Millcroft Hydrogeological Assessment
City of Burlington

Millcroft Greens Corporation

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1.0 Introduction

R.J. Burnside & Associates Limited (Burnside) was retained by Millcroft Greens Corporation (Millcroft Greens) to complete a hydrogeological assessment for a portion of the Millcroft Golf Club located in the City of Burlington. Millcroft Greens is proposing to develop approximately 12.36 ha of lands (referred to herein as the Subject Property) that are currently part of the Millcroft Golf Club, which is an 18-hole public golf course located at 2155 Country Club Drive, Burlington.

The Subject Property is located approximately 0.5 km west of the intersection of Appleby Line and Upper Middle Road within an area that has previously been developed as a residential subdivision and where the fairways of the Millcroft Golf Club traverse between the houses and streets (Figure 1). The Subject Property consists of five individual parcels identified as Sites A (5.87 ha), B (3.62 ha), C (1.46 ha), D (0.75 ha) and E (0.66 ha), which are generally bounded by existing residential areas, a TransCanada Pipeline easement, a hydro corridor, a CN Rail corridor, and an irrigation/stormwater management pond (identified as Mill Pond). The locations of the parcels are shown on Figure 1.

Parcels A, B C and E of are located within the Appleby Creek watershed and Parcel D is located within the Sheldon Creek watershed. Both are under the jurisdiction of Conservation Halton (CH). As part of Millcroft Greens' Draft Plan application, CH requires a hydrogeological assessment and water balance. The '*Requirements for completion of hydrogeological studies to facilitate Conservation Halton's reviews (November 2014)*' document has been reviewed in preparation of this report.

2.0 Scope of Work

The scope of this hydrogeological assessment involved a review of the published regional geological and hydrogeological information as well as the completion of site-specific investigations as described below:

1. Review of water well records: The Ministry of the Environment, Conservation and Parks (MECP) well records database provides geological records of water supply wells drilled in Ontario. A summary of the local well records within 1 km of the Subject Property is provided in Appendix A. It should be noted that well location information provided by the records are approximations only and may not be representative of the precise well locations.

2. Review of published data: A review of existing mapping and reports for the area was completed including provincial surficial geology and bedrock geology maps, geotechnical reports prepared for the Subject Property, and the Assessment Report for the Halton Region Source Protection Area prepared by the Hamilton-Halton Source Protection staff (January 2012).

3. Review of Permit to Take Water (PTTW) monitoring data: A surface water monitoring program for the Mill Pond and Appleby Creek was implemented in 2011 as part of Millcroft Golf Club's PTTW monitoring conditions. The golf course withdraws water from Mill Pond for irrigation purposes. Millcroft Golf Club is currently in the process of obtaining CH approvals for the construction of a naturalized bypass channel around the west and south side of Mill Pond, in order to take the pond offline from the Appleby Creek system as required by the MECP.

4. Review of site-specific soils data: Borehole data was collected during two geotechnical investigations conducted by DS Consultants (DS) in 2018 for Parcels A and B and in 2019 for Parcels C, D and E, which included the advancement of 18 boreholes across the Subject Property between December 18 and 20, 2018 and November 26 and 29, 2019 to depths ranging from 2.5 to 8.0 metres below ground surface (mbgs). The borehole locations are shown on Figure 4 and the borehole logs are provided in Appendix B. Grainsize analyses were completed on 14 representative soil samples collected during drilling across the parcels and the resulting grainsize distribution plots are provided in Appendix C. These data are used to quantify the surficial sediments and estimate the hydraulic conductivities of the soils encountered.

5. Installation of groundwater monitoring wells: A total of 16 monitoring wells were installed as part of the borehole drilling programs in December 2018 and November 2019 and the names of the monitoring wells correspond to the borehole name at that location (i.e., MW18-1 is the well that was constructed at BH18-1). The locations of the monitoring wells are shown on Figure 4 and the well construction details are provided on the borehole logs in Appendix B.

6. Installation of drive-point piezometers: A piezometer nest (two separate pipes adjacent to one another but driven to different depths) was installed in the banks of Appleby Creek upstream of the Mill Pond to assess the shallow groundwater conditions, measure vertical hydraulic gradients and assess the potential groundwater/surface water interaction. The location of the piezometer nest (PZ1s/d) is shown on Figure 4.

7. Hydraulic conductivity testing: Single well response tests (i.e., slug tests) were completed in eight groundwater monitoring wells (MW18-1, MW18-4, MW18-5, MW18-7, MW19-01, MW19-03, MW19-102 and MW19-202) to assess the in situ hydraulic conductivity of the shallow soils. The testing results are provided in Appendix D.

8. Groundwater monitoring: Measurements of the depth to the water table at monitoring wells and piezometers to assess the horizontal and vertical groundwater flow conditions began monthly in January 2019 for the original wells installed on Sites A and B. Measurements began in the new wells on Sites C, D

and E in December 2019 and will continue monthly. Twelve locations (MW18-1, MW18-4, MW18-5, MW18-7, MW18-9, MW19-01, MW19-02, MW19-100, MW19-101, MW19-200, MW19-202 and PZ1s) are equipped with automatic water level recorders (dataloggers) to capture continuous water level information and fluctuations. A continuous barometric pressure datalogger was also installed at the site to accurately compensate for effects of barometric variations. The groundwater level monitoring data and hydrographs are provided in Appendix E.

9. Surface water monitoring: Surface water spot flow measurements are measured monthly along Appleby Creek to assess flow loss or gain in the vicinity of Site A, which borders the Creek to the north. Measurements are collected at two locations: at Millcroft Park Drive (SS1) and at Upper Middle Road (SS2) (refer to Figure 4). Historical spot flow measurement data and continuous water level data for Appleby Creek upstream (Golf SS2) and downstream (Golf SS3) of Mill Pond were collected as part of the PTTW monitoring (refer to Figure 4 for locations). The monitoring data are provided in Appendix F.

10. Water balance calculations: Pre-development water balance calculations (based on existing land use conditions) and post-development water balance calculations (based on the proposed development concept) were completed to assess the potential impacts of land development on the local groundwater conditions. The local climate data and detailed water balance calculations are provided in Appendix G.

3.0 Physiography

The Subject Property is located within the southwestern extents of the physiographic region known as the South Slope (Chapman and Putnam, 1984). In the vicinity of the Subject Property, the South Slope is characterized by till plains on the slopes of the Niagara Escarpment, which is located approximately 2 km west of the property. The Niagara Escarpment stretches approximately 725 km from Queenston on the Niagara River to Tobermory on the Bruce Peninsula.

4.0 Topography and Drainage

The topography across the Subject Property is flat to rolling with an overall slope to the southeast (Figure 2). Mapping suggests that the topography ranges in elevation between approximately 155 metres above sea level (masl) at Site E, the northern-most parcel, and 137 masl at Site A, the southern-most parcel for a total relief of approximately 18 m. The amplitude of relief for each individual parcel is approximately 2 m with the exception of Site A which has a relief of 4 m. Overland drainage is generally to the southeast towards Appleby Creek and Mill Pond, which has an approximate water level elevation of 137 masl. Drainage in the northeastern extents (Site D) is directed towards Sheldon Creek. Drainage between the parcels is collected

through the existing stormwater infrastructure and discharged directly to Mill Pond at the northern headwall location.

A review of statistical flow characteristics obtained through the Ontario Flow Assessment Tool (OFAT) suggests that Appleby Creek is a perennial watercourse through the Subject Property; however, the site-specific flow assessment conducted as part of the PTTW monitoring (discussed below in Section 4.2) indicates that flow in the creek occasionally stops during low flow periods.

Two watercourses are mapped through the overall Millcroft Golf Course site, including Appleby Creek and Sheldon Creek which both flow into the study area beneath Dundas Street in the northwest. Appleby Creek flows through the center of the golf course, eventually discharging directly into the online Mill Pond. Sheldon Creek generally flows parallel to Appleby Creek but traverses the northern extents of the golf course property.

In addition to Appleby Creek, two stormwater culverts discharge into Mill Pond; one coming from the north (Hadfield Court) while the other enters from the southwest (Country Club Drive). An overflow weir structure at the southeast corner of Mill Pond controls the creek's flow downstream. The structure consists of a narrow concrete weir anchored in place by approximately 12 rectangular concrete barrier blocks. The structure has been reset and reinforced on multiple occasions over the years due to its leaky nature (Burnside, 2018). It should be noted that detailed design has been completed for a separate project to take Mill Pond offline (as required by MECP) by constructing a naturalized channel and berm around the pond and is awaiting CH approval before construction.

4.1 Surface Water Monitoring

Surface water flow monitoring stations were established for this study at two locations to record the flows along Appleby Creek at the upstream and downstream limits of Site A and are identified as SS1 and SS2 (Figure 4). The flow data collected from these stations is summarized in Table-F-1, Appendix F. Spot flow measurements at these stations were collected during monthly monitoring events with 18 measurements conducted to date. The data at SS1 indicates that the flows ranged from < 0.5 L/s (minimal flow) to 78 L/s to over the monitoring period, with the highest flows occurring in the spring (March to May) and the lowest occurring in the summer (June to September). Two events of frozen conditions were observed in January and February of 2019. At SS2 the flows ranged from standing water (i.e., no flow) from July to October 2019 up to 164 L/s which was observed in January 2020. Events of net flow gains and net flow losses occurred in 2019 between the flow stations, and the variation in flows is likely the result of the stormwater attenuation capacity of the Mill Pond.

Historical seasonal surface water data dating back to 2011 and collected as part of the golf club's PTTW monitoring was reviewed to contribute to this study. Two monitoring stations (identified as Golf SS2 and Golf SS3 on Figure 4) are well-established Appleby

Creek monitoring cross-sections. Detailed streamflow measurements at both stations are conducted to establish stream discharge-ratings curves in support of an ongoing site-specific low flow assessment. Dataloggers are maintained seasonally at Golf SS2 as well as within Mill Pond. The streamflow data are provided in Table F-2 and hydrographs are shown on Figures F-1 to F-4 in Appendix F.

A review of the historical PTTW monitoring data indicates that a total of 39 flow measurements along Appleby Creek have been conducted since 2011 (Table F-2, Appendix F). The magnitude of the measured flow at Golf SS2 (upstream of Mill Pond) ranges from minimal (i.e., below the operating tolerance of the instrument) to upwards of109 L/s as recorded on January 17, 2012. Flow downstream of Mill Pond was generally measured to be less than the flows measured upstream on the same days, suggesting a net loss of flow through the retention capacity of the pond (Burnside, 2018). Continuous water level data at Golf SS2 (Figures F-1 and F-2, Appendix F) suggest that the average water level at the cross section is approximately 0.20 m deep, with fluctuations upwards to a maximum of 1.30 m as the result of significant rainfall events. Periods of zero flow have been observed at Golf SS2 as early as May and as late as November (Burnside, 2018).

Similarly, water levels in Mill Pond generally remain at or above the elevation of the weir, with the exceptions of prolonged durations during the summer low flow periods (typically annually through July and August) as shown on Figures F-3 and F-4 (Appendix F). These durations are the result of drought conditions and golf course pumping (the golf course utilizes the pond as a source for irrigation water). Mill Pond water levels are also observed to respond to moderate precipitation events (>20 mm/day).

4.2 Groundwater/Surface Water Interaction

Piezometer nest PZ1s/d is located immediately downstream of the Appleby Creek box culvert underneath Millcroft Park Drive, where the Creek enters Site A (Figure 4). In 2019, groundwater levels observed in this nest show that the water level in the shallow piezometer (PZ1s) is consistently above those in the deep piezometer (PZ1d) by a range of 0.09 m to 0.34 m (Figure E-8, Appendix E). Both piezometers were observed to go dry for an extended period between the months of July and October 2019, with the exception of brief responses to precipitation events. In the winter of 2020, the shallow groundwater levels are above the deep groundwater levels ranging from 0.1 m to 0.23 m (Figure E-8, Appendix E) before PZ1s goes dry in April. The data suggest a weak to moderate downward gradient and groundwater recharge conditions at this location. The results of this hydrogeological assessment suggest that Appleby Creek primarily has a surface water runoff conveyance function in the vicinity of the Subject Property.

5.0 Geology

5.1 Surficial Geology

Surficial geology mapping published by the Ontario Geological Survey (OGS; 2003) shows that the entire Subject Property is covered by fine-grained glaciolacustrine derived deposits of clay and silt till (i.e., Halton till) (Figure 3).

The results of the drilling program generally confirm the regional characterization. The borehole logs (Appendix B) suggest that a thin veneer of topsoil blankets the Subject Property (up to 0.18 m thick), which is underlain by a layer of clayey silt fill that ranges in thickness from 0.6 to 2.6 m and is likely re-worked material from previous earthworks at the Subject Property. Underlying the fill are native deposits of clayey silt till and sandy silt till ranging in thickness from 0.6 m to 6.5 m overlying shale bedrock or a till/shale complex. The sandy silt till layers were limited to boreholes BH18-2, BH18-3, BH18-4, BH18-8, BH18-9, BH19-01, BH19-02, BH19-03, BH19-102, BH19-201 and BH19-202. The total thickness of the overburden across the Subject Property ranges from 1.5 m (BH18-6) to over 8.0 m (BH19-02).

To illustrate the subsurface soil conditions across the Subject Property, six schematic cross-sections have been prepared based on the borehole logs. The locations of the cross-sections are shown on Figure 4 and the cross-sections are presented on Figures 5 to 10. Interpretation of the main stratigraphic layers have been made on these figures to show the surficial deposits of clayey silt fill overlying the clayey and/or sandy silt till and shale bedrock.

5.2 Bedrock Geology

Bedrock mapping shows that the Subject Property is underlain by Ordovician-aged layered red shale of the Queenston Formation. Shale was encountered in all boreholes with the exception of five; BH18-8 and BH18-9 (Site A), and BH19-01 to BH19-03 (Site E), which were drilled to depths ranging from 4.1 mbgs to 8.0 mbgs. At Site C, the bedrock was encountered between 3.3 mbgs and 6.2 mbgs and at Site D bedrock was encountered between 3.7 mbgs and 4.6 mbgs. At Site A and B, the bedrock was encountered at depths ranging from 1.5 mbgs at BH18-6, located adjacent to Mill Pond, and 6.1 mbgs at BH18-1 located adjacent to Millcroft Park Drive in Site B. The bedrock gently slopes to the south with a relief of 7.2 m across the Subject Property with the highest elevation observed at BH19-202 (142.8 masl) and lowest at BH18-5 (135.6 masl).

5.3 Soil Hydraulic Conductivity

There are various methods that can be used to assess soil hydraulic conductivity, i.e., the ability of the soil to transmit groundwater. Grainsize data and soil characteristics can be used to provide a general estimate of hydraulic conductivity. In situ single well

response tests can also be used in groundwater monitoring wells to assess site-specific hydraulic conductivity. These methods have been used to estimate the hydraulic conductivity of the soils encountered in the Subject Property as discussed below.

5.3.1 Grainsize Analysis

During the geotechnical investigation undertaken by DS Consultants, representative soil samples were collected and a total of 14 samples were submitted for laboratory analysis for grainsize distribution (Appendix C). The results of the grainsize analyses were assessed using the Hazen estimation (D_{10}) to evaluate the hydraulic conductivity of these sediments. It is acknowledged that the Hazen estimation method is designed to approximate the hydraulic conductivity of more permeable sediments; however, it is still considered useful in finer grained sediments to provide a general indication of the low range of the hydraulic conductivity values.

Nine of the samples submitted for grainsize analysis were described as sandy silt till material with trace clay and gravel. These samples were generally noted to be compact to very dense with high blow counts. The Hazen estimation provided hydraulic conductivity values between 1.4×10^{-6} cm/sec and 4.2×10^{-5} cm/sec. The variability in the values is accredited to sample composition; samples within the higher range (i.e., 10^{-5} cm/sec) were observed to have around 10% to 15% more sand content as well as approximately half the clay content than those in the lower range (i.e., 10^{-6} cm/sec). Overall, these values are considered relatively low and indicate that these types of soils have generally low permeabilities and transmit groundwater poorly.

The remaining five samples were described as clayey silt till material, sandy with trace to some gravel. These samples were noted to be very stiff to hard with similarly high blow counts. Due to the very fine nature of the material, a D_{10} value cannot be deduced from the grainsize distribution plots (i.e., the particle size in which 10% of the material is smaller than is less than 0.001 mm) and therefore it is estimated that the hydraulic conductivity value is less than 10^{-6} cm/sec. This value is considered very low and indicates that the material has very low permeability for groundwater movement.

5.3.2 In Situ Well Response Tests

To assess the in situ hydraulic conductivity of the overburden sediments, bail-down slug tests were completed in January 2018 at monitoring wells MW18-1, MW18-4, MW18-5 and MW18-7 which are all located on Parcels A and B of the Subject Property. Additional tests were completed in June 2020 at MW19-01, MW19-03, MW19-102 and MW19-202 which are located at Parcels C, D and E. The tests consisted of removing a known volume of water from the well using a 1-litre bailer and monitoring the groundwater level as it recovers back to static conditions. The resulting data were analyzed and are provided in Appendix D. The calculated hydraulic conductivity values are discussed below:

- MW18-1 is screened in a hard-clayey silt till/shale complex, which is interpreted to be a transitional deposit resulting from glacial movement on top of the underlying shale. The results of the bail-down test at this location suggest a low hydraulic conductivity of 5.8 x 10^{-6} cm/sec.

- MW18-4 is screened in the dense sandy silt till deposit. The results of the testing provided a low hydraulic conductivity value of 5.7 x 10^{-6} cm/sec.

- MW18-5 is screened in clayey silt till, although a portion of the screen extends up into the overlying clayey silt fill. The results of the testing suggest a low hydraulic conductivity of 2.3 x 10^{-6} cm/sec.

- MW18-7 is screened in the shale bedrock and the overlying clayey silt till deposit. The bail-down test conducted here resulted in a moderate to low hydraulic conductivity of 7.9 x 10^{-5} cm/sec. This is noted to be higher than the results provided for similar materials and is likely accredited to the weathered/fractured bedrock.

- MW19-01 and MW19-03 are also screened in the dense deposit of sandy silt to silty sand till that overlies the bedrock on Parcel E. The results of the testing suggest very low hydraulic conductivity values of 3.6 x 10^{-7} cm/sec and 2.6 x 10^{-6} cm/sec, respectively.

- MW19-102 is located on Parcel C and is screened in the dense sandy silt till. The results of the testing provided a low hydraulic conductivity value of 1.4 x 10^{-6} cm/sec.

- MW19-202 is screened in the shale bedrock. The bail-down test conducted here resulted in a very low hydraulic conductivity value of 6.7 x 10^{-8} cm/sec. The hydrograph for MW19-202 (Figure E-17, Appendix E) indicate that the well was still recovering approximately 17 days after the test was conducted.

Similar to the conclusions from the grainsize data assessment (Section 5.3.1), the calculated hydraulic conductivity values are considered to be low and indicate that the till soils will limit groundwater movement in the subsurface across the Subject Property.

5.3.3 Summary of Hydraulic Conductivity Results

The various methods used to estimate the hydraulic conductivity of the sediments encountered on the Subject Property are summarized in the following table based on soil type. Overall, the geological materials encountered across the Subject Property are of low to very low permeability and generally restrict significant groundwater movement.

Table 1: Summary of Hydraulic Conductivity Values

Soil Type	K, Grainsize (cm/sec)	K, In Situ Test (cm/sec)
Sandy Silt to Silty Sand Till	$1.4 \times 10^{-6} – 4.2 \times 10^{-5}$	$3.6 \times 10^{-7} – 5.7 \times 10^{-6}$
Clayey Silt Till	$< 10^{-6}$	2.3×10^{-6}
Clayey Silt Till/Shale Complex	-	5.8×10^{-6}
Shale	-	6.7×10^{-8} - 7.9×10^{-5}

6.0 Hydrogeology

6.1 Local Groundwater Use

Municipal water supply for the City of Burlington is surface water obtained from Lake Ontario. The residential and commercial developments surrounding the Subject Property are serviced through the municipal supply, which is also proposed to service the Subject Property. There is no groundwater use proposed for the development.

A review of the MECP database within 1,000 m of the Subject Property returned a total of 32 well records (Appendix A). The majority of the well records were for documenting well abandonment/decommissioning or were for observation wells. A total of nine well records were for water supply wells drilled from 1957 to 1970 to service homes prior to the area being developed and municipally serviced. It is presumed that all of these wells have been decommissioned and are no longer in use.

All of these wells were screened in the upper 2 m to 5 m of the shale bedrock, which has a maximum depth of approximately 15 mbgs. This supports the regional characterization that the Queenston Formation shale is generally water-bearing in the upper 5 m where the bedrock is weathered and may provide sufficient water supplies to meet domestic needs (Singer et al., 2003).

6.2 Groundwater Level Monitoring Results

Seven groundwater monitoring wells were installed across the Subject Property in December 2018 and nine were installed in November 2019 as shown on Figure 4 (well construction details are shown on the borehole logs in Appendix B). Four monitoring wells were installed at Site A. Three monitoring wells were installed in each of the Sites B, C, D and E. A piezometer nest (two pipes installed adjacent to each other at different depths) was installed in Appleby Creek at the northern extents of Site A to monitor shallow groundwater levels and evaluate the potential for groundwater/surface water interaction.

Monitoring of the original seven 2018 wells (Sites A and B) initiated in January 2018 and continued monthly to June 2020 (20 events). Monitoring of the nine new 2019 wells (Sites C, D and E) was initiated in December 2019 and also continued monthly through to June 2020 (seven events). Groundwater levels will continue to be monitored monthly through 2020. The groundwater monitoring data collected at the Subject Property are summarized on Table E-1 and are plotted on hydrographs presented in Appendix E (Figures E-1 through E-17). Automatic water level recorders were installed on January 22, 2019 in wells MW18-1, MW18-4, MW18-5, MW18-7 and MW18-9 and were programmed to record water levels at 1-hour intervals. An additional datalogger was installed in PZ1d in March 2019 once the threat of freezing conditions had passed. Additional dataloggers were installed in select wells on Sites C, D and E in January 2020 (MW19-01, MW19-02, MW19-100, MW19-101, MW19-200 and MW19-202).

A review of the groundwater level data suggests the following:

- The groundwater levels in wells installed in December 2018 typically exhibit seasonal fluctuations with the highest elevations observed in the spring (May 2019) and the lowest elevations observed in the late summer and early fall (September and October 2019). In 2020, the highest groundwater elevations occurred in January and remained relatively high through to April before beginning to decline as a result of drier conditions.

- At the wells installed across Sites A and B (MW18-1 to MW18-9, Figures E-1 to E-7, Appendix E), the seasonally high groundwater level occurred in May 2019 with groundwater levels ranging from as high as 0.7 mbgs (MW18-2, Figure E-2, Appendix E) to as low as 4.1 mbgs (MW18-1, Figure E-1, Appendix E). In 2020, seasonal high groundwater conditions were generally observed in January, interpreted to be a result of the mild winter (i.e., minimal snow accumulation).

- Dry conditions were observed at MW18-2 (4.7 m deep) and MW18-9 (3.8 m deep) during the seasonally low period which occurred in September and October 2019.

- The groundwater levels in the original 2018 monitoring wells MW18-1 (Figure-E-1, Appendix E), MW18-6 (Figure E-5, Appendix E) and MW18-7 (Figure-E-6, Appendix E) remained relatively stable with a seasonal fluctuation of around 1.0 m. Conversely, the highest fluctuations occurred in MW18-2 (Figure E-2, Appendix E) with 3.7 m throughout 2019.

- Groundwater conditions observed in January 2020 in wells installed across Sites C, D and E (Figures E-9 to E-17, Appendix E) are interpreted to represent seasonal high levels and generally remained high before declining in April during drier conditions. Groundwater levels in two wells (MW19-01 & MW19-101) were observed to spike higher than January levels in response to rain events before quickly returning to static conditions.

- Seasonal high levels across Sites C, D and E ranged from a high of 0.09 mbgs at MW19-202 (Figure E-17) to a low of 2.09 mbgs at MW19-100 (Figure E-12). Seasonal fluctuations to date have ranged from 0.28 m at MW19-100 (Figure E-12) to 1.67 m at MW19-202 (Figure E-17).

- All wells equipped with dataloggers indicate groundwater level responses to precipitation events.

6.3 Groundwater Flow Systems

Areas where water from precipitation percolates or infiltrates into the ground and moves downward from the water table are known as recharge areas. These areas are generally in areas of relatively higher topographic elevation. Areas where groundwater moves upward are discharge areas and generally occur in areas of relatively lower elevation, such as along watercourses. Recharge and discharge may occur in local, intermediate and more regional flow systems. Infiltrating water at any given location may follow a shallow flow path and discharge a short distance away from the recharge area, i.e., along the nearest slopes or in small watercourses, swales, ditches, and wetlands. This is referred to as a local groundwater flow system (i.e., flows that closely follow the existing topography with relatively short flow distances, e.g., up to a few hundred metres).

Some water may follow much deeper and/or longer flow paths (hundreds to thousands of metres) resulting in recharge to underlying aquifers and discharge at more distant features and watercourses. Such conditions may be referred to as intermediate and/or regional groundwater flow systems depending on the scale.

6.3.1 Interpreted Groundwater Flow Conditions

For the Subject Property, the shallow groundwater flow is interpreted to closely follow the local topography and surface water drainage patterns (Figure 11) and is interpreted to be a local groundwater flow system. As such, the interpretation is flow moves downslope from topographically higher areas toward the topographical lower areas. The shallow groundwater across the site will generally flow southeast towards Appleby Creek and Mill Pond, and Sheldon Creek, and more regionally towards Lake Ontario. The interpreted direction of groundwater movement is shown on Figure 11. Groundwater levels shown on Figure 11 represent the December 9, 2019 monitoring event.

6.3.2 Recharge and Discharge Conditions

A review of the Hamilton-Halton Source Water Protection mapping indicates that the Subject Property has not been identified as an area of Significant Groundwater Recharge (SGRA) or Highly Vulnerable Aquifer (HVA). The tablelands proposed for development are interpreted to be groundwater recharge areas, i.e., areas where

infiltrating precipitation may recharge into the topsoil and underlying sediments. ESGRA mapping is not available for the Subject Property.

As discussed in Section 4.2, a downward gradient was observed at PZ1s/d which suggests recharge conditions at this location near Appleby Creek. Based on the low permeability of the surficial soils, the magnitude of recharge across the Subject Property is considered to be limited. Groundwater movement through the subsurface is predominantly controlled by 'secondary hydraulic conductivity'. This includes any fracturing and layering in the shallow till that may provide some lateral connection and some local infiltration.

7.0 Water Balance

7.1 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 conditions as well as the soil and land cover conditions (i.e., rainfall intensity, land slope, soil hydraulic conductivity and vegetation). Runoff, for example, occurs particularly during periods of snowmelt when the ground is frozen, or during intense rainfall events. Precise measurement of the water balance components is difficult and as such, approximations and simplifications are made to characterize the water balance of a property. Field observations of the drainage conditions, land cover and soil types, groundwater levels and local climatic records are important inputs to the water balance calculations.

The groundwater balance components for the Subject Property are discussed below.

Precipitation (P)

The reported long-term average annual precipitation for the period between 1981 and 2010 is 897 mm based on data from the Environment Canada Hamilton Royal Botanical Gardens (RBG) Climate Station climate station (Station 6153300 - 43° 17'.00.000 N, 79° 53'.00.000' W, elevation 102.1 masl). Average monthly records of precipitation and

temperature from this station have been used for the water balance calculations in this study (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.

Evapotranspiration (ET)

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

Water Surplus (R + I)

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

7.2 Approach and Methodology

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

Considering the predominantly silt and clay fill soils encountered during the drilling program, a soil moisture storage capacity of 100 mm was used for the shallow-rooted vegetation across the golf course. Table G-1 in Appendix G details the monthly potential evapotranspiration calculations accounting for latitude and climate, and then calculates the actual evapotranspiration and water surplus components of the water balance based on the monthly precipitation and soil moisture conditions.

The MECP SWM Planning and Design Manual (2003) methodology for calculating total infiltration based on topography, soil type and land cover was used, and a corresponding runoff component was calculated for the soil moisture storage conditions. The calculated water balance components were then used to assess the pre-development volumes for runoff and infiltration for each of the five Sites which comprise the Subject Property based on the existing land use characteristics (open space/golf course).

A post-development water balance scenario was also calculated for each Site based on the proposed land development plan. A percentage of imperviousness for these proposed land uses has been provided by Urbantech and assigned for the groundwater balance calculations as shown in Table G-3, Appendix G.

7.3 Component Values

The detailed monthly calculations of the water balance components are provided on Table G-1 in Appendix G. The calculations show that a water surplus is generally available from November to May. The monthly water balance calculations illustrate that infiltration occurs during periods when there is sufficient water available to overcome the soil moisture storage requirements. The monthly calculations are summed to provide estimates of the annual water balance component values (Tables G-1, Appendix G). A summary of these values is provided in Table 2 (note that the values from the calculation table in Appendix G have been rounded, accounting for the minor variances in balance addition).

Table 2: Water Balance Component Values

Water Balance Component	Open Space/Golf Course*
Average Precipitation	897 mm/year
Actual Evapotranspiration	591 mm/year
Water Surplus	306 mm/year
Infiltration	138 mm/year
Runoff	168 mm/year

*It is acknowledged that the infiltration and runoff values presented in Table 2 are estimates. Single values are used for the water balance calculations, but it is important to understand that infiltration rates are dependent upon the hydraulic conductivity of the surficial soils which may vary over several orders of magnitude. As such, the margins of error for the calculated infiltration and runoff component values are potentially quite large. These margins of error are recognized, but for the purposes of this assessment, the numbers used in the water balance calculations are

considered reasonable estimates based on the site-specific conditions and useful for comparison of pre- to post-development conditions.

7.4 Pre-Development Water Balance (Existing Conditions)

The pre-development water balance calculations based on the existing land use are presented in Table G-3 in Appendix G. The total area of the development is approximately 12.36 ha. The water balance component values from Table G-1 were used to calculate the average annual volume of infiltration and runoff for each Site and the Subject Property as a whole.

The pre-development average annual infiltration volume for each Site on the Subject Property was calculated in Table G-3, Appendix G and summarized below in Table 3.

Table 3: Pre-Development Infiltration Volumes

Site	Area (m^2)	Pre-Development Infiltration Volume (m^3/year)
Site A	58,700	6,300
Site B	36,200	4,700
Site C	14,600	1,900
Site D	7,500	1,000
Site E	6,600	700
TOTAL	**123,600**	**14,700**

7.5 Post-Development Water Balance

As previously described, the proposed development concept has been broken down into various land use areas and these data have been used to calculate the potential post-development runoff and recharge volumes for each Site comprising the Subject Property assuming no mitigation measures are in place (Table G-3, Appendix G). The infiltration and runoff factors for the post-development calculations reflect the proposed change in grading and vegetation (rolling open space/urban lawns to graded urban lawns) across the Subject Property (refer to Table G-2, Appendix G). These calculations suggest that, without mitigation, the proposed development has the potential to reduce shallow infiltration across the Subject Property by 37% (5,500 m^3/year), as summarized below in Table 4. The potential impacts of these changes and recommended mitigation measures are discussed below.

Table 4: Post-Development Infiltration Volumes

Site	Area (m^2)	Post-Development Infiltration Volume (m^3/year)	% Change from Pre-Development
Site A	58,700	4,450	30%
Site B	36,200	2,650	44%
Site C	14,600	1,000	47%
Site D	7,500	500	48%
Site E	6,600	600	18%
TOTAL	**123,600**	**9,200**	**37%**

7.6 Water Balance Impact Assessment and Recommended Mitigation Measures

7.6.1 Runoff Quantity

Urban 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 reduces the evapotranspiration component of the natural water balance. The evaporation component from impervious surfaces is relatively minor (estimated to be 10% to 20% of precipitation) compared to the evapotranspiration component that occurs with vegetation in this area (about 66% of precipitation). So, the net effect of the urbanization of the site is that most of the precipitation that falls onto impervious surfaces increases the surplus water resulting in more direct runoff from developed areas and reduced natural infiltration.

The increases in surface water runoff that will occur with urban development are typically addressed using appropriate stormwater management and low impact development (LID) techniques to control flows to the watercourses. Details of the stormwater management strategies for the property are provided in the Functional Servicing and Stormwater Management Report prepared by Urbantech (2020).

7.6.2 Infiltration Quantity

Development of the Subject Property will reduce infiltration to the shallow groundwater flow system. The groundwater balance calculations suggest that, without mitigation, a potential reduction of 37% of the average annual groundwater infiltration could occur without any LID measures in place (refer to Table G-3, Appendix G). The results of this hydrogeological study suggest that Appleby Creek and Sheldon Creek primarily have surface water runoff conveyance functions; however, discharge from the shallow groundwater flow system may contribute to seasonally high-water table conditions in the feature. A reduction in infiltration can potentially lead to a lowering of the local water table and reduce the potential for this seasonal water table intersection and discharge.

Potential impacts to the local water table may be minimized by using LID measures to promote infiltration (refer to Section 7.6.3).

7.6.3 Mitigation Measures for Maintaining Infiltration

As outlined in the MECP SWMP Design Manual (2003) and Low Impact Development Stormwater Management Planning and Design Guide published by the TRCA (2012), there are a suite of techniques that may be considered to promote infiltration and reduce runoff. For example, these include such measures as: directing roof runoff to pervious areas, increasing the topsoil thickness or amending the topsoil to retain more water in storage, use of permeable pavements, rain gardens, bioswales, subsurface infiltration trenches, galleries and pervious pipe systems, etc. It is noted, however, that subsurface infiltration methods can only be considered in areas where there is sufficient soil permeability and depth to water table to accommodate the systems within the unsaturated zone. Preliminary findings suggest that subsurface infiltration would not generally be considered suitable at the Subject Property due to factors such as low permeable till, high water table and shallow depth to bedrock.

7.6.4 Post-Development with LID Measures

The basic premise for low impact development is to try to minimize changes to runoff and infiltration. Urbantech has advised that the following LID measures will be incorporated into the stormwater management plans for the development:

- Increased topsoil depth across all lots and park areas. The intention with increased topsoil depth is to aid retention of runoff through increased soil storage and evapotranspiration and promote more infiltration in these areas. Typically, topsoil is increased to about 300 mm.

- Disconnection of roof leaders to discharge to rear yards. Directing roof water to rear yards reduces direct runoff by approximately 25% in silt/clay loam soils.

These types of LID techniques promote natural infiltration by providing additional water volumes in the pervious areas. This is particularly effective in the summer months when natural infiltration would not generally occur because the additional water overcomes the natural soil moisture deficit.

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 for the Subject Property, the water balance component values were recalculated assuming that all of the roof water from Sites A, B, C and D will be directed to rear/side yards and that the average topsoil depth is increased to assist with water retention (Table G-5, Appendix G). These pervious areas would receive precipitation as well as extra water from roof runoff, and

with the increase in available water, evapotranspiration can meet the potential occur at the maximum potential rate.

No LIDs are proposed for Site E other than increased topsoil depth. Underground parking is proposed for the high-rise development, resulting in minimal opportunity for infiltration. An underground cistern is proposed for Site E to capture runoff for re-use/irrigation.

Recalculation of the water balance for the Subject Property with these LID measures in place suggests that infiltration across the Subject Property will be maintained in post-development. The typical increases in runoff that may occur with development can be reduced (i.e., an increase in runoff of 1.7 times as compared to 1.8 times without LID measures; Table G-5, Appendix G). Considering the margin of error in such calculations, it is concluded that implementation of these LID measures is a very effective method to maintain the natural groundwater balance conditions.

