Preliminary Hydrogeological Assessment

Shadow Creek Subdivision

Township of Severn

Prepared for:
LIV Communities

Prepared by:
Azimuth Environmental
Consulting, Inc.

January 2022

AEC 21-098

AZIMUTH ENVIRONMENTAL
CONSULTING, INC.
Environmental Assessments & Approvals

January 20, 2022 AEC 21-098

LIV Communities
1005 Skyview Drive, Suite 301
Burlington, Ontario
L7P 5B1

Attention: Sam Badawi
Land Development

Re: Preliminary Hydrogeological Assessment
Parts of Lots 3, 4, & 5, Concession 9, Township of Severn, Ontario

Dear Mr. Badawi:

Azimuth Environmental Consulting, Inc. (Azimuth) is pleased to provide our Preliminary Hydrogeological Assessment for the property located within Parts of Lots 3, 4, & 5, Concession 9, within the Township of Severn, Ontario (the "Site"). The municipal address of the Site is 3651 Menoke Beach Road and 8743 Highway 11. This evaluation was focused on the existing soil and ground water regime underlying the Site.

Should you have any questions or wish to discuss the report in greater detail, please do not hesitate to contact the undersigned.

Yours truly,

AZIMUTH ENVIRONMENTAL CONSULTING, INC.

PROFESSIONAL GEOSCIENTIST
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1.0 INTRODUCTION

Azimuth Environmental Consulting, Inc. ("Azimuth") has been retained by LIV Communities to conduct a Hydrogeological Assessment for the proposed Shadow Creek Subdivision development located within Parts of Lots 3, 4, & 5, Concession 9, within the Township of Severn, Ontario (the "Site"). The municipal address of the Site is 3651 Menoke Beach Road and 8743 Highway 11 (Figure 1).

The proposed development is approximately 45.4 hectares (ha) in size and is located on the south east side of Highway 11 and the north east side of Menoke Beach Road (Figure 2). The parcel is currently composed of agricultural land, with numerous drainage channels intersecting the site in a west to east direction. The channels are surrounded with shrub and/or forest vegetation, and flow toward Lake Couchiching, which is located approximately 230 m to the east. A cluster of barn structures and a silo are located adjacent to Highway 11 in the north west portion of the Site.

The proposed development includes the construction of 319 single lot residential homes and 215 townhomes with associated road, storm water management, open space, and park space (Site Plan; Appendix B)

The current assessment provides a summary of the existing environmental conditions as it relates to the soil and ground water regime at the Site. A preliminary water balance was also completed, which compares the pre- and post-development infiltration/runoff values for the Site.

2.0 BACKGROUND

The following documents were reviewed as part of the current assessment:

- Soil-Mat Engineers & Consultants Ltd. 2021. Preliminary Geotechnical Investigation. Proposed Shadow Creek Residential Development. Highway 11 and Menoke Beach Road. Township of Severn, Ontario.

3.0 ENVIRONMENTAL SETTING

3.1 Soil

The soil map of Simcoe County (Soil Survey Report No. 29, Scale 1:63,360) shows the uppermost soil at the Site to be composed primarily of Lovering silty clay loam with some Tioga loamy sand along the Highway 11 corridor. Lovering silty clay loam is classified within hydrologic soil group C, while Tioga loamy sand is classified within hydrologic soil group A. Group A soils represent material with low runoff potential and high infiltration rates even when thoroughly wetted. Group C soils represent material with moderately high runoff potential when thoroughly wet and where water transmission through the soil is somewhat restricted.

3.2 Physiography

The Ontario Geologic Survey (Chapman and Putnam, 1984) describes the area as being located within the Simcoe Lowlands Physiographic region. The Simcoe Lowlands represent areas that were flooded by glacial Lake Algonquin and are bordered by shorecliffs, beaches, and boulder terraces. This area covers approximately 2,850 square kilometres and is separated into two areas: the Lake Simcoe basin and the Nottawasaga River basin, of which the Site is located in the Lake Simcoe basin. This area was under Lake Algonquin, so some beaches and offshore sand deposits are found locally.

3.3 Topography and Drainage

According to local topographic mapping and the information reviewed in Appendix B, the Site is found at an elevation of 219 – 226 masl (Figure 5). In general, the Site and surrounding area slopes from west to east, toward the shore of Lake Couchiching. Numerous drainage channels intersect the Site, collecting runoff from the onsite and upland agricultural area. The drainage channels direct water into a wetland area immediately east of the Site associated with Shadow Creek which flows from the north and an unnamed creek flowing from the south. These features are directly connected to Lake Couchiching, such that water levels in these features are primarily controlled by the lake levels (Figure 5).

Figure 5 displays the presence of surface water drainage channels and the adjacent wetland feature on the Site and in the vicinity of the Site. The EIS also completed by Azimuth for the Site has identified potential ground water seepage areas along the northern branch of the retained wetland area at the western side of the Site. These areas were noted through vegetation assessment and persistent saturation into late spring / early summer, where the remaining drainage channels were observed to have only trickle flow, indicating that from a quantitative perspective, the on-site and off-site wetland and water course features are primarily surface water fed. Despite the ground water seepage present, the flow from these are noted to be localized and do not create a significant contribution to the main Site drainage channel relative to the surface water contributions from the surrounding area.

3.4 Bedrock Geology

The Ontario Geologic Survey (OGS) Earth Database shows that the uppermost bedrock unit at the subject property consists of limestone and dolostone of the Simcoe Group of the Gull River Formation (OGS, 2021). The Simcoe Group is Middle Ordovician in age. Based on information reviewed in Section 3.5, the depth to bedrock was inferred based on auger refusal, and was found between 2.3 and 11 mbgs.

3.5 Quaternary Geology

The mapped surficial material for the Site is composed primarily of coarse-textured glaciolacustrine deposits containing sand, gravel, and minor silt and clay (OGS, 2021). However, a portion of the Site to the south east is reportedly composed of fine-textured glaciolacustrine deposits containing silt and clay with minor sand and gravel.

Soil Mat Engineers & Consultants Ltd. completed a geotechnical drilling program for the Site on April 8th and 9th, 2021 (Soil-Mat, 2021). As part of this program, nine (9) boreholes were advanced at the Site to a depth between 2.3 and 11.0 mbgs. Four of the boreholes were completed as monitoring wells (MW-3, MW-6, MW-7, and MW-9). The soils are described as silt and clayey silt with trace sand and gravel content ranging from firm to stiff indicating the surficial material is comprised of glacial till. Additional test pits were completed across the Site to facilitate Guelph Permeameter testing and installation of shallow standpipe monitoring wells at additional locations on the Site. The soils observed in these locations generally matched those described in the Soil Mat logs comprised mainly of sandy and clayey silt glacial till although more surficial granular sands were observed at the western and eastern extents of the Site. All borehole / monitoring well locations have been in illustrated on Figure 2, while the logs for each are included in Appendix E.

3.6 Hydrogeology

The Ontario Ministry of Environment, Conservation, and Parks (MECP)'s Water Well Records (Appendix D) were referenced for any recorded well information within the vicinity (1,000 m of centre) of the Site (GIN, 2021). The development will be serviced with municipal services (water and sewer); however many adjacent parcels still utilize private wells for potable water. Historic well records can also be used to gain subsurface information which can provide insight into the geological formations within the area. All wells within 1,000 m of the centre of the Site are provided on Figure 4 and a table summarizing the details for each well are provided in Appendix C.

The well records indicated they were advanced primarily for domestic use, with some commercial, cooling and A/C, livestock, and public water users listed. Three records were listed as abandoned. Table 1 below summarizes the well depths recorded.

Table 1: Summary of Adjacent Well Record Depth

Depth (m)	Number of Records
0 – 10	19
10 – 20	60
20 – 30	18
30 – 40	6
40+	11
Total	**114**

The wells were drilled between 6.5 and 91.4 mbgs, with corresponding water levels ranging between 0.0 and 31.4 mbgs. In general, the overburden material is composed of surficial clay over limestone bedrock. The limestone was typically encountered within 10 m of the ground surface.

Nineteen (19) well records within 1,000 m of the Site are reportedly less than 10 m deep. This is not unexpected due to the shallow ground water level and proximity of the Site to Lake Couchiching. Due to the fine grained nature of the surficial material (clay and silt), most wells records are drilled into and obtain potable water from the underlying limestone bedrock.

The entire Site is considered a Significant Ground Water Recharge Area (SGRA) and a Highly Vulnerable Aquifer (HVA). The Site is also considered an Intake Protection Zone (IPZ) 2, due to the proximity to the West Shore Water Treatment Plant and associated intake pipe within Lake Couchiching. Given the development is residential in nature, located in the IPZ-2, with a vulnerability score of 5.6, there would be no additional reporting requirement (*i.e.* risk management plans) or development limitations due to its location within the IPZ. This was confirmed with the Severn Sound Environmental Association (SSEA) Risk Management Official.

4.0 MONITORING

4.1 Groundwater Elevations

The water level at each of the monitoring wells installed at the Site were measured in April and November of 2021. The ground water table elevations are given in the below Table 2 and Figure 4. Continued water level monitoring is being completed every three months for a year including continuous water level monitoring at three monitoring well locations to assess shorter term trending. The data collected to date would suggest high water table conditions exist across the Site (<1 mbgs) and that the November 2021 data is likely most representative of the seasonally high water table.

Table 2: Summary of Ground Water Measurements

Well ID	Ground Elevation (masl)	Screen Interval (mbgs)	Water Level (mbgs)			Water Level (masl)		
			13-Apr-21	11-Nov-21	17-Nov-21	13-Apr-21	11-Nov-21	17-Nov-21
BH-3	221.06	2.8 to 5.8	0.78	0.81	0.69	220.28	220.25	220.37
BH-6	220.99	2.8 to 5.4	0.33	0.28	0.13	220.66	220.71	220.86
BH-7	219.83	3.3 to 4.0	0.57	0.45	0.30	219.26	219.38	219.53
BH-9	221.28	2.7 to 4.2	0.67	0.82	0.72	220.61	220.46	220.56
TP-1	226.30	0.13 to 1.5			0.12			226.18
TP-2	224.80	1.5 to 3.0			1.06			223.74
TP-3	219.48	0.6 to 2.1			0.16			219.32
TP-4	225.20	1.4 to 2.9			1.52			223.68
TP-5	221.98	1.4 to 2.9			0.43			221.55

In general, the available data shows the shallow ground water flow matches the local topography and flows from west to east (Figure 5). This is consistent with the regional understanding, which is that shallow ground water flows toward Lake Couchiching discharging into the Lake.

4.2 Hydraulic Conductivity Testing

Azimuth staff completed single well response tests (slug tests) within three (3) monitoring wells at the Site, which given the general consistency in geology across the Site is considered representative for establish hydraulic properties of the shallow water table aquifer. The results are shown in the below Table 3 and in Appendix F.

A slug test involves the instantaneous injection or withdrawal of a volume or slug of water or solid cylinder of known volume. This is accomplished by adding or displacing a known volume to/from a well and measuring water level response time to return to equilibrium.

Table 3: Hydraulic Testing Results

Monitoring Well	Log Hydraulic Conductivity (m/s)	Soil Description
BH-3	8.1×10^{-7}	Clayey Silt / Silt
BH-6	1.6×10^{-6}	Silt
BH-9	1.3×10^{-6}	Silt

Notes: Values rounded off for presentation purposes

Slug test data indicates that the hydraulic conductivity of the deposits range between 8.1×10^{-7} to 1.6×10^{-6} m/s. These results indicate relative consistency across the Site which as noted above is expected given the general consistency in soils.

4.3 Infiltration Testing

The current Infiltration Assessment focused on the potential across the Site to accommodate potential LID features by determining infiltration rates. As such, locations were selected to provide coverage across the entire Site, while input on locations were also solicited from the project storm water engineers. The locations correlated with the "TP" monitoring well locations on Figure 4.

4.3.1 Methodology

A field program was conducted by Azimuth staff on November 9th and 10th 2021 during which the weather was approximately 4-13°C and overcast. The locations were recorded by a handheld GPS and incorporated into the Site drawings such that a spot elevation from the Site survey could be utilized to establish elevations for each location.

The Infiltration Assessment was completed in accordance with Appendix C of the *Low Impact Development Stormwater Management Planning and Design Guide* (TRCA 7 CVC, 2010). As no details are available with respect to target elevations for the potential LID's, test pits were excavated such that testing depths would target approximately 0.5 m above the observed water table based on visual observations of seepage within the test pits upon completion. A hand auger was then used within the test pit to remove approximately 0.2 m of additional soil. Test pits were typically about 2 m wide and 4 m long with depths ranging between 2 and 3.3 mbgs to visually assess ground water conditions, while testing depths ranged between 0.4 and 1.1 mbgs.

The Guelph Permeameter Model 2800K1 (Soil Moisture Equipment Corp.) was used to measure the in-situ hydraulic conductivity as per the *Guelph Permeameter Operating Instructions* (Soil Moisture, 2012). The two head method utilizing a combined reservoir was utilized. Two tests are typically completed with varying well head height; however, saturation in some locations were observed as the testing sequence was completed such that only a single test was complete or the second test did not show a response due to the saturated conditions.

