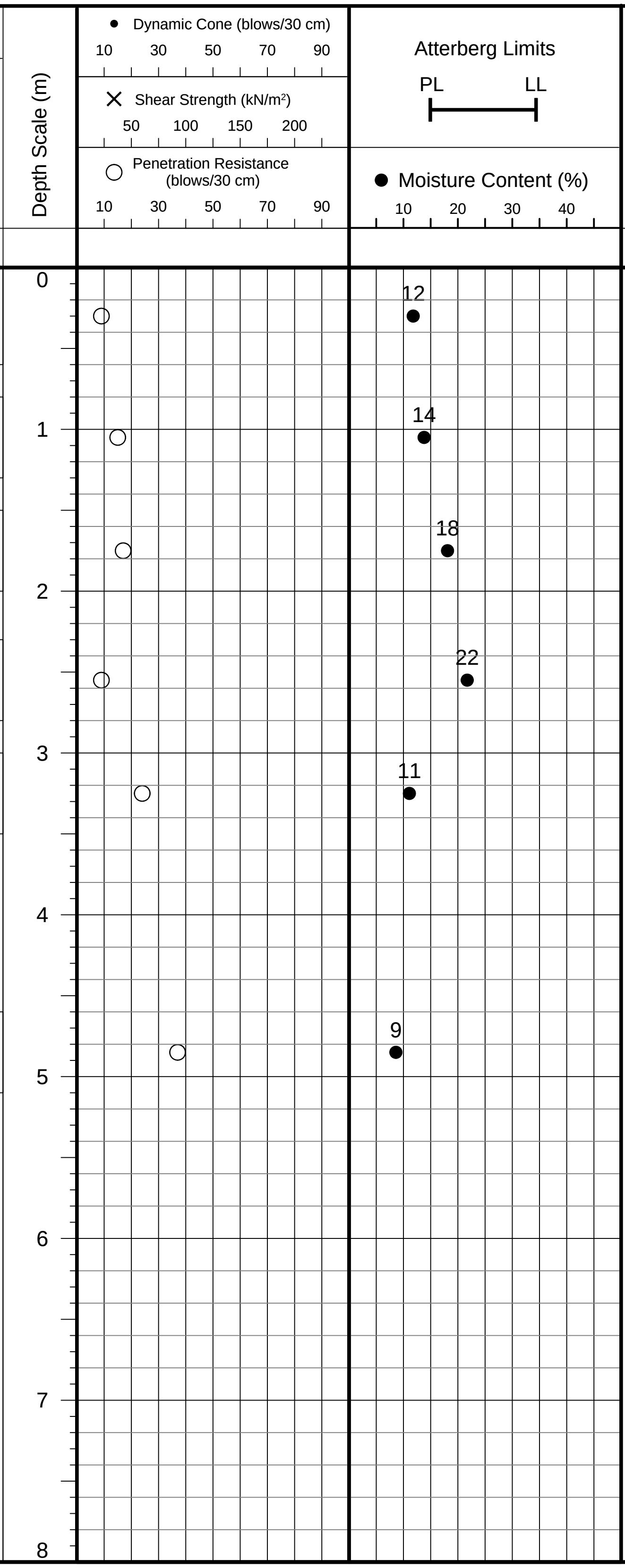
PROJECT DESCRIPTION: Due Diligence for Land Acquisition

METHOD OF BORING: Flight Auger (Solid Stem)

PROJECT LOCATION: North of Lisgar Drive and Doug Leavens Boulevard,
City of Mississauga

DRILLING DATE: February 24, 2023

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	WATER LEVEL
193.8	Ground Surface				
0.0	**10 cm of Topsoil** **EARTH FILL** Brown Silty Clay traces of gravel and sand occ. rootlets and wood fragments	1	DO	9	
		2	DO	15	
		3	DO	17	
191.7 2.1	Brown, stiff to very stiff **SILTY CLAY TILL** traces of gravel and sand	4	DO	9	
		5	DO	24	
189.8 4.0	Grey, dense **SANDY SILT TILL** traces of gravel and clay	6	DO	37	Dry upon Completion
188.6 5.2	**END OF BOREHOLE DUE TO AUGER REFUSAL ON PROBABLE BOULDER OR BEDROCK**				



Soil Engineers Ltd.

JOB NO.: 2302-S052

LOG OF BOREHOLE: 5

FIGURE NO.: 5

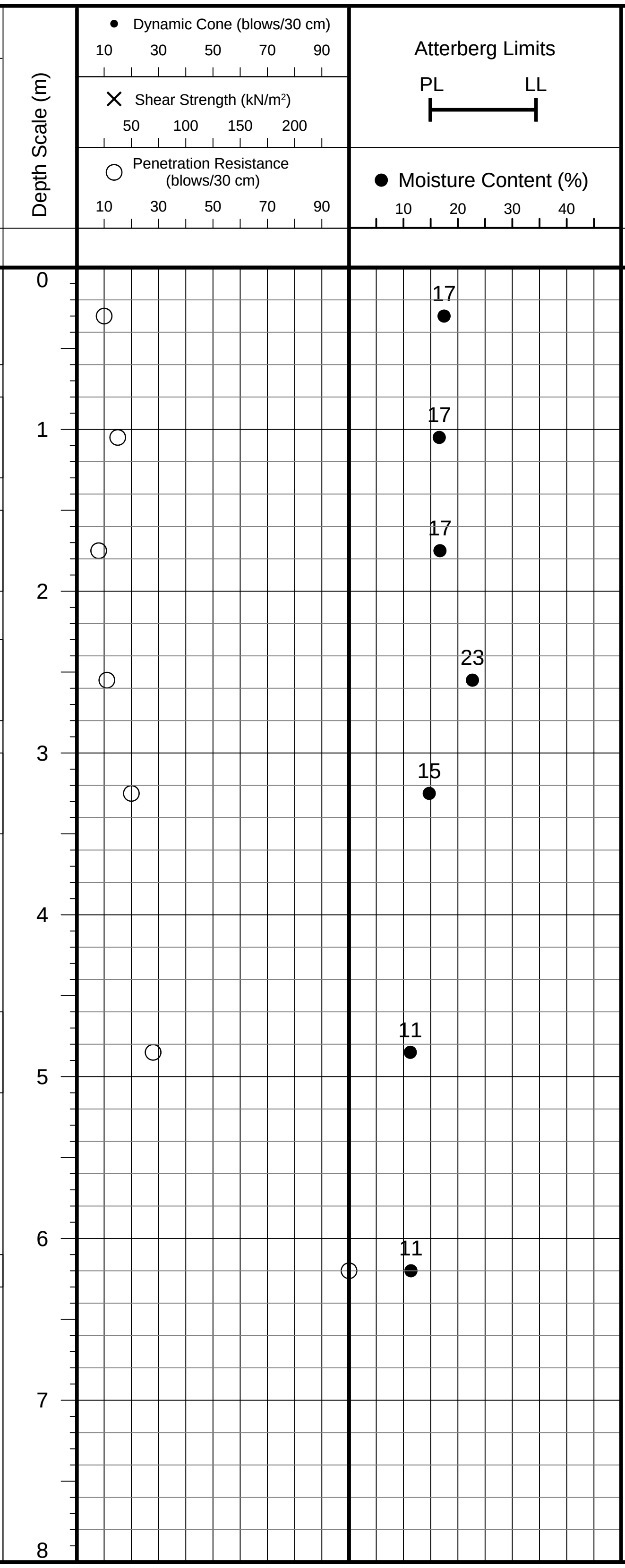
PROJECT DESCRIPTION: Due Diligence for Land Acquisition

METHOD OF BORING: Flight Auger (Solid Stem)

PROJECT LOCATION: North of Lisgar Drive and Doug Leavens Boulevard, City of Mississauga

DRILLING DATE: February 24, 2023

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	WATER LEVEL
194.5	Ground Surface				
0.0	**13 cm of Topsoil** **EARTH FILL** Reddish Brown to Brown Silty Clay traces of gravel and sand occ. rootlets and wood fragments	1	DO	10	Dry upon Completion
		2	DO	15	
		3	DO	8	
		4	DO	11	
		5	DO	20	
191.2 3.3	Brown, very stiff **SILTY CLAY TILL** traces of gravel and sand				
190.4 4.0	Brown, compact to very dense **SANDY SILT TILL** traces of gravel and clay	6	DO	28	
		7	DO	50/15	
188.2 6.3	**END OF BOREHOLE**				



Soil Engineers Ltd.

JOB NO.: 2302-S052

LOG OF BOREHOLE: 6

FIGURE NO.: 6

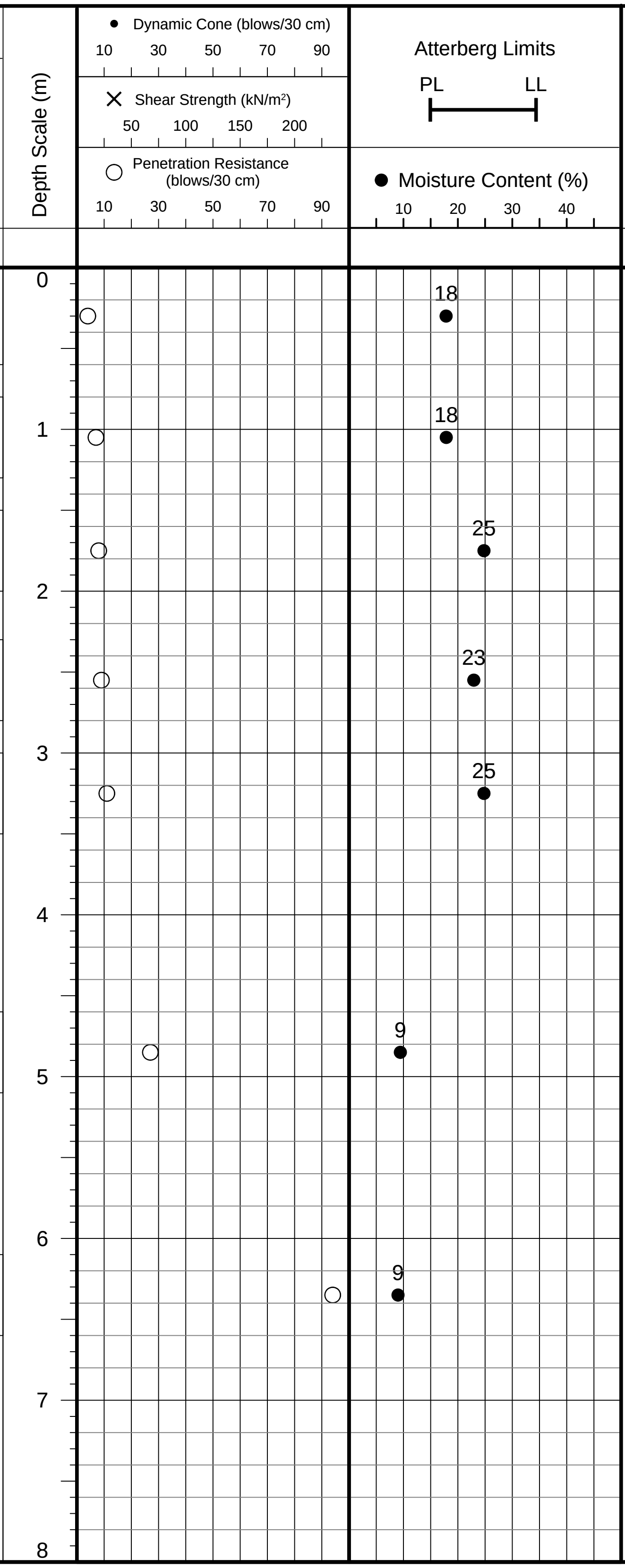
PROJECT DESCRIPTION: Due Diligence for Land Acquisition