7.6.5 Groundwater Quality

Depending on land use, runoff from urban developments may contain a variety of dilute contaminants such as suspended solids, chloride from road salt, oil and grease, metals, pesticide residues, bacteria and viruses. For groundwater, generally with the exception of the dissolved constituents such as nitrogen and salt, most contaminants are attenuated by filtration during groundwater flow through the soils.

Groundwater quality is expected to improve nominally as a result of the overall reduction in managed golf course areas and the subsequent reduction of the applications of fertilizers/herbicides/pesticides/etc. Any potential changes to the shallow groundwater quality are not expected to influence the surface water in Appleby Creek or Mill Pond given the limited groundwater discharge volumes anticipated.

8.0 Construction Considerations

8.1 Construction Below Water Table

The construction of buried services below the water table has the potential to capture and redirect shallow groundwater flow through more permeable granular pipe base or backfill materials. Over the long-term, these impacts can lower the groundwater table across the development area. Use of appropriate best management practices (BMP) for servicing and construction throughout the Subject Property is recommended where necessary to prevent long-term lowering of the water table. This will include the use of anti-seepage collars or clay plugs to provide barriers to flow to prevent groundwater flow along the granular bedding and erosion of the backfill materials.

Building foundations and underground parking constructed below the water table will require a perimeter drainage system around the exterior. Specific details of the

perimeter drainage system will be determined during detailed design. Impacts to regional groundwater flow are not anticipated where development is proposed below the water table.

8.2 Dewatering/Depressurization Requirements

Sewer trenches and excavations may encounter groundwater during the construction of the development. Groundwater seepage from the shallow till soils is expected to be controllable by the use of sump pumps. Although it isn't anticipated, if higher permeable sands or gravels are encountered, the use of well-point dewatering systems may be required.

Dewatering and/or depressurization requirements and the anticipated water flow volumes will be confirmed in the dewatering assessment to be completed in support of detailed servicing design. 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 management and monitoring plans are required to support EASR and PTTW applications. Depressurization of underlying sediments are not anticipated based on the regional geology and results of the drilling program.

8.3 Private Water Wells

Typically, any existing private wells within 500 m of the Subject Project should be identified via a private well survey to establish the existing conditions of the well and water supply pre-development and ensure that supplies are maintained during and post-development. However, in the case of the Subject Property, all nearby water users receive municipal supply through the Region of Halton.

8.4 Well Decommissioning

It will be necessary to ensure that all groundwater monitoring wells installed for study purposes are decommissioned by a licensed water well contractor according to Ontario Regulation 903 prior to or during the site development unless they are to be maintained through the construction period for monitoring purposes.

9.0 Summary and Conclusions

- The Subject Property are predominantly characterized as having low permeable till at ground surface. Bedrock was encountered at depths as shallow as 1.5 mbgs. Although the Subject Property is generally in a recharge area, the actual amount of water that infiltrates and recharges the subsurface is limited by the clayey/silty nature of the surficial soils. Based on the results of the grainsize

analyses and in situ well tests completed, the estimated hydraulic conductivity varies between 3.6 x 10^{-7} cm/s and 4.2 x 10^{-5} cm/s.

- Groundwater movement in the shallow subsurface is predominantly controlled by 'secondary hydraulic conductivity'. This includes any fracturing and layering in the shallow till that may provide some lateral connection and some local infiltration.

- Seasonal high groundwater levels have been found to range from a high of 0.09 mbgs (MW19-202) to a low of 4.1 mbgs (MW18-1). Seasonal fluctuations to date have ranged from 0.28 m at MW19-100 to 3.7 m at MW18-2.

- Municipal water supply for the City of Burlington is surface water obtained from Lake Ontario. The residential and commercial developments surrounding the Subject Property are serviced through the municipal supply, which is also proposed to service the Subject Property. There is no groundwater use proposed for the development.

- The results of surface water monitoring along Appleby Creek within Site A suggest that Appleby Creek primarily has a surface water runoff conveyance function in the vicinity of the Subject Property.

- The proposed development will result in decreased infiltration without mitigation. To promote infiltration, low impact development (LID) measures designed to maximize infiltration across pervious areas were considered. Implementation of increased topsoil depth and downspout disconnection to direct roof runoff to pervious areas across the proposed development will result in maintaining pre-development infiltration volumes compared to a 37% reduction in infiltration without mitigation.

- Additional measures currently being evaluated to further promote infiltration, reduce runoff and improve water quality across the proposed development include infiltration trenches, bioretention swales, bioretention cells, vegetated filter strips and oil/grit separators. Refer to Figures LID-A1, LID-A2, LID-B, LID-C, LID-D and LID-E in the Functional Servicing Report for proposed locations (Urbantech, 2020).

- It is recommended that any subsurface LIDs approved for the proposed development be monitored in post-development to assess how well they function.

10.0 References

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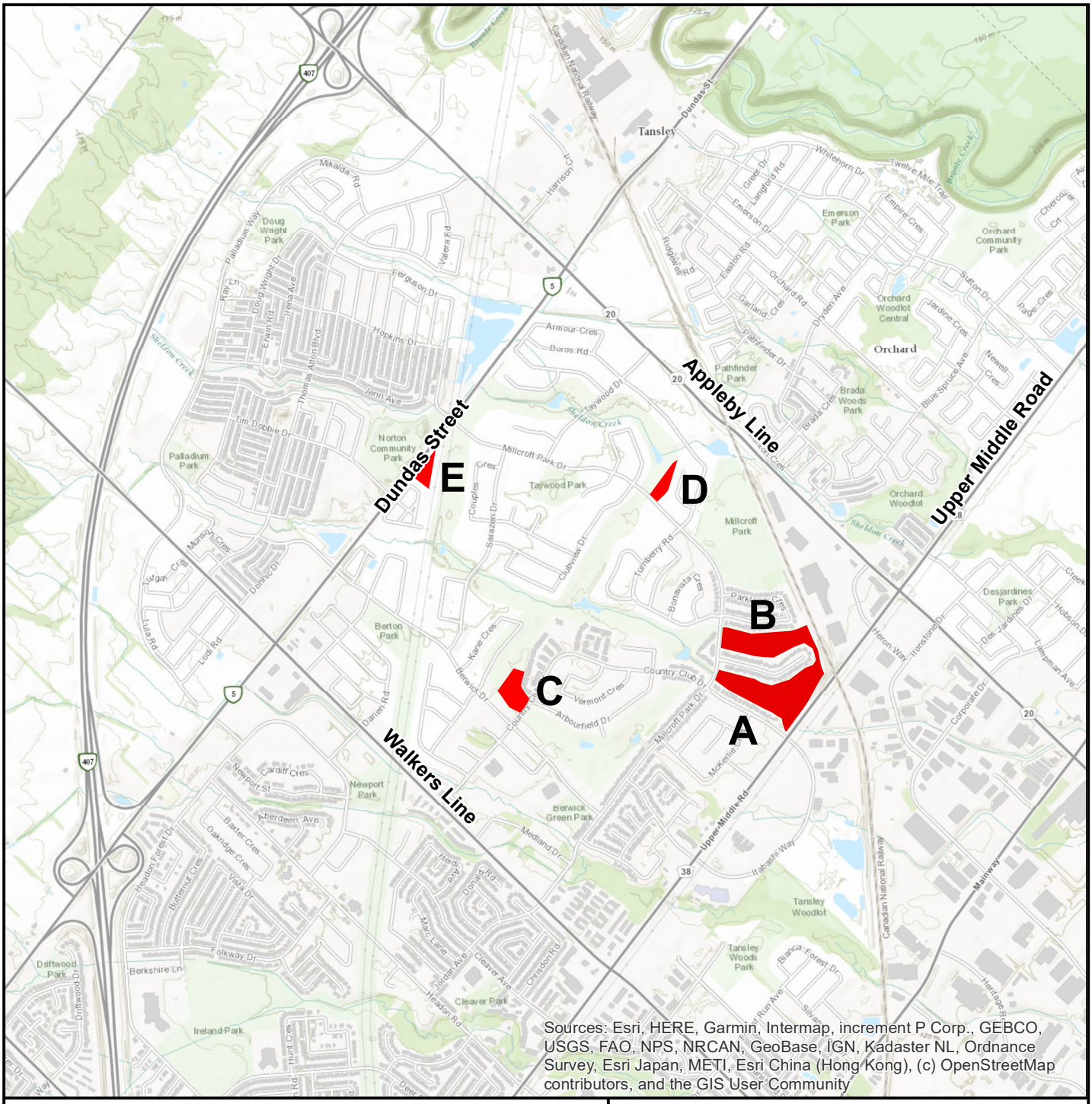
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BURNSIDE

[THE DIFFERENCE IS OUR PEOPLE]

Figures



LEGEND

SUBJECT PROPERTY

0 125 250 500 750 1,000 1,250 1,500 1,750

Metres

N

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Client / Report

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BURLINGTON, ONTARIO

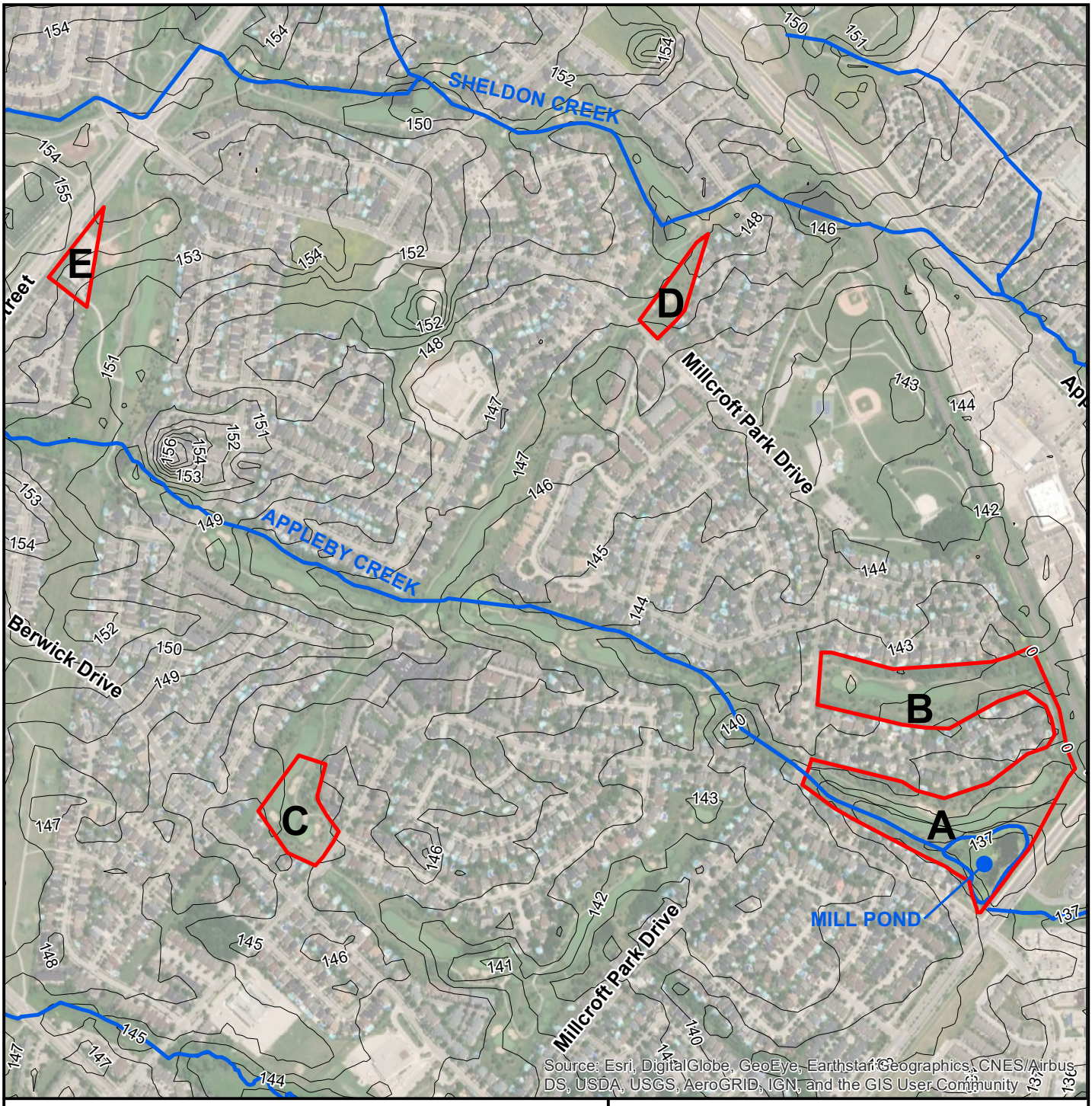
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Figure Title:

SITE LOCATION

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LEGEND

- SUBJECT PROPERTY
- WATERCOURSE
- CONTOUR (1m intervals - masl)

0 100 200 400 600 800

Metres

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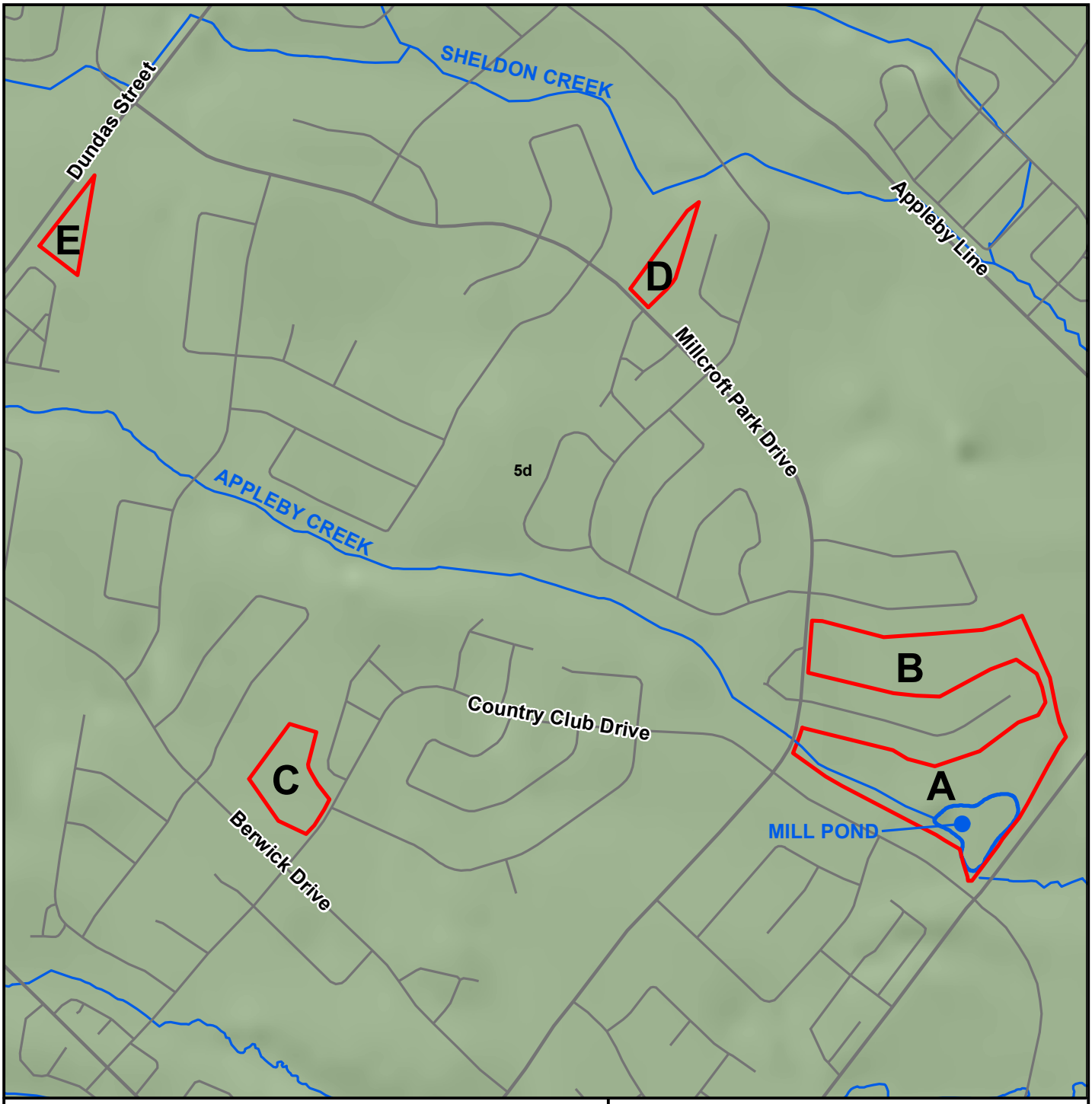
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Figure Title:

TOPOGRAPHY AND DRAINAGE

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LEGEND

- SUBJECT PROPERTY
- WATERCOURSE
- 5d: Glaciolacustrine-derived silty to clayey till

Sources:

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

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Metres

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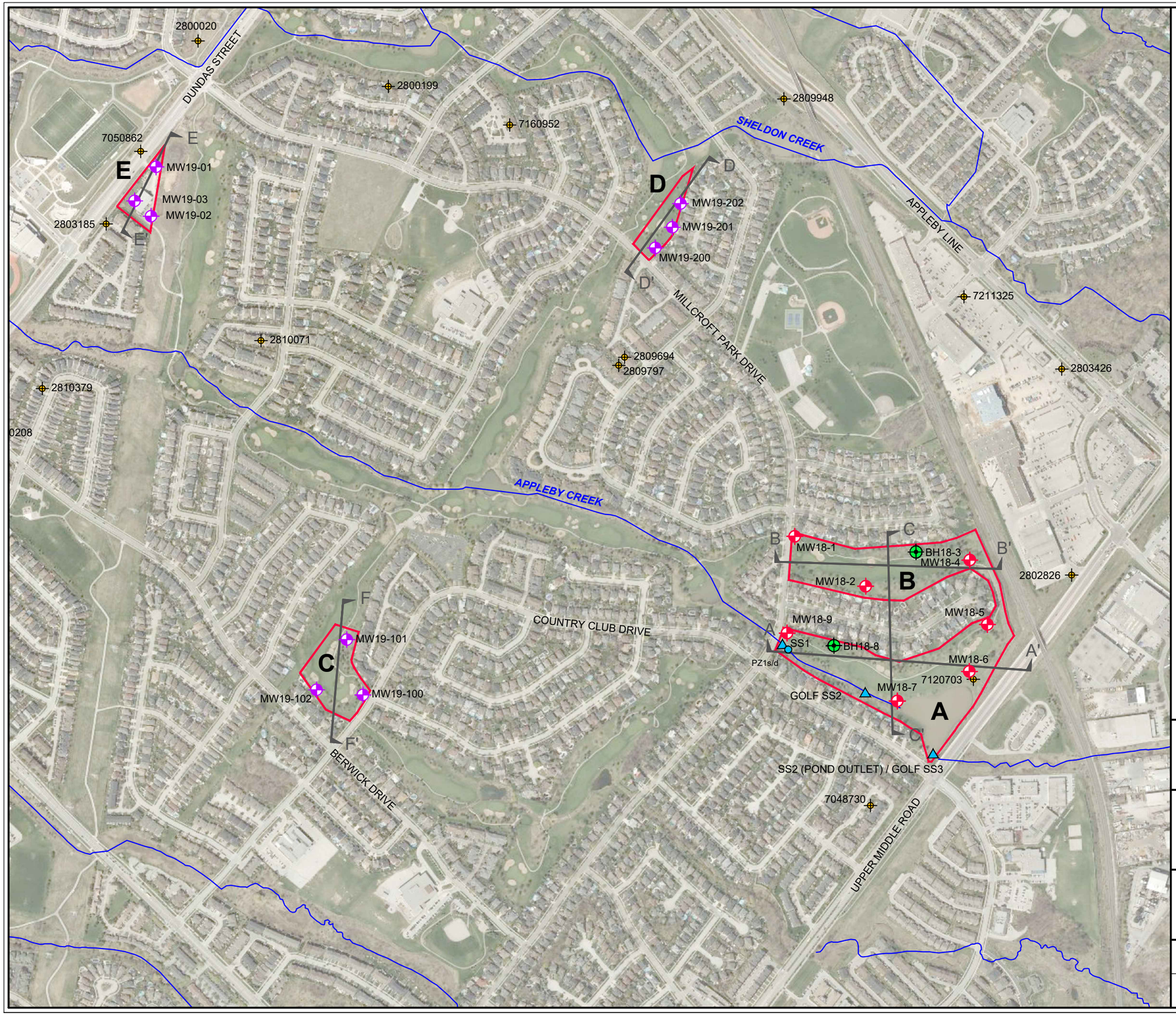
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SURFICIAL GEOLOGY

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LEGEND

- SUBJECT PROPERTY
- WATERCOURSE
- MONITORING WELL (DS CONSULTANTS, 2018)
- MONITORING WELL (DS CONSULTANTS, 2019)
- BOREHOLE (DS CONSULTANTS, 2018)
- MECP WELL RECORD LOCATION
- DRIVE POINT PIEZOMETER
- SURFACE WATER MONITORING LOCATION
- A A' CROSS-SECTION LOCATION

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Metres

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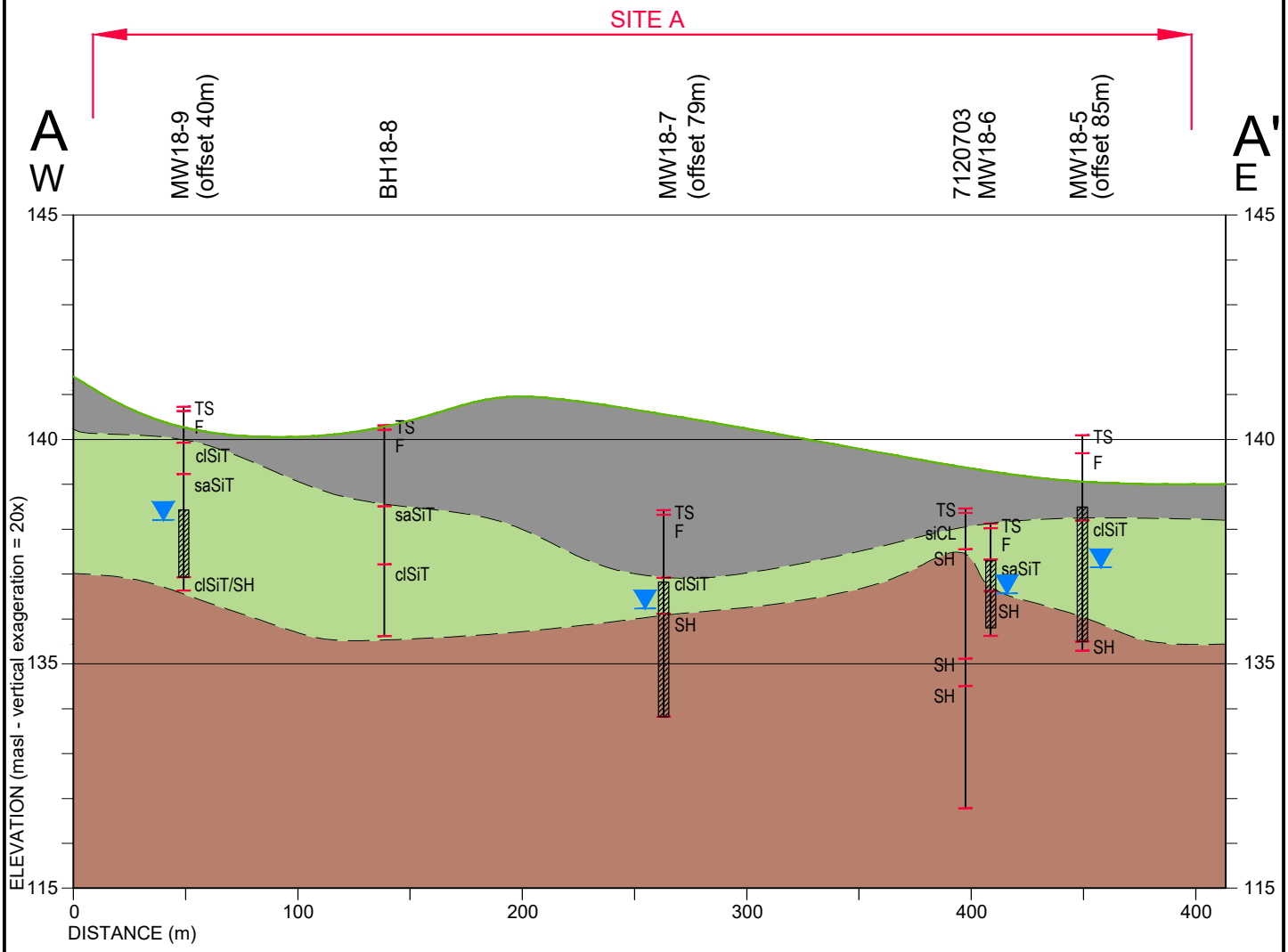
HYDROGEOLOGICAL ASSESSMENT

Figure Title

BOREHOLE, MONITORING AND CROSS-SECTION LOCATIONS

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LEGEND

BH1

EXISTING GROUND PROFILE

GEOLOGICAL CONTACT

MEASURED WATER LEVEL (December, 2019)

WELL SCREEN

INTERPRETED STRATIGRAPHY

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

TOPSOIL / FILL

TILL

SHALE / BEDROCK

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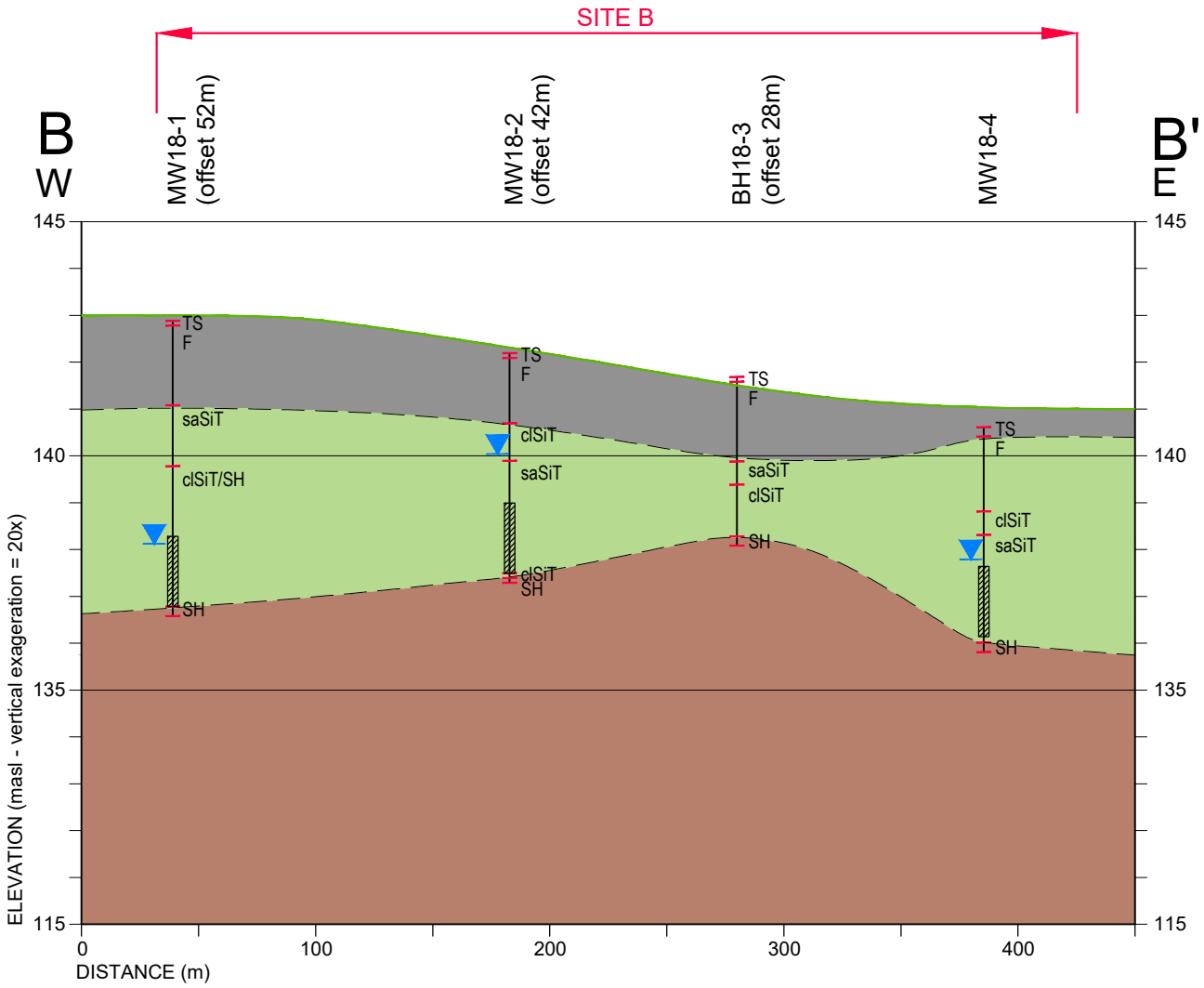
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Figure Title

INTERPRETED GEOLOGICAL CROSS-SECTION A-A'

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LEGEND

BH1

EXISTING GROUND PROFILE

GEOLOGICAL CONTACT

MEASURED WATER LEVEL (December, 2019)

WELL SCREEN

INTERPRETED STRATIGRAPHY

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

TOPSOIL / FILL

TILL

SHALE / BEDROCK

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Client / Report

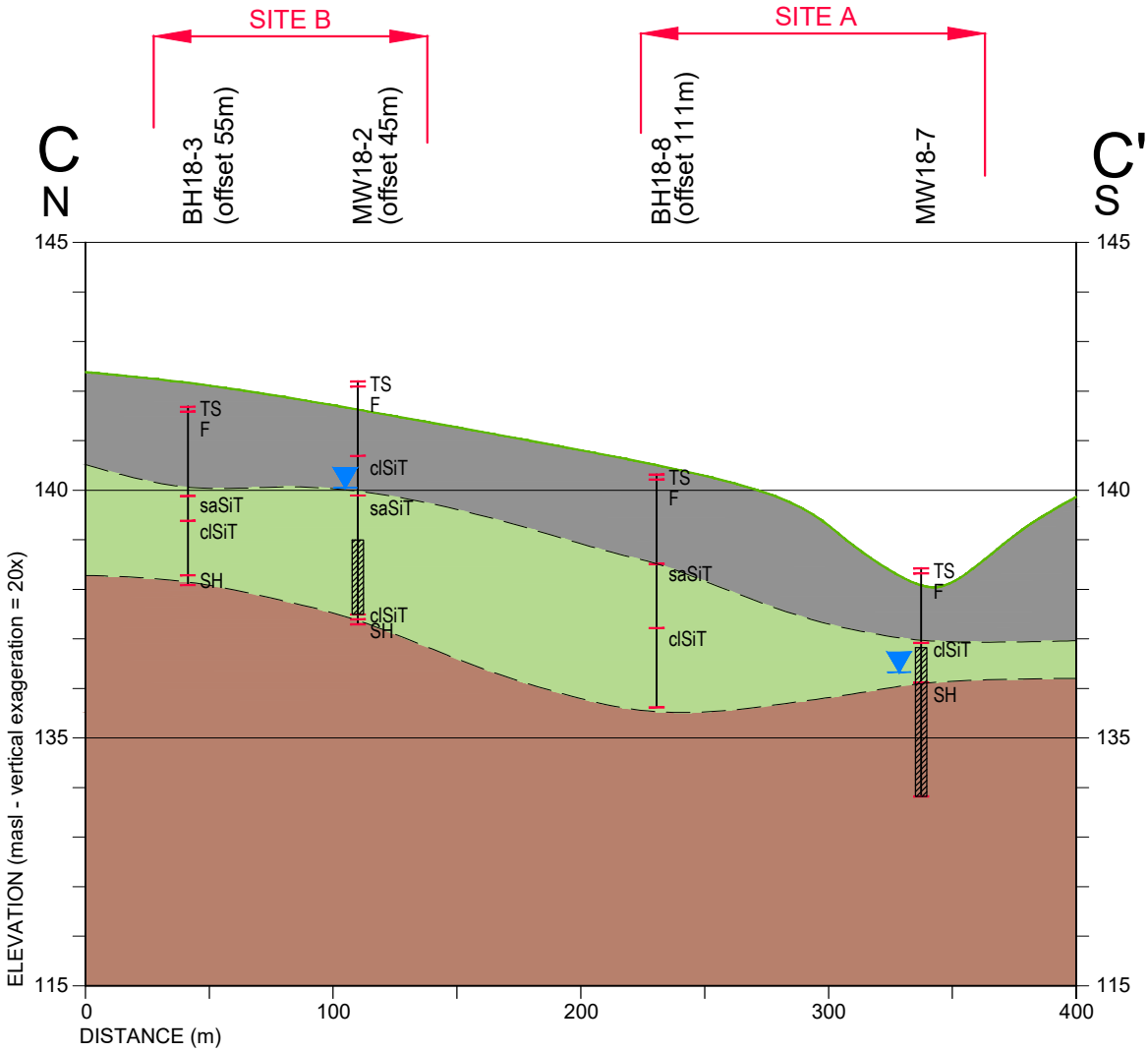
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Figure Title

INTERPRETED GEOLOGICAL CROSS-SECTION B-B'

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LEGEND

BH1

EXISTING GROUND PROFILE

GEOLOGICAL CONTACT

MEASURED WATER LEVEL (December, 2019)

WELL SCREEN

INTERPRETED STRATIGRAPHY

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

TOPSOIL / FILL

TILL

SHALE / BEDROCK

BURNSIDE

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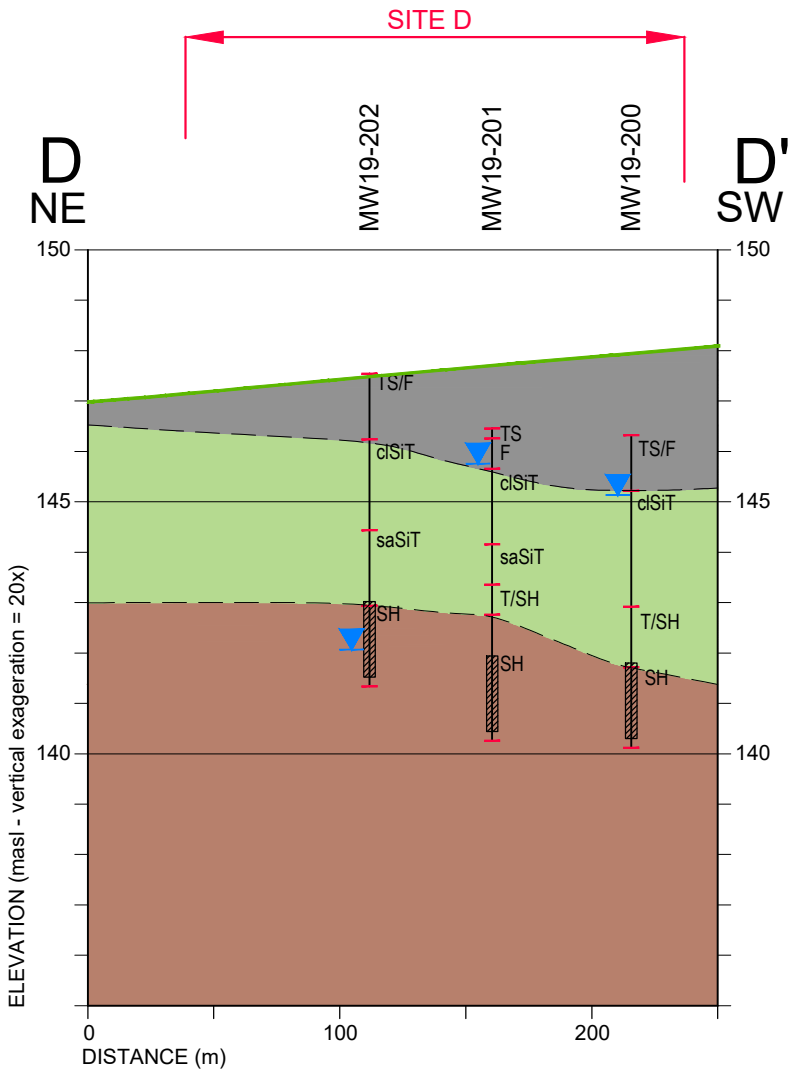
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Figure Title