Soil samples were collected from each test pit at the depth of the testing intervals for laboratory grain size and T-Time analysis. The soil sample analysis was used to confirm the in-situ results. After the infiltration tests were completed, the test pits were utilized for standpipe installations and were backfilled with the original soil material.

4.3.2 Test Results

The material encountered within the test pit was composed of mainly of sandy and clayey silt glacial till to approximately 3.0 mbgs. Ground water was observed in all test pits with the exception of TP-4 with observed seepage depths ranging from 0.8 m to 3.2 mbgs although saturated conditions more elevated in the test pit profile developed over the testing sequence. The complete test pit log is included in Appendix E, while the results of the infiltration assessment are included in Appendix G and Table 4 below.

The Guelph Permeameter generates a result as a hydraulic conductivity (K_{fs}) value. As per Table C1 from CVC & TRCA (2010), the K_{fs} values from the Guelph Permeameter and percolation rate (T-Time) values from the grain size analysis have been converted to an infiltration rate (1/T).

Based on the information provided in Table 4, the measured in-situ infiltration rate at the Site ranged between 0 and 46 mm/hr. As per TRCA & CVC (2010), the infiltration rate used to design infiltration LIDs must incorporate a safety correction factor that compensates for potential reductions in soil permeability due to compaction or smearing during construction, gradual accumulation of fine sediments over the lifespan of the LID, and an uncertainty in measured values when less permeable soil horizons exist. Based on the results of the current test pit program and the geotechnical program completed in May (Soil-Mat, 2021), significantly less permeable soil horizons below the testing depth are not anticipated. Therefore, a safety correction factor of 2.5 was used as per TRCA & CVC (2010) and incorporated into the Design Infiltration Rate. Overall, these rates are variable and elevated in some instances above values expected from a silt or clayey silt. Given the saturated conditions observed at the outset of the test pit excavation, throughout testing, and measured water table conditions the following week, it is apparent that the saturated conditions limited the ability to collect accurate infiltration data. As such, for reference, it is likely more appropriate to utilize the estimated infiltration rate determined through the soil sample T-time data for design of any potential LID's at the Site above the water table. Regardless, the results for the Site indicate that the infiltration rate for the material observed in the shallow soils at the Site are considered low.

Table 4: Results of Infiltration Assessment

Test Pit ID / Depth (mbgs)	Soil Type at Depth[1]	Guelph Permeameter Results			Design Infiltration Rate (mm/hr)	Estimated Infiltration Rate from Soil Sample [1,3] (mm/hr)
		Test # 1 Infiltration Rate[2] (mm/hr)	Test # 2 Infiltration Rate[2] (mm/hr)	Geometric Mean Infiltration Rate (mm/hr)		
TP-1 (0.4)	Silt, Some Sand, Some Clay	0*	0*	0*	0*	12 mm/hr
TP-2 (0.7)	Sandy Silt, Trace Clay	42	0*	42	17	15 mm/hr
TP-3 (0.8)	Silt, Some Sand, Trace Clay	Testing not attempted as saturation visible immediately upon completion of test pit				12 mm/hr
TP-4 (0.7)	Clayey Silt, Trace Sand	46	0*	46	18	< 12 mm/hr
TP-5 (0.4)	Silt, Trace Clay, Trace Sand	34	0*	34	14	12 mm/hr

Notes:

1 - As per GEI Consultants T-Time Analyses (Appendix G)

2 - Guelph Permeameter results are converted from K_{fs} to 1/T according to Table C1 from TRCA & CVC (2010)

3- Soil sample collection results are converted from T-Time to 1/T according to Table C1 from TRCA & CVC (2010)

* - Test not analyzed as no or insufficient infiltration was observed owing to saturated conditions in the soil

5.0 WATER BALANCE

In order to determine the potential changes to the natural ground water recharge conditions, a pre- and post-development water balance assessment has been completed using the Thornthwaite and Mather method (1957). This method evaluates evapotranspiration based on precipitation and temperature. Residual soil saturation is a function of topography and soil type. Monthly data are tabulated from daily average temperature and precipitation, and the water budget is a continuous calculation over the period of record. To clarify, the method and the approach used by many individuals in examining infiltration resets annual conditions (moisture deficit, snow storage, etc) over the winter months because of the general lack of infiltration during the frost period. However, we maintain those records and carry them forward from month to month during the entire period of record.

Values were determined on a monthly basis, compiled from daily Environment Canada meteorological data station located in Orillia, Ontario between 1992 and 2019 (Station ID 6115811). The calculations are based on the average conditions during this period; the average precipitation was 1,079 mm, rainfall was 742 mm, evapotranspiration was 542 mm and the surplus was 537 mm.

5.1 Land Use

5.1.1 Pre-Development

The pre-development Site area was classified according to land use/vegetation type. Land within the pre-development area is considered structure and pavement, agricultural, naturalized forest/shrub, and wetland. A summary of the pre-development land use is provided in Table 5.

Table 5: Pre Development Area Classification

Land Use	Land Area (m^2)
Structure and Pavement (impervious)	2,500
Agricultural (pervious)	306,500
Forest/ shrub (pervious)	118,386
Wetland (impervious)	27,114
TOTAL	**454,500**

Land within the pre-development scenario is considered 7% impervious.

5.1.2 Post-Development

The land classification in the post-development scenario was based on the proposed MHBC development plan (Appendix B). Land within the post-development Site is summarized in the below Table 6:

Table 6: Post Development Area Classification

Land Use	Land Area (m^2)
Townhomes (pervious)*	22,040
Townhomes Roof (impervious)*	27,550
Townhomes Driveway (impervious)*	5,510
Single Detached Lot Grass (pervious)*	53,200
Single Detached Lots Roof (impervious)*	66,500
Single Detached Lots Driveway (impervious)*	13,300
Streets / Walkways (impervious)**	71,570
Streets / Walkways (pervious [grass blvd.])**	12,630
Stormwater Management Pond Blocks (pervious)***	15,350
Stormwater Management Pond Blocks (impervious)***	15,350
Pump Station Block (pervious)***	500
Pump Station Block (impervious)***	500
Environmental Protection Area (pervious [forested])	111,186
Waterfront Access & Open Space (pervious [grassed])	12,200
Environmental Protection Area (impervious [wetland])	27,114
TOTAL	**454,500**

* - Roof (50%) / Driveway (10%) / Grass (40%) ratio assumed
** - Road, Sidewalk & Blvd. Driveway (85%) / Grass Blvd. (15%) ratio assumed
*** - impervious (50%) / pervious (50%) ratio assumed

Land within the post-development scenario is considered 50% impervious.

5.2 Infiltration

Infiltration is generated one of two ways: (1) directly from rainfall impact on pervious surfaces; and (2) indirectly when runoff from impervious surfaces is diverted into adjacent naturalized areas.

Infiltration factors for the Site were estimated based on the underlying soil, local topography, and ground cover as per Table 2 of the Ministry of Environment and Energy (MOEE) Hydrogeological Technical Information Requirements for Land Development Applications (1995).

The soil variable factor was determined by taking into account information obtained from the regional geologic mapping and the Site borehole / test pit logs (Appendix E). This information suggests that the surficial material at the Site is primarily composed of silt till native material. The infiltration factors utilized in the water balance assessment are summarized in Table 7 below.

Table 7: Summary of Pervious Land Infiltration Factor

Scenario	Land Use	Infiltration Factor	Assumption
Pre-Development	Forest / Shrub	0.55	Rolling land (0.2), silt till soil (0.15), woodland (0.2)
	Agricultural	0.45	Rolling land (0.2), silt till soil (0.15), cultivated lands (0.1)
	Wetland	0.0	Saturated ground does not permit infiltration
Post-Development	Landscaped	0.45	Rolling land (0.2), silt till soil (0.15), cultivated lands (0.1)
	Forest / Shrub	0.55	Rolling land (0.2), silt till soil (0.15), woodland (0.2)
	Wetland	0.0	Saturated ground does not permit infiltration
	Impervious (rooftop, road, stormwater pond, other hard surface)	0.0	No infiltration on hard surface

5.2.1 Pre-Development Infiltration

Pre-development infiltration was determined by multiplying the annual average surplus amount, the area of each land use, and the infiltration factor for each land use. The pre-development annual infiltration is therefore 108,625 m^3/year (Appendix D).

5.2.2 Post-Development Infiltration

Post-development infiltration (without mitigation) was determined by multiplying the annual average surplus amount, the area of each land use, and the infiltration factor for each land use. The post-development annual direct infiltration is therefore 60,624 m^3/year. There is therefore a decrease in infiltration of 48,001 m^3/year from pre- to post-development without any mitigation measures employed.

Additional infiltration will be gained by directing rooftop runoff toward the adjacent grass surface. There is approximately 101,150 m^2 of rooftop area which will contribute to indirect infiltration. The infiltration volume for rooftop downspouts is determined by multiplying the area (94,550 m^2) by the annual rainfall (742 mm) by the by 50% as per the CVC LID Manual for HSG A & B soils and by 80% to account for a 20% evapotranspiration factor. The total infiltration gained through this method is 28,062 m^3/year. This brings the total infiltration to 88,687 m^3/year in the post-development (with mitigation) scenario which leaves a deficit of 19,938 m^3/year or a reduction of approximately 18% from the predevelopment setting. In reality, this deficit is likely lower as the rooftop infiltration assumes only rainfall is collected, whereas snow melt, although difficult to quantify given the variability in snow pack conditions and presence of ground frost in the winter would create additional infiltration potential.

5.3 Water Balance Summary

Using the climate model data and calculations mentioned above, the water balance was completed for pre-development, post-development, and post-development with mitigation (Appendix D).

The pre-development infiltration volume is 108,625 m^3/year. This assumes the Site is composed of forest, shrub/meadow, wetland, pavement/gravel, and existing structures. The post-development without mitigation infiltration volume is 60,624 m^3/year, which is a deficit of 48,001 m^3/year. This assumes the Site is composed of forest, landscaped grass, and impervious land (road, structures, driveways, storm water management ponds, etc). An additional 28,062 m^3/year of infiltration can be obtained by direction of rooftop runoff to adjacent yards, creating a post-development with mitigation volume of 88,687 m^3/year. This represents a decrease of 19,938 m^3/year (18%) from the pre-development setting.

As noted above, infiltration testing was completed to assess feasibility of additional subsurface LID features to promote additional ground water infiltration. However, it is noted that high water table conditions are present across the Site and the soils have shown to have limited permeability / infiltration such that there may be limitations with respect to mitigation at the Site. It is noted that the low permeability of the soils would limit ground water infiltration at the Site such that the adjacent wetland features are primarily sourced by surface runoff which will be maintained post development, however, the details of the stormwater management plan are not known at this time. Although there is ground water seepage present at the Site, it is noted to be localized and does not represent the primary source for water contributions to this retained feature or the off-site wetland.

It is noted that the above water balance is considered preliminary and could be updated with additional information relating to the stormwater management design for the Site, including potential LID's to mitigated ground water deficits if feasible.

6.0 SUMMARY AND CONCLUSIONS

Azimuth was retained by LIV Communities to conduct a Preliminary Hydrogeological Assessment for the proposed Shadow Creek Subdivision development located at within Parts of Lots 3, 4, & 5, Concession 9, within the Township of Severn. The proposed development is approximately 45.6 ha in size and is located on the south east side of Highway 11 and the north east side of Menoke Beach Road. The parcel is currently composed of agricultural land, with numerous drainage channels intersecting the site in a west to east direction. The proposed development includes the construction of 319 single lot residential homes and 215 townhomes with associated road, storm water management, open space, and park space.

The Site is found at an elevation of 219 – 226 masl. In general, the Site slopes from west to east towards Lake Couchiching, while an unevaluated wetland is present along Shadow Creek that bound much of the eastern section of the Site. Numerous drainage channels extend through the Site, including a larger feature which is composed of a wetland which is being retained as part of the development. Flow in these features has been observed to be only trickle flow indicating that from a quantitative perspective, the on-site and off-site wetland and water course features are primarily surface water fed. An area of ground water seepage was documented at the western end of the retained wetland feature; however, the flow is noted to be localized and does not create a significant contribution to the main Site drainage channel relative to the surface water contributions from the surrounding area.

Ground water table measurements were collected from nine (9) monitoring wells installed across the Site in November 2021 and four (4) locations in April 2021. The measured water level at the Site ranged from 219.26-223.68 masl. In general, the available data shows the shallow ground water flow matches the local topography and flows from west to east. Although spring water levels were only measured at four locations, the data when correlated to the November data would indicate that the November 2021 data likely represents high water table conditions. It is noted that monitoring will continue into the summer of 2022 such that high water table conditions can be confirmed during the spring of 2022.

Hydraulic (slug) testing was completed at three (3) of the monitoring wells to characterize the hydraulic conductivity of the soils associated with the shallow water table aquifer. The hydraulic conductivity ranged between 8.1×10^{-7} to 1.6×10^{-6} m/s. These results indicate relative consistency across the Site which is expected given the general consistency in soils across the Site. The results also correlate to the sandy and clayey silt glacial till, which have low to moderate hydraulic conductivity.