METHOD OF BORING: Flight Auger
(Solid Stem)

PROJECT LOCATION: North of Lisgar Drive and Doug Leavens Boulevard,
City of Mississauga

DRILLING DATE: February 24, 2023

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
194.1	Ground Surface			
0.0	**10 cm of Topsoil** **EARTH FILL** Brown Silty Clay traces of gravel and sand occ. rootlets and wood fragments	1	DO	4
		2	DO	7
		3	DO	8
191.9 2.1	Brown, stiff **SILTY CLAY TILL** traces of gravel and sand	4	DO	9
		5	DO	11
190.0 4.0	Brown, compact to very dense **SANDY SILT TILL** traces of gravel and clay	6	DO	27
		7	DO	94
187.5 6.6	**END OF BOREHOLE**			



WATER LEVEL

Dry upon Completion

Soil Engineers Ltd.

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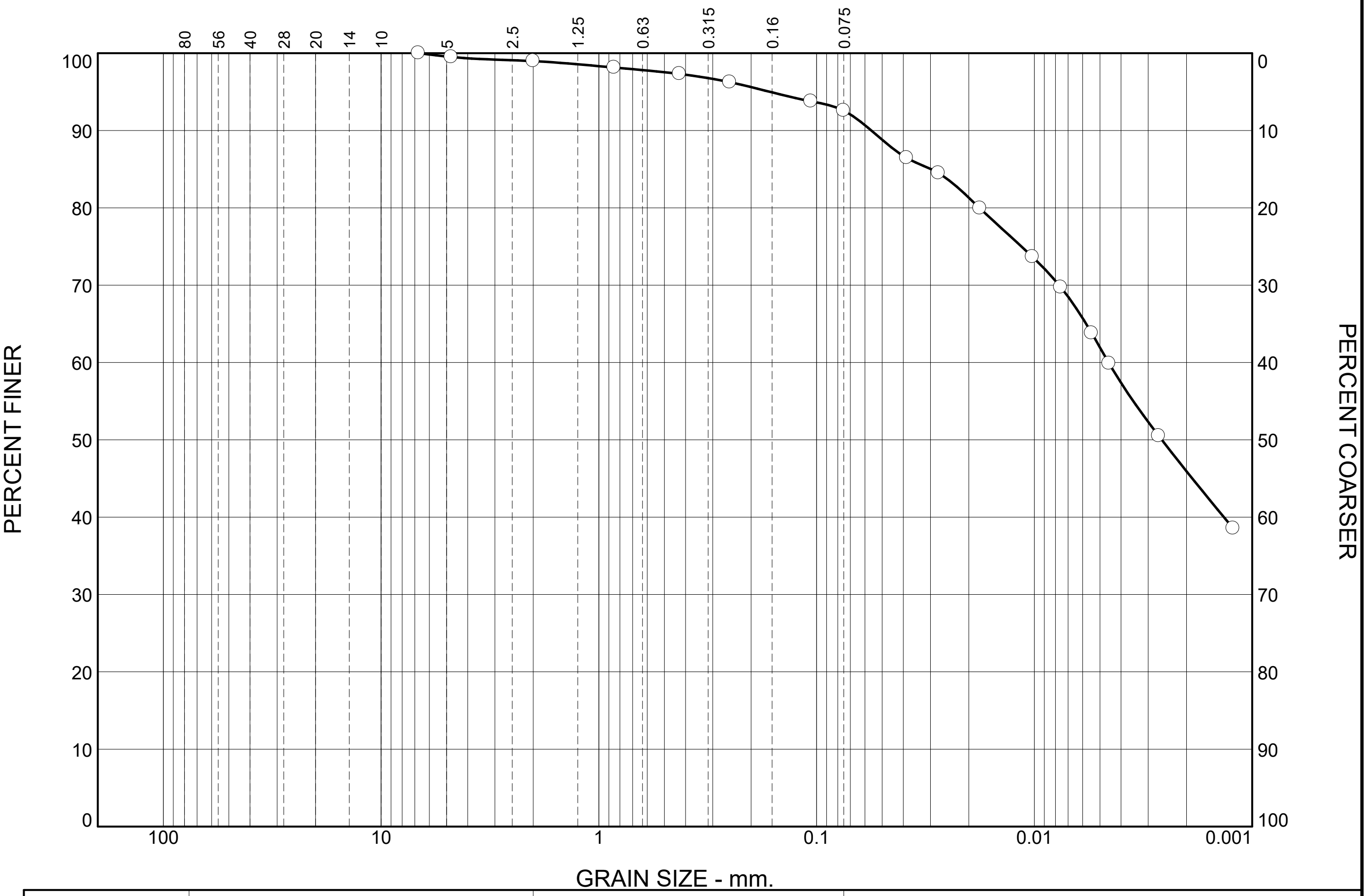
Appendix C

Grainsize Analysis

Particle Size Distribution Report



	% +3"	% Gravel	% Sand		% Fines	
			Coarse	Fine	Silt	Clay
○	0.0	1.0	1.7	4.7	46.7	45.9

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.0298	0.0046	0.0026					

Material Description	USCS	AASHTO
○ SILT AND CLAY trace sand trace gravel		

Project No. CA20069 **Client:** R.J. Burnside and Associates Ltd

Project: RJ Burnside Prj No 300057229.0000

○ **Sample Number:** MW1 SS5

Terrapex

Toronto, Ontario

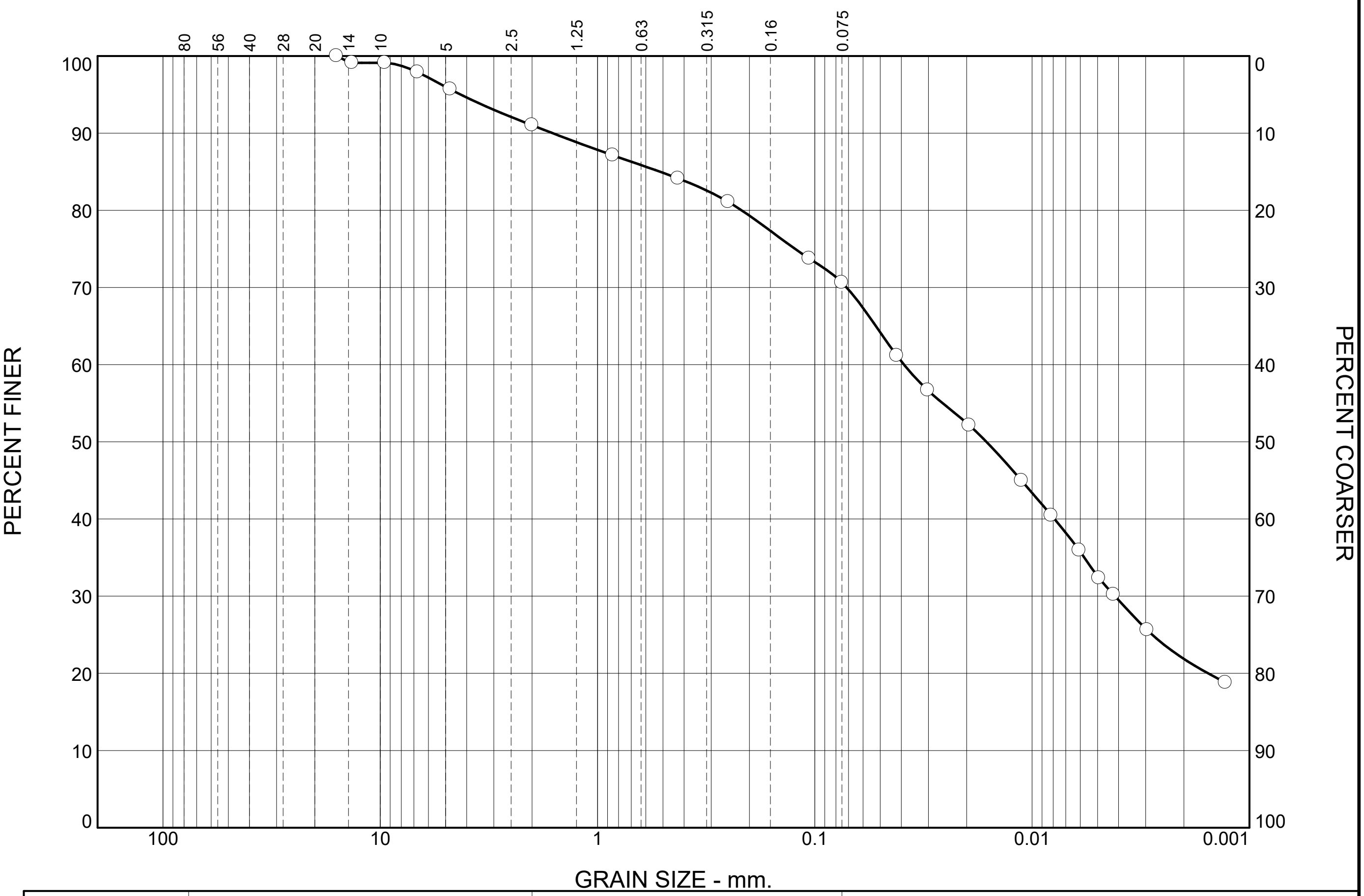
Remarks:

○HYDROMETER DETAILS: Spec. Grav. 2.75(assumed);Vb=53cm^3; L2=13.8cm; L1=10.7cm; hs= 0.16cm/Div; A=30.2cm^2; Mass of Disp. Agent=40g/1 Test Date: Sept.6, 2023

Figure 1

Tested By: AR/AM

Particle Size Distribution Report



	% +3"	% Gravel	% Sand		% Fines	
			Coarse	Fine	Silt	Clay
○	0.0	9.0	6.9	13.5	48.7	21.9

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.5159	0.0389	0.0162	0.0042				

Material Description	USCS	AASHTO
○ CLAYEY SILT some sand to SANDY trace gravel		

Project No. CA20069 **Client:** R.J. Burnside and Associates Ltd

Project: RJ Burnside Prj No 300057229.0000

○ **Sample Number:** MW2 SS4

Terrapex

Toronto, Ontario

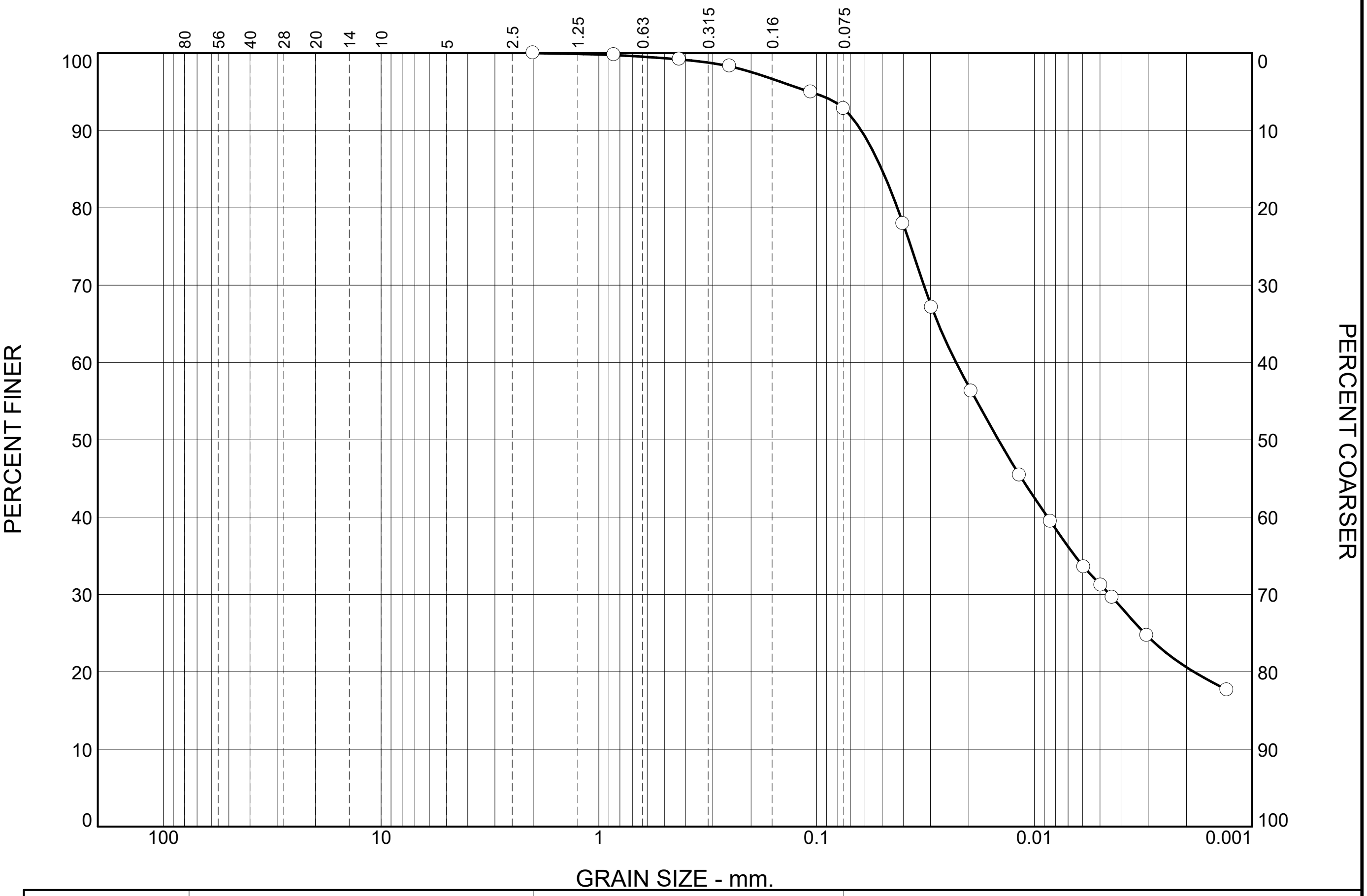
Remarks:

○HYDROMETER DETAILS: Spec. Grav. 2.75(assumed);Vb=53cm^3; L2=13.8cm; L1=10.7cm; hs= 0.16cm/Div; A=30.2cm^2; Mass of Disp. Agent=40g/1 Test Date: Sept.6, 2023

Figure 2

Tested By: AM

Particle Size Distribution Report



	% +3"	% Gravel	% Sand		% Fines	
			Coarse	Fine	Silt	Clay
○	0.0	0.0	0.8	6.4	72.2	20.6

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.0502	0.0229	0.0146	0.0045				

Material Description	USCS	AASHTO
○ CLAYEY SILT trace sand		

Project No. CA20069 **Client:** R.J. Burnside and Associates Ltd

Project: RJ Burnside Prj No 300057229.0000

○ **Sample Number:** MW4 SS7

Terrapex

Toronto, Ontario

Remarks:

○HYDROMETER DETAILS: Spec. Grav. 2.75(assumed);Vb=53cm^3; L2=13.8cm; L1=10.7cm; hs= 0.16cm/Div; A=30.2cm^2; Mass of Disp. Agent=40g/1 Test Date: Sept.6, 2023

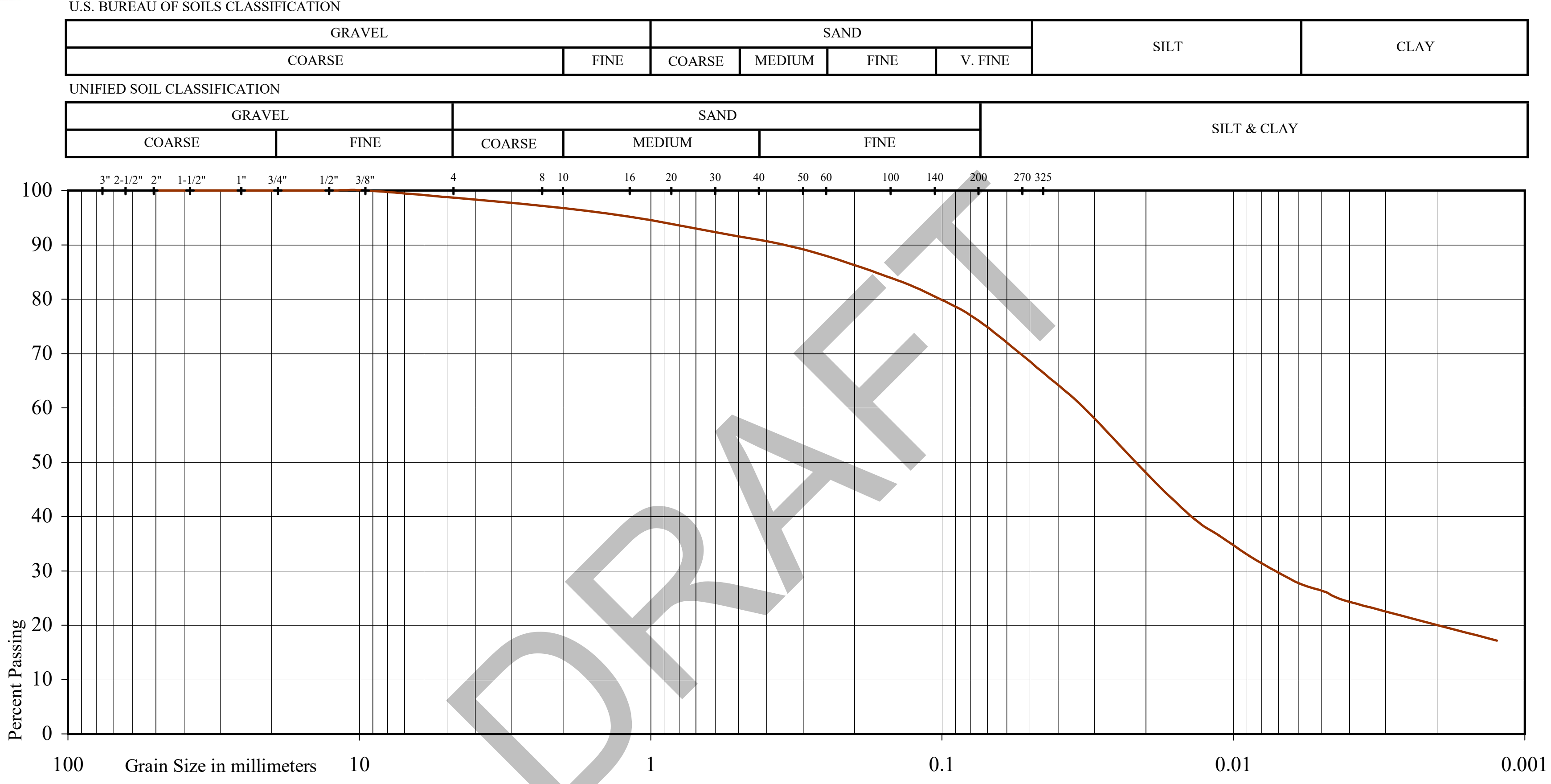
Figure 3

Tested By: AM

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

Reference No: 2302-S052



Project: Proposed Residential Development

Location: North of Lisgar Drive and Doug Leavens Boulevard, City of Mississauga

Liquid Limit (%) = 24

Plastic Limit (%) = 16

Plasticity Index (%) = 8

Moisture Content (%) = 22

Estimated Permeability (cm./sec.) = 10^{-7}

Borehole No: 4

Sample No: 4

Depth (m): 2.3

Elevation (m): 191.5

Classification of Sample [& Group Symbol]: SILTY CLAY TILL
sandy, a trace of gravel