INTERPRETED GEOLOGICAL CROSS-SECTION C-C'

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LEGEND

BH1

EXISTING GROUND PROFILE

GEOLOGICAL CONTACT

MEASURED WATER LEVEL (December, 2019)

WELL SCREEN

INTERPRETED STRATIGRAPHY

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

TOPSOIL / FILL

TILL

SHALE / BEDROCK

BURNSIDE

Client / Report

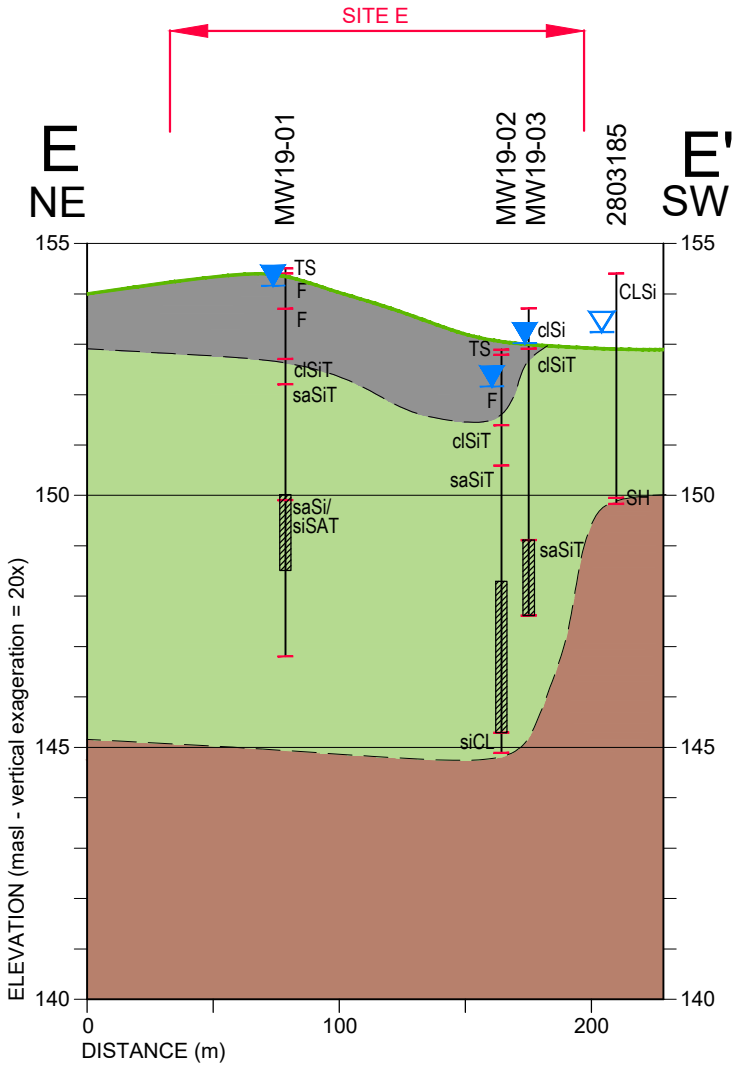
MILLCROFT GREENS CORPORATION
BURLINGTON, ONTARIO
MILLCROFT
HYDROGEOLOGICAL ASSESSMENT

Figure Title

INTERPRETED GEOLOGICAL CROSS-SECTION D-D'

Drawn	Checked	Date	Figure No.
SK	JS	OCTOBER 2020	8
Scale		Project No.	
1:3,000		300043939	

File Name:Nigel/Shared Work Areas/043939 Millcroft/ 043939 Millcroft HG Study Drawing Set Additional Sites.dwg Date Plotted: October 2, 2020 - 8:41 AM



LEGEND

BH1

EXISTING GROUND PROFILE

GEOLOGICAL CONTACT

STATIC WATER LEVEL (MECP Well Record)

MEASURED WATER LEVEL (December, 2019)

WELL SCREEN

INTERPRETED STRATIGRAPHY

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

TOPSOIL / FILL

TILL

SHALE / BEDROCK

BURNSIDE

Client / Report

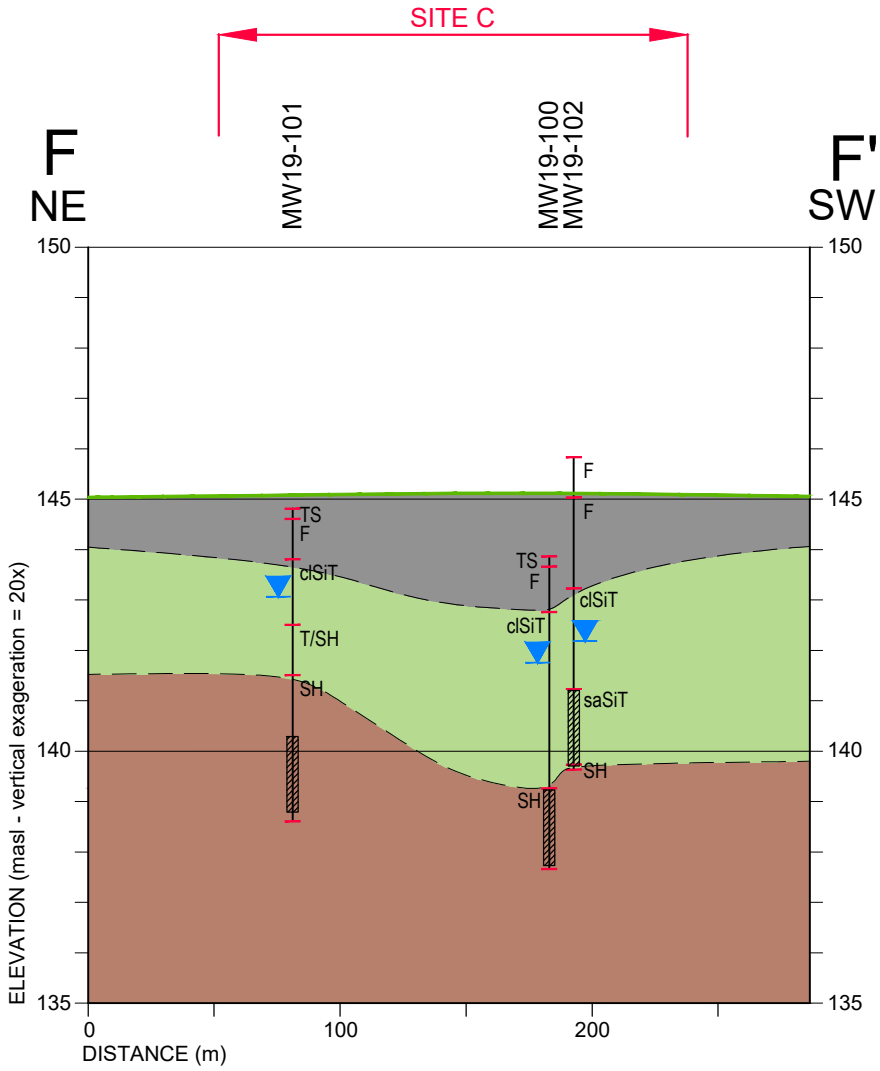
MILLCROFT GREENS CORPORATION
BURLINGTON, ONTARIO
MILLCROFT
HYDROGEOLOGICAL ASSESSMENT

Figure Title

INTERPRETED GEOLOGICAL CROSS-SECTION E-E'

Drawn	Checked	Date	Figure No.
SK	JS	OCTOBER 2020	9
Scale		Project No.	
1:3,000		300043939	

File Name:Nigel/Shared Work Areas/043939 Millcroft/ 043939 Millcroft HG Study Drawing Set Additional Sites.dwg Date Plotted: October 2, 2020 - 8:42 AM



LEGEND

BH1

EXISTING GROUND PROFILE

GEOLOGICAL CONTACT

MEASURED WATER LEVEL (December, 2019)

WELL SCREEN

INTERPRETED STRATIGRAPHY

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

TOPSOIL / FILL

TILL

SHALE / BEDROCK

BURNSIDE

Client / Report

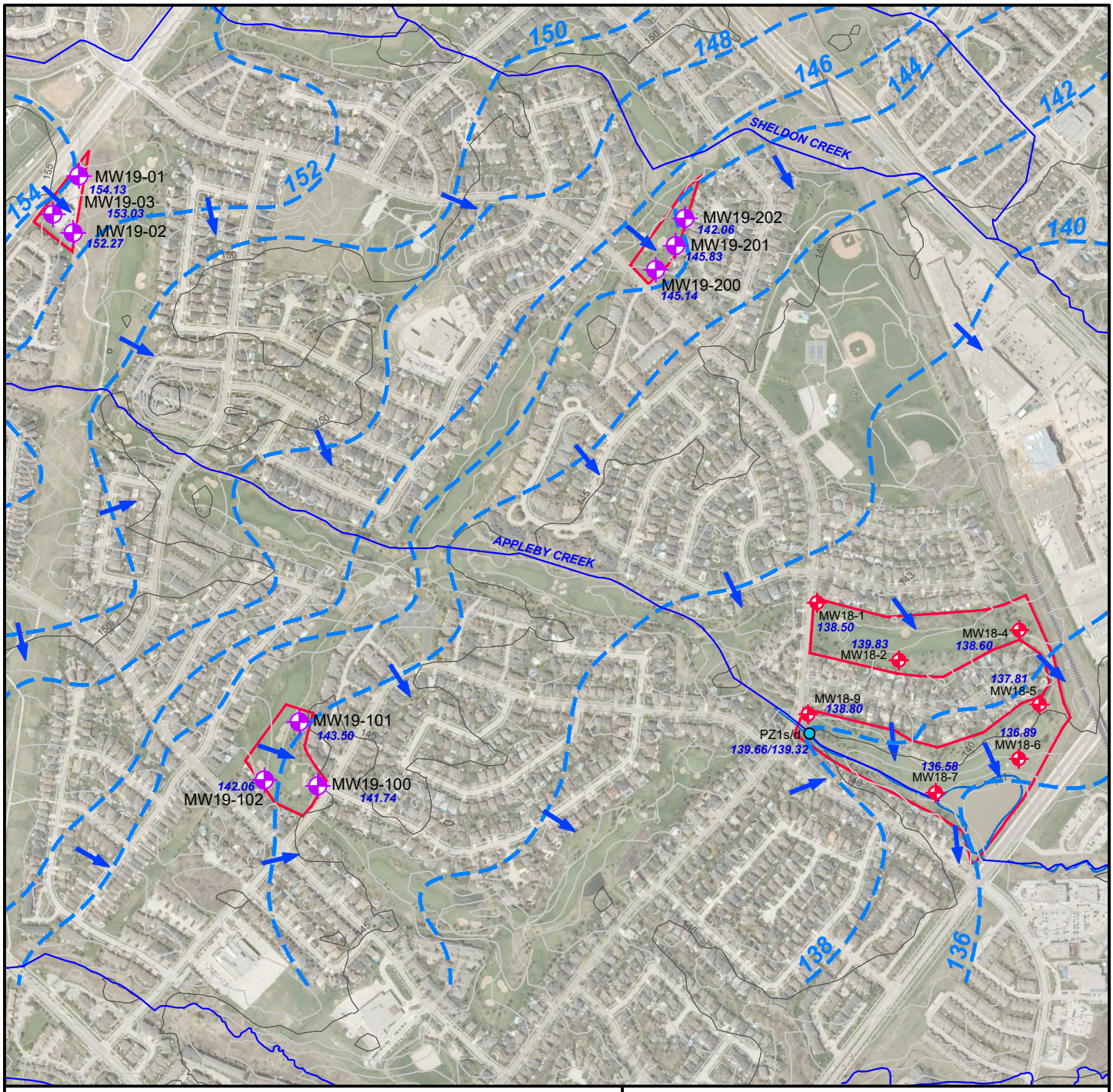
MILLCROFT GREENS CORPORATION
BURLINGTON, ONTARIO
MILLCROFT
HYDROGEOLOGICAL ASSESSMENT

Figure Title

INTERPRETED GEOLOGICAL CROSS-SECTION F-F'

Drawn	Checked	Date	Figure No.
SK	JS	OCTOBER 2020	**10**
Scale		Project No.	
1:3,000		300043939	

File Name:Nigel/Shared Work Areas/043939 Millcroft/ 043939 Millcroft HG Study Drawing Set Additional Sites.dwg Date Plotted: October 2, 2020 - 8:42 AM



LEGEND

- SUBJECT PROPERTY
- CONTOUR (1m intervals - masl)
- CONTOUR (5m intervals - masl)
- MONITORING WELL (DS CONSULTANTS, 2018)
- DRIVE POINT PIEZOMETER
- INTERPRETED GROUNDWATER CONTOUR (masl)
- 136.51 MEASURED WATER LEVEL (DECEMBER 9, 2019)
- INTERPRETED GROUNDWATER FLOW DIRECTION

0 100 200 400 600 800
Metres

N

BURNSIDE

Client / Report

MILLCROFT GREENS CORPORATION
BURLINGTON, ONTARIO

MILLCROFT
HYDROGEOLOGICAL ASSESSMENT

Figure Title

INTERPRETED GROUNDWATER FLOW

Drawn	Checked	Date	Figure No.
SK	JS	OCTOBER 2020	11
Scale		Project No.	
1:10,000		300043939	

File Name:Nigel/Shared Work Areas/043939 Millcroft/ 043939 Millcroft HG Study Drawing Set Additional Sites.dwg Date Plotted: October 2, 2020 - 8:43 AM

BURNSIDE

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Appendix A

MECP Well Records

Water Well Records

Monday, January 21, 2019
4:25:21 PM

TOWNSHIP CON LOT	UTM	DATE CNTR	CASING DIA	WATER	PUMP TEST	WELL USE	SCREEN	WELL	FORMATION
BURLINGTON CITY	17 598274 4804496 W	2006/11 6607	2.00	FR 0013			0005 15	2810665 (Z56639) A048392	BRWN CLAY SILT GRVL 0010 RED SHLE 0020
BURLINGTON CITY	17 598243 4805606 W	2015/07 7247	2	UT 0020		MT	0015 10	7253139 (Z208475) A179546	BRWN SILT SAND GRVL 0007 BRWN SAND GRVL CLAY 0014 GREY SAND SILT GRVL 0024
BURLINGTON CITY	17 597936 4804347 W	2014/03 7238						7218978 (Z182475) A	
BURLINGTON CITY	17 598363 4804854 W	2014/02 7295	1.79			MO	0017 10	7218181 (Z179661) A156035	BRWN LOAM 0005 RED SHLE HARD DRY 0020 RED SHLE HARD 0024 RED SHLE SAND WBRG 0026 RED SHLE HARD DRY 0027
BURLINGTON CITY	17 598350 4804940 W	2014/01 7484	1	0002		OT	0020 10	7218052 (Z141650) A136388	BRWN SILT CLAY 0008 RED SHLE 0030
BURLINGTON CITY	17 597539 4805577 W	2013/09 7215						7211325 (C23174) A152035 P	
BURLINGTON CITY	17 597890 4804596 W	2012/07 6607						7189061 (C19016) A134167 P	
BURLINGTON CITY	17 597913 4804753 W	2011/01 7464	1.34 1.34			NU		7159637 (M08986) A111475	BRWN SILT CLAY 0002 RED SILT 0006 RED SHLE WTHD 0008
BURLINGTON CITY	17 598162 4804695 W	2010/08 7215	2			TH	0022 10	7153283 (Z121711) A103152	BRWN FILL SAND GRVL 0004 BRWN TILL GRVL SILT 0006 RED SHLE PCKD WTHD 0032
BURLINGTON CITY	17 597159 4804245 W	2009/04 7082	6.21					7139231 (Z70750) A	
BURLINGTON CITY	17 597558 4804816 W	2010/01 7423						7138903 (Z105680) A081524 A	
BURLINGTON CITY	17 597558 4804816 W	2008/09 1129	6.69 1.97			MO		7120703 (Z80400) A081524	LOAM 0000 BRWN CLAY SAND GRVL 0003 BRWN SHLE WTHD 0011 BRWN SHLE 0013 SHLE WBRG 0022
BURLINGTON CITY	17 598202 4804648 W	2016/10 7215						7279210 (C35140) A206631 P	

TOWNSHIP CON LOT	UTM	DATE CNTR	CASING DIA	WATER	PUMP TEST	WELL USE	SCREEN	WELL	FORMATION
BURLINGTON CITY 02 005	17 598110 4805290 W	2006/11 6607	2.00				0004 10	7039196 (Z56655) A051087	BRWN CLAY TILL 0012 BRWN SHLE 0014
BURLINGTON CITY 3-4	17 598462 4805634 W	2007/10 6988				TH		7100721 (M00226) A064001 A	PRDR 0011
BURLINGTON CITY DS S 01 005	17 598261 4805831 W	2002/06 3030						2809604 (229645) A	
BURLINGTON CITY DS S 01 006	17 597734 4805433 W	1970/06 5417	6	FR 0015 FR 0048	6/36/5/1:0	DO		2803426 ()	BRWN CLAY 0008 RED SHLE 0049
BURLINGTON CITY DS S 01 006	17 597754 4805023 W	1968/06 5417	6 6	FR 0045	8/33/1/1:15	DO		2802826 ()	RED CLAY 0007 RED SHLE 0047
BURLINGTON CITY DS S 01 007	17 596865 4805455 L	2003/09 4005				NU		2809797 (258694) A	
BURLINGTON CITY DS S 01 007	17 596854 4805440 W	2003/01 4005						2809694 (241420) A	
BURLINGTON CITY DS S 01 008	17 597254 4804303 W	1968/09 5417	6 6	FR 0034	12/24/2/0:45	DO		2802822 ()	BRWN CLAY 0006 RED CLAY SHLE 0011 RED SHLE 0036
BURLINGTON CITY DS S 01 009	17 596992 4804014 W	1957/07 5417	6 6	FR 0033	10/20/0/0:30	DO		2800200 ()	RED CLAY 0019 RED SHLE 0034
BURLINGTON CITY DS S 01 009	17 597094 4804113 W	1968/06 1620	6 6	SA 0034	8/30/3/1:0	DO		2802836 ()	BRWN CLAY 0010 RED SHLE 0035
BURLINGTON CITY DS S 01 009	17 597208 4804284 W	1959/08 4001	6 6	FR 0032	12/32/1/2:0	DO		2800201 ()	BLUE CLAY 0021 RED SHLE 0032
BURLINGTON CITY DS S 01 010	17 596454 4803933 W	1956/07 4002	6 6	FR 0035	20/35/1/:	DO		2800203 ()	CLAY 0018 RED SHLE 0035
BURLINGTON CITY DS S 01 010	17 596442 4803923 W	1956/06 4002	6 6	FR 0035	25/35/1/:	DO		2800202 ()	CLAY 0012 RED SHLE 0035
BURLINGTON CITY DS S 02 009	17 597060 4803992 W	1964/10 4602	6 6	FR 0027 FR 0030	10/33/4/1:0	DO		2800250 ()	BRWN CLAY 0019 RED CLAY 0020 RED SHLE 0033
CALEDON TOWN (CALEDO 07 019	17 597355 4804566 W	2007/07 4011	29.5		9///:			7048730 (Z57011) A	

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

Notes:
UTM: UTM in Zone, Easting, Northing and Datum is NAD83; L: UTM estimated from Centroid of Lot; W: UTM not from Lot Centroid
DATE CNTR: Date Work Completedand Well Contractor Licence Number
CASING DIA: .Casing diameter in inches
WATER: Unit of Depth in Fee. See Table 4 for Meaning of Code
PUMP TEST: Static Water Level in Feet / Water Level After Pumping in Feet / Pump Test Rate in GPM / Pump Test Duration in Hour : Minutes
WELL USE: See Table 3 for Meaning of Code
SCREEN: Screen Depth and Length in feet
WELL: WEL (AUDIT #) Well Tag . A: Abandonment; P: Partial Data Entry Only
FORMATION: See Table 1 and 2 for Meaning of Code

1. Core Material and Descriptive terms

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

2. Core Color

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

3. Well Use

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

4. Water Detail

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

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Appendix B

Borehole Logs

LOG OF BOREHOLE BH18-1

PROJECT: Geotechnical, Environmental, Hydrogeological Investigation
CLIENT: Argo Development Corp
PROJECT LOCATION: 2155 Country Club Drive, Burlington
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4805100.1 E 597203.488

DRILLING DATA
Method: Solid Stem Auger
Diameter: 150 mm
Date: Dec-18-2018

REF. NO.: 18-687-100
ENCL NO.: 2

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION
142.8						
142.0 / 0.0	**TOPSOIL:** 140 mm					
0.1	**FILL:**clayey silt, trace rootlets, moist, dark brown to brown, loose to compact	1	SS	8		
		2	SS	20		142
					Bentonite	
141.0		3	SS	32		141
1.8	**SANDY SILT TILL:**some gravel/cobble, trace clay, greyish brown, moist, dense to very dense					
	reddish brown below 2.3 m	4	SS	80/ 230mm	Filter Pack	
139.7						
3.1	**CLAYEY SILT TILL/SHALE COMPLEX:** reddish brown, moist, hard	5	SS	50/ 50mm		139
					W. L. 138.6 m Jan 03, 2019n Jan 07, 2019	
					Slotted Pipe	
		6	SS	50/ 50mm		138
136.7						137
6.1	**SHALE BEDROCK:** Highly weathered shale	7	SS	50/ 100mm		
136.5						
6.3	**END OF BOREHOLE**					

Notes:
1) 50mm dia. monitoring well installed upon completion.
2) Water Level Readings

Date	Water Depth (mbgs)
Jan. 3, 2019	4.16
Jan. 7, 2019	4.27

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH (kPa)
○ UNCONFINED + FIELD VANE & Sensitivity
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%)
10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

METHANE AND GRAIN SIZE DISTRIBUTION (%)

GR	SA	SI	CL
14	23	54	9

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
+3, ×3: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

DS SOIL LOG 18-687-100 - MILLCROFT GOLF COURSE, BURLINGTON.GPJ DS.GDT 19-1-21

LOG OF BOREHOLE BH18-2

PROJECT: Geotechnical, Environmental, Hydrogeological Investigation
CLIENT: Argo Development Corp
PROJECT LOCATION: 2155 Country Club Drive, Burlington
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4805001.917 E 597344.446

DRILLING DATA
Method: Solid Stem Auger
Diameter: 150 mm
Date: Dec-18-2018

REF. NO.: 18-687-100
ENCL NO.: 3

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
142.2												
142.0 0.0	**TOPSOIL:**											
0.1	**FILL:** clayey silt, trace topsoil, very moist, brown, loose to compact		1	SS	5		142					
			2	SS	15	▽		W. L. 141.1 m Jan 03, 2019				
140.7						▼		W. L. 140.8 m Jan 07, 2019				
1.5	**CLAYEY SILT TILL:** sandy, trace gravel/cobble, greyish brown, moist, hard		3	SS	32							
139.9							140					
2.3	**SANDY SILT TILL:** trace clay, trace gravel/cobble, reddish brown, moist, very dense		4	SS	50			Filter Pack				
			5	SS	50/ 150 mm		139					5 26 61 8
								Slotted Pipe				
137.6							138					
137.6 4.7	**CLAYEY SILT TILL:** trace sand, reddish brown, moist, hard		6	SS	50/ 75mm							
137.3 4.9	**SHALE BEDROCK:** Highly weathered shale											
	END OF BOREHOLE											

Notes:
1) 50mm dia. monitoring well installed upon completion.
2) Water Level Readings

Date	Water Depth (mbgs)
Jan. 3, 2019	1.04
Jan. 7, 2019	1.36

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES: +3, ×3: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

DS SOIL LOG 18-687-100 - MILLCROFT GOLF COURSE, BURLINGTON.GPJ DS.GDT 19-1-21

LOG OF BOREHOLE BH18-3

PROJECT: Geotechnical, Environmental, Hydrogeological Investigation
CLIENT: Argo Development Corp
PROJECT LOCATION: 2155 Country Club Drive, Burlington
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4805069.474 E 597444.447

DRILLING DATA
Method: Solid Stem Auger
Diameter: 150 mm
Date: Dec-18-2018

REF. NO.: 18-687-100
ENCL NO.: 4

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS / 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION
141.7							
141.6 0.0	**TOPSOIL:**						
0.1	**FILL:** clayey silt, trace topsoil, very moist, brown to reddish brown, loose to compact		1	SS	7		
			2	SS	21		141
139.9 1.8	**SANDY SILT TILL:** silt pockets, trace gravel/cobble, reddish brown, moist, compact to very dense		3	SS	29		140
139.4 2.3	**CLAYEY SILT TILL:** trace sand, reddish brown to grey, hard		4	SS	84/ 280mm		139
138.3			5	SS	87/ 255mm		
3.4 138.1	**SHALE BEDROCK:** Highly weathered shale						
3.6	**END OF BOREHOLE**						

Notes:
1) Borehole dry upon completion

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH (kPa)
○ UNCONFINED + FIELD VANE & Sensitivity
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%)
10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

METHANE AND GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

DS SOIL LOG 18-687-100 - MILLCROFT GOLF COURSE, BURLINGTON.GPJ DS.GDT 19-1-21

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
+3, ×3: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

LOG OF BOREHOLE BH18-4

PROJECT: Geotechnical, Environmental, Hydrogeological Investigation
CLIENT: Argo Development Corp
PROJECT LOCATION: 2155 Country Club Drive, Burlington
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4805053.465 E 597551.071

DRILLING DATA
Method: Solid Stem Auger
Diameter: 150 mm
Date: Dec-19-2018

REF. NO.: 18-687-100
ENCL NO.: 5

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
140.6												
0.0 / 140.4	**TOPSOIL:** 180 mm											
0.2	**FILL:** clayey silt, trace rootlets, moist, dark brown to brown, compact		1	SS	11				○			
			2	SS	11		140		○			
							Bentonite					
138.8							139					
1.8	**CLAYEY SILT TILL:** trace sand, trace gravel/cobble, reddish brown, moist, hard		3	SS	61	▽	W. L. 138.8 m Jan 03, 2019		○			
138.3						▽	W. L. 138.5 m Jan 07, 2019					
2.3	**SANDY SILT TILL:** trace clay, some gravel/cobble, reddish brown, moist, very dense		4	SS	50/ 50mm		Filter Pack 138		○			18 40 39 3
			5	SS	50/ 25mm		Slotted Pipe 137		○			
136.0							136					
4.6 / 135.8	**SHALE BEDROCK:** Highly weathered shale		6	SS	50/ 25mm				○			
4.8	**END OF BOREHOLE**											

Notes:
1) 50mm dia. monitoring well installed upon completion.
2) Water Level Readings

Date	Water Depth (mbgs)
Jan. 3, 2019	1.76
Jan. 7, 2019	2.07

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES: + 3, × 3: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

DS SOIL LOG 18-687-100 - MILLCROFT GOLF COURSE, BURLINGTON.GPJ DS.GDT 19-1-21

LOG OF BOREHOLE BH18-5

PROJECT: Geotechnical, Environmental, Hydrogeological Investigation
CLIENT: Argo Development Corp
PROJECT LOCATION: 2155 Country Club Drive, Burlington
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4804925.877 E 597586.938

DRILLING DATA
Method: Solid Stem Auger
Diameter: 150 mm
Date: Dec-19-2018

REF. NO.: 18-687-100
ENCL NO.: 6

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
140.2												
0.0 / 139.8	**TOPSOIL:** 350 mm		1	SS	4		140					
0.4	**FILL:**clayey silt, trace topsoil, moist, dark brown to brown, loose						Bentonite					
1			2	SS	9		Filter Pack					
138.3			3	SS	26							
2 1.9	**CLAYEY SILT TILL:** sandy, some gravel/cobble, reddish brown, moist, very stiff to hard						138					
			4	SS	77	▽	W. L. 137.5 m Jan 03, 2019					17 28 29 26
3	trace shale fragments below 3.1 m						Slotted Pipe					
			5	SS	99		137 W. L. 136.7 m Jan 07, 2019					
4							136					
135.6												
4.6 / 135.4	**SHALE BEDROCK:** Highly weathered shale		6	SS	50/ 100mm							
4.8	**END OF BOREHOLE**											

Notes:
1) 50mm dia. monitoring well installed upon completion.
2) Water Level Readings

Date	Water Depth (mbgs)
Jan. 3, 2019	2.62
Jan. 7, 2019	3.44

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES + 3, × 3: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

DS SOIL LOG 18-687-100 - MILLCROFT GOLF COURSE, BURLINGTON.GPJ DS.GDT 19-1-21

LOG OF BOREHOLE BH18-6

PROJECT: Geotechnical, Environmental, Hydrogeological Investigation
CLIENT: Argo Development Corp
PROJECT LOCATION: 2155 Country Club Drive, Burlington
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4804813.93 E 957552.765

DRILLING DATA
Method: Solid Stem Auger
Diameter: 150 mm
Date: Dec-19-2018

REF. NO.: 18-687-100
ENCL NO.: 7

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	TYPE	BLOWS 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
138.1												
138.0 / 0.0	**TOPSOIL:**											
0.1	**FILL:** clayey silt, very moist, brown, loose		1	SS	4		138					
137.3						Bentonite / Filter Pack						
0.8	**SANDY SILT TILL:** trace clay, trace gravel/cobble, trace shale fragments, reddish brown, moist, very dense		2	SS	59		137					5 34 57 4
136.6												
1.5	**SHALE BEDROCK:** Highly weathered shale		3	SS	67	W. L. 136.6 m Jan 03, 2019n Jan 07, 2019	136					
135.6			4	SS	50/ 25mm							
2.5	**END OF BOREHOLE**											

Notes:
1) Auger refusal at 2.3 m
2) 50mm dia. monitoring well installed upon completion.
3) Water Level Readings

Date	Water Depth (mbgs)
Jan. 3, 2019	1.49
Jan. 7, 2019	1.60

DS SOIL LOG 18-687-100 - MILLCROFT GOLF COURSE, BURLINGTON.GPJ DS.GDT 19-1-21

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES: +3, ×3: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

LOG OF BOREHOLE BH18-7

PROJECT: Geotechnical, Environmental, Hydrogeological Investigation
CLIENT: Argo Development Corp
PROJECT LOCATION: 2155 Country Club Drive, Burlington
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4804773.829 E 597407.198

DRILLING DATA
Method: Solid Stem Auger
Diameter: 150 mm
Date: Dec-20-2018

REF. NO.: 18-687-100
ENCL NO.: 8

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	TYPE	BLOWS 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
138.6												
138.5	**TOPSOIL:**											
0.1	**FILL:** clayey silt, trace rootlet/ topsoil, moist, dark brown to brown, loose		1	SS	4							
			2	SS	8		Bentonite					
137.1							Filter Pack					
1.5	**CLAYEY SILT TILL:** sandy, some gravel/cobble, reddish brown to grey, moist, hard		3	SS	43		137					16 22 46 16
136.3						W. L. 136.5 m Jan 03, 2019 Jan 07, 2019						
2.3	**SHALE BEDROCK:** Highly weathered shale		4	SS	50/ 50mm		136					
							Slotted Pipe					
			5	SS	50/ 100mm		135					
			6	SS	50/ 25mm							
134.0							134					
4.6	**END OF BOREHOLE**											

Notes:
1) Water level at 2.1 mbgl upon completion of drilling
2) 50mm dia. monitoring well installed upon completion.
3) Water Level Readings

Date	Water Depth (mbgs)
Jan. 3, 2019	2.06
Jan. 7, 2019	2.14

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES: +3, ×3: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

DS SOIL LOG 18-687-100 - MILLCROFT GOLF COURSE, BURLINGTON.GPJ DS.GDT 19-1-21

LOG OF BOREHOLE BH18-8

PROJECT: Geotechnical, Environmental, Hydrogeological Investigation
CLIENT: Argo Development Corp
PROJECT LOCATION: 2155 Country Club Drive, Burlington
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4804883.544 E 597281.841

DRILLING DATA
Method: Solid Stem Auger
Diameter: 150 mm
Date: Dec-20-2018

REF. NO.: 18-687-100
ENCL NO.: 9

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS / 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION
140.4 / 0.0	**TOPSOIL:**						
0.1	**FILL:** clayey silt, trace rootlet/ topsoil, trace organics, moist, dark brown to brown, loose		1	SS	8		140
			2	SS	8		139
138.6							
1.8	**SANDY SILT TILL :** trace clay, trace gravel/cobble, reddish brown, moist, compact		3	SS	16		
			4	SS	23		138
137.3							
3.1	**CLAYEY SILT TILL:** sandy, trace gravel/ cobble, trace shale fragments, reddish brown, moist, hard		5	SS	66/ 230mm		137
							136
135.7			6	SS	50/ 100mm		
4.7	**END OF BOREHOLE** Notes: 1) Auger refusal at 4.6 m 2) Borehole dry upon completion						

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH (kPa)
○ UNCONFINED + FIELD VANE & Sensitivity
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

METHANE AND GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

DS SOIL LOG 18-687-100 - MILLCROFT GOLF COURSE, BURLINGTON.GPJ DS.GDT 19-1-21

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
+3, ×3: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

LOG OF BOREHOLE BH18-9

PROJECT: Geotechnical, Environmental, Hydrogeological Investigation
CLIENT: Argo Development Corp
PROJECT LOCATION: 2155 Country Club Drive, Burlington
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4804908.419 E 597188.154

DRILLING DATA
Method: Solid Stem Auger
Diameter: 150 mm
Date: Dec-20-2018

REF. NO.: 18-687-100
ENCL NO.: 10

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS / 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
140.8												
140.7	**TOPSOIL:** 130 mm											
0.1 / 140.0	**FILL:** clayey silt, trace rootlet/ topsoil, moist, dark brown to brown, loose		1	SS	7							
0.8 / 139.3	**CLAYEY SILT TILL:** some sand, trace gravel/cobble, greyish brown, moist, hard		2	SS	30		140 Bentonite					
1.5	**SANDY SILT TILL :** trace to some clay, some gravel/cobble, reddish brown, moist, dense to very dense		3	SS	47		W. L. 139.1 m Jan 03, 2019 W. L. 138.8 m Jan 07, 2019					
			4	SS	81		138 Slotted Pipe					15 28 47 10
137.0			5	SS	95/ 250mm							
3.8 / 136.7	**CLAYEY SILT TILL/SHALE COMPLEX:** reddish brown, trace shale fragments, moist, hard		6	SS	99/ 180mm		137					
4.1	**END OF BOREHOLE**											

Notes:
1) Auger refusal at 3.9 m
2) 50mm dia. monitoring well installed upon completion.
3) Water Level Readings

Date	Water Depth (mbgs)
Jan. 3, 2019	1.74
Jan. 7, 2019	1.95

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES: +3, ×3: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

DS SOIL LOG 18-687-100 - MILLCROFT GOLF COURSE, BURLINGTON.GPJ DS.GDT 19-1-21

DS CONSULTANTS LTD.
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LOG OF BOREHOLE BH19-01

PROJECT: Preliminary Geotechnical Investigation
CLIENT: Millcroft Greens Corporation
PROJECT LOCATION: 4252 Dundas Street, Burlington, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4805736.2 E 595924.1