A water balance was completed for pre-development, post-development, and post-development with mitigation scenarios of the Site. The pre-development infiltration volume is 108,625 m^3/year. This assumes the Site is composed of forest, shrub/meadow, wetland, pavement/gravel, and existing structures. The post-development without mitigation infiltration volume is 60,624 m^3/year, which is a deficit of 48,001 m^3/year. This assumes the Site is composed of forest, landscaped grass, and impervious land (road, structures, driveways, storm water management ponds, etc). An additional 28,062 m^3/year of infiltration can be obtained by direction of rooftop runoff to adjacent yards, creating a post-development with mitigation volume of 88,687 m^3/year. This represents a decrease of 19,938 m^3/year (18%) from the pre-development setting.

Further ground water infiltration mitigation may be incorporated in the stormwater management design; however, it is noted that high water table conditions are present across the Site and the soils have shown to have limited permeability / infiltration such that there may be limitations with respect to mitigation at the Site. It is also noted that the low permeability of the soils would limit ground water infiltration at the Site such that the adjacent wetland features are primarily sourced by surface runoff which will be maintained post-development, although the details of the stormwater management plan are not known at this time. Despite there being ground water seepage present within the wetland at the Site, it is noted to be localized and does not represent the primary source for water contributions to this retained feature or the off-site wetland.

It is noted that the water balance prepared as part of this report is considered preliminary and could be updated with additional information relating to the stormwater management design for the Site, including potential LIDs to mitigate ground water deficits if feasible.

7.0 REFERENCES

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APPENDICES

Appendix A:	Figures
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Appendix D:	Water Balance Information
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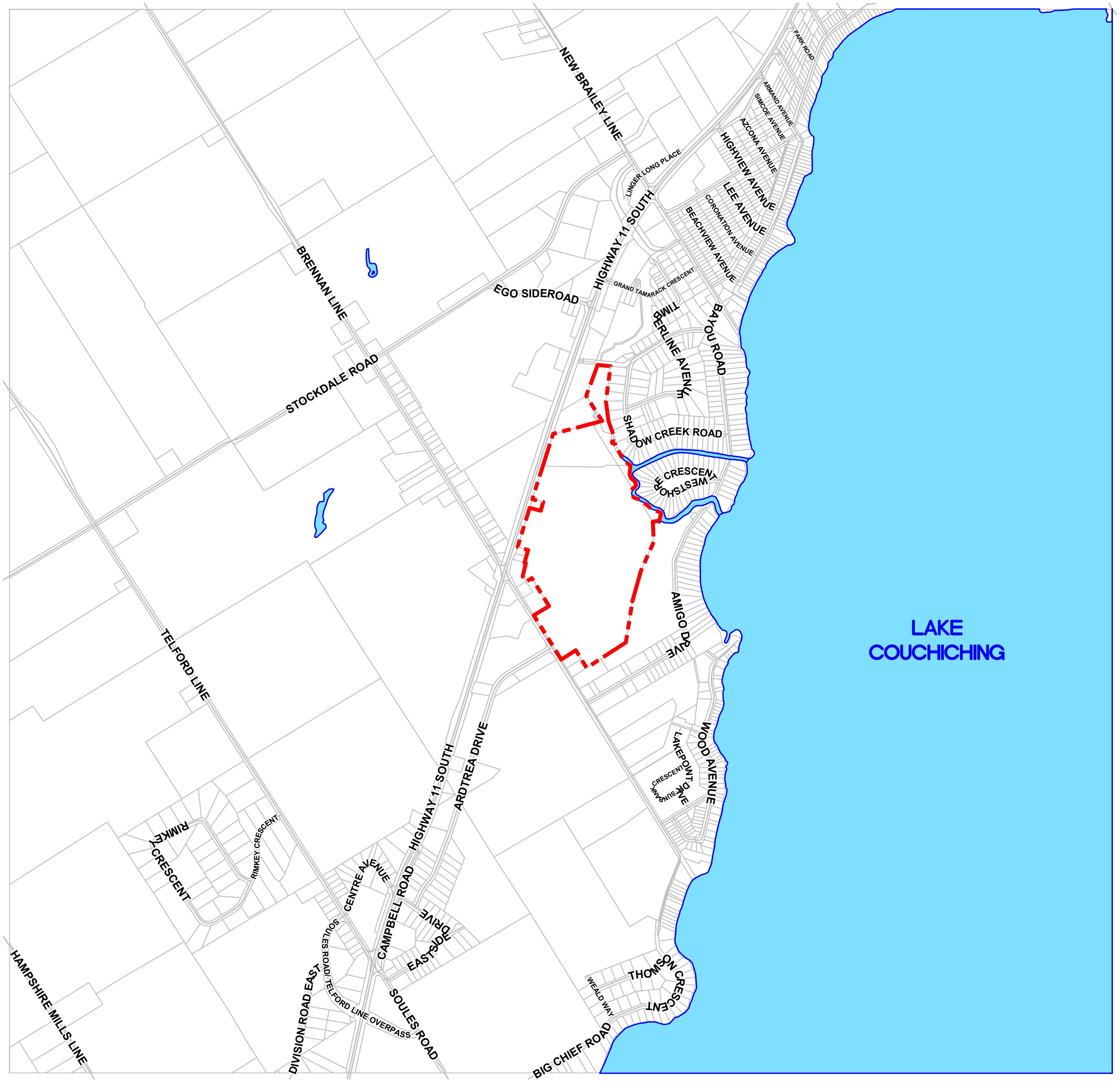
Appendix F:	Slug Testing Results
Appendix G:	Guelph Permeameter Testing Data

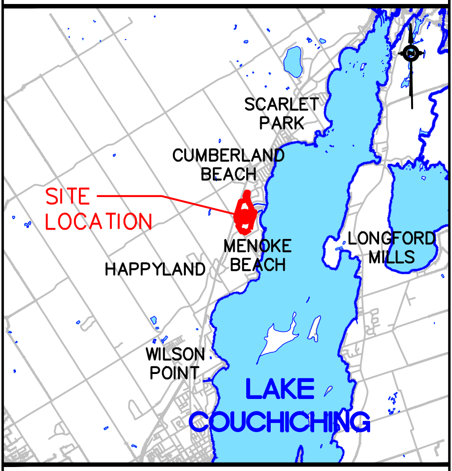
APPENDIX A

Figures



LEGEND:

▬ ▪ ▬ APPROX. PROPERTY BOUNDARY



REGIONAL MAP

SCALE 1:250000

N

0 625 1250

HORIZONTAL SCALE 1:25000

AZIMUTH ENVIRONMENTAL CONSULTING, INC.
ENVIRONMENTAL ASSESSMENTS & APPROVALS

SITE LOCATION

MENOKE BEACH ROAD
SEVERN, ON

DATE ISSUED: *DECEMBER 2021*	Figure No.
CREATED BY: *A.L.*	1
PROJECT NO.: *21-098*	
REFERENCE: *SIMCOE COUNTY*	

Plotted by: ALU on December 14, 2021 at 11:42am
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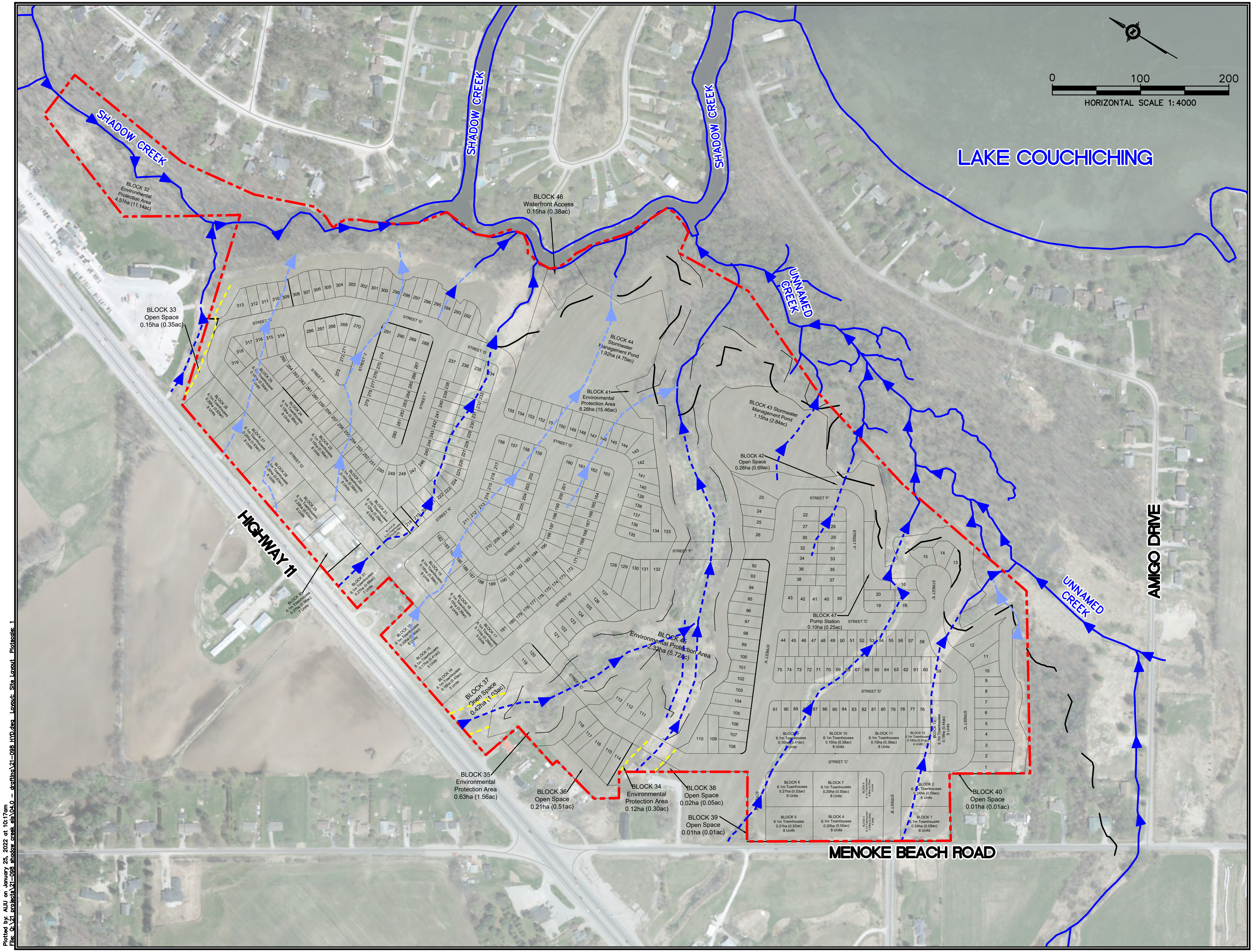


LEGEND:

- APPROX. PROPERTY BOUNDARY
- DRAINAGE CHANNELS

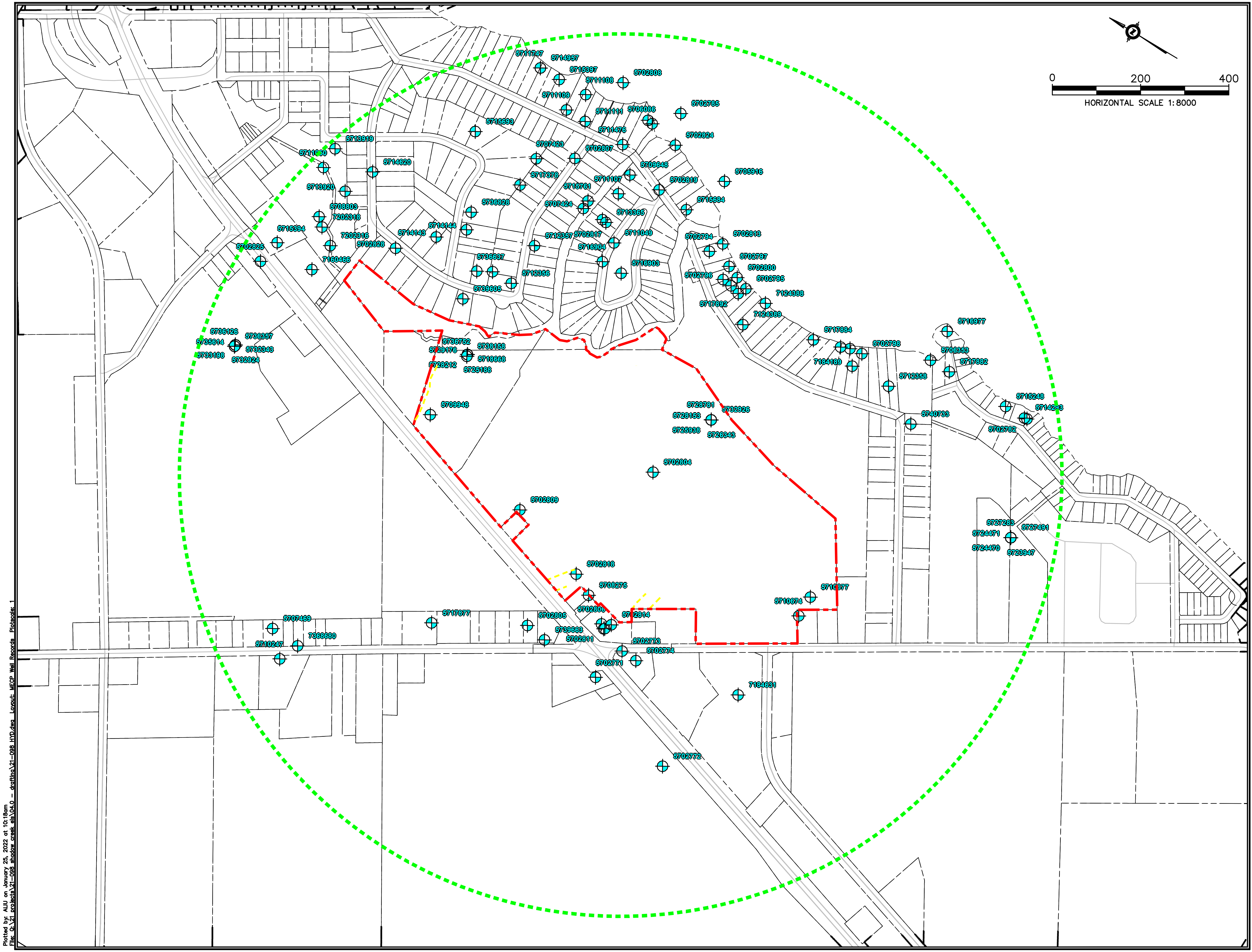
AZIMUTH ENVIRONMENTAL CONSULTING, INC.