Figure: 7

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Appendix D

Hydraulic Conductivity Tests

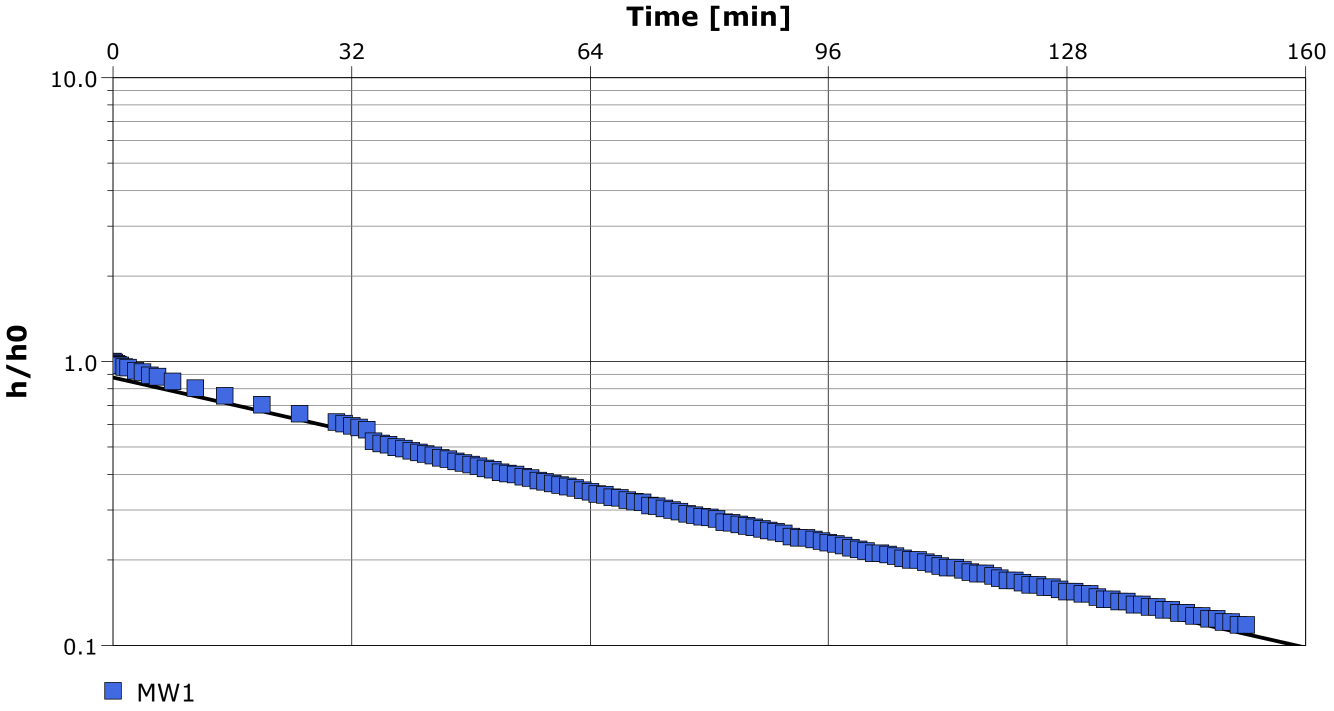
Slug Test Analysis Report

Project: Avenia - Lisgar Drive

Number: 300057229

Client: Avenia Construction Inc.

Location: Lisgar Drive, Mississauga, ON	Slug Test: MW1 - rising head	Test Well: MW1
Test Conducted by: EP, AC		Test Date: 8/29/2023
Analysis Performed by: AC	Screened in sandy silt till	Analysis Date: 9/18/2023
Aquifer Thickness: 6.35 m		

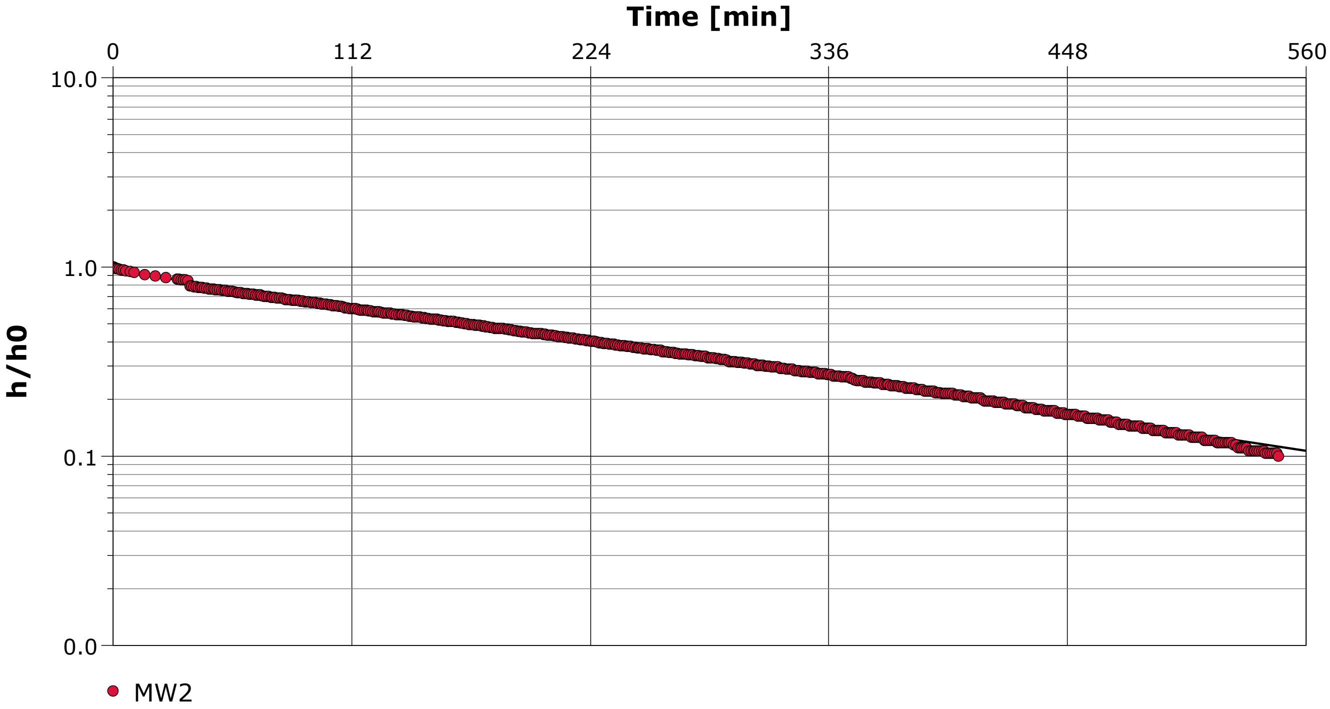


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [cm/s]	
MW1	1.61 × 10^{-5}	

BURNSIDE	**Slug Test Analysis Report**
	Project: Avenia - Lisgar Drive
	Number: 300057229
	Client: Avenia Construction Inc.

Location: Lisgar Drive, Mississauga, ON	Slug Test: MW2 - rising head	Test Well: MW2
Test Conducted by: EP, AC		Test Date: 8/29/2023
Analysis Performed by: AC	Screened in sandy silt till	Analysis Date: 9/18/2023
Aquifer Thickness: 4.70 m		

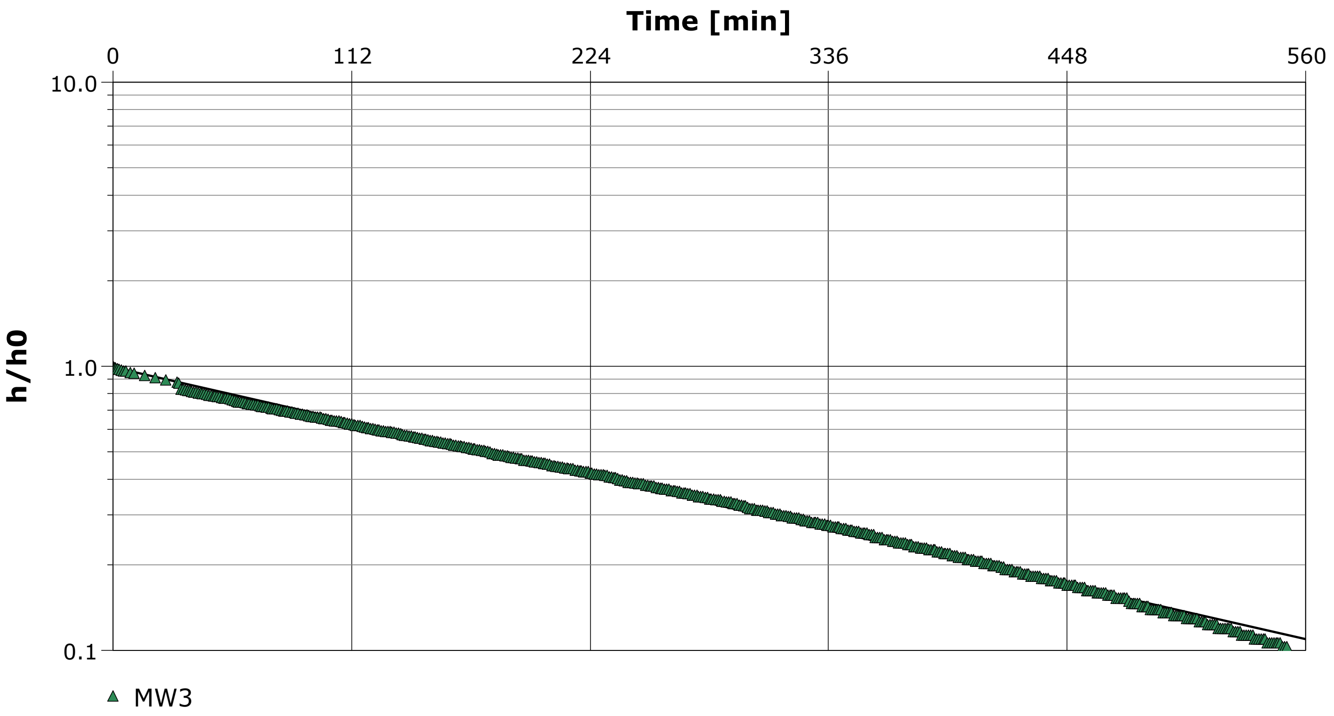


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [cm/s]	
MW2	4.63 × 10^{-6}	

Slug Test Analysis Report	
Project:	Avenia - Lisgar Drive
Number:	300057229
Client:	Avenia Construction Inc.