DRILLING DATA
Method: Solid Stem Auger
Diameter: 150mm
Date: Nov/29/2019

REF. NO.: 19-199-102
ENCL NO.: 2

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION
152.9							
152.8	**TOPSOIL:** 125mm						
0.1	**FILL:** sand and gravel, some asphalt, black, moist, compact		1	SS	15		
152.1							
0.8	**FILL:** silty clay, trace gravel, trace to some topsoil, greyish brown to reddish brown, moist, stiff to very stiff		2	SS	10		152
151.1			3	SS	17		
1.8	**CLAYEY SILT TILL:** sandy, trace gravel, occasional cobble, greyish brown, moist, very stiff						151
150.6						Bentonite	
2.3	**SANDY SILT TILL:** trace clay, trace gravel, occasional cobble/boulder, brown, moist, very dense		4	SS	60	W. L. 150.3 m Dec 04, 2019	
			5	SS	50/ 100mm		149
			6	SS	50/ 75mm	Filter Pack Slotted Pipe	148
	reddish brown below 6.1m		7	SS	50/ 75mm		147
							146
145.2	Auger refusal at 7.7m on a possible boulder		8	SS	50/ 25mm		
7.7	**END OF BOREHOLE:** Notes: 1) 50mm dia. monitoring well installed upon completion. 2) Water level Reading: Date: Dec 04, 2019 Water Level (mbgl): 2.6						

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH (kPa)
○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30

POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
225		
		2 35 58 5

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES: +3, ×3: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

DS SOIL LOG 19-199-102_A-BOREHOLE LOGS.GPJ DS.GDT 7/7/20

DS CONSULTANTS LTD.
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LOG OF BOREHOLE BH19-02

PROJECT: Preliminary Geotechnical Investigation
CLIENT: Millcroft Greens Corporation
PROJECT LOCATION: 4252 Dundas Street, Burlington, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4805761 E 595873.5

DRILLING DATA
Method: Solid Stem Auger
Diameter: 150mm
Date: Nov/28/2019

REF. NO.: 19-199-102
ENCL NO.: 3

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS "N" 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
153.7												
153.6	**TOPSOIL:** 100mm											
0.1	**FILL:** clayey silt, trace gravel, trace to some topsoil, greyish brown, moist, firm		1	SS	7							
1	trace organics below 1.0m		2	SS	7		W. L. 153.1 m Dec 04, 2019					
152.2												
1.5	**CLAYEY SILT TILL:** sandy, trace gravel, greyish brown, moist, very stiff		3	SS	17		152			200		
2							Bentonite					
151.4												
2.3	**SANDY SILT TILL:** trace clay, trace gravel, occasional cobble/boulder, brown, wet, very dense		4	SS	71		151			225		6 22 68 4
3			5	SS	50/ 100mm					225		
							150					
4												
			6	SS	50/ 50mm		149					
5												
							148					
6			7	SS	50/ 100mm		Slotted Pipe Filter Pack					
							147					
7												
146.1												
7.6	**SILTY CLAY:** trace shale fragments, reddish brown, moist, hard		7	SS	50/ 125mm		146					
145.7												
8.0	**END OF BOREHOLE:**											

Notes:
1) 50mm dia. monitoring well installed upon completion.
2) Water level Reading:

Date:	Water Level (mbgl):
Dec 04, 2019	0.6

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES: +3, ×3: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

DS SOIL LOG 19-199-102_A-BOREHOLE LOGS.GPJ DS.GDT 7/7/20

DS CONSULTANTS LTD.
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LOG OF BOREHOLE BH19-03

PROJECT: Preliminary Geotechnical Investigation
CLIENT: Millcroft Greens Corporation
PROJECT LOCATION: 4252 Dundas Street, Burlington, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4805834.5 E 595934.8

DRILLING DATA
Method: Solid Stem Auger
Diameter: 150mm
Date: Nov/29/2019

REF. NO.: 19-199-102
ENCL NO.: 4

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS / 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
154.7												
0.0	**FILL:** clayey silt, trace gravel, trace rootlets, brown, moist, firm		1	SS	7							
153.9							154					
0.8	**CLAYEY SILT TO SILTY CLAY TILL:** sandy, trace gravel, occasional cobble/ boulder, brown, moist, very stiff to hard		2	SS	24		W. L. 154.0 m Dec 10, 2019			225		
			3	SS	28		153					4 22 52 22
							Bentonite					
	greyish brown below 2.3m		4	SS	23		152					
			5	SS	32		151					
150.1												
4.6	**SANDY SILT TILL:** trace clay, trace gravel, cobble/boulder, greyish brown, moist, very dense		6	SS	50/ 50mm		150					
							Filter Pack					
							Slotted Pipe					
							149					
	Auger refusal at 6.1m on a possible boulder											
148.6												
6.1	**END OF BOREHOLE:**		7	NR	50/ no penetration							

Notes:
1) 50mm dia. monitoring well installed upon completion.
2) Water level Reading:

Date:	Water Level (mbgl):
Dec 10, 2019	0.7

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES: +3, ×3: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

DS SOIL LOG 19-199-102_A-BOREHOLE LOGS.GPJ DS.GDT 7/7/20

DS CONSULTANTS LTD.
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LOG OF BOREHOLE BH19-100

PROJECT: Preliminary Geotechnical Investigation - Area 'C'
CLIENT: Millcroft Greens Corporation
PROJECT LOCATION: Millcroft Golf Club, Burlington, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4804785.16 E 596345.5

DRILLING DATA
Method: Solid Stem Auger
Diameter: 150mm
Date: Nov/26/2019

REF. NO.: 19-199-101
ENCL NO.: 2

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION
143.9						
0.0 / 143.7	**TOPSOIL:** 150mm					
0.2	**FILL:** clayey silt, trace gravel, brown, moist, very stiff	1	SS	18		
1 / 142.8		2	SS	19		143
1.1	**CLAYEY SILT TILL:** some sand, trace gravel, brown, moist, very stiff to hard reddish brown below 1.5m	3	SS	32		142
2	trace shale fragments below 2.3m	4	SS	59	Bentonite	141
3	sandy below 3.1m	5	SS	79/ 230	W. L. 140.7 m Dec 04, 2019	140
139.3						
4.6	**SHALE:** weathered, reddish brown	6	SS	50/ 50mm	Filter Pack Slotted Pipe	139
5						138
6 / 137.7		7	SS	50/ 50mm		
6.2	**END OF BOREHOLE:**					

Notes:
1) 50mm dia. monitoring well installed upon completion.
2) Water level Reading:

Date:	Water Level (mbgl):
Dec 04, 2019	3.2

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH (kPa)
○ UNCONFINED + FIELD VANE & Sensitivity
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

METHANE AND GRAIN SIZE DISTRIBUTION (%)

GR	SA	SI	CL
6	17	59	18

DS SOIL LOG 19-199-101_C.GPJ DS.GDT 7/7/20

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
+ 3, × 3: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

DS CONSULTANTS LTD.
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LOG OF BOREHOLE BH19-101

PROJECT: Preliminary Geotechnical Investigation - Area 'C'
CLIENT: Millcroft Greens Corporation
PROJECT LOCATION: Millcroft Golf Club, Burlington, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4804895.06 E 596313.79

DRILLING DATA
Method: Solid Stem Auger
Diameter: 150mm
Date: Nov/26/2019

REF. NO.: 19-199-101
ENCL NO.: 3

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS 0.3 m "N"	ELEVATION
144.9					
0.0 / 144.7	**TOPSOIL:** 180mm				
0.2 / 143.9	**FILL:** clayey silt, trace rootlets/ topsoil, brown, moist, stiff	1	SS	8	
1.0 / 142.6	**CLAYEY SILT TILL:** some sand, trace gravel, greyish brown, moist, hard	2	SS	31	144
		3	SS	30	143
2.3 / 141.7	**TILL/ SHALE COMPLEX:** trace cobble, brown, moist, hard	4	SS	49	142
		5	SS	50/ 50	
3.3 / 141.1	**SHALE:** weathered, reddish brown				141
		6	SS	50/ 50mm	140
6.2 / 138.7	**END OF BOREHOLE:**	7	SS	50/ 50mm	139

Notes:
1) 50mm dia. monitoring well installed upon completion.
2) Water level Reading:

Date:	Water Level (mbgl):
Dec 04, 2019	4.5

Bentonite
W. L. 140.4 m Dec 04, 2019
Filter Pack
Slotted Pipe

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH (kPa)
○ UNCONFINED + FIELD VANE & Sensitivity
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30

POCKET PEN. (Cu) (kPa)
NATURAL UNIT WT (kN/m³)
METHANE AND GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
+3, ×3: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

DS SOIL LOG 19-199-101_C.GPJ DS.GDT 7/7/20

DS CONSULTANTS LTD.
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LOG OF BOREHOLE BH19-102

PROJECT: Preliminary Geotechnical Investigation - Area 'C'
CLIENT: Millcroft Greens Corporation
PROJECT LOCATION: Millcroft Golf Club, Burlington, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4804795.87 E 596253.44

DRILLING DATA
Method: Solid Stem Auger
Diameter: 150mm
Date: Nov/27/2019

REF. NO.: 19-199-101
ENCL NO.: 4

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
145.8												
0.0 / 145.0	**FILL:** clayey silt, trace rootlets/ topsoil, brown, wet, firm		1	SS	6		145			50		
0.8 / 143.2	**FILL:** silty clay, trace gravel, brown, very moist, firm to stiff		2	SS	6	▽				50		
			3	SS	9		144			50		
			4	SS	18		143			225		
2.6	**CLAYEY SILT TILL:** some sand, trace gravel, trace shale fragments, brown, moist, very stiff to hard		5	SS	46		142			225		
	sandy below 4.6m		6	SS	50/ 50mm		141					27 24 36 13
139.7							140					
139.6	**SHALE:** weathered, reddish brown		7	SS	50/ 25mm							
6.2	**END OF BOREHOLE:**											

Notes:
1) 50mm dia. monitoring well installed upon completion.
2) Water level Reading:

Date:	Water Level (mbgl):
Dec 04, 2019	1.4

W. L. 144.3 m Dec 04, 2019
Bentonite
Filter Pack
Slotted Pipe

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES: +3, ×3: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

DS SOIL LOG 19-199-101_C.GPJ DS.GDT 7/7/20

DS CONSULTANTS LTD.
Geotechnical ◆ Environmental ◆ Materials ◆ Hydrogeology

LOG OF BOREHOLE BH19-200

PROJECT: Preliminary Geotechnical Investigation - Area 'D'
CLIENT: Millcroft Greens Corporation
PROJECT LOCATION: Millcroft Golf Club, Burlington, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4805673.28 E 596926.73

DRILLING DATA
Method: Solid Stem Auger
Diameter: 150mm
Date: Nov/27/2019

REF. NO.: 19-199-100
ENCL NO.: 2

ELEV / DEPTH (m)	DESCRIPTION	NUMBER	TYPE	BLOWS "N" 0.3 m	ELEVATION
146.3					
146.2 / 0.1	**TOPSOIL:** 75mm **FILL:** clayey silt, trace topsoil/ rootlets, brown, moist, firm	1	SS	4	146
145.2 / 1.1	**CLAYEY SILT TILL:** some sand to sandy, trace gravel, occasional cobble/ boulder, brown, moist, very stiff to hard	2	SS	15	
		3	SS	30	
		4	SS	69	144
142.9 / 3.4	**TILL/ SHALE COMPLEX:** brown, moist, hard	5	SS	80/ 255mm	143
141.7 / 4.6	**SHALE:** highly weathered, reddish brown	6	SS	50/ 100mm	142
140.1 / 6.2	**END OF BOREHOLE:**	7	SS	50/ 50mm	

Notes:
1) 50mm dia. monitoring well installed upon completion.
2) Water level readings:

Date:	W.L. Depth (mbgl):
Dec 04, 2019	1.1

W. L. 145.1 m Dec 04, 2019
Bentonite
Filter Pack
Slotted Pipe

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)
SHEAR STRENGTH (kPa)
○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE
(20 40 60 80 100)

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%) (10 20 30)

POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
158		
225		
		12 19 51 18

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES: +3, ×3: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

DS SOIL LOG 19-199-100_J.GPJ DS.GDT 7/7/20

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LOG OF BOREHOLE BH19-201

PROJECT: Preliminary Geotechnical Investigation - Area 'D'
CLIENT: Millcroft Greens Corporation
PROJECT LOCATION: Millcroft Golf Club, Burlington, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4805714.39 E 596960.66

DRILLING DATA
Method: Solid Stem Auger
Diameter: 150mm
Date: Nov/27/2019

REF. NO.: 19-199-100
ENCL NO.: 3

ELEV / DEPTH (m)	DESCRIPTION	NUMBER	TYPE	BLOWS "N" 0.3 m	ELEVATION
146.4 / 0.0	**TOPSOIL:** 150mm				
0.2 / 145.6	**FILL:** clayey silt, some topsoil, grey to brown, moist, stiff	1	SS	8	146
0.8 / 144.1	**CLAYEY SILT TILL:** some sand, trace gravel, greyish brown, moist, very stiff	2	SS	20	145
		3	SS	23	
2.3 / 143.3	**SANDY SILT TILL:** some clay, trace gravel, trace cobble, reddish brown, moist, very dense	4	SS	80/ 280mm	144
3.1 / 142.7	**TILL/ SHALE COMPLEX:** reddish brown, moist, hard	5	SS	50/ 100mm	143
3.7 / 140.2	**SHALE:** highly weathered, reddish brown	6	SS	50/ 50mm	142
		7	SS	50/ 50mm	
6.2	**END OF BOREHOLE:**				

Notes:
1) 50mm dia. monitoring well installed upon completion.
2) Water level readings:

Date:	W.L. Depth (mbgl):
Dec 04, 2019	0.5

GROUND WATER CONDITIONS: W. L. 145.8 m Dec 04, 2019; Bentonite; Filter Pack; Slotted Pipe

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)
SHEAR STRENGTH (kPa) (20 40 60 80 100)
○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%) (10 20 30)

POCKET PEN. (Cu) (kPa): 210 (1); 225 (2)
NATURAL UNIT WT (kN/m³)

METHANE AND GRAIN SIZE DISTRIBUTION (%)

	GR	SA	SI	CL
3	7	22	60	11

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES: +3, ×3: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

DS SOIL LOG 19-199-100_J.GPJ DS.GDT 7/7/20

DS CONSULTANTS LTD.
Geotechnical ◆ Environmental ◆ Materials ◆ Hydrogeology

LOG OF BOREHOLE BH19-202

PROJECT: Preliminary Geotechnical Investigation - Area 'D'
CLIENT: Millcroft Greens Corporation
PROJECT LOCATION: Millcroft Golf Club, Burlington, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4805761.36 E 596976.46

DRILLING DATA
Method: Solid Stem Auger
Diameter: 150mm
Date: Nov/28/2019

REF. NO.: 19-199-100
ENCL NO.: 4

ELEV / DEPTH (m)	DESCRIPTION	NUMBER	TYPE	BLOWS "N" 0.3 m	ELEVATION
147.4					
147.0 / 0.4	**TOPSOIL:** 50mm				
	FILL: clayey silt, some topsoil, trace gravel, grey to brown, moist, firm to very stiff	1	SS	7	147
146.3 / 1.1		2	SS	25	
	CLAYEY SILT TILL: sandy, trace gravel, occasional cobble/ boulder, greyish brown, moist, very stiff to hard	3	SS	46	146
		4	SS	75	145
144.3 / 3.1	**SANDY SILT TILL:** some clay, trace gravel, greyish brown, moist, very dense	5	SS	50/ 125mm	144
142.8 / 4.6	**SHALE:** highly weathered, reddish brown	6	SS	50/ 75mm	143
141.2 / 6.2	**END OF BOREHOLE:**	7	SS	50/ 50mm	

Notes:
1) 50mm dia. monitoring well installed upon completion.
2) Water level readings:

Date:	W.L. Depth (mbgl):
Dec 04, 2019	4.5

Bentonite
W. L. 142.9 m Dec 04, 2019
Filter Pack
Slotted Pipe

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH (kPa)
○ UNCONFINED + FIELD VANE & Sensitivity
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30

POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)
75	
225	

METHANE AND GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
+3, ×3: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

DS SOIL LOG 19-199-100_J.GPJ DS.GDT 7/7/20

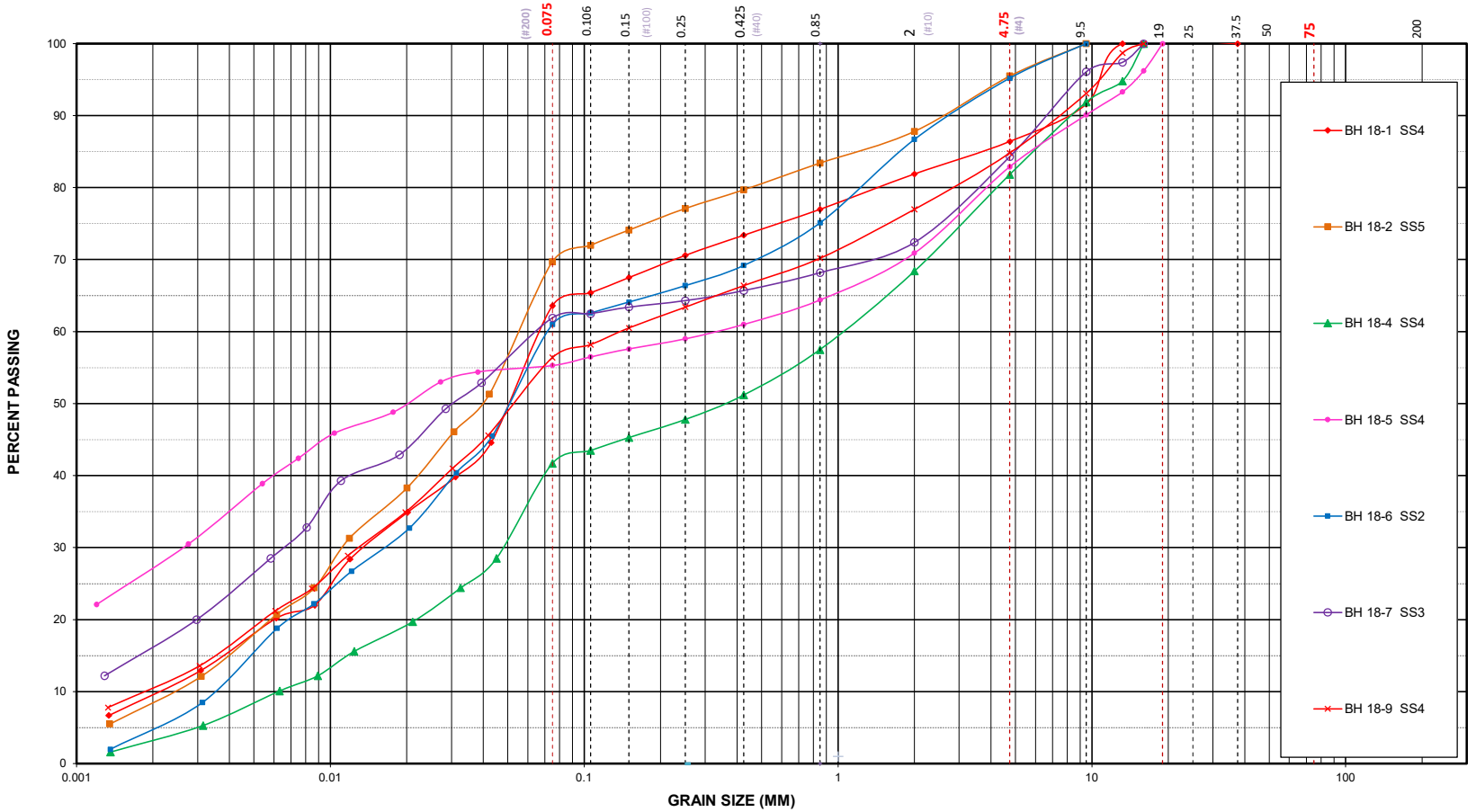
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Appendix C

Grainsize Analysis

Particle Size Distribution (ASTM-D421/D422)



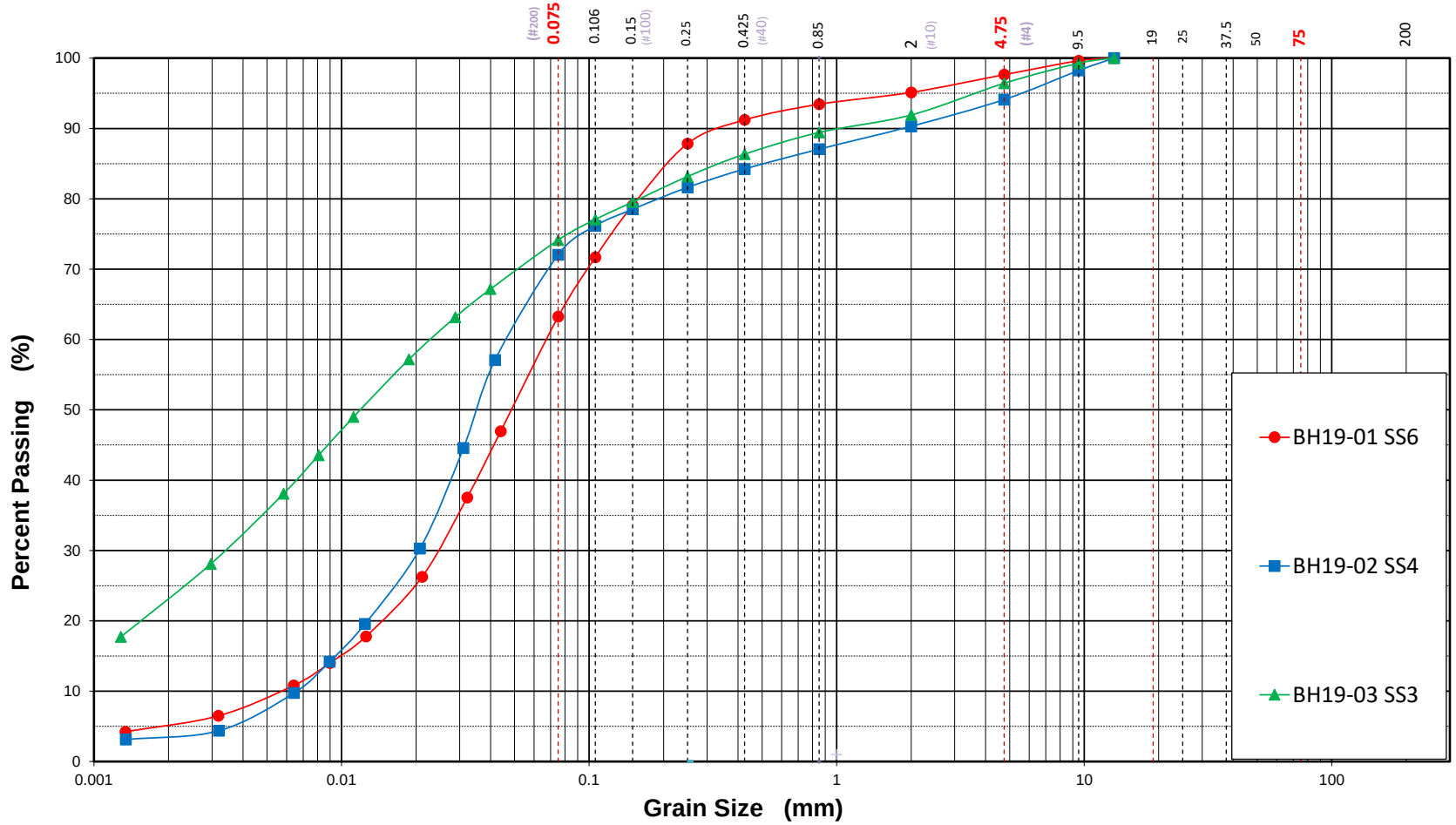
Silt and Clay		Sand			Gravel		Cobble +
Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	

Specification and Comments:

DS Consultants Ltd
Geotechnical • Enviromental • Materials • Hydrogeology

Project:	**100 Millcroft Golf Course**	Project No.:	**18-687-10**
Client:	**Millcroft Greens Corporation**	Date:	**January 21, 2019**
Location:	**Burlington, ON**	Figure No.:	2

Particle Size Distribution (ASTM-D421/D422)

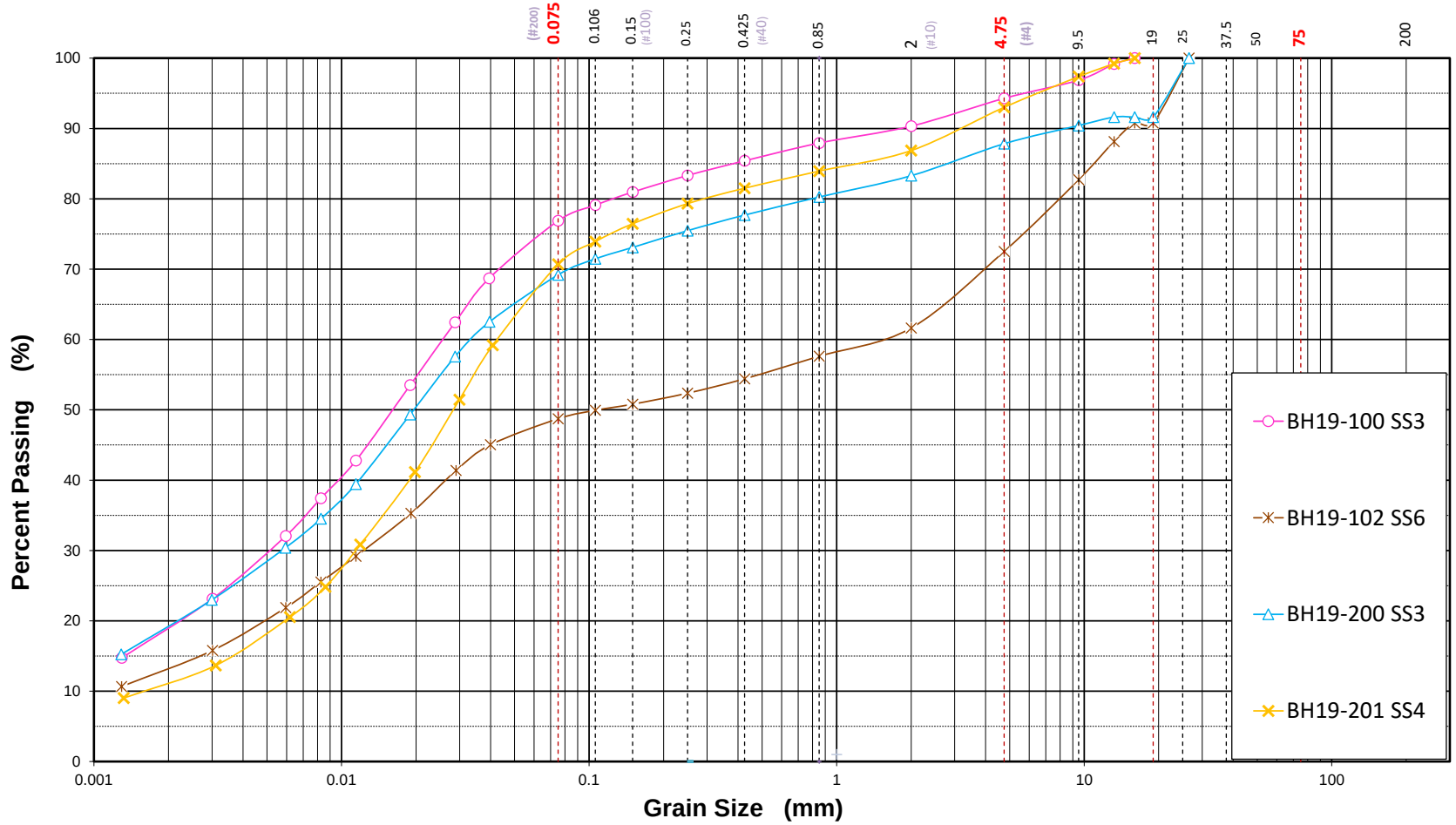


Silt and Clay		Sand			Gravel		Cobble +
Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	

DS CONSULTANTS LTD.
6221 Highway 7, Unit 16
Vaughan, Ontario, L4H 0K8
Telephone: (905) 264-9393
www.dsconsultants.ca

Project	**Preliminary Geotechnical Investigation**	Project No	**19-199-102**
Location	**4252 Dundas Street, Burlington, ON**	Date	**Dec-09-2019**
Client	**Millcroft Greens Corporation**	Figure No	6

Particle Size Distribution (ASTM-D421/D422)



Silt and Clay		Sand			Gravel		Cobble +
Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	

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Vaughan, Ontario, L4H 0K8
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www.dsconsultants.ca

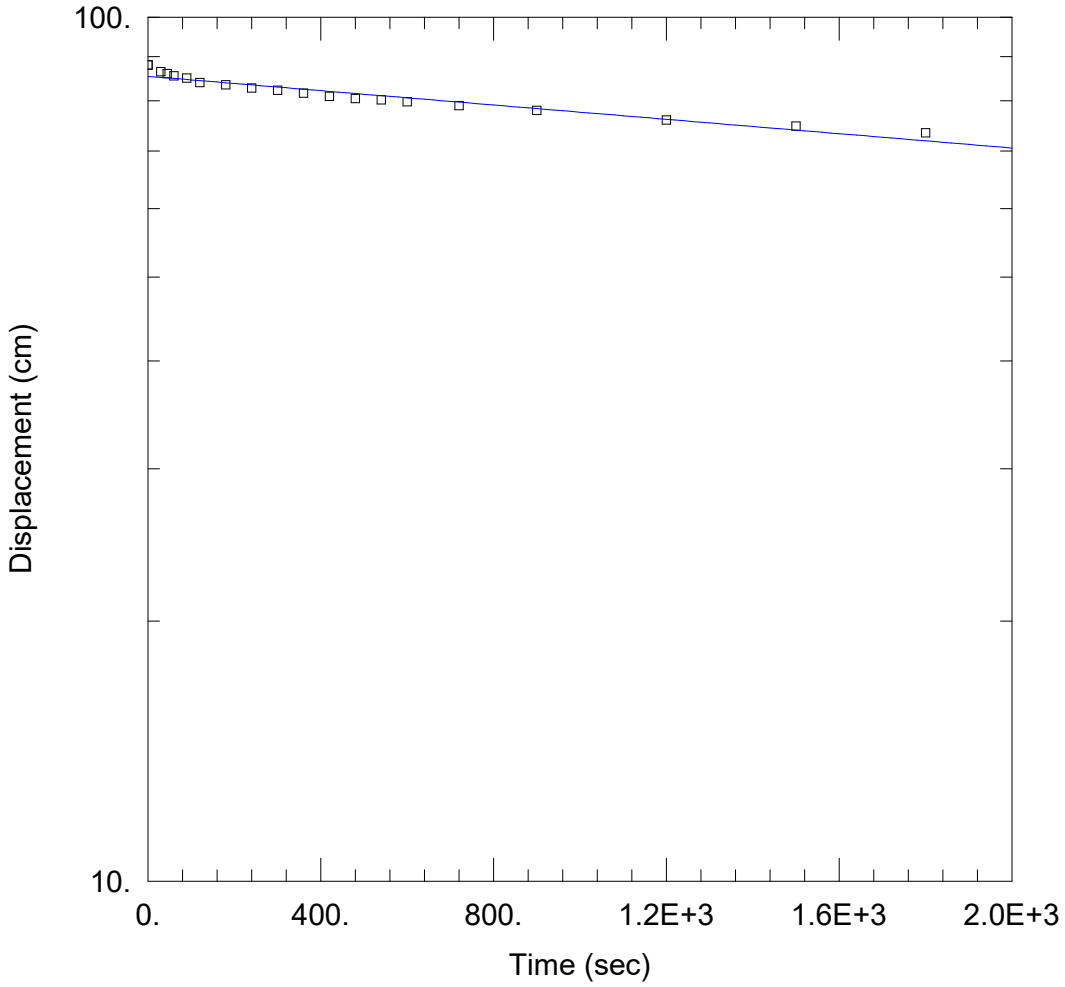
Project	**Milcroft Golf Course, Blocks 'C' & 'D'**	Project No	**19-199-100**
Location	**Burlington, ON**	Date	**Dec-09-2019**
Client	**MILLCROFT GREENS CORPORATION**	Figure No	3

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Appendix D

Hydraulic Conductivity Tests



HYDRAULIC CONDUCTIVITY TEST AT MW18-1 (CLAYEY SILT TILL/SHALE COMPLEX)

PROJECT INFORMATION

Company: R.J. Burnside & Associates
Client: Millcroft Greens Corporation
Project: 300043939
Location: Millcroft Golf
Test Well: MW18-1
Test Date: Jan. 22, 2018

AQUIFER DATA

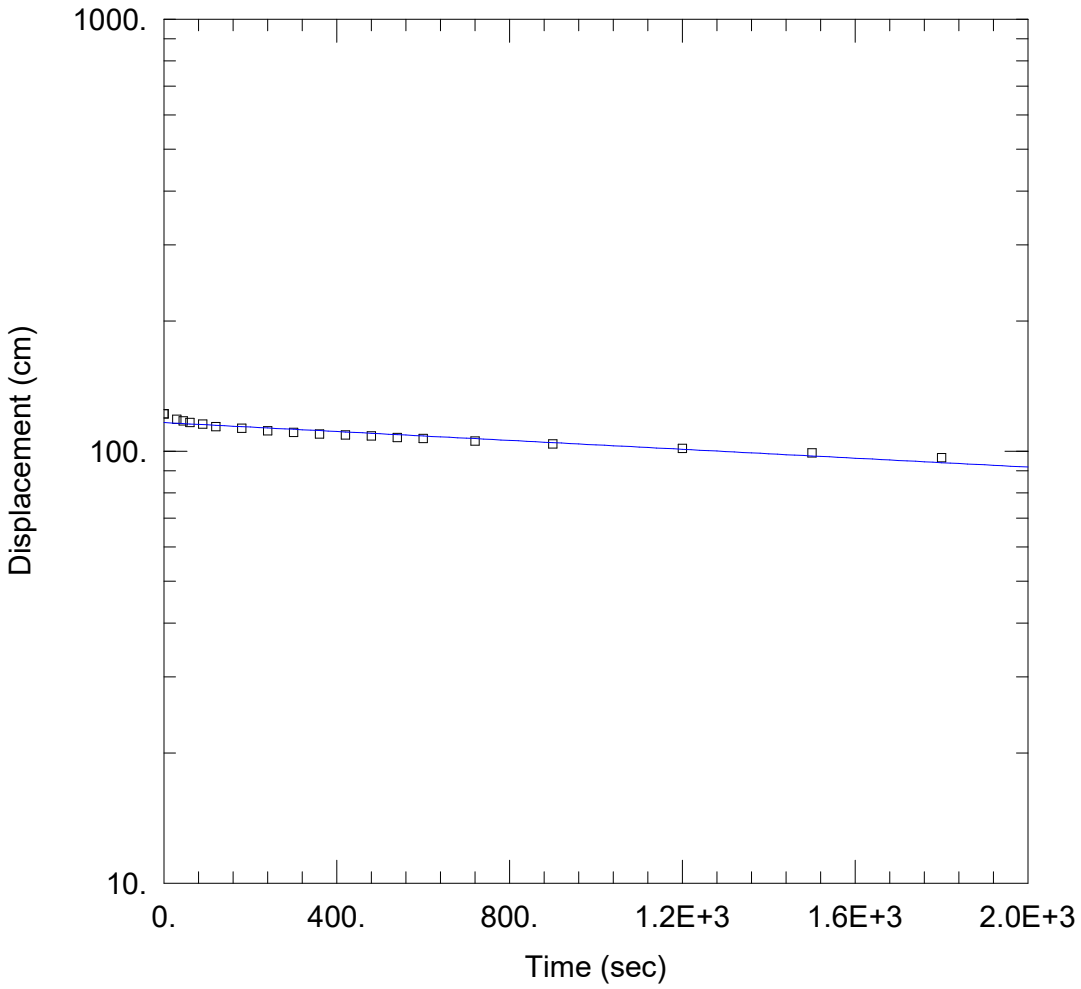
Saturated Thickness: 137. cm
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW18-1)