SITE LAYOUT

MENOKE BEACH ROAD
SEVERN, ON

DATE ISSUED:	JANUARY 2022	Figure No.
CREATED BY:	A.L.	2
PROJECT NO.:	21-098	
REFERENCE:	SIMCOE COUNTY	

Plotted by: ALIU on January 25, 2022 at 10:17am
File: Q:\21 projects\21-098 shadow creek eis\04.0 - drafting\21-098 HYD.dwg Layout: Site Layout Plotscale: 1



Plotted by: ALIU on January 25, 2022 at 10:18am
File: Q:\21 projects\21-098 shadow creek eis\04.0 – drafting\21-098 HYD.dwg Layout: MECP Well Records Plotscale: 1

LEGEND:

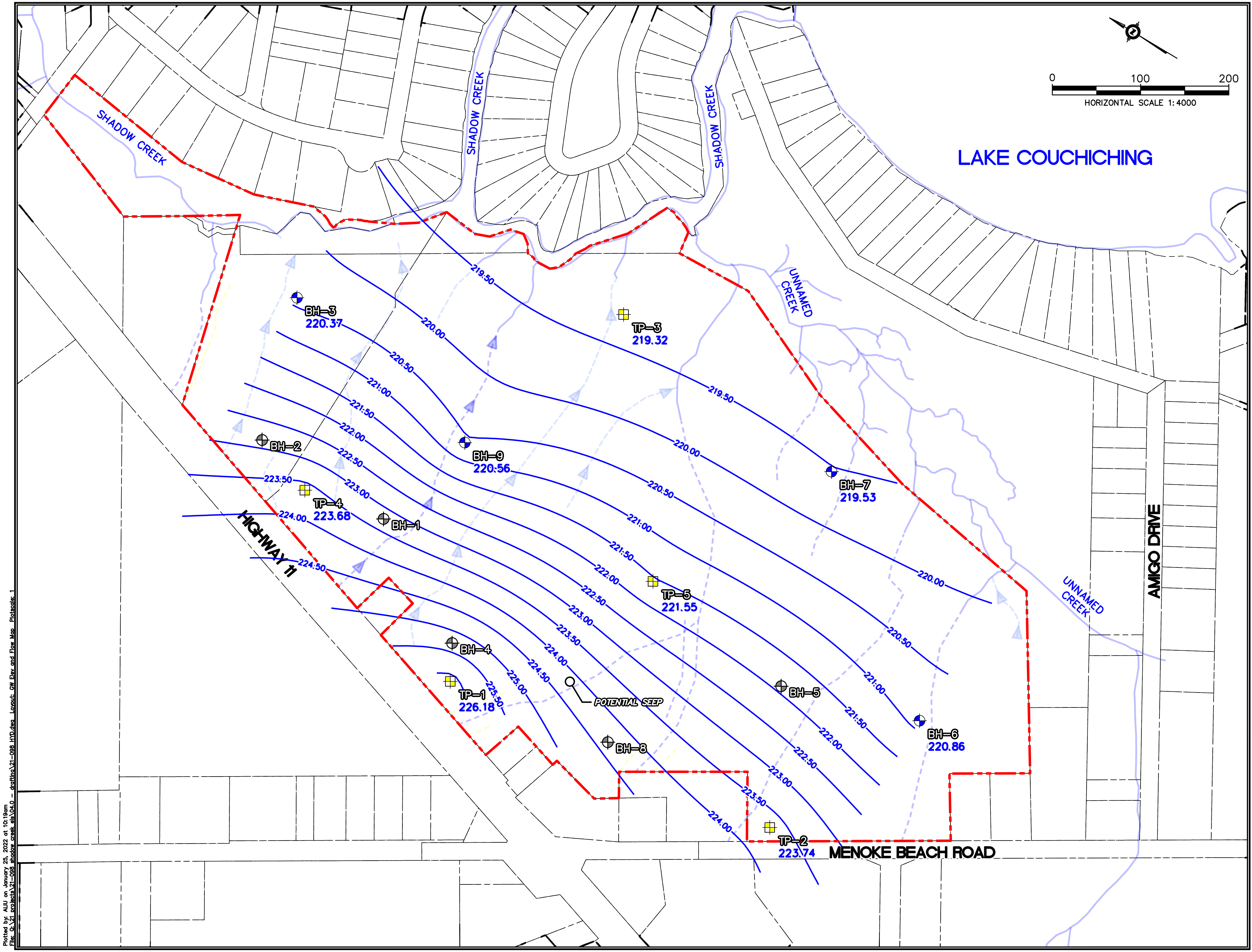
🟥	APPROX. PROPERTY BOUNDARY
🟩	1 KM RADIUS STUDY AREA
⊕#	WATER WELL LOCATIONS / I.D. (MECP, 2021)

AZIMUTH ENVIRONMENTAL CONSULTING, INC.

MECP WELL RECORD LOCATIONS

MENOKE BEACH ROAD
SEVERN, ON

DATE ISSUED:	JANUARY 2022	Figure No.
CREATED BY:	A.L.	3
PROJECT NO.:	21-098	
REFERENCE:	SIMCOE COUNTY	



LEGEND:

- APPROX. PROPERTY BOUNDARY
- DRAINAGE CHANNELS
- SOIL-MATERIAL BOREHOLE
- SOIL-MATERIAL MONITORING WELL
- AZIMUTH MONITORING WELL (NOV. 2021)
- 186.00 GROUND WATER CONTOURS (masl)

AZIMUTH ENVIRONMENTAL CONSULTING, INC.

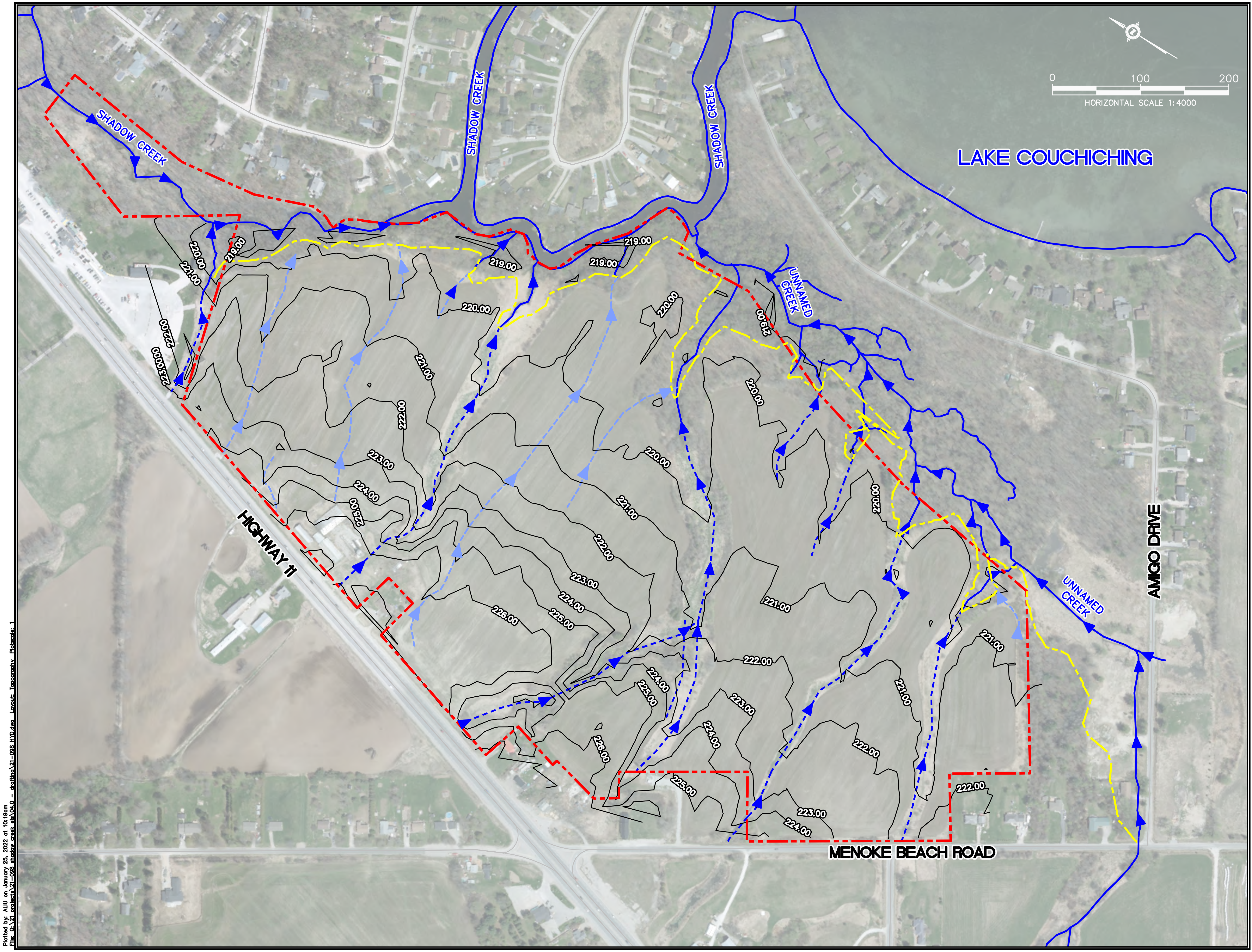
GROUND WATER ELEVATION & FLOW MAP

MENOKE BEACH ROAD
SEVERN, ON

DATE ISSUED: JANUARY 2022
CREATED BY: A.L.
PROJECT NO.: 21-098
REFERENCE: SIMCOE COUNTY

Figure No.
4

Plotted by: ALIU on January 25, 2022 at 10:19am
File: Q:\21 projects\21-098 shadow creek eis\04.0 - drafting\21-098 HYD.dwg Layout: GW Elev and Flow Map Plotscale: 1



LEGEND:

- APPROX. PROPERTY BOUNDARY
- DRAINAGE CHANNELS
- 2–YEAR FLOOD LINE (Crozier, 2021)
- 186.00 1m CONTOURS

AZIMUTH ENVIRONMENTAL CONSULTING, INC.