Location: Lisgar Drive, Mississauga, ON	Slug Test: MW3 - rising head	Test Well: MW3
Test Conducted by: EP, AC		Test Date: 8/29/2023
Analysis Performed by: AC	Screened in sandy silt till	Analysis Date: 9/18/2023
Aquifer Thickness: 5.49 m		

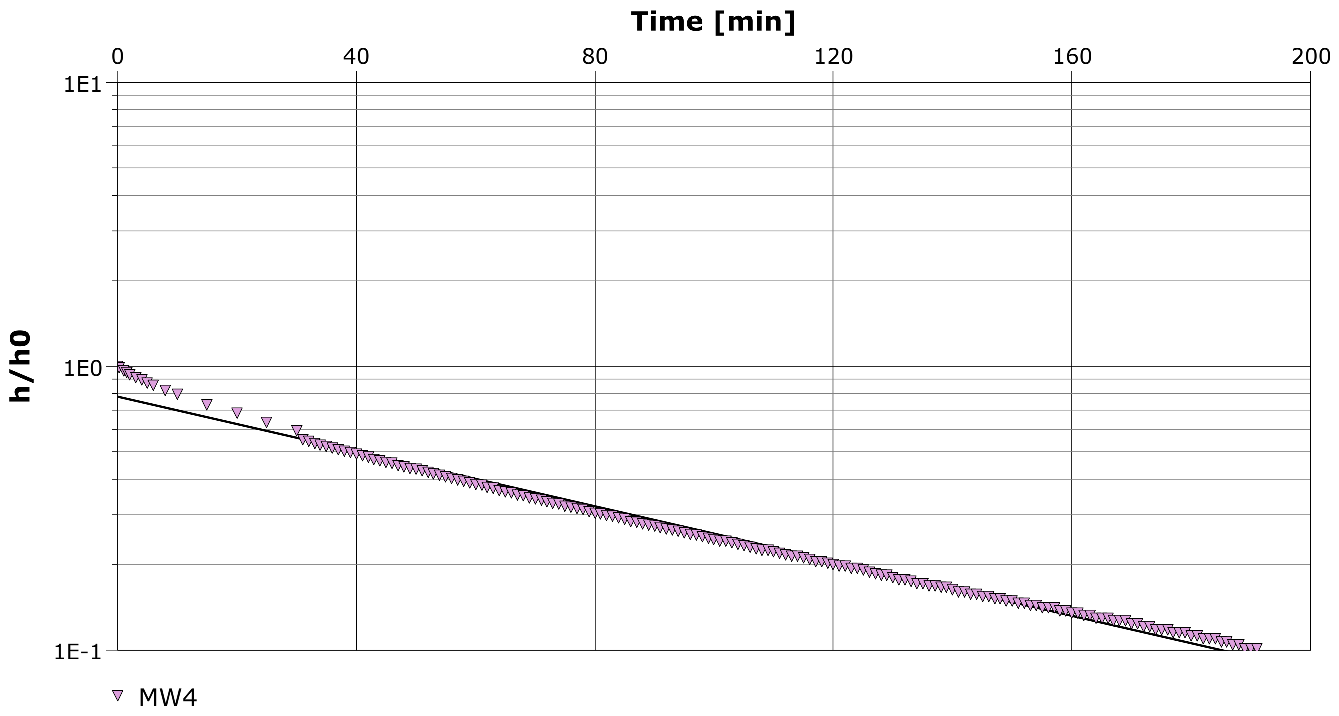


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [cm/s]	
MW3	4.65×10^{-6}	

	Slug Test Analysis Report
	Project: Avenia - Lisgar Drive
	Number: 300057229
	Client: Avenia Construction Inc.

Location: Lisgar Drive, Mississauga, ON	Slug Test: MW4 - rising head	Test Well: MW4
Test Conducted by: EP, AC		Test Date: 8/29/2023
Analysis Performed by: AC	Screened in clayey silt till	Analysis Date: 9/18/2023
Aquifer Thickness: 5.92 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [cm/s]	
MW4	1.31×10^{-5}	

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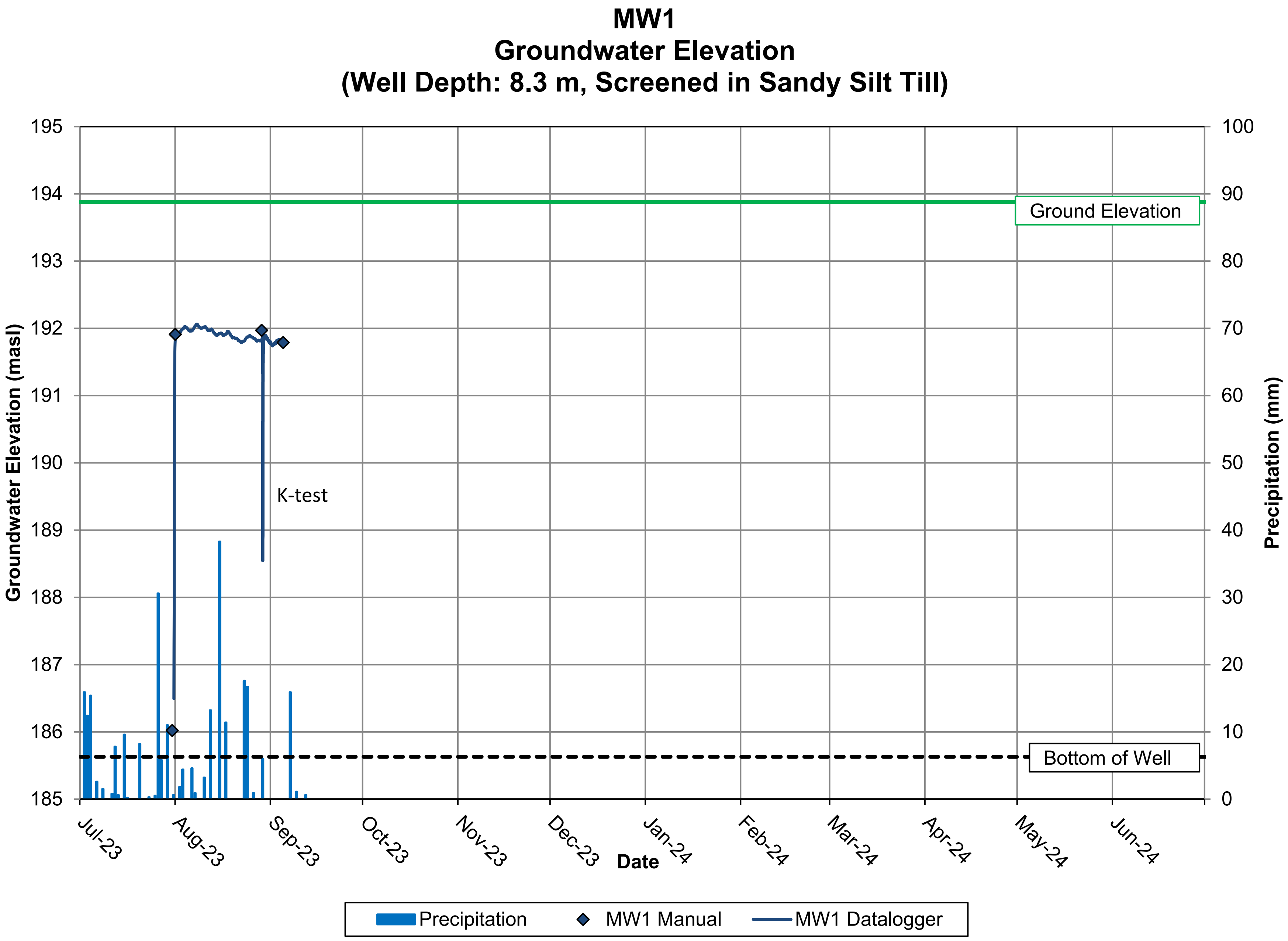
Appendix E

Groundwater Elevation Data

Table E-1
Groundwater Elevations - Monitoring Wells

Monitoring Well	Well Depth (mbgl)	Ground Elevation (masl)	31-Jul-23		01-Aug-23		29-Aug-23		05-Sep-23	
			Water Level (mbgl)	Water Elevation (masl)	Water Level (mbgl)	Water Elevation (masl)	Water Level (mbgl)	Water Elevation (masl)	Water Level (mbgl)	Water Elevation (masl)
MW1	**8.25**	**193.88**	7.86	186.02	1.97	191.91	1.91	191.97	2.09	191.79
MW2	**6.12**	**194.36**	-	-	dry	dry	1.42	192.94	1.50	192.86
MW3	**7.63**	**195.99**	-	-	7.61	188.38	2.13	193.86	2.15	193.84
MW4	**7.57**	**194.31**	7.45	186.86	2.20	192.11	1.65	192.66	1.78	192.53

mbgl - metres below ground level
masl - metres above sea level
' - ' - instrument not installed



R.J. Burnside & Associates Limited
300057229

Figure E-1

MW2
Groundwater Elevation
(Well Depth: 6.1 m, Screened in Sandy Silt Till)