Initial Displacement: 88. cm
Total Well Penetration Depth: 305. cm
Casing Radius: 2.54 cm
Static Water Column Height: 137. cm
Screen Length: 305. cm
Well Radius: 7.62 cm

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 5.812E-6 cm/sec
y0 = 85.4 cm



HYDRAULIC CONDUCTIVITY TEST AT MW18-4 (SANDY SILT TILL)

PROJECT INFORMATION

Company: R.J. Burnside & Associates
Client: Millcroft Greens Corporation
Project: 300043939
Location: Millcroft Golf
Test Well: MW18-4
Test Date: Jan. 22, 2018

AQUIFER DATA

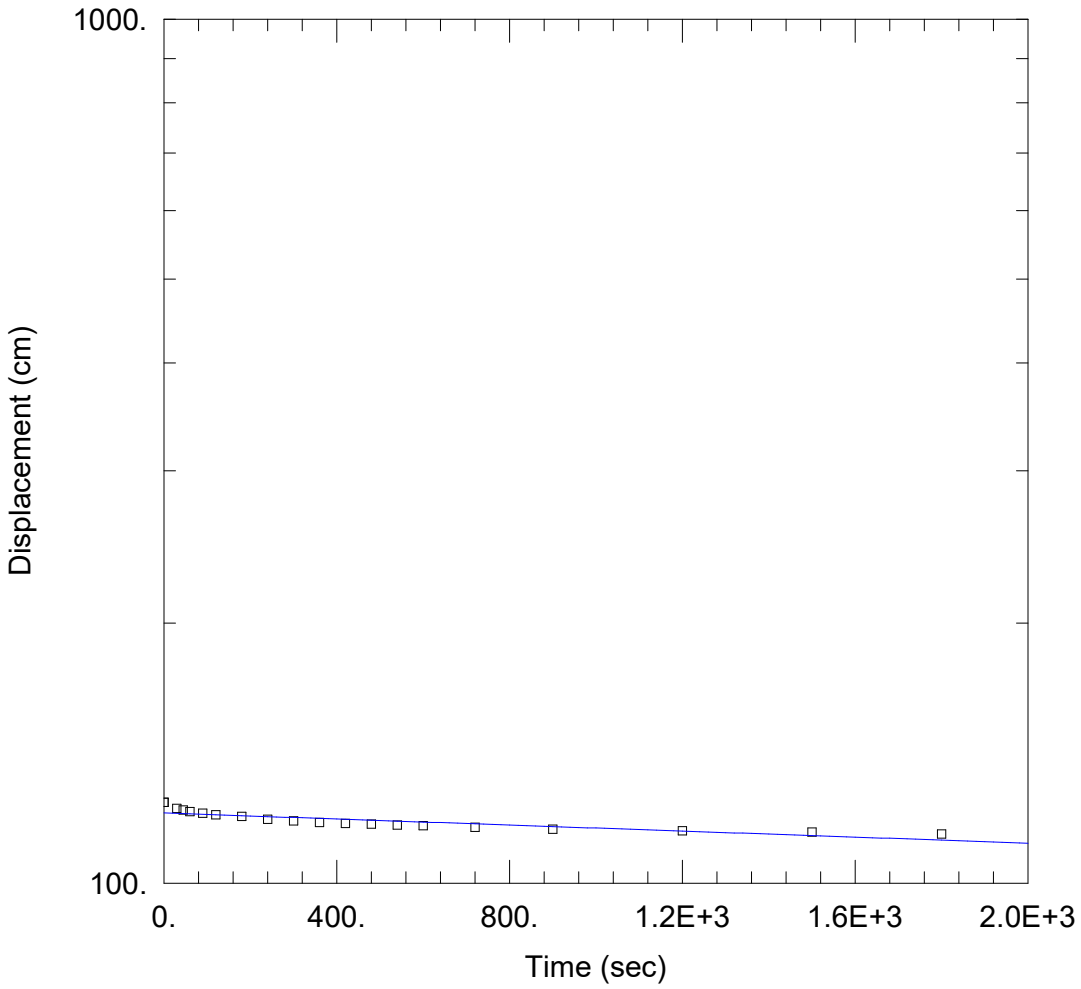
Saturated Thickness: 168. cm
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW18-4)

Initial Displacement: 122. cm
Total Well Penetration Depth: 168. cm
Casing Radius: 2.54 cm
Static Water Column Height: 168. cm
Screen Length: 152. cm
Well Radius: 7.62 cm

SOLUTION

Aquifer Model: Unconfined
K = 5.732E-6 cm/sec
Solution Method: Bouwer-Rice
y0 = 116.4 cm



HYDRAULIC CONDUCTIVITY TEST AT MW18-5 (CLAYEY SILT TILL)

PROJECT INFORMATION

Company: R.J. Burnside & Associates
Client: Millcroft Greens Corporation
Project: 300043939
Location: Millcroft Golf
Test Well: MW18-5
Test Date: Jan. 22, 2018

AQUIFER DATA

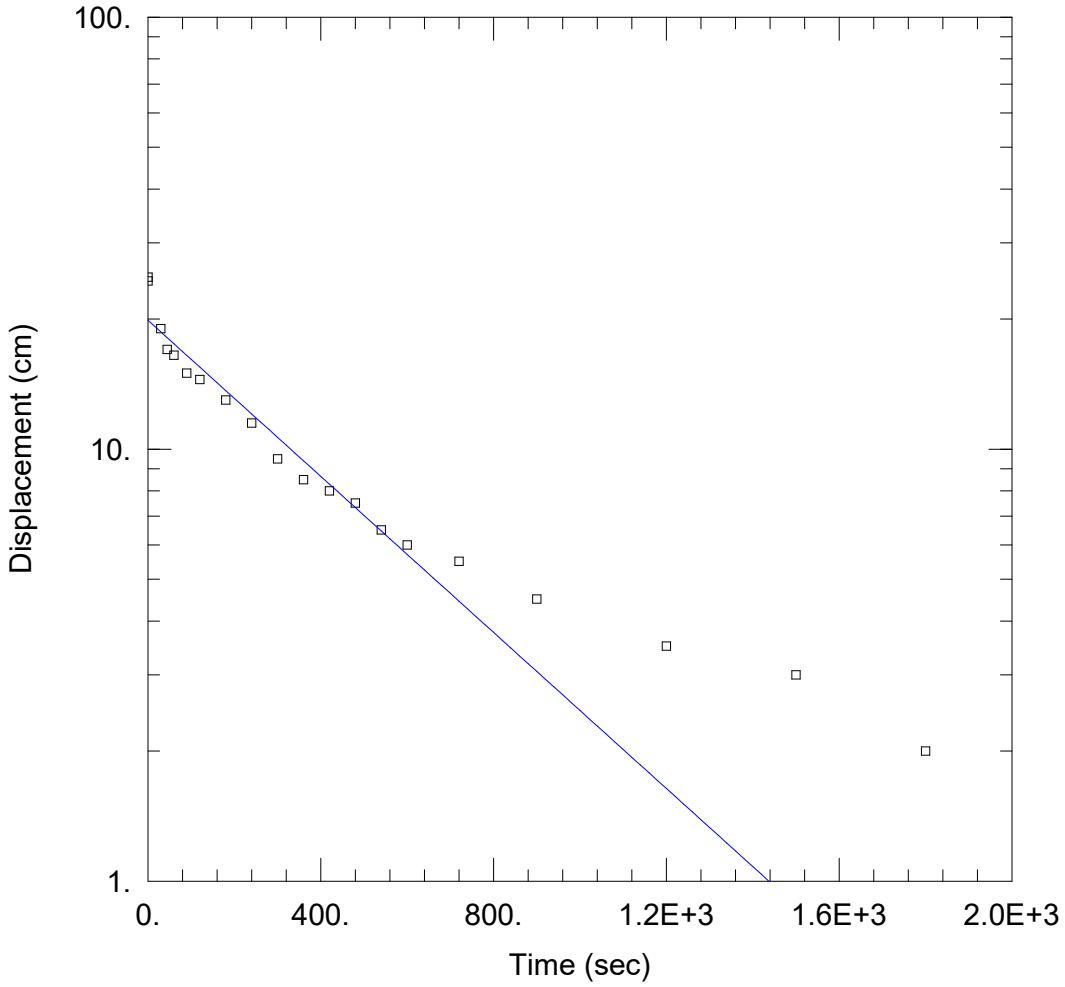
Saturated Thickness: 151. cm
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW18-5)

Initial Displacement: 124. cm
Total Well Penetration Depth: 305. cm
Casing Radius: 2.54 cm
Static Water Column Height: 151. cm
Screen Length: 305. cm
Well Radius: 7.62 cm

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 2.25E-6 cm/sec
y0 = 120.6 cm



HYDRAULIC CONDUCTIVTY TEST AT MW18-7 (SHALE/CLAYEY SILT TILL)

PROJECT INFORMATION

Company: R.J. Burnside & Associates
Client: Millcroft Greens Corporation
Project: 300043939
Location: Millcroft Golf
Test Well: MW18-7
Test Date: Jan. 22, 2018

AQUIFER DATA

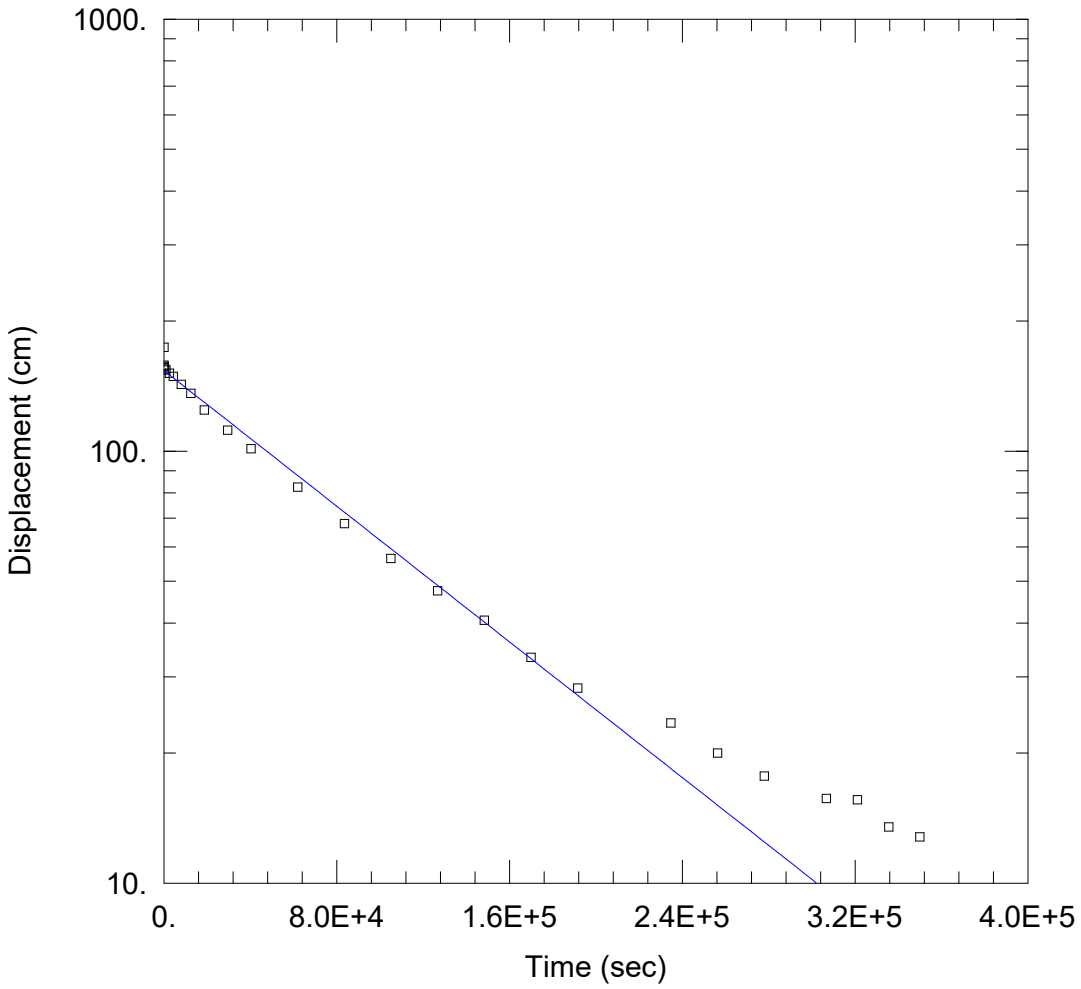
Saturated Thickness: 235.5 cm
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW18-7)

Initial Displacement: 25. cm
Total Well Penetration Depth: 305. cm
Casing Radius: 2.54 cm
Static Water Column Height: 235.5 cm
Screen Length: 305. cm
Well Radius: 7.62 cm

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 7.852E-5 cm/sec
y0 = 19.87 cm



HYDRAULIC CONDUCTIVITY TEST AT MW19-01 (SANDY SILT TO SILTY SAND)

PROJECT INFORMATION

Company: R.J. Burnside & Associates
Client: Millcroft Greens Corporation
Project: 300043939
Location: Millcroft Golf
Test Well: MW19-01
Test Date: June 8, 2020

AQUIFER DATA

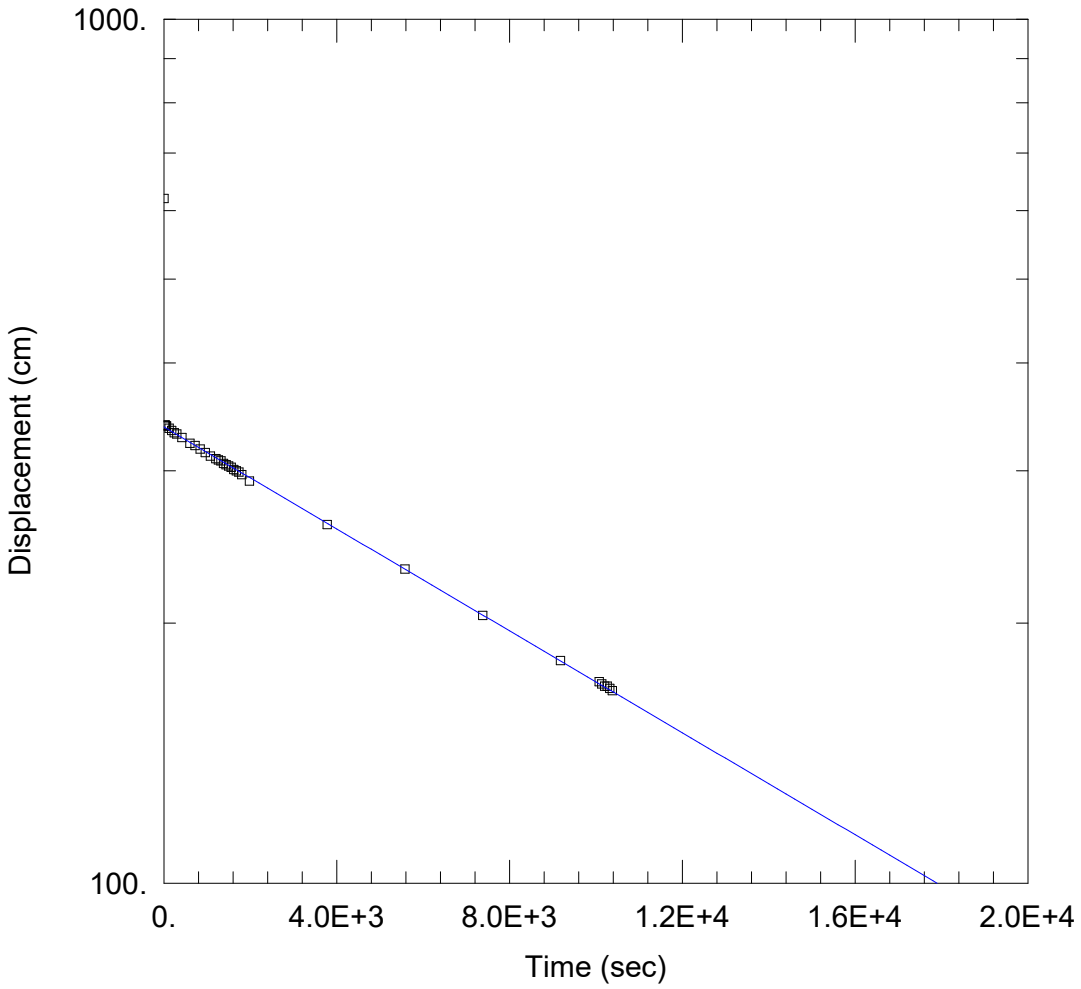
Saturated Thickness: 309. cm
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH19-01)

Initial Displacement: 174. cm
Total Well Penetration Depth: 152. cm
Casing Radius: 2.54 cm
Static Water Column Height: 309. cm
Screen Length: 152. cm
Well Radius: 7.62 cm

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 3.645E-7 cm/sec
y0 = 153.6 cm



HYDRAULIC CONDUCTIVITY TEST AT MW19-03 (SANDY SILT TILL)

PROJECT INFORMATION

Company: R.J. Burnside & Associates
Client: Millcroft Greens Corporation
Project: 300043939
Location: Millcroft Golf
Test Well: MW19-03
Test Date: June 8, 2020

AQUIFER DATA

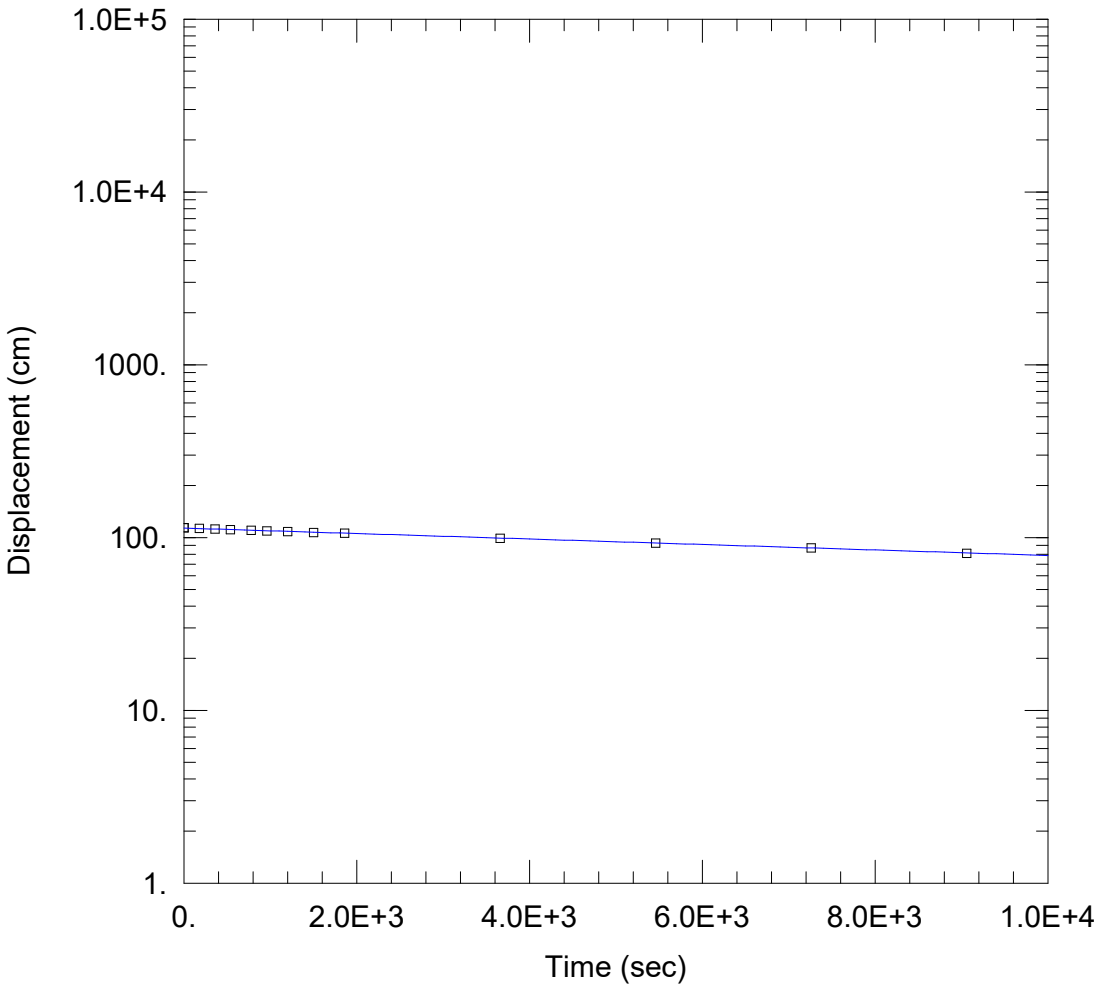
Saturated Thickness: 620. cm
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH19-03)

Initial Displacement: 620. cm
Total Well Penetration Depth: 152. cm
Casing Radius: 2.54 cm
Static Water Column Height: 341. cm
Screen Length: 152. cm
Well Radius: 7.62 cm

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 2.646E-6 cm/sec
y0 = 337.2 cm



HYDRAULIC CONDUCTIVITY TEST AT MW19-102 (SANDY SILT TILL)

PROJECT INFORMATION

Company: R.J. Burnside & Associates
Client: Millcroft Greens Corporation
Project: 300043939
Location: Millcroft Golf
Test Well: MW19-102
Test Date: June 8, 2020

AQUIFER DATA

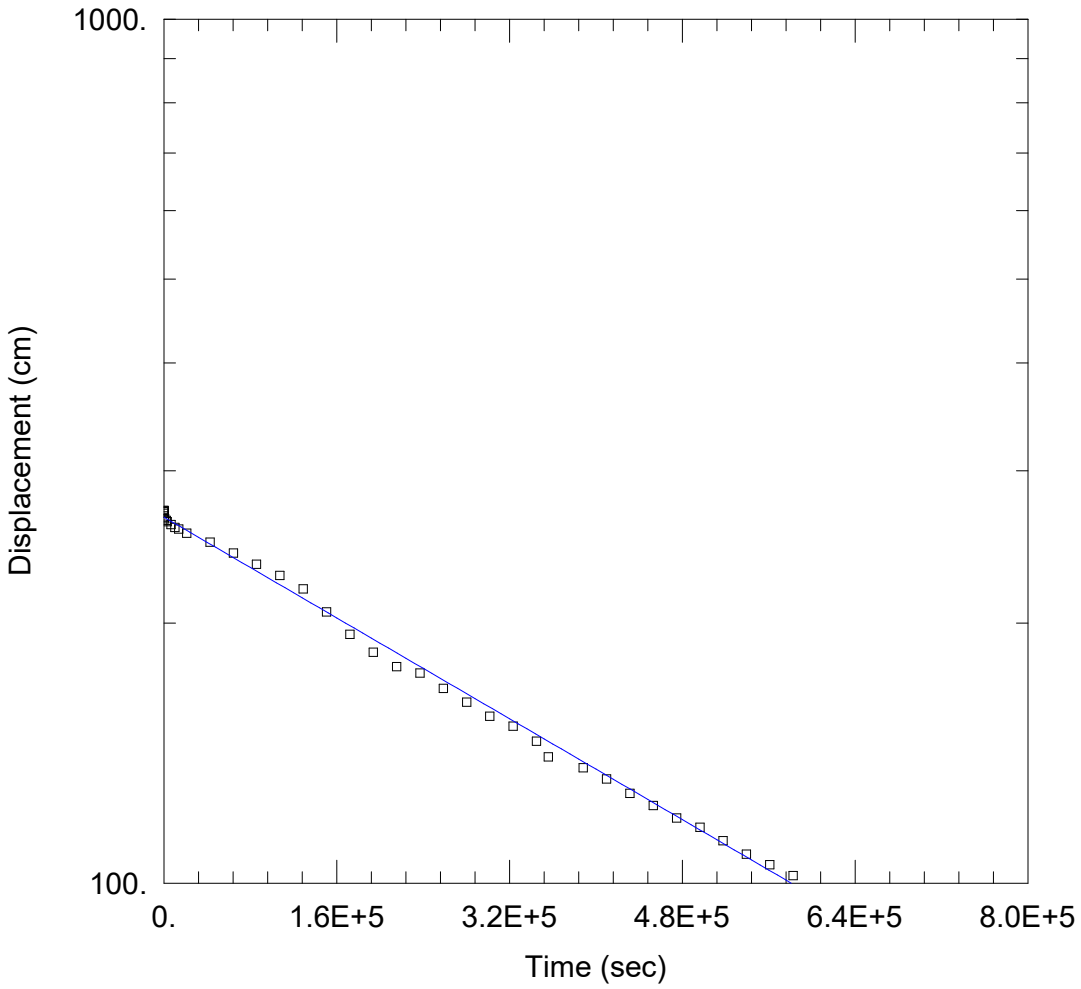
Saturated Thickness: 418. cm
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH19-102)

Initial Displacement: 114. cm
Total Well Penetration Depth: 152. cm
Casing Radius: 2.54 cm
Static Water Column Height: 418. cm
Screen Length: 152. cm
Well Radius: 7.62 cm

SOLUTION

Aquifer Model: Unconfined
K = 1.447E-6 cm/sec
Solution Method: Bouwer-Rice
y0 = 113.4 cm



HYDRAULIC CONDUCTIVITY TEST AT MW19-202 (SHALE)

PROJECT INFORMATION

Company: R.J. Burnside & Associates
Client: Millcroft Greens Corporation
Project: 300043939
Location: Millcroft Golf
Test Well: MW19-202
Test Date: June 8, 2020

AQUIFER DATA

Saturated Thickness: 415. cm
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH19-202)

Initial Displacement: 270. cm
Total Well Penetration Depth: 152. cm
Casing Radius: 2.54 cm
Static Water Column Height: 415. cm
Screen Length: 152. cm
Well Radius: 7.62 cm

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 6.662E-8 cm/sec
y0 = 265.2 cm

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Appendix E

Groundwater Elevation Data

Table E-1
Water Elevations

Location	Total Measured Well Depth (mbgl)	Ground Elevation (masl)	3-Jan-19		7-Jan-19		22-Jan-19		22-Feb-19		18-Mar-19		11-Apr-19	
			Water Level Depth (mbgl)	Elevation (masl)	Water Level Depth (mbgl)	Elevation (masl)	Water Level Depth (mbgl)	Elevation (masl)	Water Level Depth (mbgl)	Elevation (masl)	Water Level Depth (mbgl)	Elevation (masl)	Water Level Depth (mbgl)	Elevation (masl)
MW18-1	6.07	142.78	4.16	138.62	4.27	138.51	4.70	138.08	4.17	138.61	4.17	138.61	4.22	138.56
MW18-2	4.71	142.17	1.04	141.13	1.36	140.81	2.08	140.09	2.22	139.95	2.39	139.78	2.14	140.03
MW18-4	4.40	140.58	1.76	138.82	2.07	138.51	2.72	137.86	1.93	138.65	2.31	138.27	2.03	138.56
MW18-5	4.49	140.16	2.62	137.54	3.44	136.72	2.98	137.18	2.67	137.49	2.35	137.81	1.85	138.31
MW18-6	2.48	138.10	1.49	136.61	1.60	136.50	1.71	136.39	1.47	136.63	1.35	136.75	1.42	136.68
MW18-7	4.69	138.57	2.06	136.51	2.14	136.43	2.34	136.23	2.27	136.30	2.15	136.42	2.14	136.43
MW18-9	3.75	140.80	1.74	139.06	1.95	138.85	2.49	138.31	1.36	139.44	1.58	139.22	1.54	139.26
PZ1s	0.57	**140.00**	-	-	-	-	0.57	139.43	0.43	139.57	0.26	139.74	dry	dry
PZ1d	1.09	**140.00**	-	-	-	-	0.69	139.31	0.53	139.47	0.48	139.52	0.64	139.36
MW19-01	4.41	154.70												
MW19-02	6.27	152.90												
MW19-03	7.28	153.70												
MW19-100	5.88	143.90												
MW19-101	5.81	144.90												
MW19-102	5.88	145.80												
MW19-200	6.13	146.30												
MW19-201	5.98	146.40												
MW19-202	5.91	147.40												

mbgl - metres below ground level

masl - metres above sea level

'-' - denotes unavailable data

Bold ground elevation indicates an estimated value (not surveyed)

Table E-1
Water Elevations

Location	Total Measured Well Depth (mbgl)	Ground Elevation (masl)	17-May-19		20-Jun-19		9-Jul-19		2-Aug-19		6-Sep-19		11-Oct-19	
			Water Level Depth (mbgl)	Elevation (masl)	Water Level Depth (mbgl)	Elevation (masl)	Water Level Depth (mbgl)	Elevation (masl)	Water Level Depth (mbgl)	Elevation (masl)	Water Level Depth (mbgl)	Elevation (masl)	Water Level Depth (mbgl)	Elevation (masl)
MW18-1	6.07	142.78	4.09	138.69	4.06	138.72	4.33	138.45	4.46	138.32	4.68	138.10	4.69	138.09
MW18-2	4.71	142.17	0.69	141.48	0.83	141.34	1.00	141.17	3.36	138.81	dry	dry	dry	dry
MW18-4	4.40	140.58	1.67	138.91	2.24	138.34	2.77	137.81	2.99	137.59	3.40	137.18	3.20	137.38
MW18-5	4.49	140.16	1.45	138.71	2.09	138.07	2.87	137.29	3.09	137.07	3.66	136.50	3.62	136.54
MW18-6	2.48	138.10	1.23	136.87	1.60	136.50	1.73	136.37	1.80	136.30	1.85	136.25	1.80	136.30
MW18-7	4.69	138.57	2.02	136.55	2.07	136.50	2.35	136.22	2.37	136.20	2.40	136.17	2.33	136.24
MW18-9	3.75	140.80	1.12	139.68	2.19	138.61	2.66	138.14	3.14	137.66	3.62	137.18	3.74	137.06
PZ1s	0.57	**140.00**	0.43	139.57	0.37	139.63	dry	dry	dry	dry	dry	dry	dry	dry
PZ1d	1.09	**140.00**	0.52	139.48	0.59	139.41	0.99	139.01	dry	dry	dry	dry	dry	dry
MW19-01	4.41	154.70												
MW19-02	6.27	152.90												
MW19-03	7.28	153.70												
MW19-100	5.88	143.90												
MW19-101	5.81	144.90												
MW19-102	5.88	145.80												
MW19-200	6.13	146.30												
MW19-201	5.98	146.40												
MW19-202	5.91	147.40												

mbgl - metres below ground level

masl - metres above sea level

'-' - denotes unavailable data

Bold ground elevation indicates an estim

Table E-1
Water Elevations

Location	Total Measured Well Depth (mbgl)	Ground Elevation (masl)	6-Nov-19		9-Dec-19		15-Jan-20		11-Feb-20		17-Mar-20		21-Apr-20	
			Water Level Depth (mbgl)	Elevation (masl)	Water Level Depth (mbgl)	Elevation (masl)	Water Level Depth (mbgl)	Elevation (masl)	Water Level Depth (mbgl)	Elevation (masl)	Water Level Depth (mbgl)	Elevation (masl)	Water Level Depth (mbgl)	Elevation (masl)
MW18-1	6.07	142.78	4.36	138.42	4.28	138.50	4.13	138.65	4.31	138.47	4.19	138.59	4.32	138.46
MW18-2	4.71	142.17	dry	dry	2.34	139.83	0.93	141.24	1.38	140.79	1.39	140.78	1.46	140.71
MW18-4	4.40	140.58	2.20	138.39	1.98	138.60	1.48	139.10	2.17	138.41	2.13	138.45	2.40	138.18
MW18-5	4.49	140.16	2.80	137.36	2.35	137.81	1.54	138.62	2.07	138.09	2.04	138.12	2.36	137.80
MW18-6	2.48	138.10	1.64	136.46	1.21	136.89	0.92	137.18	1.42	136.68	1.36	136.74	1.57	136.53
MW18-7	4.69	138.57	2.22	136.35	1.99	136.58	1.90	136.67	2.15	136.42	2.19	136.38	2.27	136.30
MW18-9	3.75	140.80	3.22	137.58	2.00	138.80	1.21	139.59	1.74	139.06	1.67	139.13	2.02	138.78
PZ1s	0.57	**140.00**	dry	dry	0.34	139.66	0.21	139.79	0.31	139.70	0.37	139.63	dry	dry
PZ1d	1.09	**140.00**	0.94	139.06	0.68	139.32	0.44	139.56	0.48	139.53	0.47	139.53	0.55	139.45
MW19-01	4.41	154.70			0.65	154.05	0.37	154.33	0.59	154.11	0.59	154.11	0.73	153.98
MW19-02	6.27	152.90			0.59	152.31	0.73	152.17	0.80	152.10	0.81	152.09	0.82	152.08
MW19-03	7.28	153.70			0.65	153.05	1.14	152.56	0.70	153.00	0.77	152.93	0.81	152.89
MW19-100	5.88	143.90			2.13	141.77	2.19	141.71	2.09	141.81	2.12	141.78	2.12	141.78
MW19-101	5.81	144.90			1.44	143.46	1.15	143.75	1.33	143.57	1.37	143.53	1.41	143.49
MW19-102	5.88	145.80			3.70	142.10	1.28	144.52	1.43	144.37	1.62	144.18	1.37	144.43
MW19-200	6.13	146.30			1.13	145.17	1.21	145.09	1.31	144.99	1.36	144.94	1.44	144.86
MW19-201	5.98	146.40			0.53	145.87	0.52	145.88	0.61	145.79	0.74	145.66	0.83	145.57
MW19-202	5.91	147.40			2.41	144.99	0.09	147.31	0.52	146.88	0.55	146.85	0.71	146.69

mbgl - metres below ground level

masl - metres above sea level

'-' - denotes unavailable data

Bold ground elevation indicates an estim

Table E-1
Water Elevations

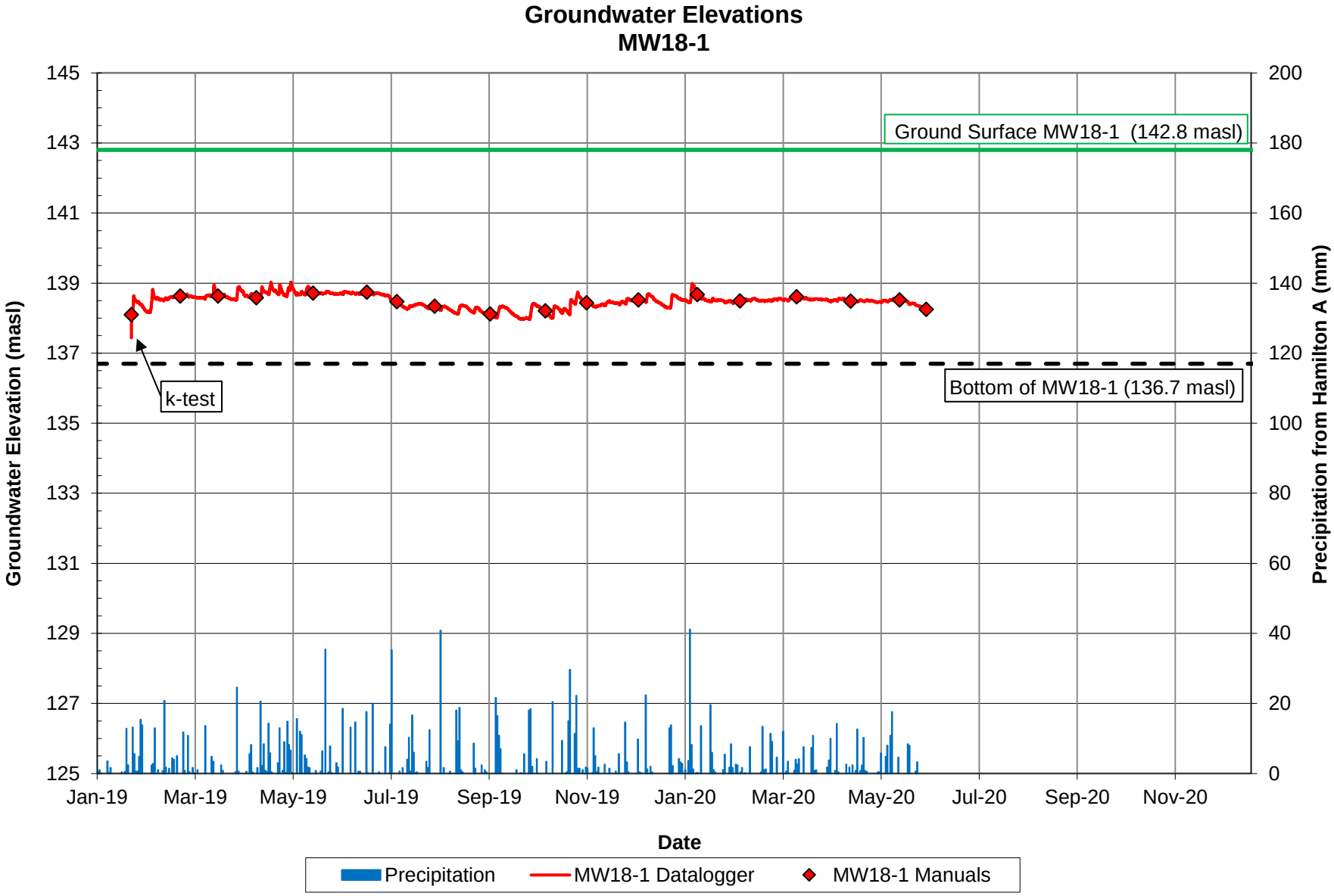
Location	Total Measured Well Depth (mbgl)	Ground Elevation (masl)	22-May-20		8-Jun-20	
			Water Level Depth (mbgl)	Elevation (masl)	Water Level Depth (mbgl)	Elevation (masl)
MW18-1	6.07	142.78	4.28	138.50	4.55	138.23
MW18-2	4.71	142.17	1.86	140.31	2.71	139.46
MW18-4	4.40	140.58	2.72	137.86	2.93	137.65
MW18-5	4.49	140.16	2.89	137.27	2.85	137.31
MW18-6	2.48	138.10	1.66	136.44	1.83	136.27
MW18-7	4.69	138.57	2.26	136.31	2.43	136.14
MW18-9	3.75	140.80	2.67	138.13	2.97	137.83
PZ1s	0.57	**140.00**	dry	dry	dry	dry
PZ1d	1.09	**140.00**	0.69	139.31	0.92	139.08
MW19-01	4.41	154.70	1.02	153.69	1.32	153.38
MW19-02	6.27	152.90	0.77	152.13	1.01	151.89
MW19-03	7.28	153.70	0.81	152.89	1.08	152.62
MW19-100	5.88	143.90	2.18	141.72	2.37	141.53
MW19-101	5.81	144.90	1.64	143.26	1.78	143.12
MW19-102	5.88	145.80	1.57	144.23	1.70	144.10
MW19-200	6.13	146.30	1.61	144.69	1.85	144.45
MW19-201	5.98	146.40	1.08	145.33	1.26	145.14
MW19-202	5.91	147.40	1.64	145.76	1.76	145.64