SITE TOPOGRAPHY

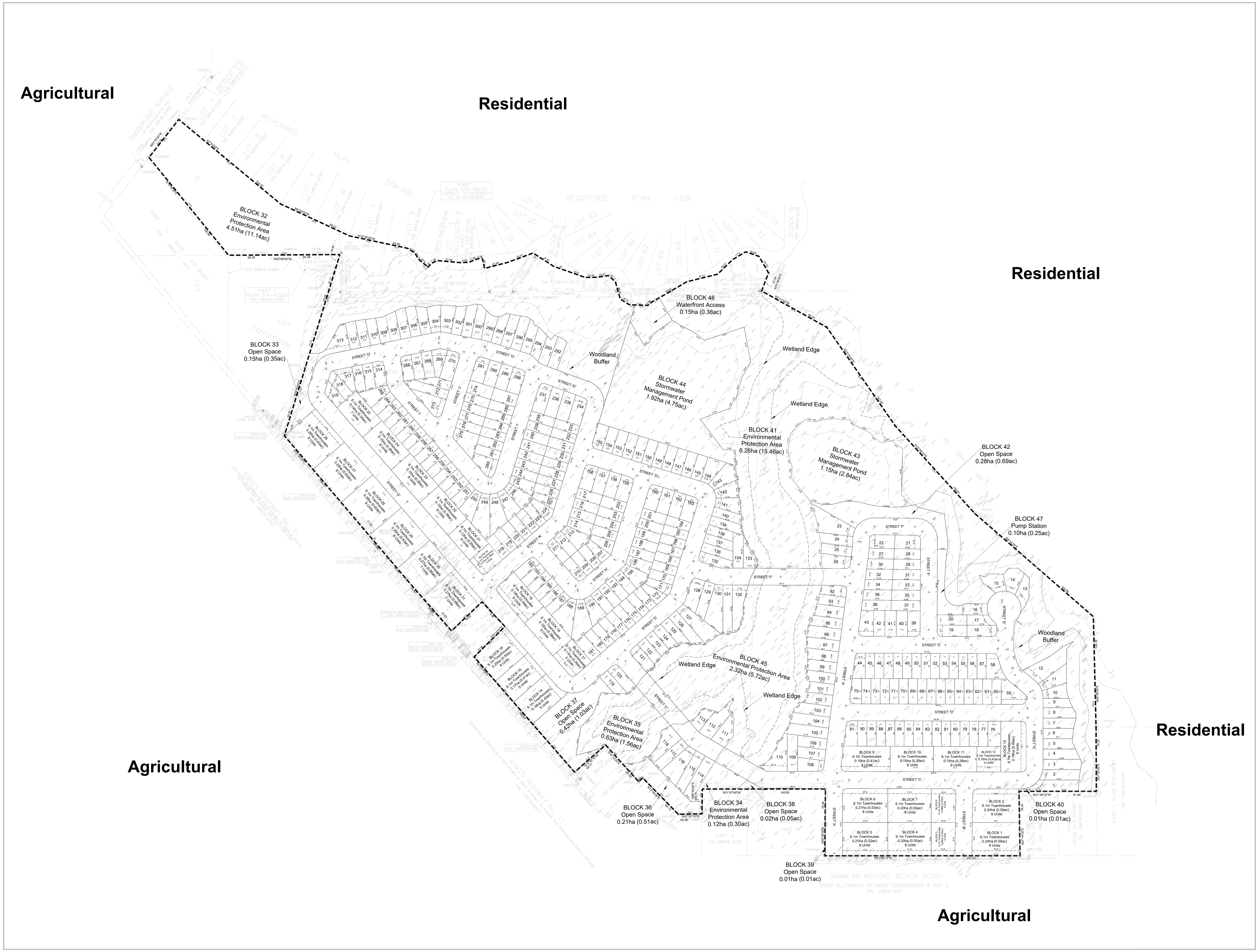
MENOKE BEACH ROAD
SEVERN, ON

DATE ISSUED:	JANUARY 2022	Figure No.
CREATED BY:	A.L.	5
PROJECT NO.:	21-098	
REFERENCE:	SIMCOE COUNTY	

Plotted by: ALIU on January 25, 2022 at 10:19am
File: Q:\21 projects\21-098 shadow creek eis\04.0 - drafting\21-098 HYD.dwg Layout: Topography Plotscale: 1

APPENDIX B

Development Plan



Legal Description

PART OF LOTS 3, 4, AND 5
CONCESSION 9 (NORTH DIVISION)
(GEOGRAPHIC TOWNSHIP OF NORTH ORILLIA)
NOW IN THE
TOWNSHIP OF SEVERN
COUNTY OF SIMCOE

Owner's Certificate

I HEREBY AUTHORIZE MACNAUGHTON HERMSEN BRITTON CLARKSON PLANNING LIMITED TO SUBMIT THIS PLAN FOR APPROVAL.

DATE: ______________________ ______________________

LIV Communities

Surveyor's Certificate

I HEREBY CERTIFY THAT THE BOUNDARIES OF THE LAND TO BE SUBDIVIDED ON THIS PLAN AND THEIR RELATIONSHIP TO THE ADJACENT LANDS ARE ACCURATELY AND CORRECTLY SHOWN.

DATE: ______________________ ______________________

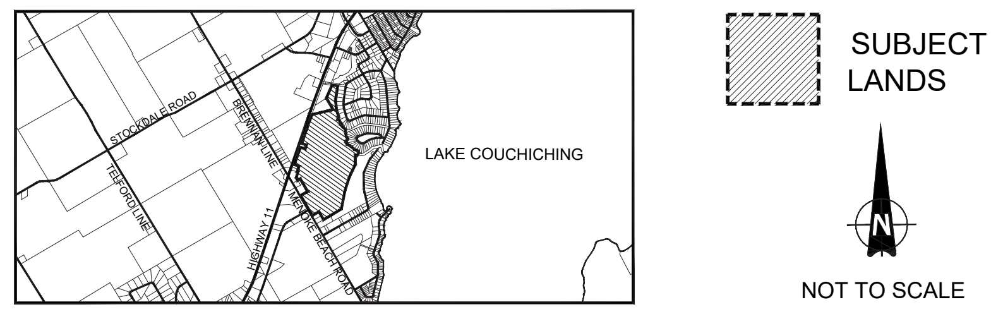
PIER DE ROSA- O.L.S.
J.D. BARNES LIMITED

Revision No.	Date	Issued / Revision	By

Additional Information Required Under Section 51(17) of the Planning Act R.S.O. 1990, c.P.13 as Amended

A. As Shown
B. As Shown
C. As Shown
D. Residential, Parkland
E. As Shown
F. As Shown
G. As Shown
H. Municipal Water Supply (Piped)
I. Tioga Loamy Sand
Lovering Silty Clay Loam
Alliston Sandy Loam
J. As Shown
K. All Services As Required
L. As Shown

KEY PLAN



County Signing Block

APPROVED IN ACCORDANCE WITH SECTION 51(31) OF THE PLANNING ACT RSO, 1990, CHAPTER P.13, AS AMENDED

THIS ______________ DAY OF ______________________, 20_____

DIRECTOR OF PLANNING, DEVELOPMENT AND TOURISM
COUNTY OF SIMCOE

Area Schedule

Description	Lots/Blocks	Units	Area
11m (36') Single Detached	9-11, 44-91, 130-132, 135-140, 164-229, 232-233, 238-239, 242-265, 271-287	170	6.36 ha (15.70 ac)
12.2m (40') Single Detached	1-8, 12-43, 92-129, 133-134, 141-163, 230-231, 234-237, 240-241, 266-270, 288-318	149	6.94 ha (17.14 ac)
6.1m (20') Townhouses	Block 1-31	215	5.51 ha (13.62 ac)
Open Space	Block 33, 36, 37, 38, 39, 40, 42		1.07 ha (2.63 ac)
Pump Station	Block 47		0.10 ha (0.25 ac)
Environmental Protection Area	Block 32, 34, 35, 41, 45		13.83 ha (34.18 ac)
Stormwater Management Pond	Block 43, 44		3.07 ha (7.59 ac)
Waterfront Access	Block 46		0.15 ha (0.38 ac)
Street A-K			8.42 ha (20.80 ac)
Total		534	45.45 ha (112.31 ac)

MHBC PLANNING URBAN DESIGN & LANDSCAPE ARCHITECTURE
230-7050 WESTON ROAD WOODBRIDGE, ON, L4L 8G7 | P: 905 761 5588 F: 905 761 5589 | WWW.MHBCPLAN.COM

Stamp

Date	November 9, 2021
File No.	15226X
Plan Scale	1:2000 (Arch D)
Drawn By	T.H.
Checked By	E.T.
Other	

Project

8743 Highway 11
Draft Plan of Subdivision

north

File Name DRAFT PLAN OF SUBDIVISION

Dwg No. 1 of 1

Scale Bar

0 25 50 100 200

MEASUREMENTS SHOWN ON THIS PLAN ARE IN METRES AND CAN BE CONVERTED TO FEET BY DIVIDING BY 0.3048

N:\15226\X – MBR Phase III – Shadow Creek, Severn\1 – MHBC Documents\Draft Plan\CAD\15226X– Draft Plan of Subdivision– 03 January 2022.dwg