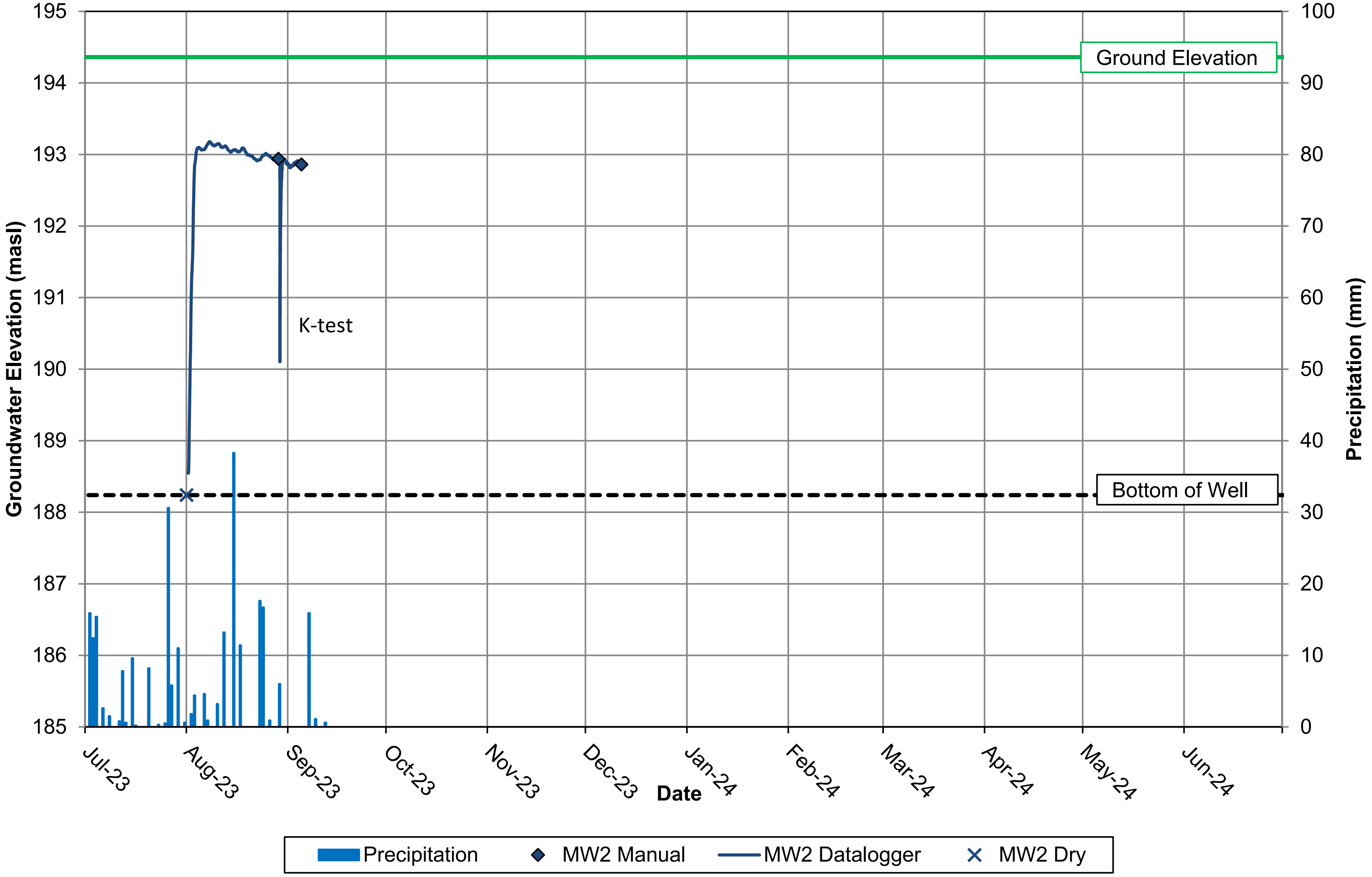


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Figure E-2

MW3
Groundwater Elevation
(Well Depth: 7.6 m, Screened in Sandy Silt Till)

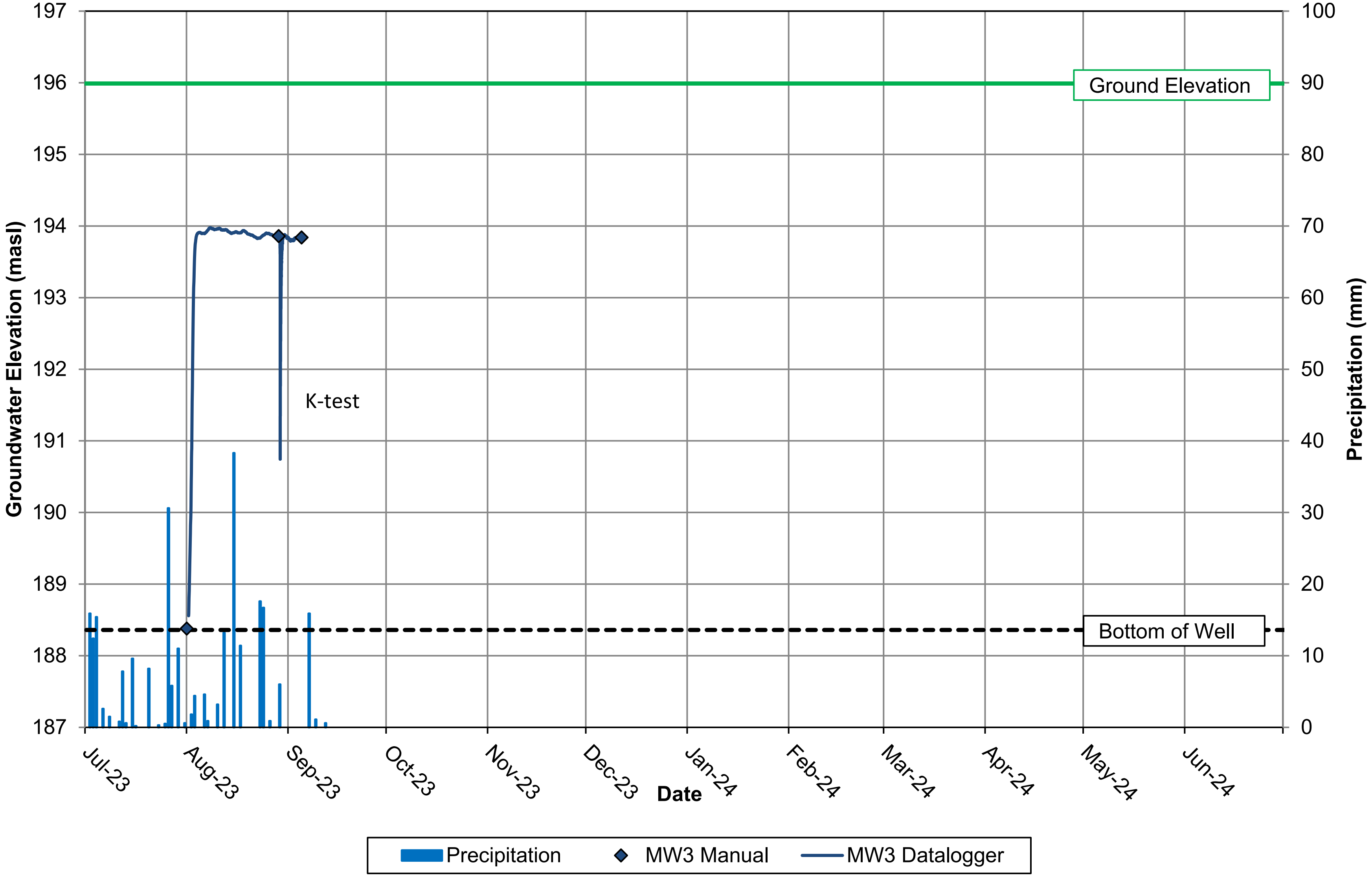
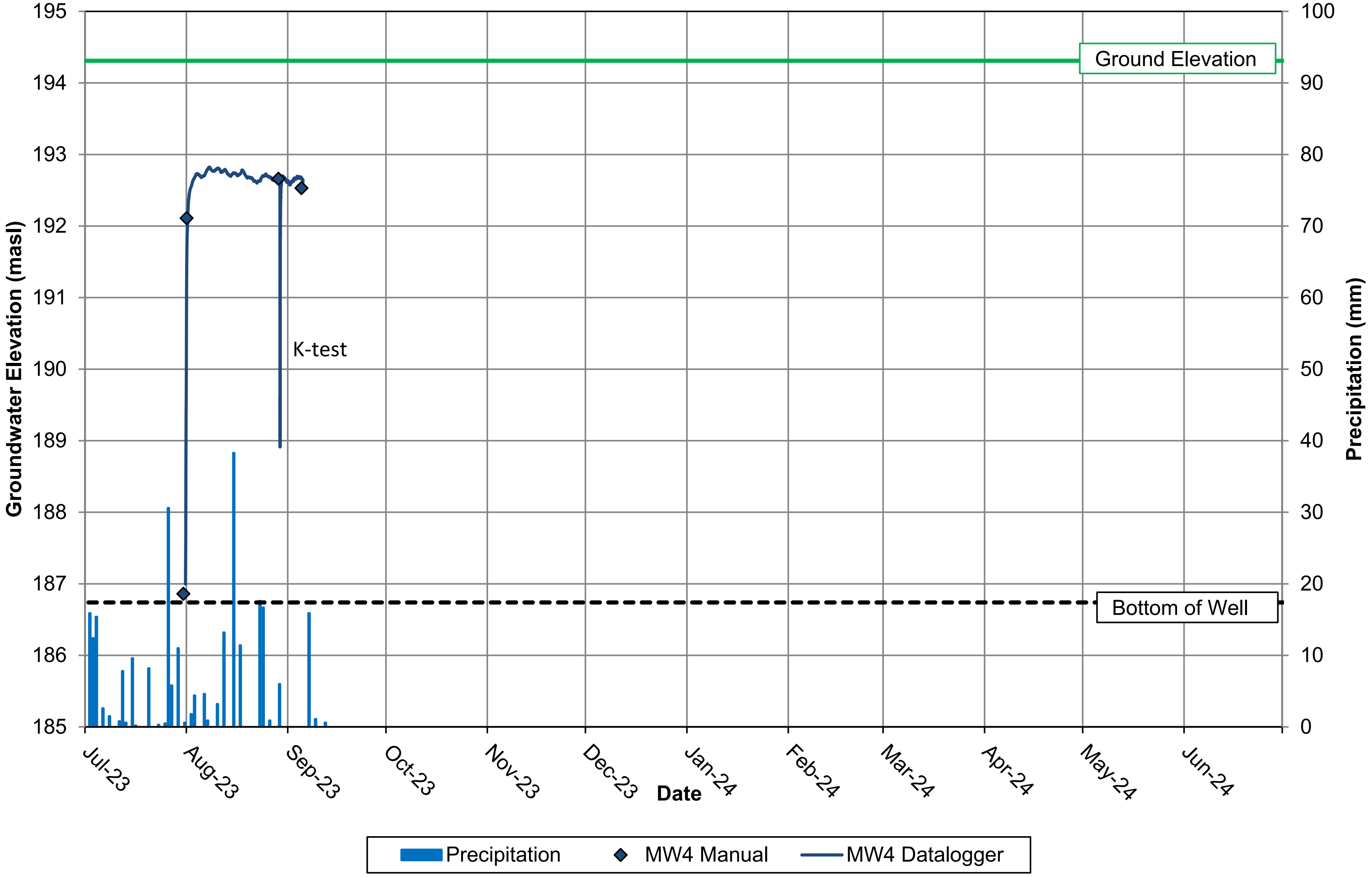