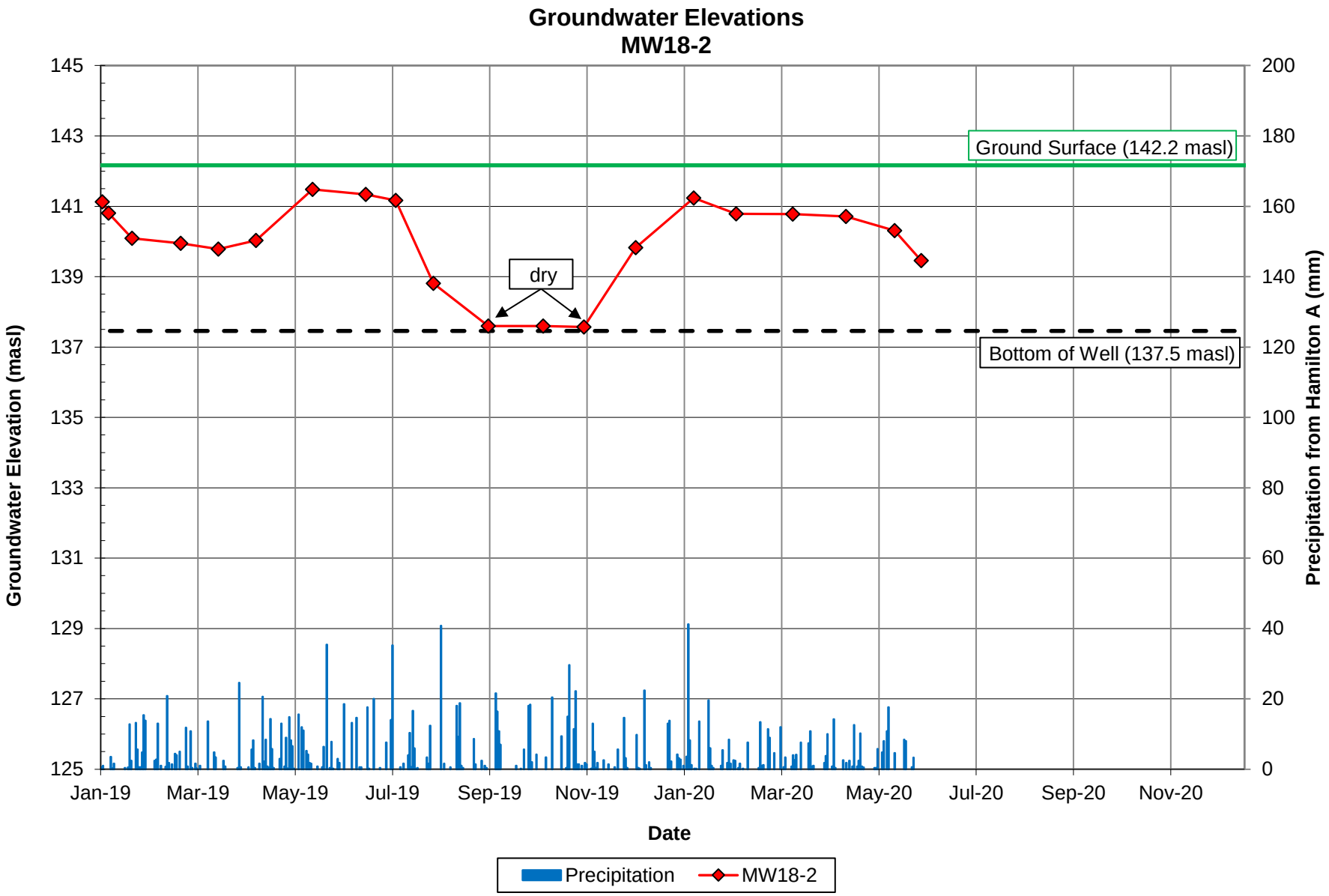
mbgl - metres below ground level

masl - metres above sea level

'-' - denotes unavailable data

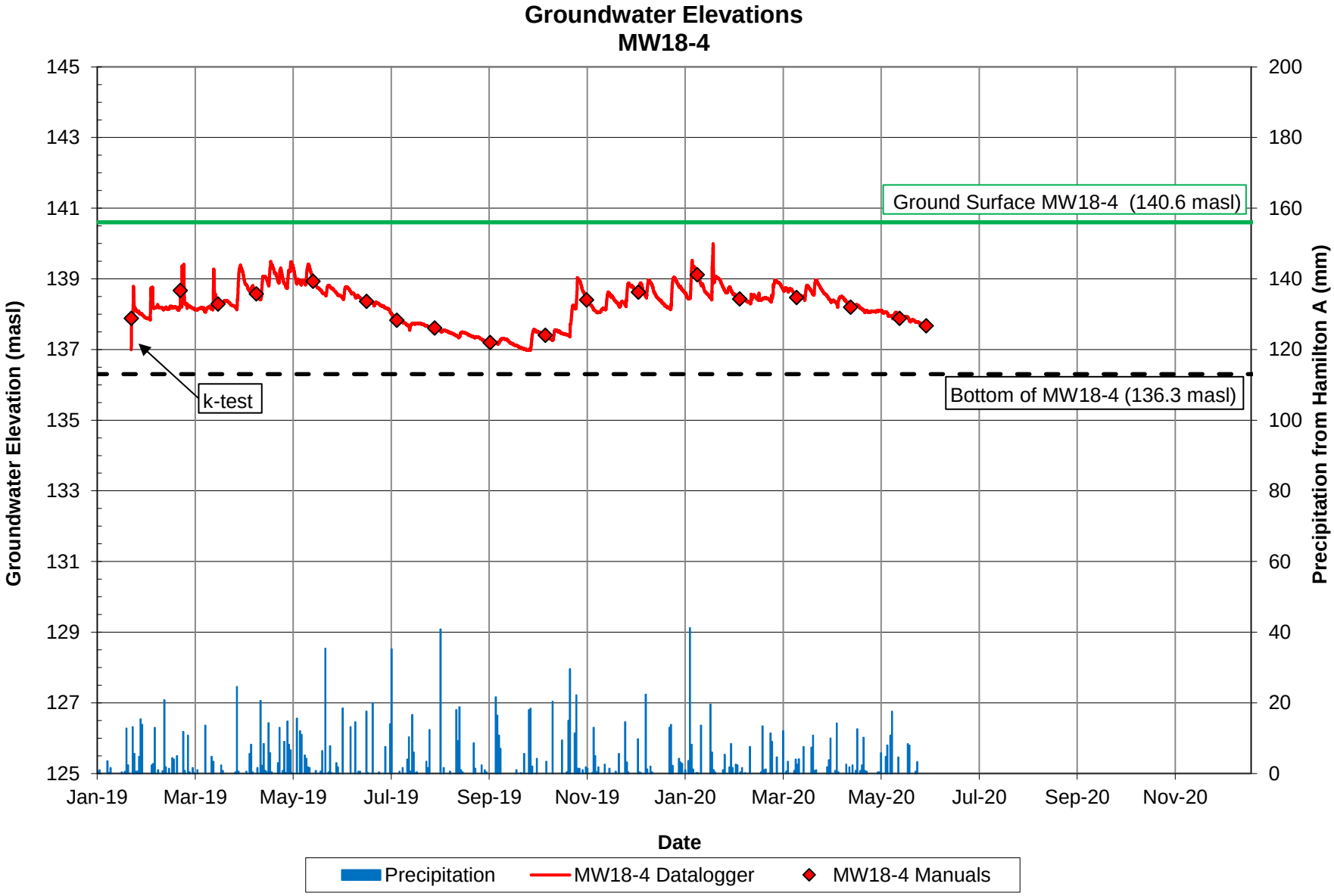
Bold ground elevation indicates an estim

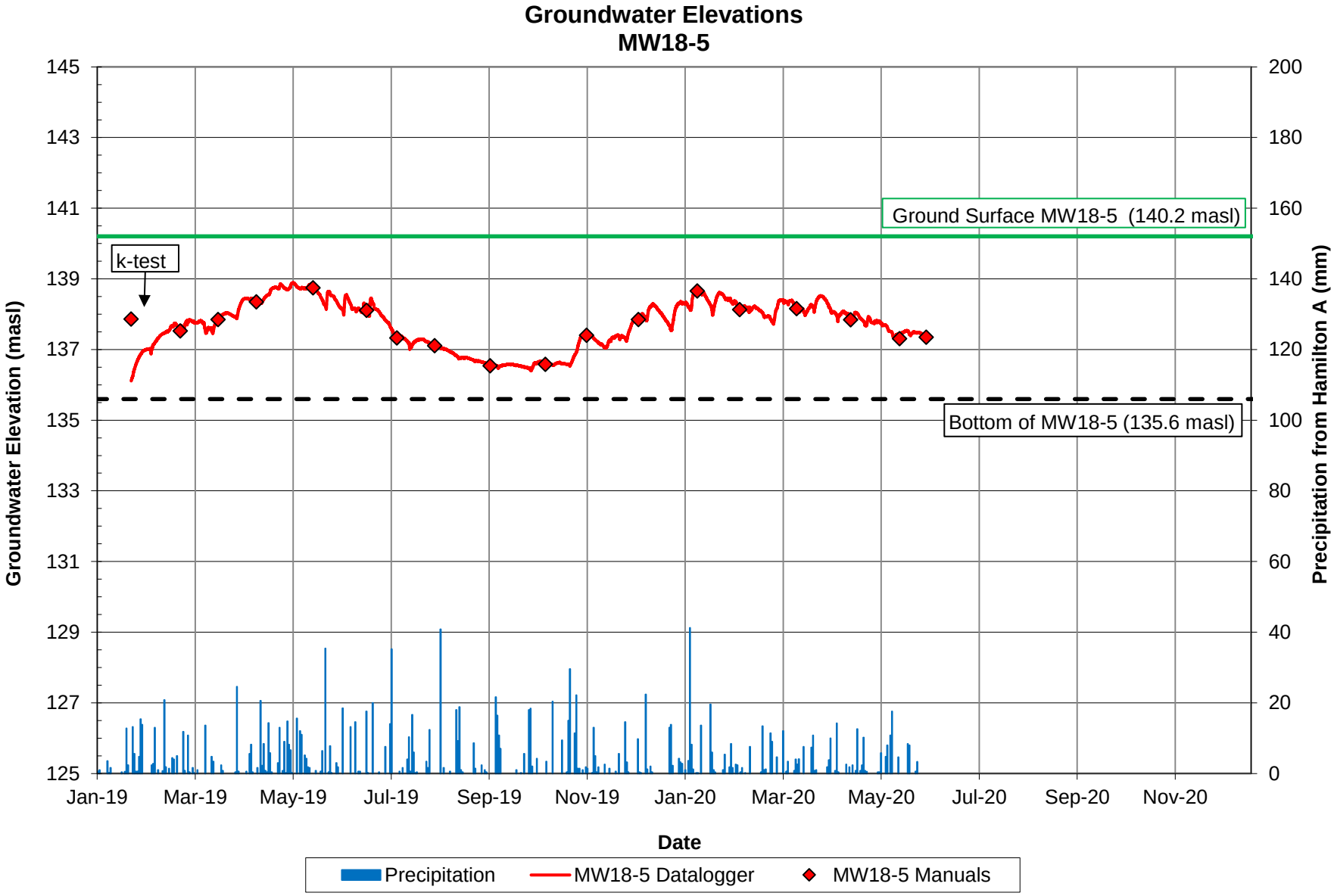

Groundwater Elevations
MW18-1
Groundwater Elevation (masl)
Precipitation from Hamilton A (mm)
Date
Ground Surface MW18-1 (142.8 masl)
Bottom of MW18-1 (136.7 masl)
k-test
145
143
141
139
137
135
133
131
129
127
125
200
180
160
140
120
100
80
60
40
20
0
Jan-19
Mar-19
May-19
Jul-19
Sep-19
Nov-19
Jan-20
Mar-20
May-20
Jul-20
Sep-20
Nov-20
Precipitation
MW18-1 Datalogger
MW18-1 Manuals



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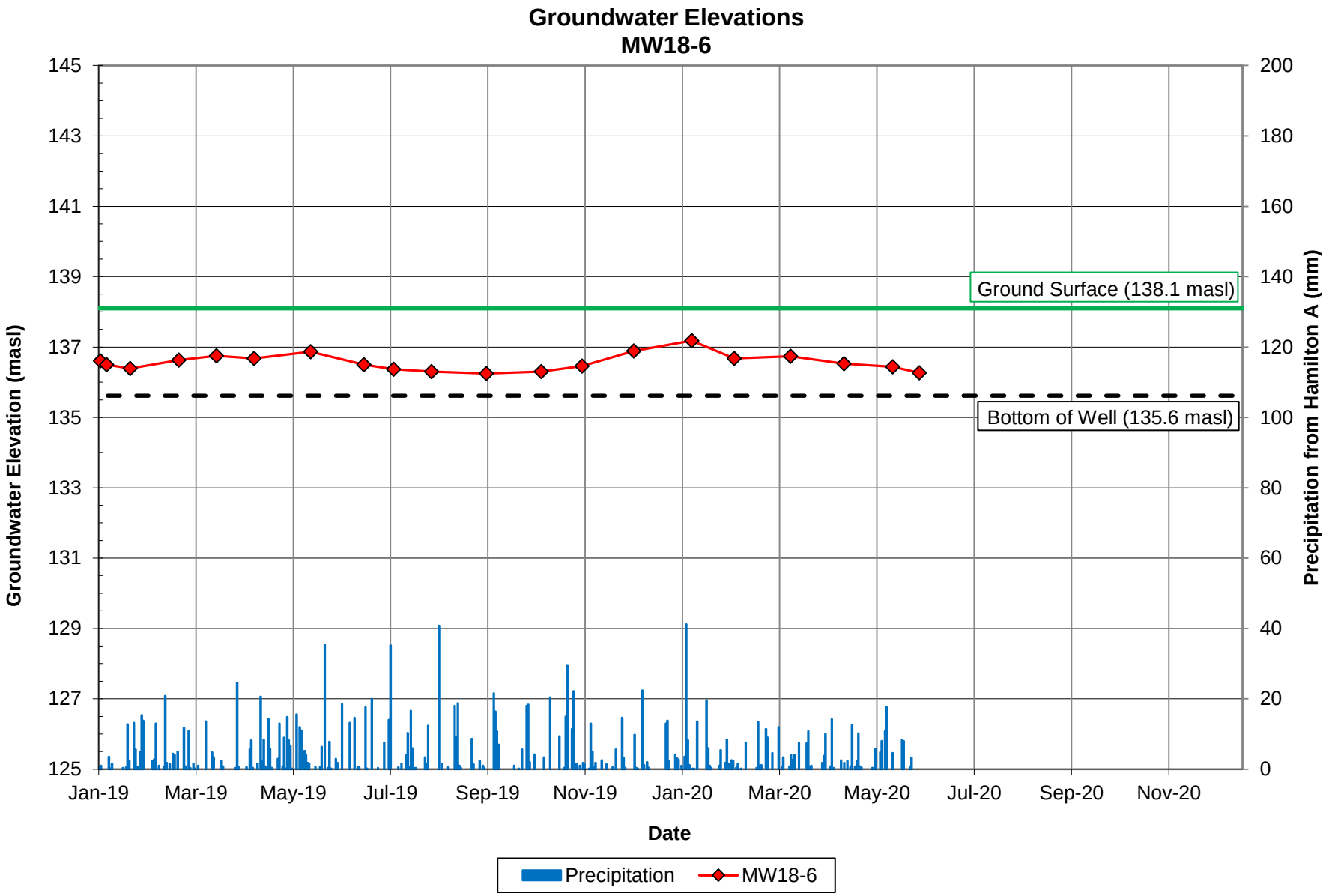
Figure E-2


Groundwater Elevations
MW18-4
Groundwater Elevation (masl)
Precipitation from Hamilton A (mm)
Date
Ground Surface MW18-4 (140.6 masl)
Bottom of MW18-4 (136.3 masl)
k-test
145
143
141
139
137
135
133
131
129
127
125
200
180
160
140
120
100
80
60
40
20
0
Jan-19
Mar-19
May-19
Jul-19
Sep-19
Nov-19
Jan-20
Mar-20
May-20
Jul-20
Sep-20
Nov-20
Precipitation
MW18-4 Datalogger
MW18-4 Manuals



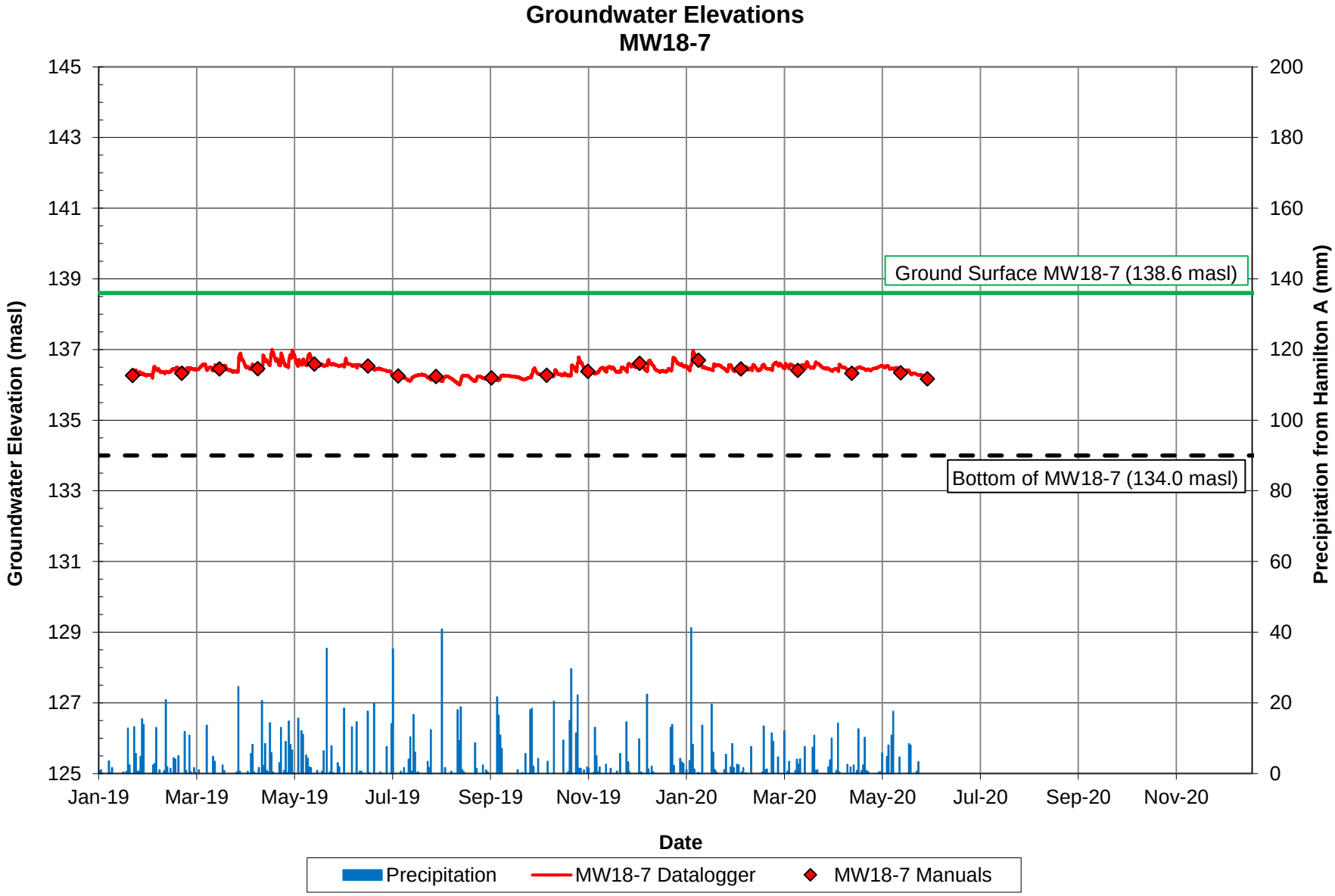
R.J. Burnside & Associates Limited
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Figure E- 4



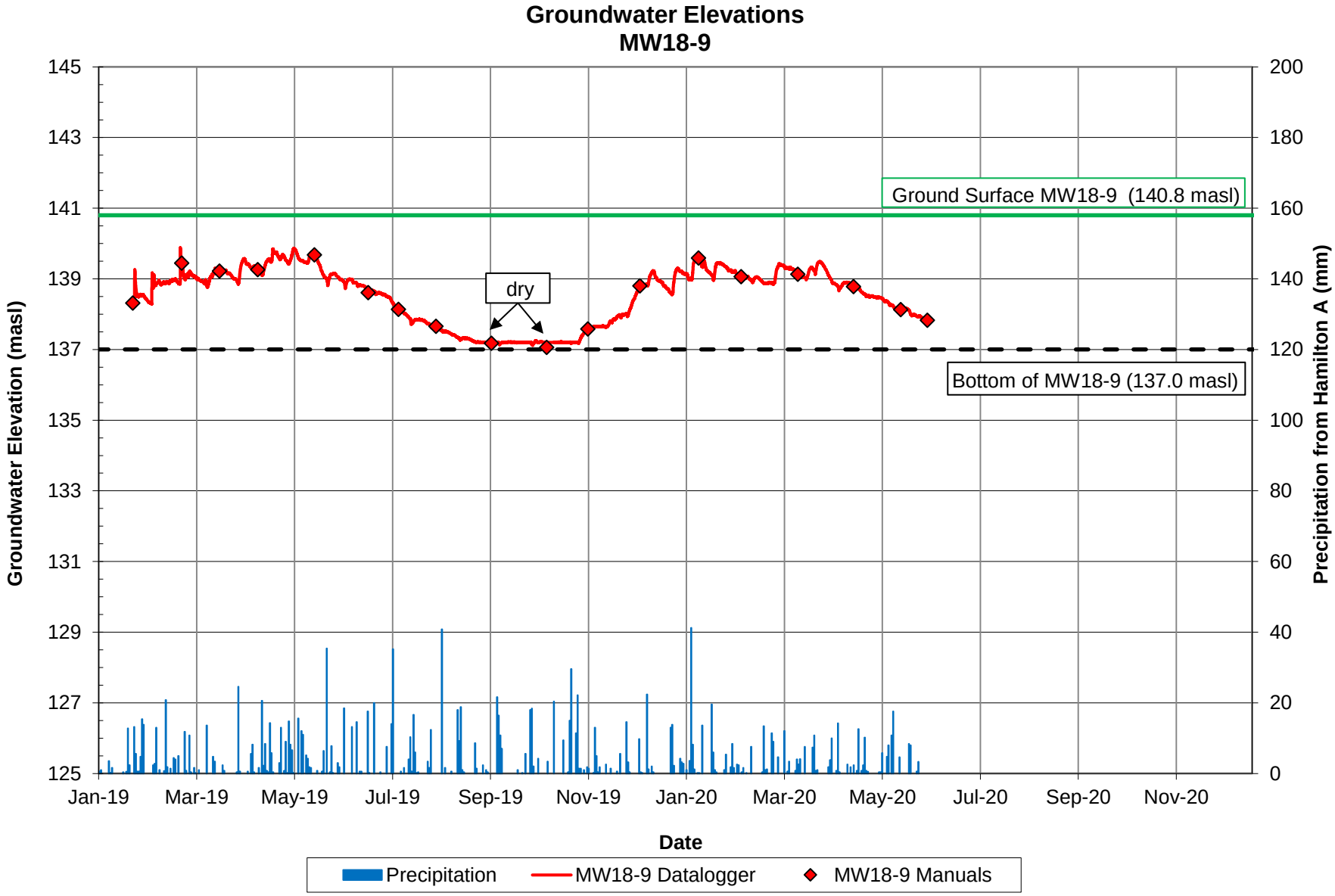
R.J. Burnside Associates Limited
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Figure E-5



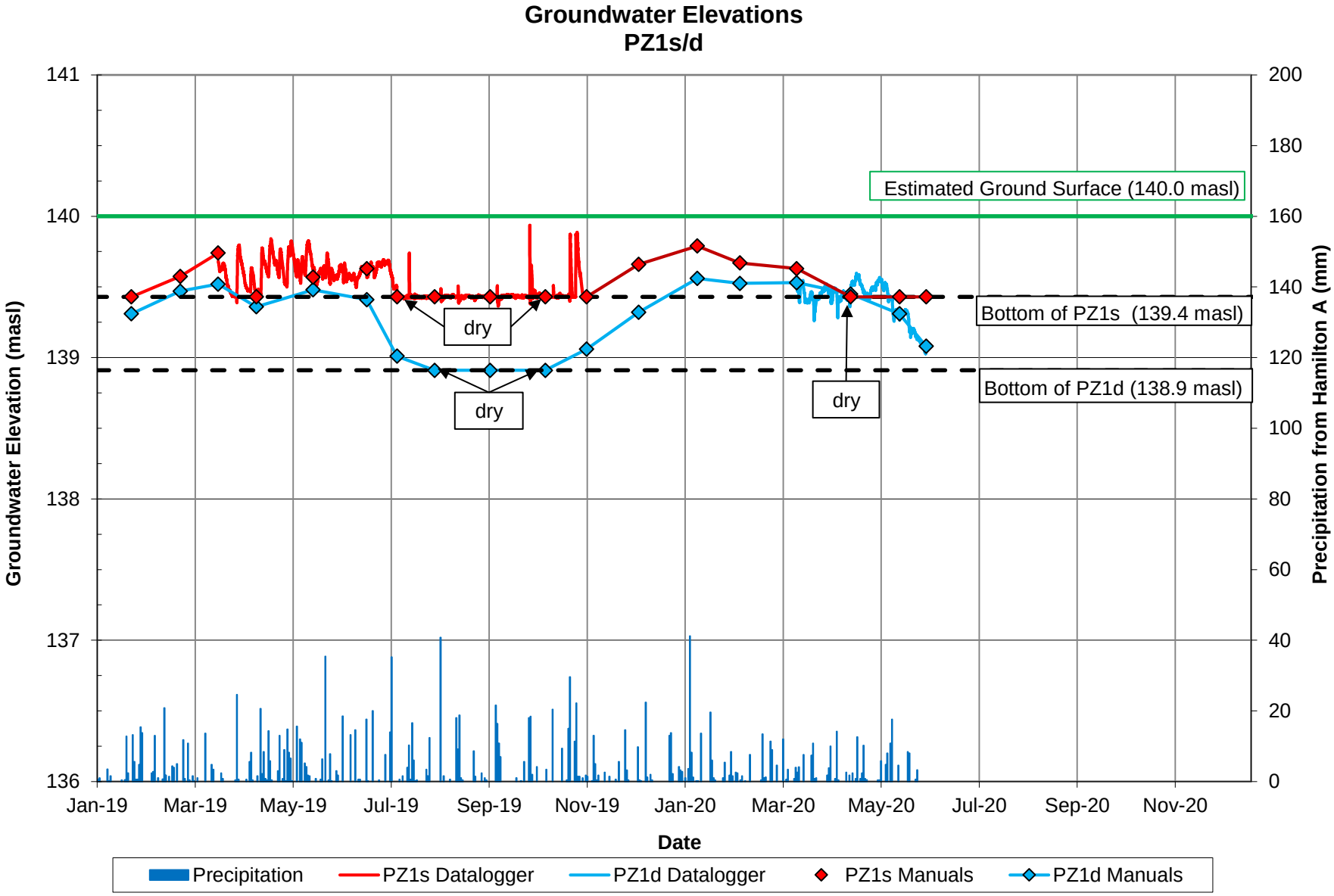
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Figure E-6



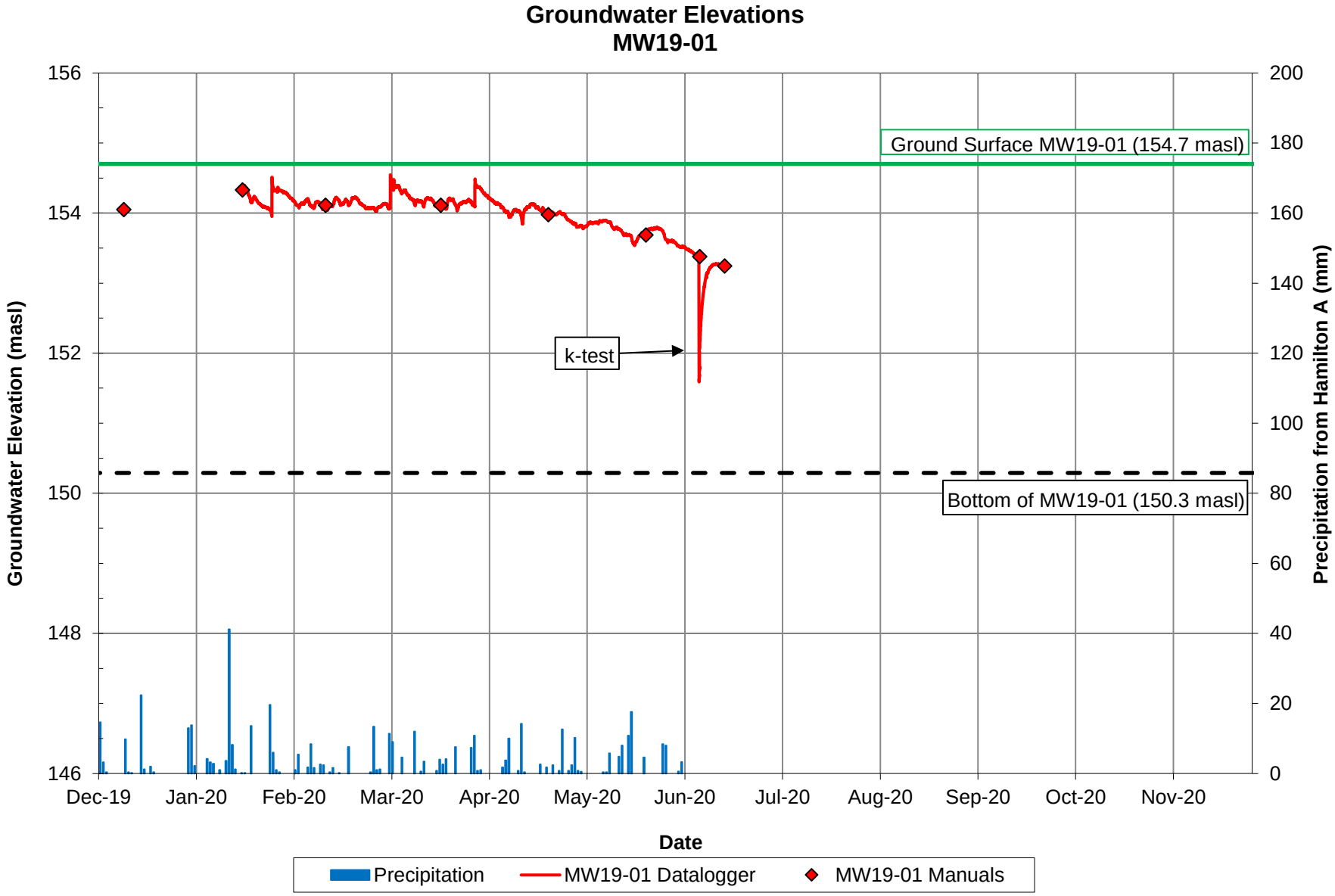
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300043939