APPENDIX C

MECP Well Records

Well Records Within 1,000m of Site Centre

WellID	Elevation (m)	Depth (m)	WaterLevel (m)	WaterYield (lps)	Water use	Water status	Lithology	Completion Date
5702771	220.98	17.07	4.88	N/A	Public	Water Supply	Limestone	08/15/1947
5702772	228.60	11.58	4.88	N/A	Domestic	Water Supply	Clay	09/03/1950
5702773	220.98	11.89	4.27	N/A	Commercial	Water Supply	Clay	06/14/1955
5702774	220.98	15.54	2.44	13.64	Livestock	Water Supply	Clay	04/20/1963
5702782	219.46	7.92	0.30	N/A	Domestic	Water Supply	Limestone	11/15/1954
5702783	219.46	7.92	0.30	N/A	Domestic	Water Supply	Clay	11/17/1954
5702785	219.46	7.62	0.61	13.64	Domestic	Water Supply	Limestone	06/14/1961
5702792	219.46	11.58	0.61	N/A	Domestic	Water Supply	Limestone	06/15/1950
5702793	219.46	7.32	1.52	N/A	Domestic	Water Supply	Gravel	07/13/1953
5702794	219.46	14.33	1.83	N/A	Domestic	Water Supply	Clay	08/20/1954
5702795	219.46	14.33	1.83	N/A	Domestic	Water Supply	Limestone	08/30/1954
5702796	219.46	16.76	1.83	N/A	Domestic	Water Supply	Limestone	06/21/1955
5702797	219.46	13.11	0.30	113.65	Domestic	Water Supply	Limestone	09/25/1959
5702798	219.46	15.54	1.83	13.64	Domestic	Water Supply	Soil	08/24/1961
5702799	219.46	26.82	N/A	45.46	Domestic	Water Supply	Limestone	06/07/1963
5702800	219.46	15.24	1.52	22.73	Domestic	Water Supply	Soil	07/12/1967
5702801	220.98	10.67	4.57	N/A	Domestic	Water Supply	Unknown material	10/15/1947
5702804	220.98	14.63	1.83	N/A	Domestic	Water Supply	Clay	06/27/1952
5702805	220.98	18.29	13.72	N/A	Domestic	Water Supply	Limestone	07/05/1955
5702806	220.98	12.19	3.05	N/A	Commercial	Water Supply	Limestone	11/20/1955
5702807	219.46	11.89	0.30	N/A	Domestic	Water Supply	Diamicton	06/29/1961
5702808	219.46	10.67	1.83	13.64	Domestic	Water Supply	Gravel	08/23/1961
5702809	220.98	18.29	3.66	13.64	Domestic	Water Supply	Soil	09/28/1961
5702811	220.98	11.28	1.22	18.18	Domestic	Water Supply	Sand Gravel	08/14/1962
5702813	219.46	11.89	0.91	45.46	Domestic	Water Supply	Clay	06/17/1963
5702814	220.98	8.53	3.05	36.37	Public	Water Supply	Sand Clay	10/01/1963
5702817	220.98	12.80	2.44	36.37	Domestic	Water Supply	Clay	07/20/1964
5702818	220.98	6.71	3.05	45.46	Domestic	Water Supply	Limestone	08/16/1965
5702819	220.98	11.89	0.91	22.73	Domestic	Water Supply	Limestone	05/25/1965
5702824	219.46	12.80	1.52	45.46	Domestic	Water Supply	Shale	10/03/1967
5702828	220.98	42.37	2.44	18.18	Commercial	Water Supply	Granite	05/01/1967
5702832	219.46	9.45	0.61	90.92	Domestic	Water Supply	Sand	03/30/1967
5705916	219.46	9.14	2.44	31.82	Domestic	Water Supply	Limestone	07/02/1968
5706086	219.46	14.02	N/A	22.73	Domestic	Water Supply	Clay Sand	12/21/1968
5706353	220.98	15.54	2.13	45.46	Domestic	Water Supply	Clay	04/29/1968
5707061	220.98	13.41	2.44	45.46	Domestic	Water Supply	Limestone	09/08/1969
5707064	220.98	12.19	3.66	31.82	Domestic	Water Supply	Shale Limestone	08/16/1969
5707423	220.98	16.46	4.27	13.64	Domestic	Water Supply	Clay	08/27/1970
5707424	220.98	28.04	1.83	36.37	Domestic	Water Supply	Clay Gravel	08/20/1970
5707469	236.22	44.81	15.24	31.82	Domestic	Water Supply	Limestone	07/17/1970
5708275	227.08	91.44	8.23	18.18	Commercial	Water Supply	Soil	04/01/1971
5708803	220.98	7.62	4.57	9.09	Domestic	Water Supply	Sand	04/11/1972
5709648	222.50	26.21	1.22	36.37	Domestic	Water Supply	Granite	12/01/1972
5709948	222.50	19.81	0.00	9.09	Domestic	Water Supply	Granite	04/13/1973
5710247	236.22	46.33	18.29	36.37	Domestic	Water Supply	Granite	08/30/1973
5710674	224.03	9.14	1.83	36.37	Domestic	Water Supply	Clay Sand	03/16/1973
5710677	224.03	8.53	2.44	54.55	Domestic	Water Supply	Clay Sand	12/06/1973
5711049	222.50	11.89	0.30	68.19	Domestic	Water Supply	Gravel	05/24/1974
5711107	222.50	12.19	0.00	36.37	Domestic	Water Supply	Gravel	06/02/1974
5711108	219.46	28.35	0.00	N/A	Domestic	Water Supply	Granite	06/15/1974
5711109	220.98	20.73	3.66	18.18	Domestic	Water Supply	Clay	06/02/1974
5711111	220.98	30.18	0.61	4.55	Domestic	Water Supply	Limestone	06/09/1974
5711476	220.98	28.35	1.22	9.09	Domestic	Water Supply	Clay Sand	06/13/1974
5711747	219.46	14.02	0.61	22.73	Domestic	Water Supply	Clay	09/09/1974
5712201	222.50	27.13	0.00	22.73	Domestic	Water Supply	Limestone / Granite	06/05/1975
5712356	222.50	27.13	0.00	22.73	Domestic	Water Supply	Granite	06/09/1975
5712357	222.50	16.46	1.52	45.46	Domestic	Water Supply	Limestone	06/15/1975
5712358	220.98	7.01	1.52	22.73	Domestic	Water Supply	Gravel	06/19/1975
5713365	220.98	11.89	0.91	45.46	Domestic	Water Supply	Gravel	09/10/1975
5713920	220.98	14.94	0.91	45.46	Domestic	Water Supply	Gravel	11/05/1976
5714143	222.50	19.81	1.52	22.73	Domestic	Water Supply	Limestone	04/25/1977
5714144	222.50	21.64	0.91	45.46	Domestic	Water Supply	Clay	05/07/1977
5714293	219.46	10.67	1.52	54.55	Domestic	Water Supply	Limestone	03/24/1977
5714620	220.98	26.82	2.44	45.46	Domestic	Water Supply	Limestone	06/22/1977
5714957	219.46	13.11	0.30	N/A	Domestic	Water Supply	Limestone	05/18/1977
5715248	219.46	10.67	0.61	90.92	Domestic	Water Supply	Limestone	06/12/1978
5715397	219.46	22.25	0.91	45.46	Domestic	Water Supply	Limestone	07/11/1977
5715684	220.98	13.11	10.67	45.46	Domestic	Water Supply	Limestone	10/15/1978
5715693	220.98	10.36	2.13	40.91	Domestic	Water Supply	Sand Silt	11/21/1978
5715761	220.98	22.86	3.66	90.92	Domestic	Water Supply	Clay	10/13/1978
5716903	220.98	11.89	0.61	45.46	Domestic	Water Supply	Clay	06/27/1980
5716904	220.98	11.28	0.30	45.46	Domestic	Water Supply	Clay	07/02/1980
5716977	220.98	7.01	0.91	90.92	Domestic	Water Supply	Clay Sand	10/28/1975
5717378	220.98	15.85	3.66	31.82	Domestic	Water Supply	Clay Gravel	03/28/1981
5717877	228.60	45.72	11.89	45.46	Domestic	Water Supply	Granite	07/29/1981
5717882	220.98	7.92	3.05	36.37	Domestic	Water Supply	Clay	08/13/1981
5717884	220.98	28.96	1.52	27.28	Domestic	Water Supply	Limestone	01/11/1980
5717892	220.98	28.35	4.57	31.82	Domestic	Water Supply	Limestone	06/16/1981
5718668	N/A	57.30	0.91	0.00	Commercial	Water Supply	Sand	09/12/1983
5723947	N/A	9.14	2.44	36.37	Domestic	Water Supply	Diamicton	07/10/1988
5724470	N/A	16.15	3.66	27.28	Public	Water Supply	Clay Sand	12/29/1988
5724471	N/A	34.14	2.74	9.09	Public	Water Supply	Limestone	12/15/1988
5725187	N/A	12.19	0.00	18.18	Public	Water Supply	Limestone	06/25/1989
5725188	N/A	27.43	3.66	9.09	Cooling And A/C	Water Supply	Limestone	01/12/1989
5725807	N/A	25.30	9.14	18.18	Domestic	Water Supply	Limestone	09/05/1989
5725938	N/A	7.92	1.83	36.37	Domestic	Water Supply	Limestone	11/13/1989
5726343	N/A	8.84	0.91	45.46	Domestic	Water Supply	Limestone	02/13/1990
5726453	N/A	18.29	3.66	45.46	Domestic	Water Supply	Clay Gravel	11/29/1989
5726809	N/A	75.59	1.83	9.09	Public	Water Supply	Granite	05/22/1990
5727254	N/A	72.54	5.49	68.19	Domestic	Water Supply	Granite	07/09/1990
5727283	N/A	10.06	1.52	45.46	Domestic	Water Supply	Clay	08/10/1990
5727491	N/A	15.24	2.74	18.18	Domestic	Water Supply	Limestone	10/29/1990
5727692	N/A	17.98	13.72	90.92	Domestic	Water Supply	Limestone	09/18/1990
5728153	N/A	8.23	2.44	68.19	Domestic	Water Supply	Sand	06/15/1991
5728212	N/A	24.69	8.23	22.73	Domestic	Water Supply	Limestone	05/25/1991
5728781	N/A	10.67	2.13	136.38	Domestic	Water Supply	Limestone	12/15/1991
5729176	N/A	39.01	31.39	45.46	Domestic	Water Supply	Gravel	05/10/1992
5729922	N/A	25.91	3.66	45.46	Domestic	Water Supply	Limestone	10/05/1992
5729925	N/A	17.68	3.96	45.46	Domestic	Water Supply	Diamicton Gravel	08/20/1992
5730993	N/A	13.41	1.83	18.18	Domestic	Water Supply	Clay Silt Unknown material	07/03/1994
5731907	N/A	76.20	4.57	22.73	Domestic	Water Supply	Granite	11/16/1995
5732343	N/A	38.40	5.18	54.55	Domestic	Water Supply	Granite	07/26/1996
5732924	N/A	54.86	3.66	90.92	Commercial	Water Supply	Bedrock	08/07/1997
5732926	N/A	18.29	17.98	36.37	Domestic	Water Supply	Limestone	04/25/1997
5733198	N/A		N/A	N/A	Commercial	Abandoned-Other	N/A	12/08/1997
5735614	N/A	39.93	3.66	136.38	Domestic	Water Supply	Granite	11/07/2000
5736126	N/A		N/A	N/A	Commercial	Abandoned-Other	N/A	06/23/2001
5736357	N/A	54.86	3.05	4.55	Domestic	Water Supply	Granite	09/14/2001
5736637	N/A	18.59	3.66	22.73	Domestic	Water Supply	Clay	12/18/2001
5736752	N/A	13.41	4.27	45.46	Domestic	Water Supply	Limestone	04/11/2002
5736828	N/A	17.98	4.27	31.82	Domestic	Water Supply	Sand Clay Silt	03/08/2002
5738158	N/A	14.33	3.05	31.82	Domestic	Water Supply	Clay	08/27/2003
5739605	N/A	15.24	6.40	22.00	Domestic	Water Supply	Limestone	12/01/2004
5739663	N/A	38.10	8.00	45.00	Domestic	Water Supply	Clay	04/10/2005
5740733	N/A	13.40	2.74	40.00	Domestic	Water Supply	Limestone	05/22/2006
7124388	N/A	6.50	0.74	172.07	Domestic	Water Supply	Clay Sand Gravel	05/17/2009
7124389	N/A		1.31	N/A	Not Used	Abandoned-Other	N/A	05/17/2009

APPENDIX D

Water Balance Information

Table A: Pre-Development

	Site				
Catchment Designation	**Agricultural**	**Forest**	**Wetland**	**Impervious**	**Total**
Area (m^2)	306,500	118,386	27,114	2,500	454,500
Pervious Area (m^2)	306,500	118,386	0	0	424,886
Impervious Area (m^2)	0	0	27,114	2,500	29,614
Infiltration Factors					
Topography Infiltration Factor	0.2	0.2	0	0	
Soil Infiltration Factor	0.15	0.15	0	0	
Land Cover Infiltration Factor	0.1	0.2	0	0	
Infiltration Factor	0.45	0.55	0	0	
Run-Off Coefficient	0.55	0.45	1	1	
Run-Off From Impervious Surfaces	0.8	0.8	0.8	0.8	
Inputs (Per Unit Area)					
Precipitation (mm/yr)	1,077	1,077	1,077	1,077	1,077
Rainfall (mm/yr)	742	742	742	742	742
Run-On (mm/yr)	0	0	0	0	0
Other Inputs (mm/yr)	0	0	0	0	0
Total Inputs (mm/yr)	**1,077**	**1,077**	**1,077**	**1,077**	1,077
Outputs (Per Unit Area)					
Precipitation Surplus (mm/yr)	535	535	862	862	556
Net Surplus (mm/yr)	535	535	862	862	556
Evapotranspiration (mm/yr)	542	542	215	215	521
Infiltration (mm/yr)	241	294	0	0	239
Surplus Infiltration (mm/yr)	0	0	0	0	0
Total Infiltration (mm/yr)	241	294	0	0	239
Run-Off Pervious Areas (mm/yr)	294	241	0	0	261
Run-Off Impervious Areas (mm/yr)	0	0	862	862	56
Total Run-Off (mm/yr)	294	241	862	862	317
Total Outputs (mm/yr)	**1,077**	**1,077**	**1,077**	**1,077**	**1,077**
Difference (Inputs - Outputs)	**0**	**0**	**0**	**0**	**0**
Inputs (Volumes)					
Precipitation (m^3/yr)	330,101	127,502	29,202	2,693	489,497
Run-On (m^3/yr)	0	0	0	0	0
Other Inputs (m^3/yr)	0	0	0	0	0
Total Inputs (m^3/yr)	**330,101**	**127,502**	**29,202**	**2,693**	**489,497**
Outputs (Volumes)					
Precipitation Surplus (m^3/yr)	163,978	63,337	23,361	2,154	252,829
Net Surplus (m^3/yr)	163,978	63,337	23,361	2,154	252,829
Evapotranspiration (m^3/yr)	166,123	64,165	5,840	539	236,667
Infiltration (m^3/yr)	73,790	34,835	0	0	108,625
Surplus Infiltration (m^3/yr)	0	0	0	0	0
Total Infiltration (m^3/yr)	**73,790**	**34,835**	**0**	**0**	**108,625**
Run-Off Pervious Areas (m^3/yr)	90,188	28,501	0	0	118,689
Run-Off Impervious Areas (m^3/yr)	0	0	23,361	2,154	25,515
Total Run-Off (m^3/yr)	90,188	28,501	23,361	2,154	144,204
Total Outputs (m^3/yr)	330,101	127,502	29,202	2,693	489,497
Difference (Inputs - Outputs)	**0**	**0**	**0**	**0**	**0**

Table B: Post-Development (no mit)

Catchment Designation	Forest	Landscaped Grass	Driveway	Roads	Wetland	SWM Pond	Rooftop	Total
Area (m^2)	111,186	115,920	18,810	71,570	27,114	15,350	94,550	454,500
Pervious Area (m^2)	111,186	115,920	0	0	0	0	0	227,106
Impervious Area (m^2)	0	0	18,810	71,570	27,114	15,350	94,550	227,394
Infiltration Factors								
Topography Infiltration Factor	0.2	0.2	0	0	0	0	0	
Soil Infiltration Factor	0.15	0.15	0	0	0	0	0	
Land Cover Infiltration Factor	0.2	0.1	0	0	0	0	0	
Infiltration Factor	0.55	0.45	0	0	0	0	0	
Run-Off Coefficient	0.45	0.55	1	1	1	1	1	
Run-Off From Impervious Surfaces	0.8	0.8	0.8	0.8	0.8	0.8	0.8	
Inputs (Per Unit Area)								
Precipitation (mm/yr)	1,077	1,077	1,077	1,077	1,077	1,077	1,077	1,077
Rainfall (mm/yr)	742	742	742	742	742	742	742	742
Run-On (mm/yr)	0	0	0	0	0	0	0	0
Other Inputs (mm/yr)	0	0	0	0	0	0	0	0
Total Inputs (mm/yr)	**1,077**	**1,077**	**1,077**	**1,077**	**1,077**	**1,077**	**1,077**	1,077
Outputs (Per Unit Area)								
Precipitation Surplus (mm/yr)	535	535	862	862	862	862	862	698
Net Surplus (mm/yr)	535	535	862	862	862	862	862	698
Evapotranspiration (mm/yr)	542	542	215	215	215	215	215	379
Infiltration (mm/yr)	294	241	0	0	0	0	0	133
Surplus Infiltration (mm/yr)	0	0	0	0	0	0	0	0
Total Infiltration (mm/yr)	294	241	0	0	0	0	0	133
Run-Off Pervious Areas (mm/yr)	241	294	0	0	0	0	0	134
Run-Off Impervious Areas (mm/yr)	0	0	862	862	862	862	862	431
Total Run-Off (mm/yr)	241	294	862	862	862	862	862	565
Total Outputs (mm/yr)	**1,077**	**1,077**	**1,077**	**1,077**	**1,077**	**1,077**	**1,077**	**1,077**
Difference (Inputs - Outputs)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Inputs (Volumes)								
Precipitation (m^3/yr)	119,747	124,846	20,258	77,081	29,202	16,532	101,830	489,497
Run-On (m^3/yr)	0	0	0	0	0	0	0	0
Other Inputs (m^3/yr)	0	0	0	0	0	0	0	0
Total Inputs (m^3/yr)	**119,747**	**124,846**	**20,258**	**77,081**	**29,202**	**16,532**	**101,830**	**489,497**
Outputs (Volumes)								
Precipitation Surplus (m^3/yr)	59,485	62,017	16,207	61,665	23,361	13,226	81,464	317,424
Net Surplus (m^3/yr)	59,485	62,017	16,207	61,665	23,361	13,226	81,464	317,424
Evapotranspiration (m^3/yr)	60,263	62,829	4,052	15,416	5,840	3,306	20,366	172,072
Infiltration (m^3/yr)	32,716	27,908	0	0	0	0	0	60,624
Surplus Infiltration (m^3/yr)	0	0	0	0	0	0	0	0
Total Infiltration (m^3/yr)	**32,716**	**27,908**	**0**	**0**	**0**	**0**	**0**	**60,624**
Run-Off Pervious Areas (m^3/yr)	26,768	34,109	0	0	0	0	0	60,877
Run-Off Impervious Areas (m^3/yr)	0	0	16,207	61,665	23,361	13,226	81,464	195,923
Total Run-Off (m^3/yr)	26,768	34,109	16,207	61,665	23,361	13,226	81,464	256,800
Total Outputs (m^3/yr)	119,747	124,846	20,258	77,081	29,202	16,532	101,830	489,497
Difference (Inputs - Outputs)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Table C: Post-Development (with mitigation)