Figure E-3

MW4
Groundwater Elevation
(Well Depth: 7.6 m, Screened in Clayey Silt Till)



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300057229

Figure E-4

Appendix F

Groundwater Quality

Table F-1: Groundwater Quality
Mississauga Storm Sewer Use Bylaw - Organics

Sample Description			MW4
Date Sampled			09/05/2023
Parameter	Unit	G / S	
Benzene	mg/L	0.002	<0.0002
Toluene	mg/L	0.002	<0.0002
Ethylbenzene	mg/L	0.002	<0.0001
m & p-Xylene	mg/L		<0.0002
o-Xylene	mg/L		<0.0001
Xylenes (Total)	mg/L	0.0044	<0.0001
Toluene-d8	% Recovery		97
4-Bromofluorobenzene	% Recovery		87
Acenaphthene	mg/L		<0.00010
Acenaphthylene	mg/L		<0.00011
Anthracene	mg/L		<0.00007
Benzo(a)anthracene	mg/L		<0.00008
Benzo(a)pyrene	mg/L		<0.001
Benzo(b)fluoranthene	mg/L		<0.00003
Benzo(ghi)perylene	mg/L		<0.00006
Benzo(k)fluoranthene	mg/L		<0.00006
Chrysene	mg/L		<0.00005
Dibenzo(a,h)anthracene	mg/L		<0.00009
Fluoranthene	mg/L		<0.00012
Fluorene	mg/L		<0.0002
Indeno(1,2,3-cd)pyrene	mg/L		<0.00003
Naphthalene	mg/L		<0.0003
Phenanthrene	mg/L		<0.00011
Pyrene	mg/L		<0.00012
Total PAHs	mg/L	0.002	<0.0003
Acridine-d9	%		60
Naphthalene-d8	%		85
Terphenyl-d14	%		91
1,2-Dichlorobenzene	mg/L	0.0056	<0.0001
1,4-Dichlorobenzene	mg/L	0.0068	<0.0001
Dichloromethane	mg/L	0.0052	<0.0001
Tetrachloroethylene	mg/L	0.0044	<0.0001
Trichloroethylene	mg/L	0.0076	<0.0002
Tetrachloroethene	mg/L	0.017	<0.0002
PCBs	mg/L	0.0004	<0.0002
Decachlorobiphenyl	%		106
Escherichia coli - DC Agar	CFU/100mL		0

G/S - Guideline Standard - Mississauga Storm Sewer Use Bylaw
Bold - Exceeds Mississauga Storm Sewer Use Bylaw

Table F-2: Groundwater Quality
Mississauga Storm Sewer Use Bylaw - Inorganics

		Sample Description	MW4
		Date Sampled	09/05/2023
Parameter	Unit	G / S	
pH	pH Units	6.0-9.0	7.35
BOD (5)	mg/L	15	<2
Total Suspended Solids	mg/L	15	<10
Total Residual Chlorine	mg/L	1.0	<0.01
Cyanide, SAD	mg/L	0.02	<0.002
Phenols	mg/L	0.008	<0.001
Total Phosphorus	mg/L	0.4	<0.02
Chromium VI	mg/L	0.04	<0.002
Total Aluminum	mg/L	1.0	<0.010
Total Arsenic	mg/L	0.02	<0.015
Total Cadmium	mg/L	0.008	<0.005
Total Chromium	mg/L	0.08	<0.015
Total Copper	mg/L	0.04	<0.010
Total Lead	mg/L	0.12	<0.020
Total Manganese	mg/L	2.0	0.389
Total Mercury	mg/L	0.0004	<0.0002
Total Nickel	mg/L	0.08	<0.015
Total Selenium	mg/L	0.02	0.004
Total Silver	mg/L	0.12	<0.010
Total Zinc	mg/L	0.2	<0.020

G/S - Guideline Standard - Mississauga Storm Sewer Use Bylaw
Bold - Exceeds Mississauga Storm Sewer Use Bylaw

Table F-3: Groundwater Quality
Ontario Drinking Water Quality Standards

			Sample Description	**MW4**
			Date Sampled	**09/05/2023**
Parameter	**Unit**	**OWDQS**	**Type of Standard**	
Electrical Conductivity	µS/cm			11100
pH	pH Units	6.5-8.5	OG	7.31
Hardness (as CaCO3) (Calculated)	mg/L	80-100	OG	**2910**
Total Dissolved Solids	mg/L	500	AO	**7600**
Alkalinity (as CaCO3)	mg/L	30-500	OG	146
Bicarbonate (as CaCO3)	mg/L			146
Carbonate (as CaCO3)	mg/L			<5
Fluoride	mg/L	1.5	MAC	<0.26
Chloride	mg/L	250	AO	**3070**
Nitrate as N	mg/L	10	MAC	<0.7
Nitrite as N	mg/L	1	MAC	<0.5
Sulphate	mg/L	500	AO	**1170**
Ortho Phosphate as P	mg/L			<1.3
Ammonia as N	mg/L			3.13
Dissolved Organic Carbon	mg/L			1.3
Total Phosphorus	mg/L			0.03
Total Organic Carbon	mg/L			1.4
True Colour	TCU	5	AO	<2.50
Dissolved Calcium	mg/L			641
Dissolved Magnesium	mg/L			317
Dissolved Potassium	mg/L			38.6
Dissolved Sodium	mg/L	200	AO	**1310**
Dissolved Aluminum	mg/L	0.1	OG	0.005
Dissolved Antimony	mg/L	0.006	IMAC	<0.001
Dissolved Arsenic	mg/L	0.01	IMAC	0.001
Dissolved Barium	mg/L	1.0	MAC	0.044
Dissolved Beryllium	mg/L			<0.0005
Dissolved Boron	mg/L	5	IMAC	2.39
Dissolved Cadmium	mg/L	0.005	MAC	<0.0001
Dissolved Chromium	mg/L	0.05	MAC	<0.002
Dissolved Cobalt	mg/L			0.0024
Dissolved Copper	mg/L	1	AO	0.002
Dissolved Iron	mg/L	0.3	AO	0.024
Dissolved Lead	mg/L	0.01	MAC	<0.0005
Dissolved Manganese	mg/L	0.05	AO	**0.345**
Dissolved Mercury	mg/L	0.001	MAC	<0.0001
Dissolved Molybdenum	mg/L			0.010
Dissolved Nickel	mg/L			0.002
Dissolved Selenium	mg/L	0.05	MAC	0.002
Dissolved Silver	mg/L			<0.0001
Dissolved Uranium	mg/L	0.02	MAC	0.0047
Dissolved Vanadium	mg/L			<0.002
Dissolved Zinc	mg/L	5.0	AO	0.006
Dissolved Zirconium	mg/L			<0.004

ODWQS - Ontario Drinking Water Quality Standards
AO - Aesthetic Objective
OG - Operational Guideline
MAC - Maximum allowable concentration
IMAC - Interim Maximum Acceptable Concentration
Bold - Exceeds ODWQS

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Appendix G

Water Balance Calculations

Appendix G

WATER BALANCE CALCULATIONS
Avenia Lisgar
Mississauga, Ontario
October-23
PROJECT No.300057229.0000

TABLE G-1

Pre- Development Monthly Water Balance Components

Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 250 mm (vacant land (pasture and shrubs) in silt and clay soils)

Precipitation data from Toronto Lester B. Pearson International Airport Climate Station (1981 - 2010)

Potential Evapotranspiration Calculation	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Average Temperature (Degree C)	-5.5	-4.5	0.1	7.1	13.1	18.6	21.5	20.6	16.2	9.5	3.7	-2.2	**8.2**
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.00	1.70	4.30	7.31	9.10	8.53	5.93	2.64	0.63	0.00	**40.1**
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	0.25	30.43	60.72	90.16	106.17	101.17	77.16	42.26	14.59	0.00	**523**
Adjusting Factor for U (Latitude 43° 57' N)	0.81	0.82	1.02	1.12	1.26	1.28	1.29	1.2	1.04	0.95	0.81	0.77	
Adjusted Potential Evapotranspiration PET (mm)	0	0	0	34	77	115	137	121	80	40	12	0	**617**
COMPONENTS	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Precipitation (P)	52	48	50	69	74	72	76	78	75	61	75	58	**786**
Potential Evapotranspiration (PET)	0	0	0	34	77	115	137	121	80	40	12	0	**617**
P - PET	52	48	50	34	-2	-44	-61	-43	-6	21	63	58	**169**
Change in Soil Moisture Storage	14	0	0	0	-2	-44	-61	-43	-6	21	63	58	**0**
Soil Moisture Storage max 250 mm	250	250	250	250	248	204	143	99	94	115	178	236	
Actual Evapotranspiration (AET)	0	0	0	34	77	115	137	121	80	40	12	0	**617**
Soil Moisture Deficit max 250 mm	0	0	0	0	2	46	107	151	156	135	72	14	
Water Surplus - available for infiltration or runoff	38	48	50	34	0	0	0	0	0	0	0	0	**169**
Potential Infiltration (based on MOE metholodogy*; independent of temperature)	19	24	25	17	0	0	0	0	0	0	0	0	**85**
Potential Direct Surface Water Runoff (independent of temperature)	19	24	25	17	0	0	0	0	0	0	0	0	**85**
IMPERVIOUS AREA WATER SURPLUS													
Precipitation (P)	786	mm/year											
Potential Evaporation (PE) from impervious areas (assume 15%)	118	mm/year											
P-PE (surplus available for runoff from impervious areas)	668	mm/year											

Assume January storage is 100% of Soil Moisture Storage

Soil Moisture Storage	250 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 - relatively tight clay and silt materials	0.15	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
cover - vacant land (pasture & shrubs)	0.15	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
Infiltration factor	**0.5**	

Latitude of site (or climate station) 43 ° N

WATER BALANCE CALCULATIONS
Avenia Lisgar
Mississauga, Ontario
October-23
PROJECT No.300057229.0000

TABLE G-2

Post-Development Monthly Water Balance Components

Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 250 mm (urban lawns in silt and clay soils)

Precipitation data from Toronto Lester B. Pearson International Airport Climate Station (1981 - 2010)