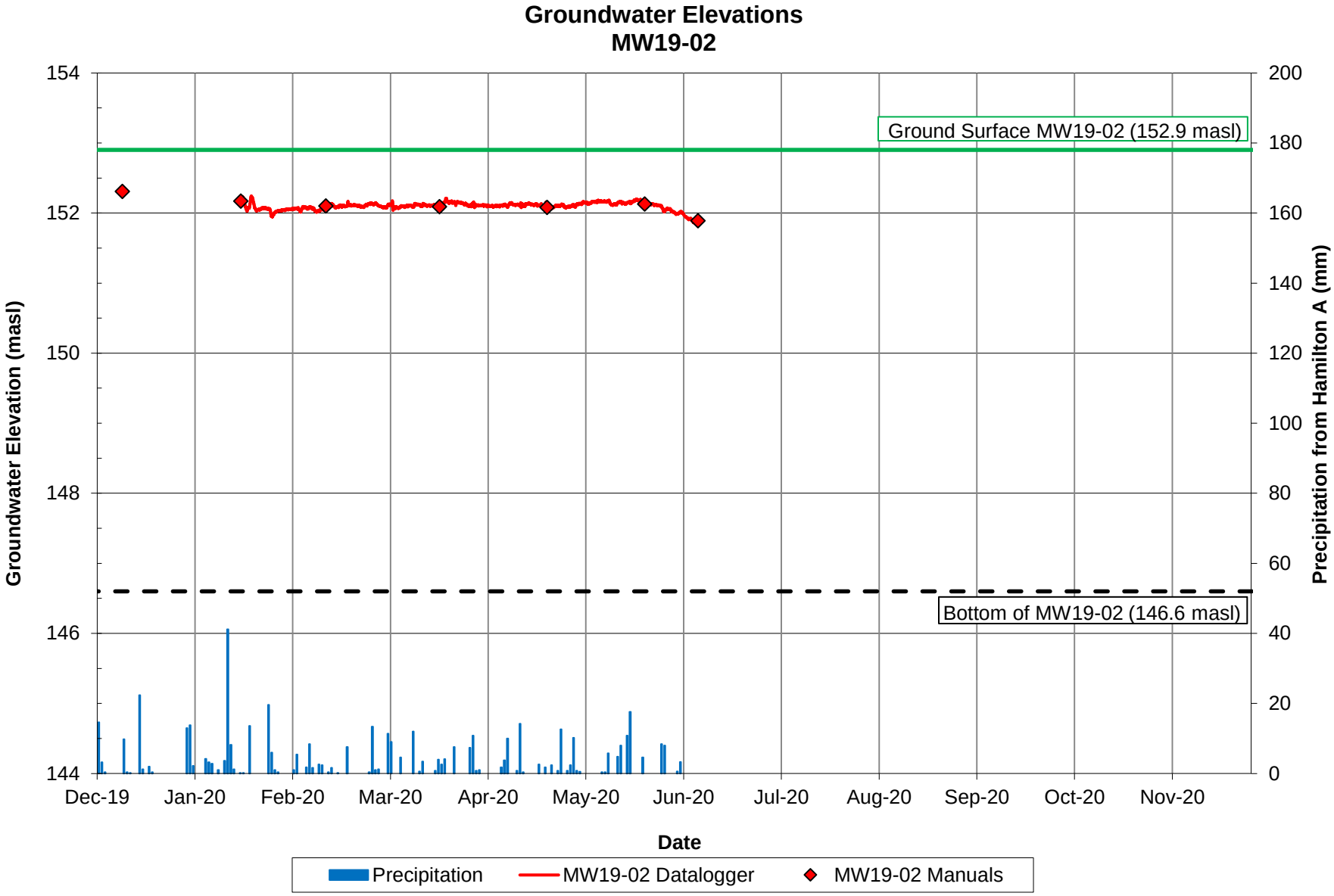
Figure E- 7



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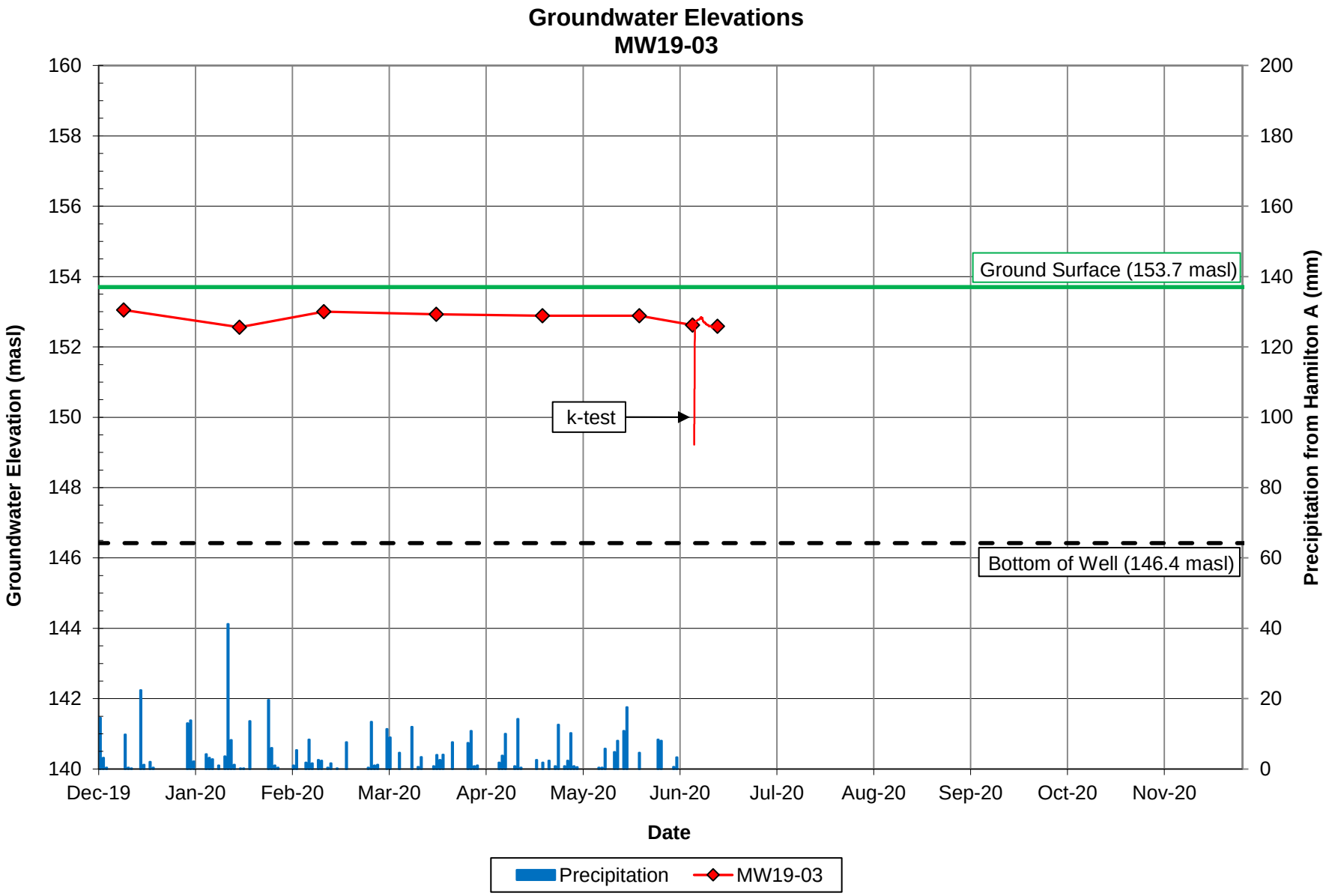
Figure E-8

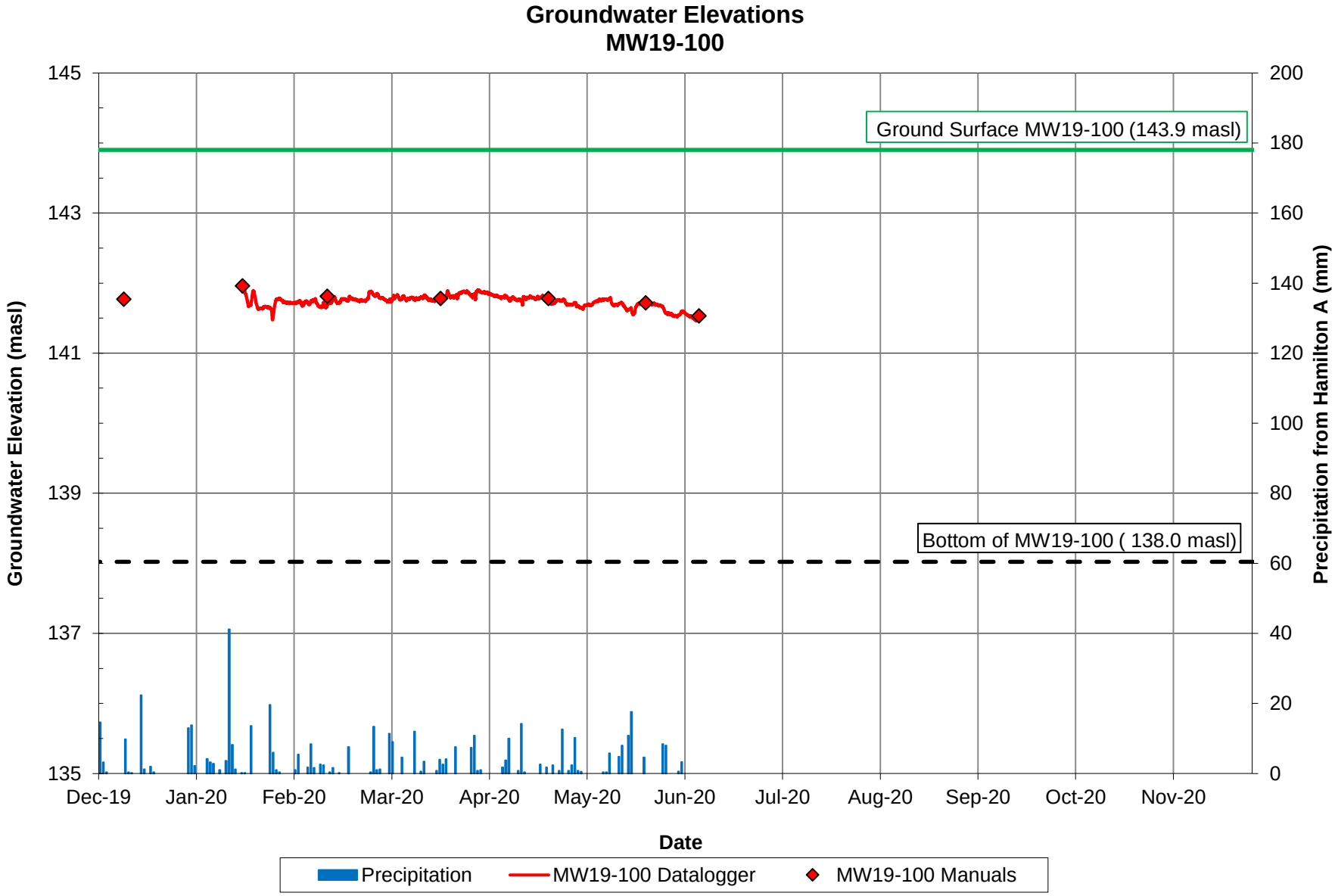

Groundwater Elevations
MW19-01
Groundwater Elevation (masl)
Precipitation from Hamilton A (mm)
156
154
152
150
148
146
200
180
160
140
120
100
80
60
40
20
0
Ground Surface MW19-01 (154.7 masl)
k-test
Bottom of MW19-01 (150.3 masl)
Dec-19
Jan-20
Feb-20
Mar-20
Apr-20
May-20
Jun-20
Jul-20
Aug-20
Sep-20
Oct-20
Nov-20
Date
Precipitation
MW19-01 Datalogger
MW19-01 Manuals



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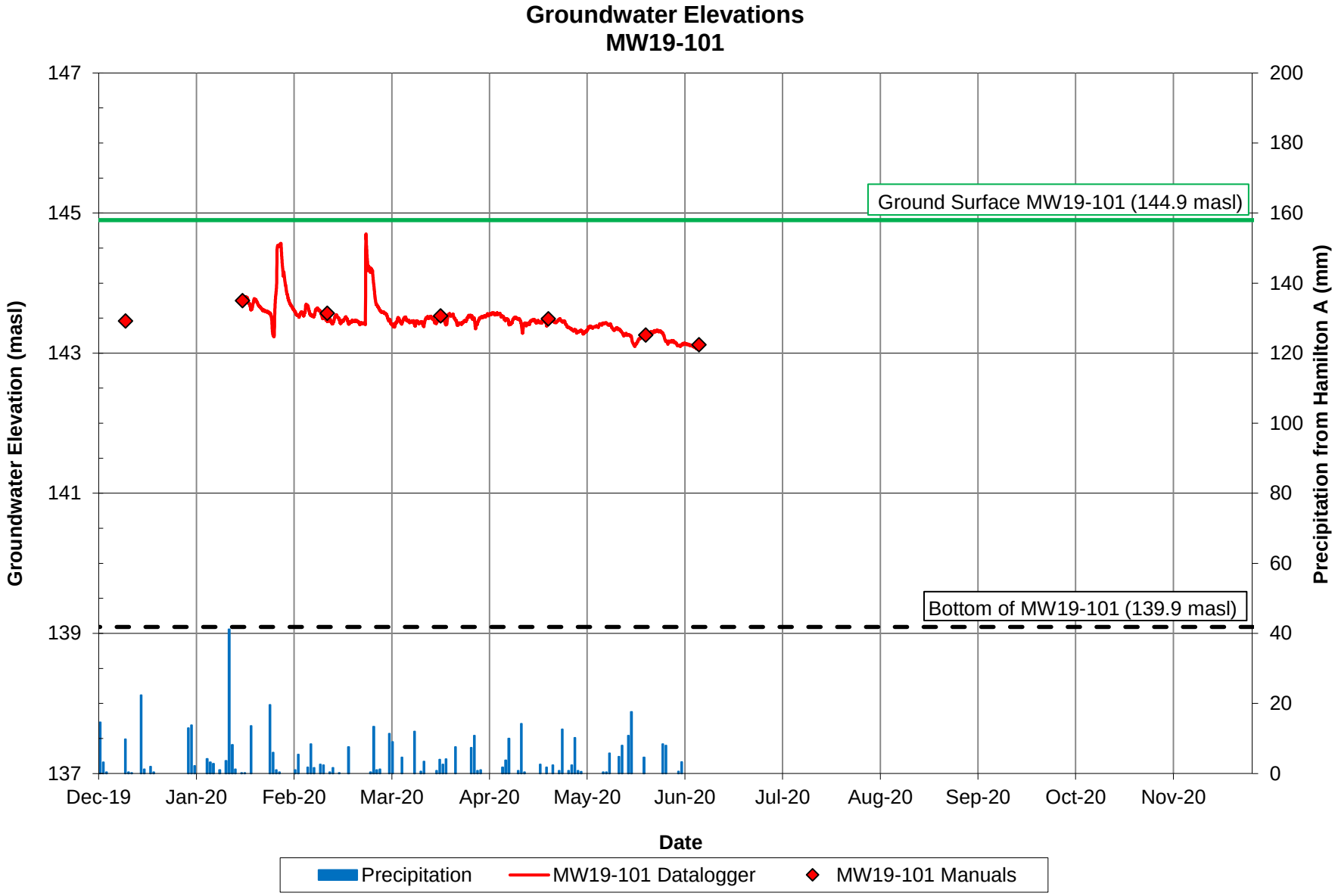
Figure E- 10


Groundwater Elevations
MW19-03
Groundwater Elevation (masl)
Precipitation from Hamilton A (mm)
160
158
156
154
152
150
148
146
144
142
140
200
180
160
140
120
100
80
60
40
20
0
Ground Surface (153.7 masl)
k-test
Bottom of Well (146.4 masl)
Dec-19
Jan-20
Feb-20
Mar-20
Apr-20
May-20
Jun-20
Jul-20
Aug-20
Sep-20
Oct-20
Nov-20
Date
Precipitation
MW19-03



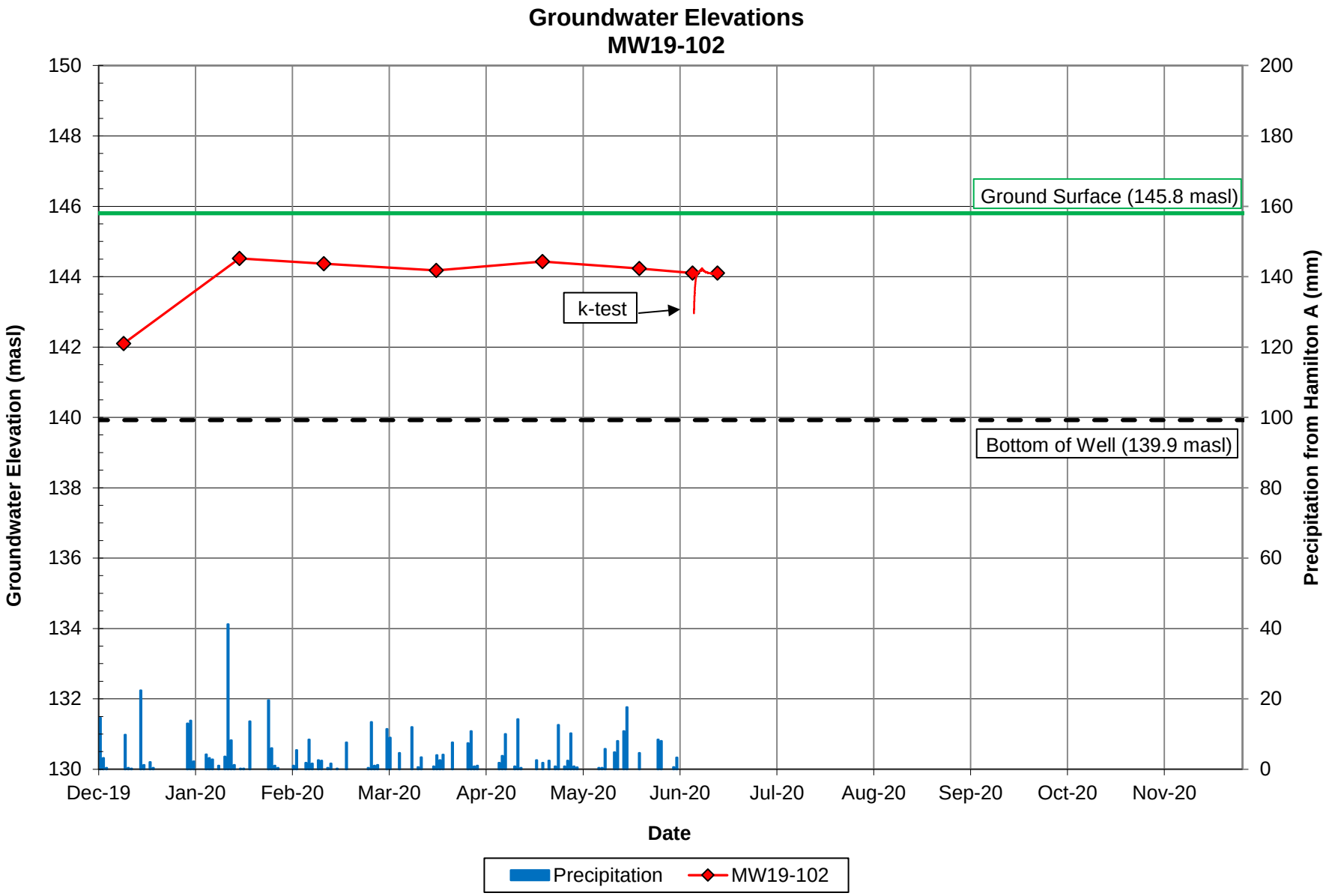
R.J. Burnside & Associates Limited
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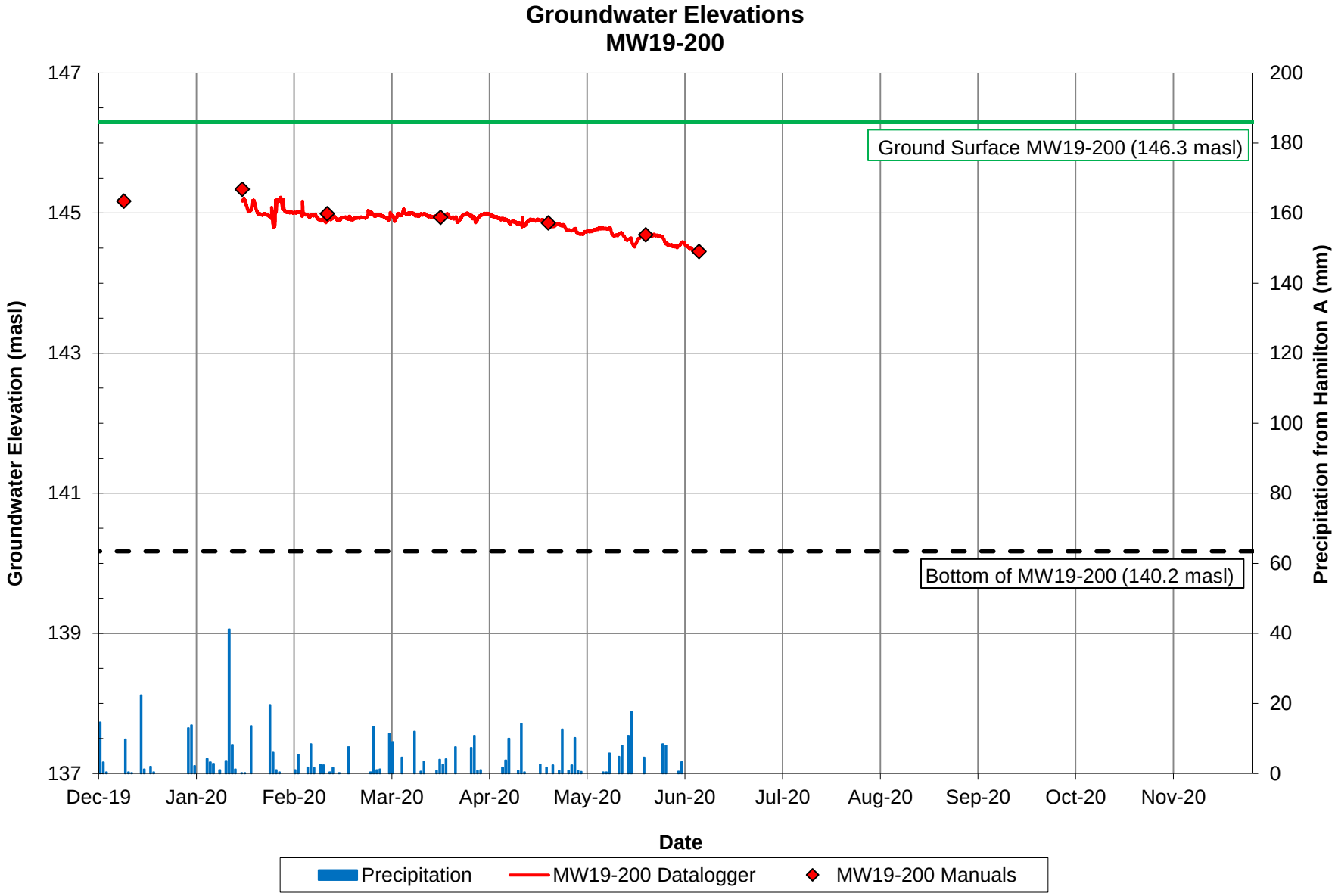
Figure E- 12



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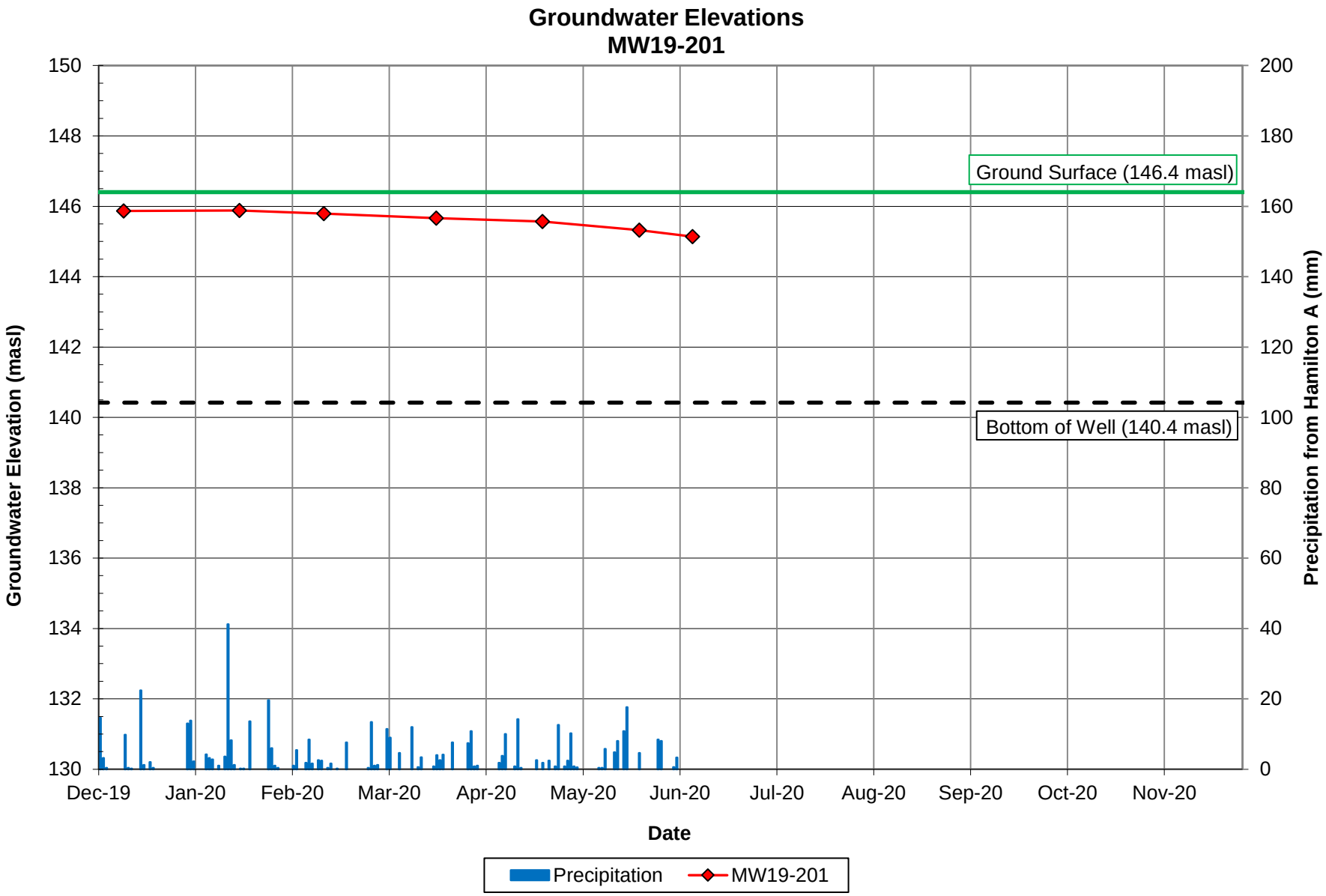
Figure E- 13

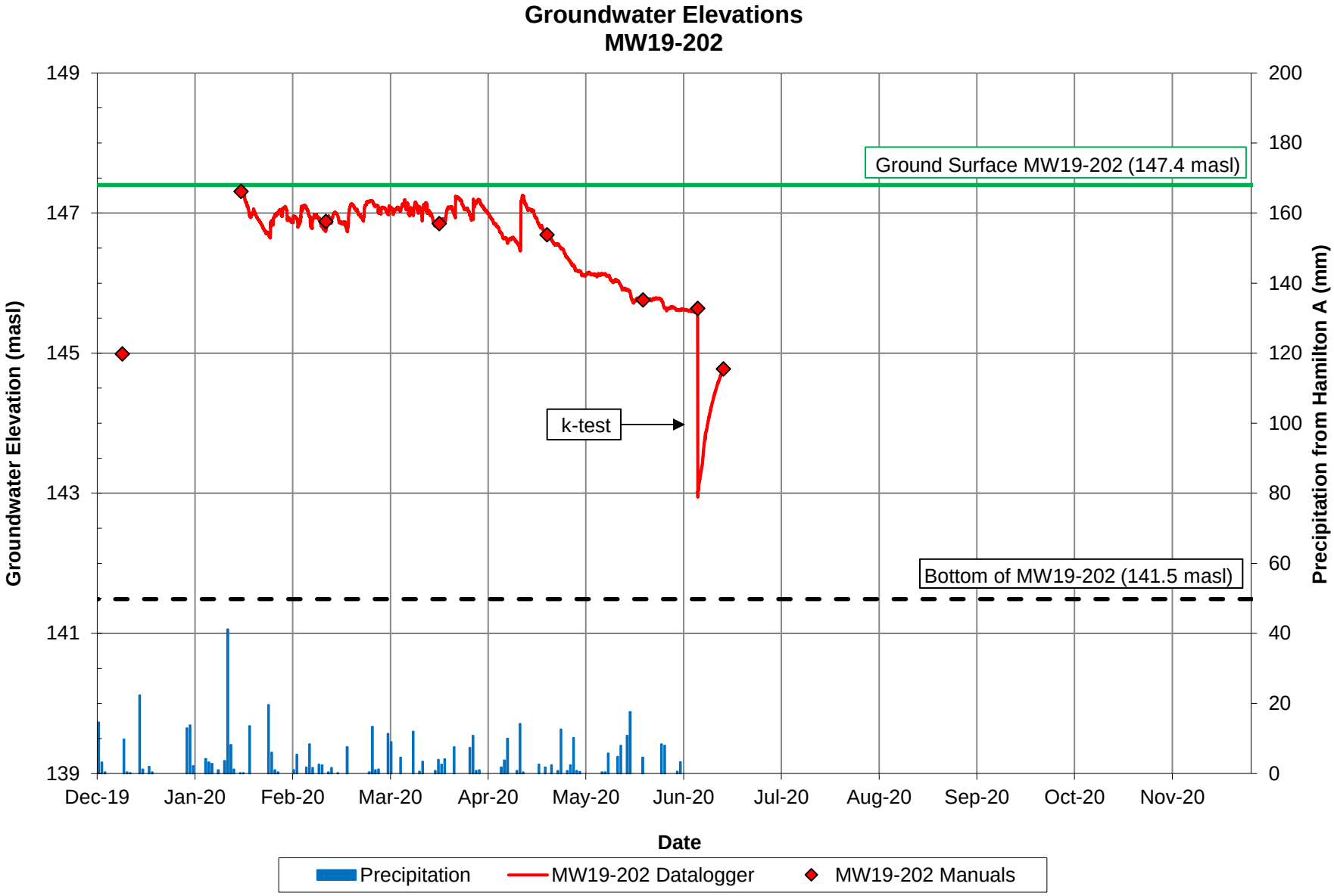

Groundwater Elevations
MW19-102
Groundwater Elevation (masl)
Precipitation from Hamilton A (mm)
Ground Surface (145.8 masl)
Bottom of Well (139.9 masl)
k-test
150
148
146
144
142
140
138
136
134
132
130
200
180
160
140
120
100
80
60
40
20
0
Dec-19
Jan-20
Feb-20
Mar-20
Apr-20
May-20
Jun-20
Jul-20
Aug-20
Sep-20
Oct-20
Nov-20
Date
Precipitation
MW19-102



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Figure E- 15


Groundwater Elevations
MW19-201
Groundwater Elevation (masl)
Precipitation from Hamilton A (mm)
Ground Surface (146.4 masl)
Bottom of Well (140.4 masl)
150
148
146
144
142
140
138
136
134
132
130
200
180
160
140
120
100
80
60
40
20
0
Dec-19
Jan-20
Feb-20
Mar-20
Apr-20
May-20
Jun-20
Jul-20
Aug-20
Sep-20
Oct-20
Nov-20
Date
Precipitation
MW19-201


Groundwater Elevations
MW19-202
Groundwater Elevation (masl)
Precipitation from Hamilton A (mm)
149
147
145
143
141
139
200
180
160
140
120
100
80
60
40
20
0
Ground Surface MW19-202 (147.4 masl)
k-test
Bottom of MW19-202 (141.5 masl)
Dec-19
Jan-20
Feb-20
Mar-20
Apr-20
May-20
Jun-20
Jul-20
Aug-20
Sep-20
Oct-20
Nov-20
Date
Precipitation
MW19-202 Datalogger
MW19-202 Manuals

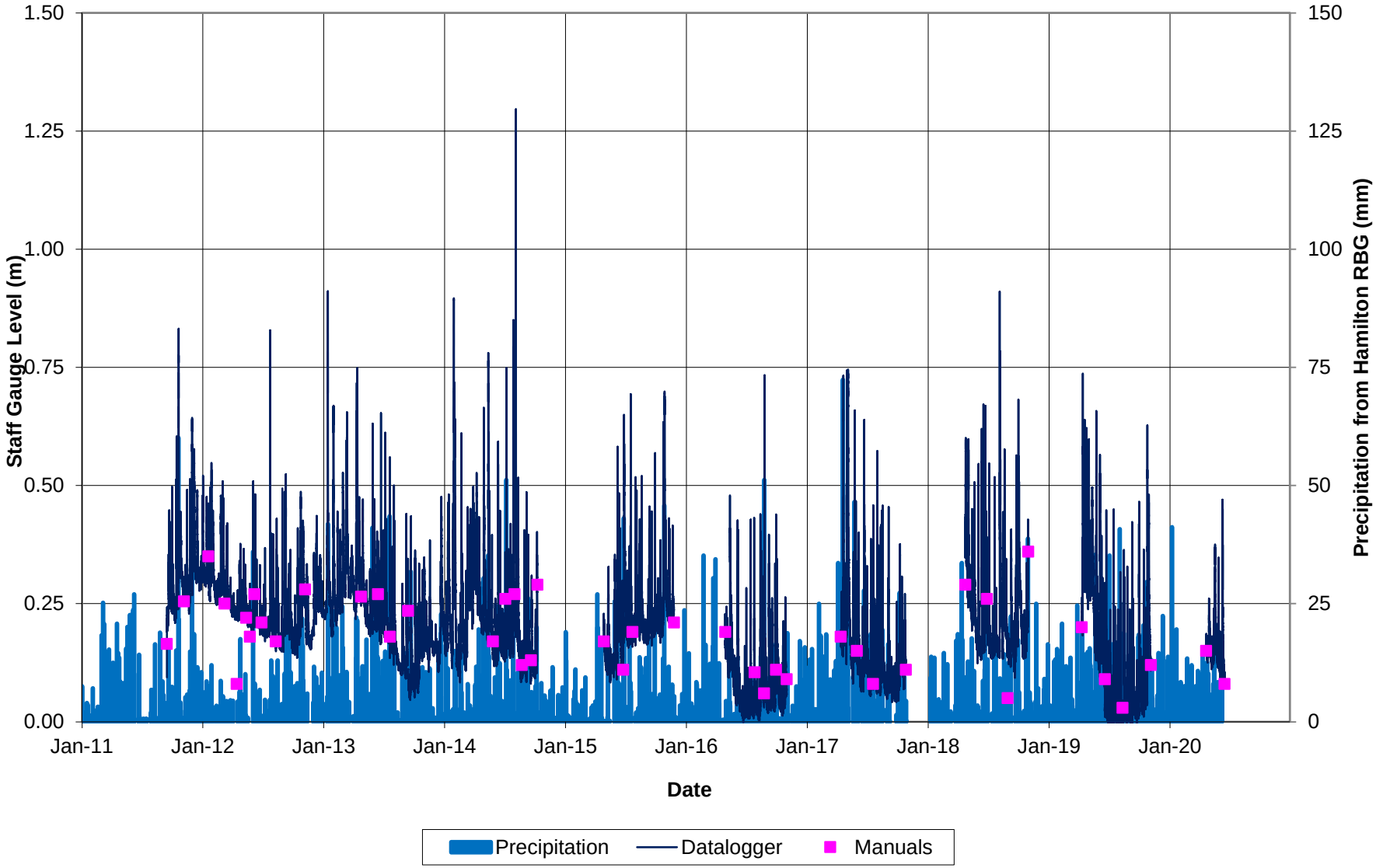
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Appendix F