Catchment Designation	Forest	Landscaped Grass	Driveway	Roads	Wetland	SWM Pond	Rooftop	Total
Area (m^2)	111,186	115,920	18,810	71,570	27,114	15,350	94,550	454,500
Pervious Area (m^2)	111,186	115,920	0	0	0	0	0	227,106
Impervious Area (m^2)	0	0	18,810	71,570	27,114	15,350	94,550	227,394
Infiltration Factors								
Topography Infiltration Factor	0.2	0.2	0	0	0	0	0	
Soil Infiltration Factor	0.15	0.15	0	0	0	0	0	
Land Cover Infiltration Factor	0.2	0.1	0	0	0	0	0	
Infiltration Factor	0.55	0.45	0	0	0	0	0	
Run-Off Coefficient	0.45	0.55	1	1	1	1	1	
Run-Off From Impervious Surfaces	0.8	0.8	0.8	0.8	0.8	0.8	0.8	
Inputs (Per Unit Area)								
Precipitation (mm/yr)	1,077	1,077	1,077	1,077	1,077	1,077	1,077	1,077
Rainfall (mm/yr)	742	742	742	742	742	742	742	742
Run-On (mm/yr)	0	0	0	0	0	0	0	0
Other Inputs (mm/yr)	0	0	0	0	0	0	0	0
Total Inputs (mm/yr)	**1,077**	**1,077**	**1,077**	**1,077**	**1,077**	**1,077**	**1,077**	1,077
Outputs (Per Unit Area)								
Precipitation Surplus (mm/yr)	535	535	862	862	862	862	862	698
Net Surplus (mm/yr)	535	535	862	862	862	862	862	698
Evapotranspiration (mm/yr)	542	542	215	215	215	215	215	379
Infiltration (mm/yr)	294	241	0	0	0	0	0	133
Surplus Infiltration (mm/yr)	0	0	0	0	0	0	297	62
Total Infiltration (mm/yr)	294	241	0	0	0	0	297	195
Run-Off Pervious Areas (mm/yr)	241	294	0	0	0	0	0	134
Run-Off Impervious Areas (mm/yr)	0	0	862	862	862	862	565	369
Total Run-Off (mm/yr)	241	294	862	862	862	862	565	503
Total Outputs (mm/yr)	**1,077**	**1,077**	**1,077**	**1,077**	**1,077**	**1,077**	**1,077**	**1,077**
Difference (Inputs - Outputs)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Inputs (Volumes)								
Precipitation (m^3/yr)	119,747	124,846	20,258	77,081	29,202	16,532	101,830	489,497
Run-On (m^3/yr)	0	0	0	0	0	0	0	0
Other Inputs (m^3/yr)	0	0	0	0	0	0	0	0
Total Inputs (m^3/yr)	**119,747**	**124,846**	**20,258**	**77,081**	**29,202**	**16,532**	**101,830**	**489,497**
Outputs (Volumes)								
Precipitation Surplus (m^3/yr)	59,485	62,017	16,207	61,665	23,361	13,226	81,464	317,424
Net Surplus (m^3/yr)	59,485	62,017	16,207	61,665	23,361	13,226	81,464	317,424
Evapotranspiration (m^3/yr)	60,263	62,829	4,052	15,416	5,840	3,306	20,366	172,072
Infiltration (m^3/yr)	32,716	27,908	0	0	0	0	0	60,624
Surplus Infiltration (m^3/yr)	0	0	0	0	0	0	28,062	28,062
Total Infiltration (m^3/yr)	**32,716**	**27,908**	**0**	**0**	**0**	**0**	**28,062**	**88,687**
Run-Off Pervious Areas (m^3/yr)	26,768	34,109	0	0	0	0	0	60,877
Run-Off Impervious Areas (m^3/yr)	0	0	16,207	61,665	23,361	13,226	53,402	167,860
Total Run-Off (m^3/yr)	26,768	34,109	16,207	61,665	23,361	13,226	53,402	228,738
Total Outputs (m^3/yr)	119,747	124,846	20,258	77,081	29,202	16,532	101,830	489,497
Difference (Inputs - Outputs)	0	0	0	0	0	0	0	0

Table D: Water Balance Summary Table

	Site						
Characteristic	**Pre-Development**	**Post-Development**	**Change (Pre to Post)**		**Post-Development with Mitigation**	**Change (Pre to Post with Mitigation)**	
Inputs (Volume)							
Precipitation (m^3/yr)	489,497	489,497	0	0%	489,497	0	0%
Run-On (m^3/yr)	0	0	0	NA	0	0	NA
Other Inputs (m^3/yr)	0	0	0	NA	0	0	NA
Total Inputs (m^3/yr)	489,497	489,497	0	0%	489,497	0	0%
Outputs (Volume)							
Precipitation Surplus (m^3/yr)	252,829	317,424	64,595	26%	317,424	64,595	26%
Net Surplus (m3/yr)	252,829	317,424	64,595	26%	317,424	64,595	26%
Evapotranspiration (m^3/yr)	236,667	172,072	-64,595	-27%	172,072	-64,595	-27%
Infiltration (m^3/yr)	108,625	60,624	-48,001	-44%	60,624	-48,001	-44%
Rooftop Infiltration (m^3/yr)	0	0	0	NA	28,062	28,062	NA
Total Infiltration (m^3/yr)	**108,625**	**60,624**	**-48,001**	**-44%**	**88,687**	**-19,938**	**-18%**
Run-Off Pervious Areas (m^3/yr)	118,689	60,877	-57,812	-49%	60,877	-57,812	-49%
Run-Off Impervious Areas (m^3/yr)	25,515	195,923	170,407	668%	167,860	142,345	558%
Total Run-Off (m^3/yr)	144,204	256,800	112,596	78%	228,738	84,533	59%
Total Outputs (m^3/yr)	**489,497**	**489,497**	**0**	**0%**	**489,497**	**0**	**0%**

APPENDIX E

Borehole / Monitoring Well Details & Ground Water Elevations

Monitoring Well Details & Ground Water Levels

Monitoring Well	Easting	Northing	Ground Elevation (masl)	Stickup (m)	Reference Elevation (masl)	Top of Screen (mbgs)	Total Depth (mbgs)	Ground Water Level (mbtop)			Ground Water Level (mbgs)			Ground Water Elevation (masl)		
								13-Apr-21	11-Nov-21	17-Nov-21	13-Apr-21	11-Nov-21	17-Nov-21	13-Apr-21	11-Nov-21	17-Nov-21
BH-3	626945	4949948	221.06	0.79	221.85	2.77	5.77	1.57	1.60	1.48	0.78	0.81	0.69	220.28	220.25	220.37
BH-6	626907	4949096	220.99	0.82	221.81	2.39	5.39	1.15	1.10	0.95	0.33	0.28	0.13	220.66	220.71	220.86
BH-7	627095	4949329	219.83	0.79	220.62	1.02	4.02	1.36	1.24	1.09	0.57	0.45	0.30	219.26	219.38	219.53
BH-9	626905	4949700	221.28	0.73	222.01	2.65	4.15	1.40	1.55	1.45	0.67	0.82	0.72	220.61	220.46	220.56
TP-1	626666	4949572	226.30	1.41	227.71	0.13	1.63			1.53			0.12			226.18
TP-2	626715	4949177	224.80	1.47	226.27	1.50	3.00			2.53			1.06			223.74
TP-3	627123	4949623	219.48	1.04	220.52	0.60	2.10			1.20			0.16			219.32
TP-4	626764	4949826	225.20	1.30	226.50	1.40	2.90			2.82			1.52			223.68
TP-5	626883	4949436	221.98	1.30	223.28	1.43	2.93			1.73			0.43			221.55

AZIMUTH ENVIRONMENTAL CONSULTING, INC.

Environmental Assessments & Approvals

TEST PIT LOG

Project Name/ Project Client	Menoke Beach Phase 3	**Project Address**	3651 Menoke Beach Road and 8743 Highway 11, Township of Severn, ON	**Date**	Tuesday, November 09, 2021
Test Pit Number	TP-1	**Contractor**	Moris Shelswell Excavating	**Elevation**	NA
Equipment	Backhoe Excavator	**Test Pit Size**	1m x 3m	**Datum**	Ground Surface
Temperature	10°C	**Weather**	Cloudy	**Sample Type**	Soil

Depth		**Soil description**	**Samples**		**Screening Parameters**	**Remarks / Chemical Analysis**
From (m)	**To (m)**		**No.**	**Depth (mbgs)**		
0.00	0.35	**Topsoil**: Black to brown silty sand, loose, poorly sorted, moist.	-	-	-	-
0.35	1.10	**Sandy Silt:** Brown to grey, trace gravel, loose to compact, poorly sorted, moist.	1	0.4	-	sample for T-Time
1.10	2.50	**Clayey Silt Till:** Brown to grey, trace gravel, firm, poorly sorted, wet to saturated	-	-	-	-
		Test Pit Terminated at 2.5 mbgs				

Comments	***Water Conditions in Test Pit***
Standpipe installed in test pit prior to backfilling. Static water level (mbtoc) = 1.53 Total Depth (mbtoc) = 3.04 Stick-up (m) = 1.41 2 inch PVC with 1.5 m screen	☑ Wet upon completion ☐ Dry upon completion

JOB No. 21-098

TEST PIT No. TP-1

FIELD STAFF Alan Turner

AZIMUTH ENVIRONMENTAL CONSULTING, INC.
Environmental Assessments & Approvals

TEST PIT LOG

Project Name/ Project Client	Menoke Beach Phase 3	**Project Address**	3651 Menoke Beach Road and 8743 Highway 11, Township of Severn, ON	**Date**	Tuesday, November 09, 2021
Test Pit Number	TP-2	**Contractor**	Moris Shelswell Excavating	**Elevation**	NA
Equipment	Backhoe Excavator	**Test Pit Size**	1.3m x 2.4m	**Datum**	Ground Surface
Temperature	10°C	**Weather**	Cloudy	**Sample Type**	Soil

Depth		**Soil description**	**Samples**		**Screening Parameters**	**Remarks / Chemical Analysis**
From (m)	**To (m)**		**No.**	**Depth (mbgs)**		
0.00	0.28	**Topsoil**: Black to brown silty sand, trace gravel, loose, poorly sorted, moist.	-	-	-	-
0.28	1.60	**Silty Sand:** Brown, trace gravel, loose to compact, poorly sorted, moist.	1	1.1	-	sample for T-Time
1.60	3.30	**Clayey Silt:** Grey, firm to stiff, poorly sorted, moist to saturated	-	-	-	Ground water seepage observed at 3.2mbgs
		Test Pit Terminated at 3.3 mbgs				

Comments

Standpipe installed in test pit prior to backfilling.

Static water level (mbtoc) = 2.53
Total Depth (mbtoc) = 4.47
Stick-up (m) = 1.47 2 inch PVC with 1.5 m screen

Water Conditions in Test Pit

☑ Wet upon completion
☐ Dry upon completion

JOB No. 21-098
TEST PIT No. TP-2.
FIELD STAFF Alan Turner

AZIMUTH ENVIRONMENTAL CONSULTING, INC.

Environmental Assessments & Approvals

TEST PIT LOG

Project Name/ Project Client	Menoke Beach Phase 3	**Project Address**	3651 Menoke Beach Road and 8743 Highway 11, Township of Severn, ON	**Date**	Tuesday, November 09, 2021
Test Pit Number	TP-3	**Contractor**	Moris Shelswell Excavating	**Elevation**	NA
Equipment	Backhoe Excavator	**Test Pit Size**	2m x 4m	**Datum**	Ground Surface
Temperature	10°C	**Weather**	Cloudy	**Sample Type**	Soil

Depth		**Soil description**	**Samples**		**Screening Parameters**	**Remarks / Chemical Analysis**
From (m)	**To (m)**		**No.**	**Depth (mbgs)**		
0.00	0.30	**Topsoil**: Black to brown silty sand, trace gravel, loose, poorly sorted, moist.	-	-	-	-
0.30	2.00	**Silty Sand:** Brown to grey, trace gravel, loose to compact, poorly sorted, moist to wet.	1	0.8	-	ground water seepage observed at 0.8 & 2.0 mbgs Sample for T-time
		Test Pit Terminated at 2.0 mbgs				

Comments

Standpipe installed in test pit prior to backfilling.

Static water level (mbtoc) = 1.20
Total Depth (mbtoc) = 3.14
Stick-up (m) = 1.04 2 inch PVC with 1.5 m screen

Water Conditions in Test Pit

☑ Wet upon completion
☐ Dry upon completion

JOB No. 21-098
TEST PIT No. TP-3
FIELD STAFF Alan Turner

AZIMUTH ENVIRONMENTAL CONSULTING, INC.