Potential Evapotranspiration Calculation	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Average Temperature (Degree C)	-5.5	-4.5	0.1	7.1	13.1	18.6	21.5	20.6	16.2	9.5	3.7	-2.2	**8.2**
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.00	1.70	4.30	7.31	9.10	8.53	5.93	2.64	0.63	0.00	**40.1**
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	0.25	30.43	60.72	90.16	106.17	101.17	77.16	42.26	14.59	0.00	**523**
Adjusting Factor for U (Latitude 43° 57' N)	0.81	0.82	1.02	1.12	1.26	1.28	1.29	1.2	1.04	0.95	0.81	0.77	
Adjusted Potential Evapotranspiration PET (mm)	0	0	0	34	77	115	137	121	80	40	12	0	**617**
COMPONENTS	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Precipitation (P)	52	48	50	69	74	72	76	78	75	61	75	58	**786**
Potential Evapotranspiration (PET)	0	0	0	34	77	115	137	121	80	40	12	0	**617**
P - PET	52	48	50	34	-2	-44	-61	-43	-6	21	63	58	**169**
Change in Soil Moisture Storage	0	0	0	0	-2	-44	-61	-18	0	21	63	41	**0**
Soil Moisture Storage max 125 mm	125	125	125	125	123	79	18	0	0	21	84	125	
Actual Evapotranspiration (AET)	0	0	0	34	77	115	137	96	75	40	12	0	**585**
Soil Moisture Deficit max 125 mm	0	0	0	0	2	46	107	125	125	104	41	0	
Water Surplus - available for infiltration or runoff	52	48	50	34	0	0	0	0	0	0	0	17	**201**
Potential Infiltration (based on MOE metholodogy*; independent of temperature)	26	24	25	17	0	0	0	0	0	0	0	9	**100**
Potential Direct Surface Water Runoff (independent of temperature)	26	24	25	17	0	0	0	0	0	0	0	9	**100**
IMPERVIOUS AREA WATER SURPLUS													
Precipitation (P)	786	mm/year											
Potential Evaporation (PE) from impervious areas (assume 15%)	118	mm/year											
P-PE (surplus available for runoff from impervious areas)	668	mm/year											

Assume January storage is 100% of Soil Moisture Storage

Soil Moisture Storage 125 mm <-- See "Water Holding Capacity" values in Table 3.1, MOE SWMPDM, 2003

*MOE SWM infiltration calculations

topography - rolling (graded)	0.25	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
soils - relatively tight clay and silt materials	0.15	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
cover - urban lawns	0.1	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
Infiltration factor	**0.5**	

Latitude of site (or climate station) 43 ° N

WATER BALANCE CALCULATIONS
Avenia Lisgar
Mississauga, Ontario
October-23
PROJECT No.300057229.0000

TABLE G-3

Water Balance - Existing Conditions and Post-Development for Avenia Lisgar with No Mitigation

Land Use	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)
Existing Land Use												
Vacant Land (pasture and shrubs)	66,600	0.00	0	0.668	0	66,600	0.085	5,634	0.085	5,634	5,634	5,634
TOTAL PRE-DEVELOPMENT	**66,600**	**-**	**0**		**0**	**66,600**	-	**5,634**	**-**	**5,634**	**5,634**	**5,634**
Post-Development Land Use												
Residential Area (no roofs)	17,600	0.07	1,232	0.668	823	16,368	0.100	1,642	0.100	1,642	2,465	1,642
Roofs	26,300	1.00	26,300	0.668	17,571	0	0.100	0	0.100	0	17,571	0
17 m ROW	15,500	0.99	15,345	0.668	10,252	155	0.100	16	0.100	16	10,268	16
SWM Tank	2,200	0.90	1,980	0.668	1,323	220	0.100	22	0.100	22	1,345	22
Parks	2,500	0.00	0	0.668	0	2,500	0.100	251	0.100	251	251	251
Soakaway Pits	2,500	0.60	1,500	0.668	1,002	1,000	0.100	100	0.100	100	1,102	100
TOTAL POST-DEVELOPMENT	**66,600**	**-**	**46,357**	**-**	**30,971**	**20,243**	**-**	**2,030**	**-**	**2,030**	**33,001**	**2,030**
										% Change from Pre to Post	586	64
										Effect of development (with no mitigation)	5.9 times increase in runoff	64% reduction in infiltration

To balance pre- to post infiltration target (m^3/a)= **3,603**

* figures from Tables G-1 and G-2

** data provided by Urbantech

WATER BALANCE CALCULATIONS
Avenia Lisgar
Mississauga, Ontario
October-23
PROJECT No.300057229.0000

TABLE G-4

Water Balance - Existing Conditions and Post-Development for Avenia Lisgar with Mitigation

Land Use		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)
Existing Land Use													
Vacant Land (pasture and shrubs)		66,600	0.00	0	0.668	0	66,600	0.085	5,634	0.085	5,634	5,634	5,634
TOTAL PRE-DEVELOPMENT		**66,600**	**-**	**0**		**0**	**66,600**	-	**5,634**	**-**	**5,634**	**5,634**	**5,634**
Post-Development Land Use													
Front Yards	Front Yards (no roofs)	8,450	0.15	1,232	0.668	823	7,218	0.100	724	0.100	724	1,547	724
	Front Roofs to be directed to Front Yard Infiltration Gallery; assume designed to accommodate 27 mm storm; 27 mm storms account for approximately 95% of total rainfall[b] (~87% of total precipitation); so assume 87% of runoff total from front roofs will infiltrate). Remaing runoff to be directed to on-site Underground SWM Tank.	13,150	1.00	13,150	0.668	8,786	0	0.100	0	0.100	0	1,168	7,617
Rear Yards	Rear Roofs to grass (assume 25% of runoff volume infiltrates[a])	13,150	1.00	13,150	0.668	8,786	0	0.100	0	0.100	0	876	2,196
	Rear Yards	9,150	0.00	0	0.668	0	9,150	0.100	918	0.100	918	122	918
	Rear Roof and Rear Yards to infiltration trench; assume designed to accommodate 27 mm storm from 13,150 m^2 of roof area and 9,150 m^2 of pervious area; 27 mm storms account for approximately 95% of total rainfall[b] (~87% of total precipitation); so assume 87% of runoff total from select roofs and rear yards calculated above will infiltrate)	NA	NA	NA	NA	NA	NA	NA	NA	NA	6,508	NA	6,508
17 m ROW	Runoff to be directed to on-site Underground SWM Tank.	15,500	0.99	15,345	0.668	10,252	155	0.100	16	0.100	16	10,268	16
SWM Tank		2,200	0.90	1,980	0.668	1,323	220	0.100	22	0.100	22	1,345	22
Parks		2,500	0.00	0	0.668	0	2,500	0.100	251	0.100	251	251	251
Soakaway Pits	Front Roofs to be directed to Front Yard Infiltration Gallery; assume designed to accommodate 27 mm storm; 27 mm storms account for approximately 95% of total rainfall[b] (~87% of total precipitation); so assume 87% of runoff total from front roofs will infiltrate)	1,500	1.00	1,500	0.668	1,002	0	0.100	0	0.100	0	133	869
	Runoff to be directed to on-site Underground SWM Tank.	1,000	0.00	0	0.668	0	1,000	0.100	100	0.100	100	100	100
TOTAL POST-DEVELOPMENT		**66,600**	**-**	**46,357**	**-**	**30,971**	**20,243**	**-**	**2,030**	**-**	**8,539**	**15,811**	**19,221**
% Change from Pre to Post												281	-241
Effect of development (with mitigation)												281% of existing conditions	241% increase in infiltration
To balance pre- to post infiltration target (m^3/a)=													**-13,587**

* figures from Tables G-1 and G-2

** data provided by Urbantech

[a] based on estimation in the LID SWM Planning and Design Guide (CVC & TRCA, 2010) for hydrologic groups C & D

[b] based on the Toronto Wet Weather Flow Management Guidelines (City of Toronto, 2006)

BURNSIDE

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Appendix H

Dewatering Calculations

Appendix H

Table H-1
Summary of Dewatering Estimates
Groundwater Seepage - Trenches

PP5 4

Source	Excavation Invert m asl	Water Table masl	Dewatering		Datum masl	K m/s	H m	h m	R$_o$ m	Width of Excavation m	Length of Trench m	Equivalent Radius (r$_s$) m	Distance to Line Source (L) m	Q unconfined L/day	Q unconfined L/min
			Level masl	Drawdown m											
Servicing Trenches	190.90	192.50	189.90	2.60	185.5	1.30E-07	7.00	4.4	1.6	4	100	2.0	1.64	15,014	10

Notes:

m	metres
masl	metres above sea level
m/s	metres per second

Dewatering level assumed to be 1 m below the base of the excavation
Datum is based on interpreted bottom of surficial aquifer.
Dewatering methods will be determined by the dewatering contractor retained to do the work.
Water table based on levels collected at monitoring wells (Burnside, 2020-2022)
Depths of excavations taken from preliminary design plans provided by SCS, November 2022.
Townhouse basements assumed to be 3 m below road elevation.

H is saturated thickness of aquifer before pumping [m];
h is saturated thickness of aquifer under pumping conditions [m];
R_0 is radius of pumping influence [m];
r_s is equivalent radius of pumping well [m]; (r_s at end of excavation = 0.5 width of excavation)
x is length of trench [m] or excavation;
L is distance from line source [m]; assumed to be radius of influence
Q is pumping rate;
K is hydraulic conductivity [m/s];

$$\boxed{Q = \frac{\pi K\left(H^2 - h^2\right)}{\ln\left(\frac{R_0}{r_s}\right)} + 2\left[\frac{xK\left(H^2 - h^2\right)}{2L}\right]}$$

Where:

$R_0=1750(H-h)K^{0.5}$

K = the hydraulic conductivity (m/sec)
H = the existing height of the water table (m)
h = the height of the water table after dewatering (m)
R_0 = the lateral extent of drawdown (m)
Q = pumping rate (m^3/s)
r_s = half the width of excavation (m)

Table H-2
Summary of Dewatering Estimates
Surface Water Runoff Volumes

Source	Width of Excavation m	Length of Excavation m	Area of Excavation m^2	Runoff Event (5 mm event) Estimated Runoff Volume m^3	Runoff Event (5 mm event) Estimated Runoff Volume L
Servicing Trenches	4	100	400	2.00	2,000

Notes:
A typical rain event assumed to be 5 mm of rain.

Table H-3
Summary of Dewatering Estimates
Total Volumes

Source	Groundwater Seepage	Runoff Event	Total Volume		Max Total Volume	
	L/day	L/day	L/day	L/min	L/day	L/min
Servicing Trenches	15,014	2,000	17,014	12	24,522	17

Notes:
Maximum volume based on Safety Factor of 50%.

R.J. Burnside & Associates Limited