Surface Water Data

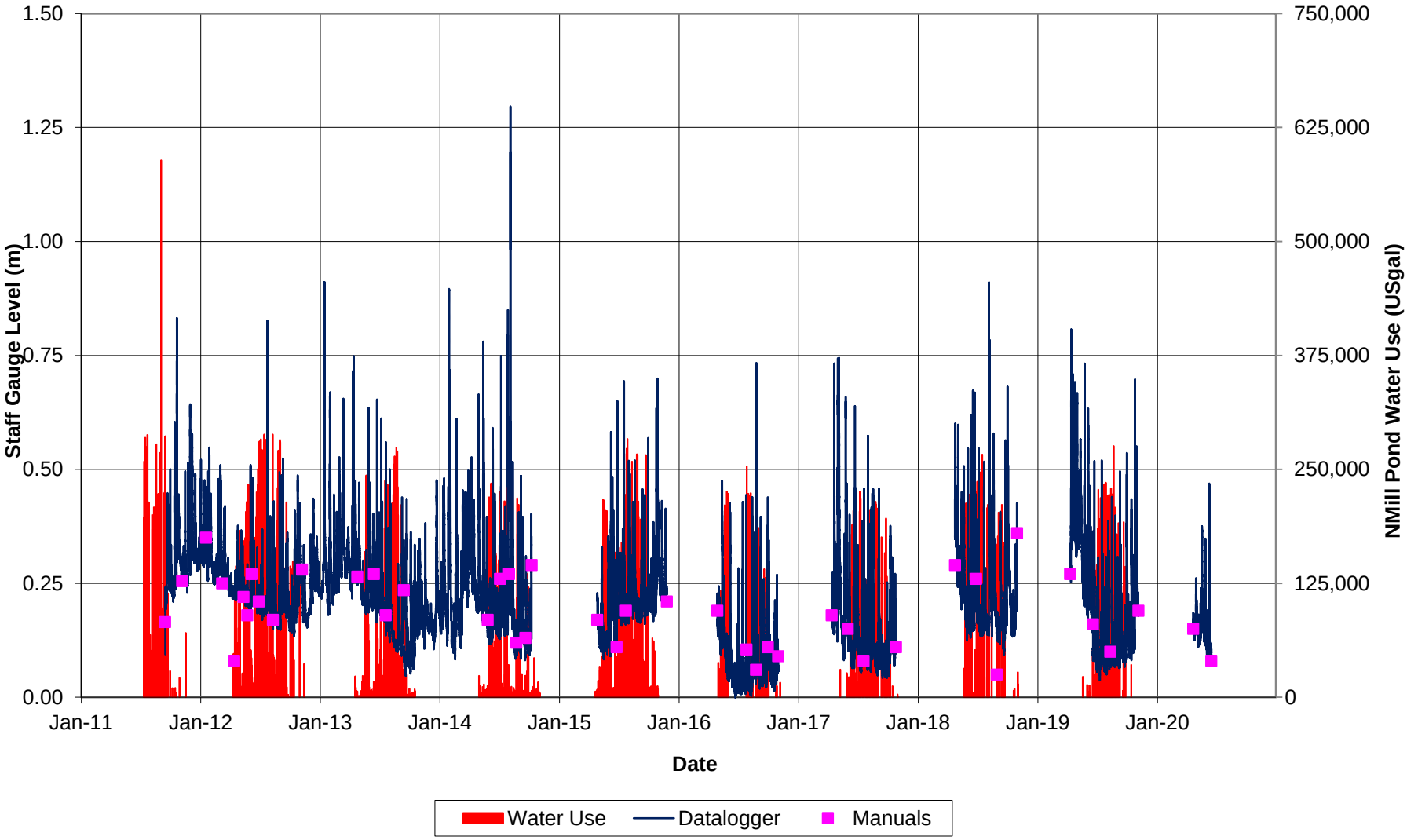
Millcroft Golf Club
Golf SS2: Upstream of Pond
2011-2020 Hydrograph with Precipitation



R.J. Burnside & Associates Limited
File: 020649_PGD Millcroft PTTW Hydrographs
Prepared By: K. Lea

Figure F-1

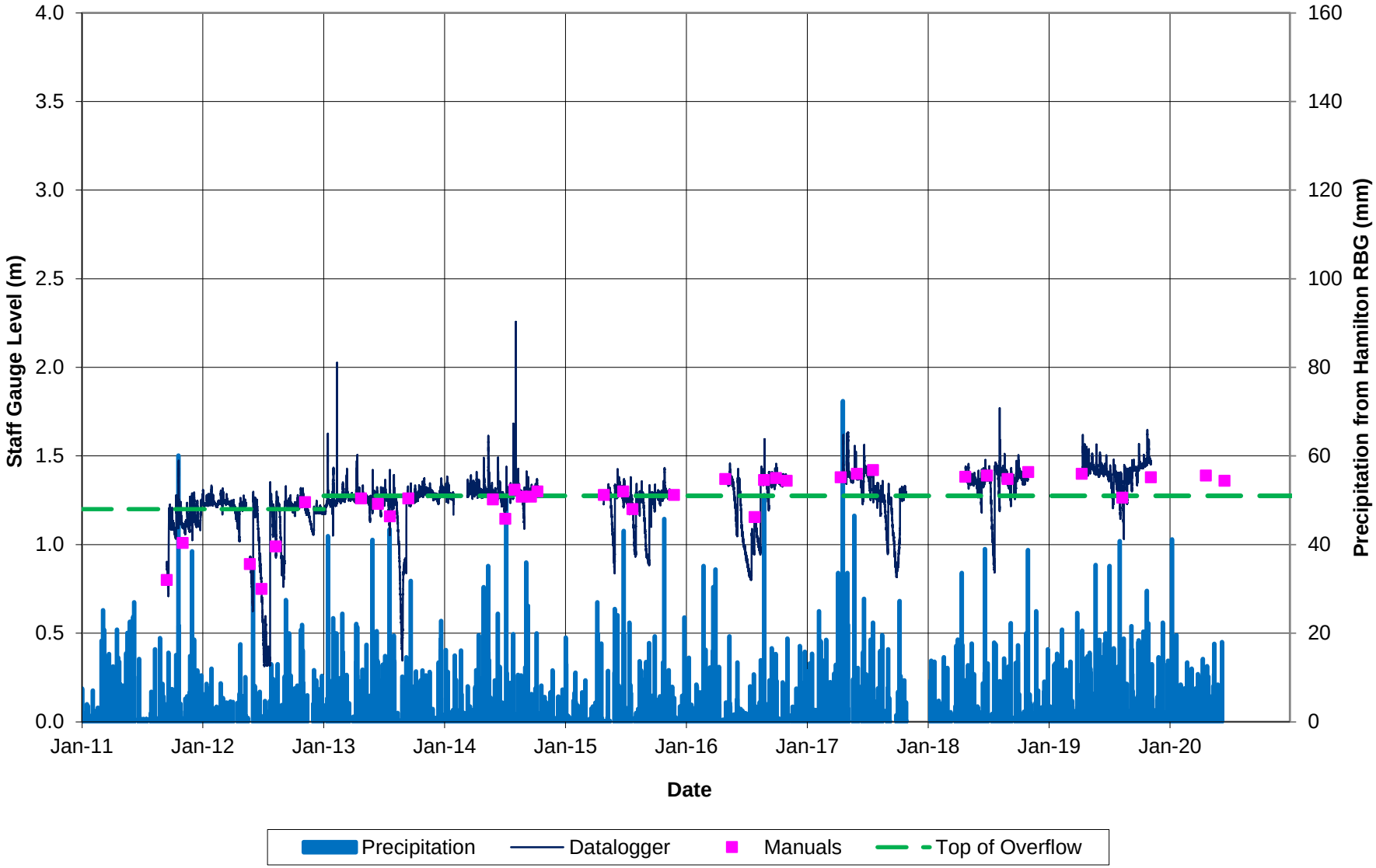
Millcroft Golf Club
Golf SS2: Upstream of Pond
2011-2020 Hydrograph with Water Use



R.J. Burnside & Associates Limited
File: 020649_PGD Millcroft PTTW Hydrographs
Prepared By: K. Lea

Figure F-2

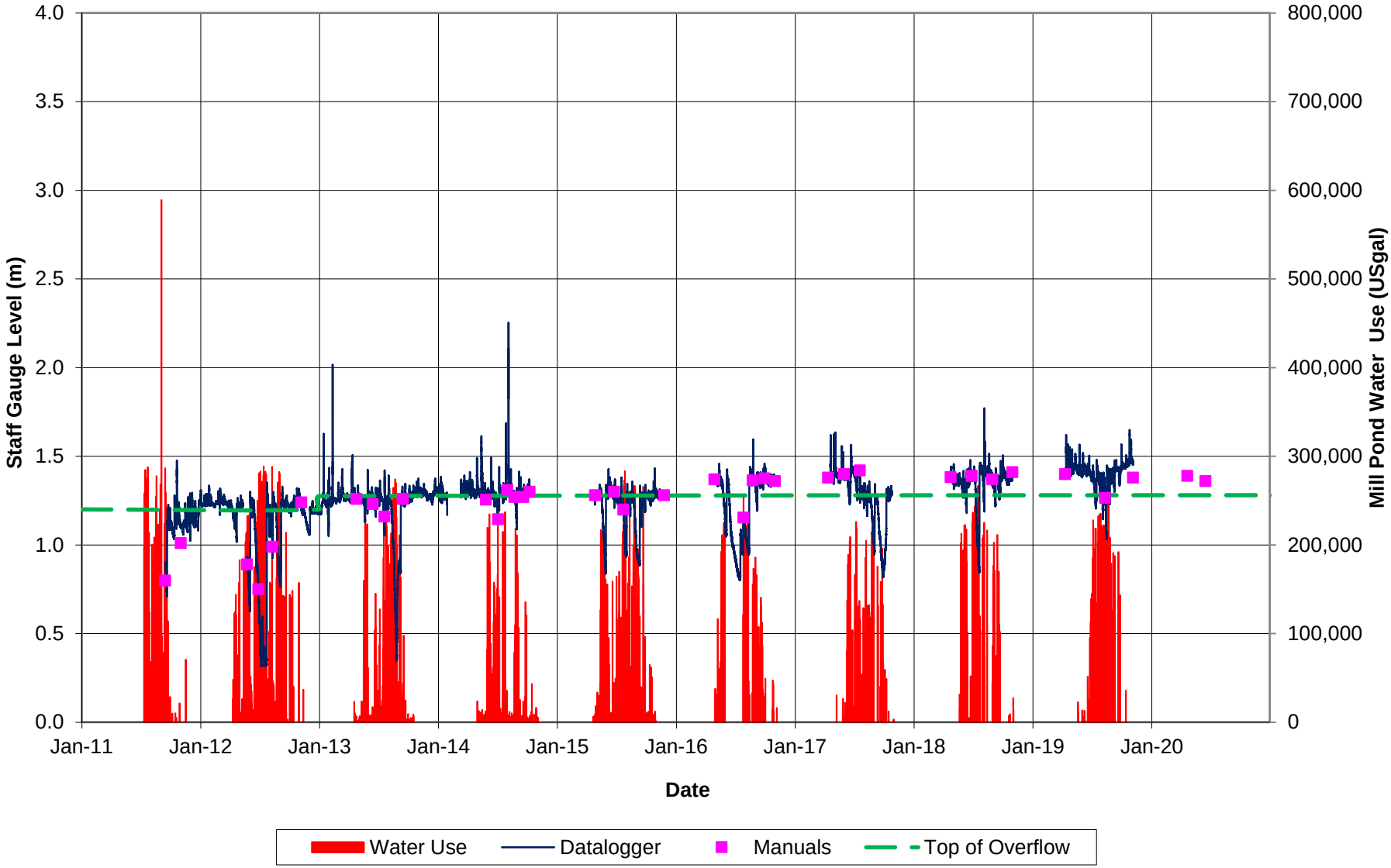
Millcroft Golf Club
SS3: Main Irrigation Pond
2011-2020 Hydrograph with Precipitation



R.J. Burnside & Associates Limited
File: 020649_PGD Millcroft PTTW Hydrographs
Prepared By: K. Lea

Figure F-3

Millcroft Golf Club
SS3: Main Irrigation Pond
2011-2020 Hydrograph with Water Use



R.J. Burnside & Associates Limited
File: 020649_PGD Millcroft PTTW Hydrographs
Prepared By: K. Lea

Figure F-4

Table F- 1
Surface Water Flows

Date	Days Since Precipitation:	Surface Water Flow (L/s)	
		SS1 (Upstream)	SS2 (Pond Outlet)
22-Jan-2019	**3**	frozen	frozen
22-Feb-2019	**3**	frozen	frozen
18-Mar-2019	**4**	78	71
11-Apr-2019	**3**	27	32
17-May-2019	**3**	40	81
20-Jun-2019	**0**	<0.5	<0.5
9-Jul-2019	**4**	<0.5	standing water
2-Aug-2019	**4**	<0.5	standing water
9-Sep-2019	**6**	<0.5	standing water
11-Oct-2019	**6**	2	standing water
6-Nov-2019	**0**	14	<0.5
9-Dec-2019	**0**	37	53
15-Jan-2020	**0**	55	164
11-Feb-2020	**1**	38	108
18-Mar-2020	**0**	29	56
21-Apr-2020	**0**	19	40
22-May-2020	**5**	15	standing water
8-Jun-2020	**6**	2	standing water

Flow measurements are in L/s

Table F-2: PTTW Surface Water Monitoring

Date	SS2 (Upstream of Pond)		SS3 (Pond Outlet)
	Stage (m)	Discharge (L/min)	Discharge (L/min)
September 14, 2011	0.165	-	-
November 1, 2011	0.255	480	-
January 17, 2012	0.35	6,540	-
March 6, 2012	0.25	2,580	-
April 12, 2012	0.08	120	-
May 10, 2012	0.22	900	-
May 22, 2012	0.18	60	-
June 4, 2012	0.27	2,160	-
June 26, 2012	0.21	-	-
August 8, 2012	0.17	120	-
November 5, 2012	0.28	3,780	-
April 23, 2013	0.27	1,620	-
June 13, 2013	0.27	1,560	-
July 19, 2013	0.18	-	-
September 13, 2013	0.24	360	-
May 27, 2014	0.17	434	324
July 3, 2014	0.26	1,266	-
July 31, 2014	0.27	2,914	1,100
August 22, 2014	0.12	379	-
September 19, 2014	0.13	470	-
October 8, 2014	0.29	4,272	6,564
June 25, 2015	0.11	257	-
July 23, 2015	0.19	133	-
April 28, 2016	0.19	147	-
July 26, 2016	0.11	575	0
August 24, 2016	0.06	55	-
September 29, 2016	0.11	216	1,576
April 12, 2017	0.18	1,968	1,320
May 31, 2017	0.15	1,755	-
July 19, 2017	0.08	570	-
October 26, 2017	0.11	702	355
April 24, 2018	0.29	2,471	1,360
June 28, 2018	0.26	2,506	-
August 30, 2018	0.05	175	-
October 31, 2018	0.36	5,870	11,110
April 11, 2019	0.20	1,583	1,906
June 20, 2019	0.09	316	-
August 12, 2019	0.03	-	-
November 6, 2019	0.12	606	-
April 21, 2020	0.15	634	2,485
June 16, 2020	0.08	87	-

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Appendix G

Water Balance Calculations

WATER BALANCE CALCULATIONS
Millcroft
Burlington, Ontario
October-20
PROJECT No.300043939

TABLE G-1

Pre- and Post-Development Monthly Water Balance Components

Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 100 mm (urban lawns in clay loam soils)

Climate data from Hamilton RBG Climate Station (1981 - 2010)

Potential Evapotranspiration Calculation	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Average Temperature (Degree C)	-4.7	-3.9	0.5	7.1	13.3	18.9	22	20.9	16.3	10	4.1	-1.4	**8.6**
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.03	1.70	4.40	7.49	9.42	8.72	5.98	2.86	0.74	0.00	**41.3**
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	1.42	29.73	61.02	91.26	108.61	102.41	77.03	44.01	15.85	0.00	**531**
Adjusting Factor for U (Latitude 43° 17' N)	0.81	0.82	1.02	1.12	1.26	1.28	1.29	1.20	1.04	0.95	0.81	0.77	
Adjusted Potential Evapotranspiration PET (mm)	0	0	1	33	77	117	140	123	80	42	13	0	**626**
COMPONENTS	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Precipitation (P)	57	57	64	73	86	73	83	90	81	72	91	72	**897**
Potential Evapotranspiration (PET)	0	0	1	33	77	117	140	123	80	42	13	0	**626**
P - PET	57	57	62	40	9	-44	-57	-33	1	30	78	72	**271**
Change in Soil Moisture Storage	0	0	0	0	0	-44	-56	0	1	30	69	0	**0**
Soil Moisture Storage max 100 mm	100	100	100	100	100	56	0	0	1	31	100	100	
Actual Evapotranspiration (AET)	0	0	1	33	77	117	139	90	80	42	13	0	**591**
Soil Moisture Deficit max 100 mm	0	0	0	0	0	44	100	100	99	69	0	0	
Water Surplus - available for infiltration or runoff	57	57	62	40	9	0	0	0	0	0	9	72	**306**
Potential Infiltration (based on MOECC metholodogy*; independent of temperature)	26	26	28	18	4	0	0	0	0	0	4	32	**138**
Potential Surface Water Runoff (independent of temperature)	31	31	34	22	5	0	0	0	0	0	5	40	**168**
IMPERVIOUS AREA WATER SURPLUS													
Precipitation (P)	897	mm/year											
Potential Evaporation (PE) from impervious areas (assume 15%)	135	mm/year											
P-PE (surplus available for runoff from impervious areas)	763	mm/year											

Assume January storage is 100% of Soil Moisture Storage

Soil Moisture Storage	100 mm	<-- See "Water Holding Capacity" values in Table 3.1, MOE SWMPDM, 2003
*MOECC SWM infiltration calculations		
topography - rolling land	0.2	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
soils - clay loam soils	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	**0.45**	
Latitude of site (or climate station)	43 ° N.	

WATER BALANCE CALCULATIONS
Millcroft
Burlington, Ontario
October-20
PROJECT No.300043939

TABLE G-2

Pre- and Post-Development Monthly Water Balance Components

Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 100 mm (urban lawns in clay loam soils - graded)

Climate data from Hamilton RBG Climate Station (1981 - 2010)

Potential Evapotranspiration Calculation	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Average Temperature (Degree C)	-4.7	-3.9	0.5	7.1	13.3	18.9	22	20.9	16.3	10	4.1	-1.4	**8.6**
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.03	1.70	4.40	7.49	9.42	8.72	5.98	2.86	0.74	0.00	**41.3**
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	1.42	29.73	61.02	91.26	108.61	102.41	77.03	44.01	15.85	0.00	**531**
Adjusting Factor for U (Latitude 43° 17' N)	0.81	0.82	1.02	1.12	1.26	1.28	1.29	1.20	1.04	0.95	0.81	0.77	
Adjusted Potential Evapotranspiration PET (mm)	0	0	1	33	77	117	140	123	80	42	13	0	**626**
COMPONENTS	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Precipitation (P)	57	57	64	73	86	73	83	90	81	72	91	72	**897**
Potential Evapotranspiration (PET)	0	0	1	33	77	117	140	123	80	42	13	0	**626**
P - PET	57	57	62	40	9	-44	-57	-33	1	30	78	72	**271**
Change in Soil Moisture Storage	0	0	0	0	0	-44	-56	0	1	30	69	0	**0**
Soil Moisture Storage max 100 mm	100	100	100	100	100	56	0	0	1	31	100	100	
Actual Evapotranspiration (AET)	0	0	1	33	77	117	139	90	80	42	13	0	**591**
Soil Moisture Deficit max 100 mm	0	0	0	0	0	44	100	100	99	69	0	0	
Water Surplus - available for infiltration or runoff	57	57	62	40	9	0	0	0	0	0	9	72	**306**
Potential Infiltration (based on MOECC metholodogy*; independent of temperature)	28	29	31	20	4	0	0	0	0	0	5	36	**153**
Potential Surface Water Runoff (independent of temperature)	28	29	31	20	4	0	0	0	0	0	5	36	**153**
IMPERVIOUS AREA WATER SURPLUS													
Precipitation (P)	897	mm/year											
Potential Evaporation (PE) from impervious areas (assume 15%)	135	mm/year											
P-PE (surplus available for runoff from impervious areas)	763	mm/year											

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

*MOECC SWM infiltration calculations

topography - rolling land (graded)	0.25	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
soils - clay loam soils	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
Millcroft
Burlington, Ontario
October-20
PROJECT No.300043939

BURNSIDE

TABLE G-3

Water Balance for Millcroft Hydrogeological Assessment
With No LID Mitigation Measures for Stormwater Management

Land Use Description		Approx. Land Area (m^2)	Estimated Impervious Fraction for Land Use	Estimated Impervious Area (m^2)	Runoff from Impervious Area** (m/a)	Runoff Volume from Impervious Area (m^3/a)	Estimated Pervious Area (m^2)	Runoff from Pervious Area** (m/a)	Runoff Volume from Pervious Area (m^3/a)	Infiltration in Pervious Area** (m/a)	Infiltration Volume in Pervious Area (m^3/a)	Total Runoff Volume (m^3/a)	Total Infiltration Volume (m^3/a)
Existing Land Use													
Site 'A'	Fairways/Greens/Cart Path	29,600	0.05	1,480	0.763	1,129	28,120	0.168	4,730	0.138	3,870	5,858	3,870
	Channel/Corridor	19,100	0.15	2,865	0.763	2,185	16,235	0.168	2,731	0.138	2,234	4,916	2,234
	Pond	10,000	0.85	8,500	0.763	6,483	1,500	0.168	252	0.138	206	6,735	206
	Subtotal	*58,700*	-	*12,845*	-	*9,797*	*45,855*	-	*7,712*	-	*6,310*	*17,509*	*6,310*
Site 'B'	Fairways/Greens/Cart Path	36,200	0.05	1,810	0.763	1,380	34,390	0.168	5,784	0.138	4,732	7,165	4,732
Site 'C'	Fairways/Greens/Cart Path	14,600	0.05	730	0.763	557	13,870	0.168	2,333	0.138	1,909	2,890	1,909
Site 'D'	Fairways/Greens/Cart Path	7,500	0.05	375	0.763	286	7,125	0.168	1,198	0.138	980	1,484	980
Site 'E'	Maintenance Shed	1,200	1.00	1,200	0.763	915	0	0.168	0	0.138	0	915	0
	Gravel Driveway/Landscaped	5,400	0.00	0	0.763	0	5,400	0.168	908	0.138	743	908	743
	Subtotal	*6,600*	-	*1,200*	-	*915*	*5,400*	-	*908*	-	*743*	*1,823*	*743*
TOTAL PRE-DEVELOPMENT		**123,600**		**16,960**		**12,935**	**106,640**		**17,936**		**14,675**	**30,871**	**14,675**
Post-Development Land Use (No LIDs)													
Site 'A'	Low Density	15,400	0.56	8,624	0.763	6,578	6,776	0.153	1,036	0.153	1,036	7,614	1,036
	Buffer/Landscape	5,300	0.15	795	0.763	606	4,505	0.153	689	0.153	689	1,295	689
	R.O.W	7,100	1.00	7,100	0.763	5,415	0	0.153	0	0.153	0	5,415	0
	Easements/CN Berm	1,800	0.00	0	0.763	0	1,800	0.153	275	0.153	275	275	275
	Channel/Corridor	19,100	0.15	2,865	0.763	2,185	16,235	0.168	2,731	0.138	2,234	4,916	2,234
	Pond	10,000	0.85	8,500	0.763	6,483	1,500	0.168	252	0.138	206	6,735	206
	Site 'A' Subtotal	*58,700*	-	*27,884*	-	*21,267*	*30,816*	-	*4,983*	-	*4,441*	*26,250*	*4,441*
Site 'B'	Low Density	23,400	0.56	13,104	0.763	9,994	10,296	0.153	1,574	0.153	1,574	11,569	1,574
	Buffer/Landscape	6,600	0.15	990	0.763	755	5,610	0.153	858	0.153	858	1,613	858
	R.O.W	4,800	1.00	4,800	0.763	3,661	0	0.153	0	0.153	0	3,661	0
	Easements/CN Berm	1,400	0.00	0	0.763	0	1,400	0.153	214	0.153	214	214	214
	Site 'B' Subtotal	*36,200*	-	*18,894*	-	*14,411*	*17,306*	-	*2,646*	-	*2,646*	*17,057*	*2,646*
Site 'C'	Low Density	9,300	0.56	5,208	0.763	3,972	4,092	0.153	626	0.153	626	4,598	626
	Cart Path	500	0.80	400	0.763	305	100	0.153	15	0.153	15	320	15
	Buffer/Landscape	2,800	0.15	420	0.763	320	2,380	0.153	364	0.153	364	684	364
	R.O.W	2,000	1.00	2,000	0.763	1,525	0	0.153	0	0.153	0	1,525	0
	Site 'C' Subtotal	*14,600*	-	*8,028*	-	*6,123*	*6,572*	-	*1,005*	-	*1,005*	*7,128*	*1,005*
Site 'D'	Low Density	4,100	0.56	2,296	0.763	1,751	1,804	0.153	276	0.153	276	2,027	276
	Buffer/Landscape	1,800	0.15	270	0.763	206	1,530	0.153	234	0.153	234	440	234
	R.O.W	1,600	1.00	1,600	0.763	1,220	0	0.153	0	0.153	0	1,220	0
	Site 'D' Subtotal	*7,500*	-	*4,166*	-	*3,177*	*3,334*	-	*510*	-	*510*	*3,687*	*510*
Site 'E'	High Density	1,400	0.85	1,190	0.763	908	210	0.153	32	0.153	32	940	32
	Open Space	900	0.00	0	0.763	0	900	0.153	138	0.153	138	138	138
	Buffer/Landscape	3,400	0.15	510	0.763	389	2,890	0.153	442	0.153	442	831	442
	R.O.W	900	1.00	900	0.763	686	0	0.153	0	0.153	0	686	0
	Site 'E' Subtotal	*6,600*	-	*2,600*	-	*1,983*	*4,000*	-	*612*	-	*612*	*2,595*	*612*
TOTAL POST-DEVELOPMENT		**123,600**		**61,572**		**46,961**	**62,028**		**9,755**		**9,213**	**56,717**	**9,213**
											% Change from Pre to Post	184	37
											Effect of development (with no mitigation)	1.8 times increase in runoff	37% reduction of infiltration

* data provided by Urbantech

** figures from Table G-1 and G-3

To balance pre- to post-, the infiltration target (m^3/a)= **5,462**

WATER BALANCE CALCULATIONS
Millcroft
Burlington, Ontario
October-20
PROJECT No.300043939

TABLE G-4

Pre- and Post-Development Monthly Water Balance Components

Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 100 mm (urban lawns in clay loam soils - graded + additional topsoil)

Climate data from Hamilton RBG Climate Station (1981 - 2010)

Potential Evapotranspiration Calculation	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Average Temperature (Degree C)	-4.7	-3.9	0.5	7.1	13.3	18.9	22	20.9	16.3	10	4.1	-1.4	**8.6**
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.03	1.70	4.40	7.49	9.42	8.72	5.98	2.86	0.74	0.00	**41.3**
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	1.42	29.73	61.02	91.26	108.61	102.41	77.03	44.01	15.85	0.00	**531**
Adjusting Factor for U (Latitude 43° 17' N)	0.81	0.82	1.02	1.12	1.26	1.28	1.29	1.20	1.04	0.95	0.81	0.77	
Adjusted Potential Evapotranspiration PET (mm)	0	0	1	33	77	117	140	123	80	42	13	0	**626**
COMPONENTS	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Precipitation (P)	57	57	64	73	86	73	83	90	81	72	91	72	**897**
Potential Evapotranspiration (PET)	0	0	1	33	77	117	140	123	80	42	13	0	**626**
P - PET	57	57	62	40	9	-44	-57	-33	1	30	78	72	**271**
Change in Soil Moisture Storage	0	0	0	0	0	-44	-56	0	1	30	69	0	**0**
Soil Moisture Storage max 100 mm	100	100	100	100	100	56	0	0	1	31	100	100	
Actual Evapotranspiration (AET)	0	0	1	33	77	117	139	90	80	42	13	0	**591**
Soil Moisture Deficit max 100 mm	0	0	0	0	0	44	100	100	99	69	0	0	
Water Surplus - available for infiltration or runoff	57	57	62	40	9	0	0	0	0	0	9	72	**306**
Potential Infiltration (based on MOECC metholodogy*; independent of temperature)	31	31	34	22	5	0	0	0	0	0	5	40	**168**
Potential Surface Water Runoff (independent of temperature)	26	26	28	18	4	0	0	0	0	0	4	32	**138**
IMPERVIOUS AREA WATER SURPLUS													
Precipitation (P)	897	mm/year											
Potential Evaporation (PE) from impervious areas (assume 15%)	135	mm/year											
P-PE (surplus available for runoff from impervious areas)	763	mm/year											

Assume January storage is 100% of Soil Moisture Storage

Soil Moisture Storage	100 mm	<-- See "Water Holding Capacity" values in Table 3.1, MOE SWMPDM, 2003
*MOECC SWM infiltration calculations		
topography - rolling land (graded)	0.25	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
soils - clay loam soils + additional topsoil	0.2	<-- 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	**0.55**	
Latitude of site (or climate station)	43 ° N.	

WATER BALANCE CALCULATIONS
Millcroft
Burlington, Ontario
October-20
PROJECT No.300043939

BURNSIDE

TABLE G-5

Water Balance for Millcroft Hydrogeological Assessment
With LID Mitigation Measures for Stormwater Management

Land Use Description		Approx. Land Area (m^2)	Estimated Impervious Fraction for Land Use	Estimated Impervious Area (m^2)	Runoff from Impervious Area** (m/a)	Runoff Volume from Impervious Area (m^3/a)	Estimated Pervious Area (m^2)	Runoff from Pervious Area** (m/a)	Runoff Volume from Pervious Area (m^3/a)	Infiltration in Pervious Area** (m/a)	Infiltration Volume in Pervious Area (m^3/a)	Total Runoff Volume (m^3/a)	Total Infiltration Volume (m^3/a)
Existing Land Use													
Site 'A'	Fairways/Greens/Cart Path	29,600	0.05	1,480	0.763	1,129	28,120	0.168	4,730	0.138	3,870	5,858	3,870
	Channel/Corridor	19,100	0.15	2,865	0.763	2,185	16,235	0.168	2,731	0.138	2,234	4,916	2,234
	Pond	10,000	0.85	8,500	0.763	6,483	1,500	0.168	252	0.138	206	6,735	206
	Subtotal	*58,700*	-	*12,845*	-	*9,797*	*45,855*	-	*7,712*	-	*6,310*	*17,509*	*6,310*
Site 'B'	Fairways/Greens/Cart Path	36,200	0.05	1,810	0.763	1,380	34,390	0.168	5,784	0.138	4,732	7,165	4,732
Site 'C'	Fairways/Greens/Cart Path	14,600	0.05	730	0.763	557	13,870	0.168	2,333	0.138	1,909	2,890	1,909
Site 'D'	Fairways/Greens/Cart Path	7,500	0.05	375	0.763	286	7,125	0.168	1,198	0.138	980	1,484	980
Site 'E'	Maintenance Shed	1,200	1.00	1,200	0.763	915	0	0.168	0	0.138	0	915	0
	Gravel Driveway/Landscaped	5,400	0.00	0	0.763	0	5,400	0.168	908	0.138	743	908	743
	Subtotal	*6,600*	-	*1,200*	-	*915*	*5,400*	-	*908*	-	*743*	*1,823*	*743*
TOTAL PRE-DEVELOPMENT		**123,600**		**16,960**		**12,935**	**106,640**		**17,936**		**14,675**	**30,871**	**14,675**
Post-Development Land Use (with LIDs)													
Site 'A'	Low Density - less roof area	7,854	0.14	1,076	0.763	821	6,778	0.138	933	0.168	1,140	1,753	1,140
	Low Density - roof area to grass. Assume 25% of runoff volume infiltrates[a].	7,546	1.00	7,546	0.763	5,755	0	0.138	0	0.168	0	4,317	1,439
	Buffer/Landscape	5,300	0.15	795	0.763	606	4,505	0.138	620	0.168	758	1,226	758
	R.O.W	7,100	1.00	7,100	0.763	5,415	0	0.138	0	0.168	0	5,415	0
	Easements/CN Berm	1,800	0.00	0	0.763	0	1,800	0.138	248	0.168	303	248	303
	Channel/Corridor	19,100	0.15	2,865	0.763	2,185	16,235	0.168	2,731	0.138	2,234	4,916	2,234
	Pond	10,000	0.85	8,500	0.763	6,483	1,500	0.168	252	0.138	206	6,735	206
	Site 'A' Subtotal	*58,700*	-	*27,882*	-	*21,266*	*30,818*	-	*4,783*	-	*4,641*	*24,610*	*6,080*
Site 'B'	Low Density - less roof area	11,934	0.14	1,635	0.763	1,247	10,299	0.138	1,417	0.168	1,732	2,664	1,732
	Low Density - roof area to grass. Assume 25% of runoff volume infiltrates[a].	11,466	1.00	11,466	0.763	8,745	0	0.138	0	0.168	0	6,559	2,186
	Buffer/Landscape	6,600	0.15	990	0.763	755	5,610	0.138	772	0.168	944	1,527	944
	R.O.W	4,800	1.00	4,800	0.763	3,661	0	0.138	0	0.168	0	3,661	0
	Easements/CN Berm	1,400	0.00	0	0.763	0	1,400	0.138	193	0.168	235	193	235
	Site 'B' Subtotal	*36,200*	-	*18,891*	-	*14,408*	*17,309*	-	*2,382*	-	*2,911*	*14,604*	*5,098*
Site 'C'	Low Density - less roof area	4,743	0.14	650	0.763	496	4,093	0.138	563	0.168	688	1,059	688
	Low Density - roof area to grass. Assume 25% of runoff volume infiltrates[a].	4,557	1.00	4,557	0.763	3,476	0	0.138	0	0.168	0	2,607	869
	Cart Path	500	0.80	400	0.763	305	100	0.138	14	0.168	17	319	17
	Buffer/Landscape	2,800	0.15	420	0.763	320	2,380	0.138	328	0.168	400	648	400
	R.O.W	2,000	1.00	2,000	0.763	1,525	0	0.138	0	0.168	0	1,525	0
	Site 'C' Subtotal	*14,600*	-	*8,027*	-	*6,122*	*6,573*	-	*905*	-	*1,106*	*6,158*	*1,974*
Site 'D'	Low Density - less roof area	2,091	0.14	286	0.763	218	1,805	0.138	248	0.168	304	467	304
	Low Density - roof area to grass. Assume 25% of runoff volume infiltrates[a].	2,009	1.00	2,009	0.763	1,532	0	0.138	0	0.168	0	1,149	383
	Buffer/Landscape	1,800	0.15	270	0.763	206	1,530	0.138	211	0.168	257	416	257
	R.O.W	1,600	1.00	1,600	0.763	1,220	0	0.138	0	0.168	0	1,220	0
	Site 'D' Subtotal	*7,500*	-	*4,165*	-	*3,177*	*3,335*	-	*459*	-	*561*	*3,253*	*944*
Site 'E'	High Density	1,400	0.85	1,190	0.763	908	210	0.138	29	0.168	35	937	35
	Open Space	900	0.00	0	0.763	0	900	0.138	124	0.168	151	124	151
	Buffer/Landscape	3,400	0.15	510	0.763	389	2,890	0.138	398	0.168	486	787	486
	R.O.W	900	1.00	900	0.763	686	0	0.138	0	0.168	0	686	0
	Site 'E' Subtotal	*6,600*	-	*2,600*	-	*1,983*	*4,000*	-	*550*	-	*673*	*2,533*	*673*
TOTAL POST-DEVELOPMENT		**123,600**		**61,565**		**46,956**	**62,035**		**9,079**		**9,891**	**51,158**	**14,768**
											% Change from Pre to Post	166	-1
											Effect of development (with mitigation)	1.7 times increase in runoff	maintains infiltration

* data provided by Urbantech

** figures from Table G-1, G-2 and G-5

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

To balance pre- to post-, the infiltration target (m^3/a)= **-94**