Environmental Assessments & Approvals

TEST PIT LOG

Project Name/ Project Client	Menoke Beach Phase 3	**Project Address**	3651 Menoke Beach Road and 8743 Highway 11, Township of Severn, ON	**Date**	Tuesday, November 09, 2021
Test Pit Number	TP-4	**Contractor**	Moris Shelswell Excavating	**Elevation**	NA
Equipment	Backhoe Excavator	**Test Pit Size**	1m x 3.5m	**Datum**	Ground Surface
Temperature	10°C	**Weather**	Cloudy	**Sample Type**	Soil

Depth		**Soil description**	**Samples**		**Screening Parameters**	**Remarks / Chemical Analysis**
From (m)	**To (m)**		**No.**	**Depth (mbgs)**		
0.00	0.35	**Topsoil**: Black to brown silty sand, trace gravel, loose, poorly sorted, moist.	-	-	-	-
0.35	2.90	**Sandy Silt Till:** Brown to grey, trace gravel, loose to compact, moist. Clay seams noted at 1.3 to 1.8mbgs	1	0.7	-	sample for T-Time
		Test Pit Terminated at 2.9 mbgs				

Comments

Standpipe installed in test pit prior to backfilling.

Static water level (mbtoc) = 2.82
Total Depth (mbtoc) = 4.2
Stick-up (m) = 1.3 2 inch PVC with 1.5 m screen

Water Conditions in Test Pit

☐ Wet upon completion
☑ Dry upon completion

JOB No. 21-098
TEST PIT No. TP-4
FIELD STAFF Alan Turner

AZIMUTH ENVIRONMENTAL CONSULTING, INC.

Environmental Assessments & Approvals

TEST PIT LOG

Project Name/ Project Client	Menoke Beach Phase 3	**Project Address**	3651 Menoke Beach Road and 8743 Highway 11, Township of Severn, ON	**Date**	Wednesday, November 10, 2021
Test Pit Number	TP-5	**Contractor**	Moris Shelswell Excavating	**Elevation**	NA
Equipment	Backhoe Excavator	**Test Pit Size**	1.3m x 3m	**Datum**	Ground Surface
Temperature	4°C	**Weather**	Partly sunny	**Sample Type**	Soil

Depth		**Soil description**	**Samples**		**Screening Parameters**	**Remarks / Chemical Analysis**
From (m)	**To (m)**		**No.**	**Depth (mbgs)**		
0.00	0.28	**Topsoil**: Black to brown silty sand, trace gravel, loose, poorly sorted, moist.	-	-	-	-
0.28	0.90	**Sandy Silt Till:** Brown to grey, trace gravel, loose to compact, moist.	1	0.4	-	sample for T-Time
0.90	2.90	**Clayey Silt:** Brown to grey, stiff, stratified, moist to saturated. Clay seams noted.				Ground water seepage noted at 2 & 2.9mbgs
		Test Pit Terminated at 2.9 mbgs				

Comments

Standpipe installed in test pit prior to backfilling.

Static water level (mbtoc) = 1.73
Total Depth (mbtoc) = 4.23
Stick-up (m) = 1.3 2 inch PVC with 1.5 m screen

Water Conditions in Test Pit

☑ Wet upon completion
☐ Dry upon completion

JOB No. 21-098
TEST PIT No. TP-5
FIELD STAFF Alan Turner

LEGEND

⊕ Borehole Location
BH#

⊕ Temporary Benchmark
Base of hydro pole.
Assumed elevation of 100.00 metres
TBM

NOTES

1. This drawing should be read in conjunction with Soil-Mat Engineers & Consultants Ltd. Geotechnical Report SM 301553-G.

2. Borehole locations are approximate.

SOIL-MAT
ENGINEERS & CONSULTANTS LTD.

Geotechnical Investigation
Proposed Shadow Creek
Residential Development
Highway 11 and Menoke Beach Road
Orillia, Ontario

Borehole Location Plan

Project No. SM 301553-G

Date: April 2021

Drawn: SW | Checked: IS

SM 301553-G Borehole Location Plan

Drawing No. 1

Log of Borehole No. 1

Project No: SM 301553-G
Project: Proposed Residential Development
Location: Highway 11 and Menoke Beach Road
Client: LIV Communities

Project Manager: Ian Shaw, P. Eng.
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4949733
E: 626783

Depth	Elevation (m)	Symbol	Description	Well Data	Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
ft m 0	100.81		Ground Surface								
			Topsoil Approximately 150 millimetres of topsoil.		SS	1	3 4 5 7	9			
	99.30		**Silt** Brown, trace sand and gravel, with some clay, firm to hard.		SS	2	3 2 1 5	3			
	98.50		Cobbles and gravel		SS	3	5 5 4 45	9			
			Transition to grey		SS	4	5 9 11 16 wet spoon	20			
					SS	5	40 17 13 25	30			
	96.40				SS	6	50/2"	100			

End of Borehole

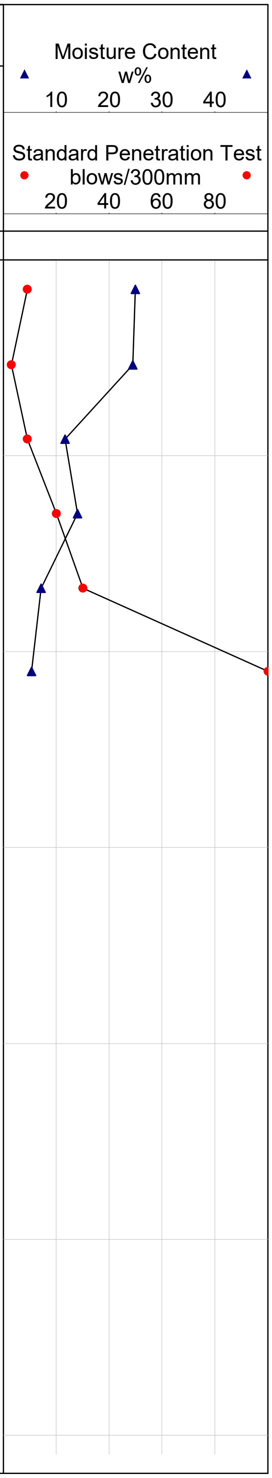
Practical auger and spoon refusal on assumed bedrock

NOTES:

1. Borehole was advanced using solid stem auger equipment on April 8, 2021 to practical auger and spoon refusal on assumed bedrock at a depth of 4.4 metres.

2. Borehole was recorded as open and 'dry' upon completion and backfilled as per Ontario Regulation 903.

3. Soil samples will be discarded after 3 months unless otherwise directed by our client.



Drill Method: Solid Stem Augers
Drill Date: April 8, 2021
Hole Size: 150 millimetres
Drilling Contractor: Walker Drilling

Soil-Mat Engineers & Consultants Ltd.
130 Lancing Drive, Hamilton, ON L8W 3A1
T: 905.318.7440 F: 905.318.7455
E: info@soil-mat.ca

Datum: Temporary
Field Logged by: SW
Checked by: IS
Sheet: 1 of 1

Log of Borehole No. 2

Project No: SM 301553-G
Project: Proposed Residential Development
Location: Highway 11 and Menoke Beach Road
Client: LIV Communities

Project Manager: Ian Shaw, P. Eng.
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4949897
E: 626787

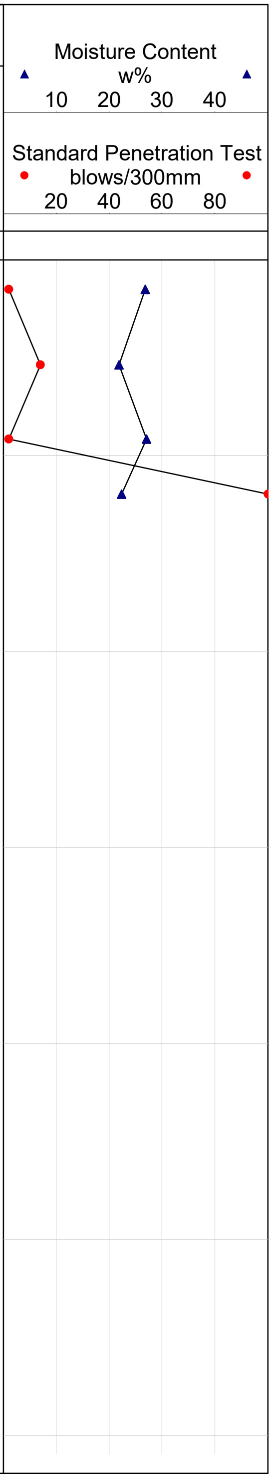
Depth (ft / m)	Elevation (m)	Symbol	Description	Well Data	SAMPLE Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
0 / 0	98.08		Ground Surface								
	97.78		**Topsoil** Approximately 300 millimetres of topsoil.		SS	1	2 1 1 1	2	▨		
			Silt Greyish brown, trace sand and gravel, with some clay, firm to hard.		SS	2	5 7 7 4 moist spoon	14	▨		
					SS	3	1 1 1 16 wet spoon	2	▨		
	95.80		End of Borehole Practical auger and spoon refusal on assumed bedrock		SS	4	50/2" wet spoon	100			

NOTES:

1. Borehole was advanced using solid stem auger equipment on April 8, 2021 to practical auger and spoon refusal on assumed bedrock at a depth of 2.3 metres.

2. Borehole was recorded as open and 'dry' upon completion and backfilled as per Ontario Regulation 903.

3. Soil samples will be discarded after 3 months unless otherwise directed by our client.



Drill Method: Solid Stem Augers
Drill Date: April 8, 2021
Hole Size: 150 millimetres
Drilling Contractor: Walker Drilling

Soil-Mat Engineers & Consultants Ltd.
130 Lancing Drive, Hamilton, ON L8W 3A1
T: 905.318.7440 F: 905.318.7455
E: info@soil-mat.ca

Datum: Temporary
Field Logged by: SW
Checked by: IS
Sheet: 1 of 1

Log of Borehole No. 3

Project No: SM 301553-G
Project: Proposed Residential Development
Location: Highway 11 and Menoke Beach Road
Client: LIV Communities

Project Manager: Ian Shaw, P. Eng.
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4949948
E: 626945

Depth ft: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
Depth m: 0 1 2 3 4 5 6 7 8 9 10 11 12

Elevation (m)	Description	Type	Number	Blow Counts	Blows/300mm	PP (kgf/cm2)	U.Wt.(kN/m3)
95.58	Ground Surface						
95.33	**Topsoil** Approximately 250 millimetres of topsoil.	SS	1	2 1 5 5	6		
	Silt Greyish brown, trace sand and gravel, with some clay, traces of black staining, firm to hard.	SS	2	4 3 3 5 moist spoon	6		
		SS	3	2 1 1 0 moist spoon	2		
		SS	4	2 2 3 2 moist spoon	5		
92.60	**Clayey Silt/Silt** Greyish brown, trace sand, soft to firm.	SS	5	2 2 1 3 moist spoon	3		
91.50	Transition to grey	SS	6	3 3 5 6 moist spoon	8	<1.0	
		SS	7	3 2 3 3 moist spoon	5	<1.0	
88.90	End of Borehole						

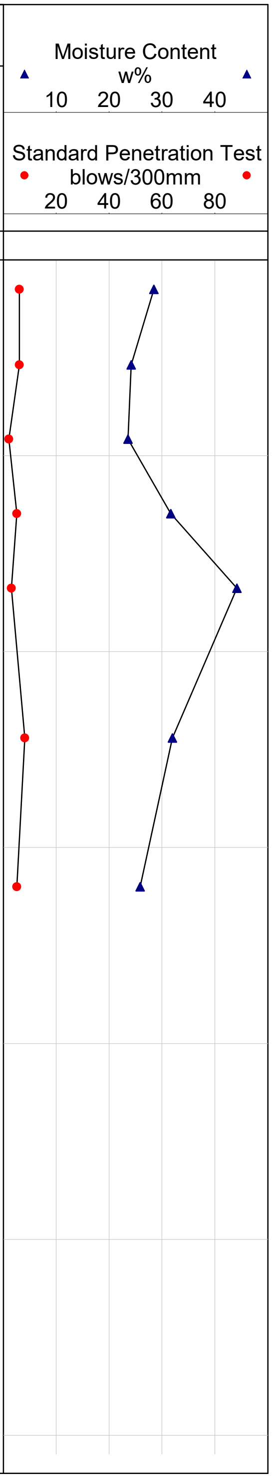
NOTES:

1. Borehole was advanced using solid stem auger equipment on April 8, 2021 to termination at a depth of 6.7 metres.

2. Borehole was recorded as open until 3.7 metres and 'wet' upon completion and backfilled as per Ontario Regulation 903.

3. Soil samples will be discarded after 3 months unless otherwise directed by our client.

4. A monitoring well was installed at this location upon completion and equipped with a data logger to monitor long-term groundwater fluctuations.



Drill Method: Solid Stem Augers
Drill Date: April 8, 2021
Hole Size: 150 millimetres
Drilling Contractor: Walker Drilling

Soil-Mat Engineers & Consultants Ltd.
130 Lancing Drive, Hamilton, ON L8W 3A1
T: 905.318.7440 F: 905.318.7455
E: info@soil-mat.ca

Datum: Temporary
Field Logged by: SW
Checked by: IS
Sheet: 1 of 1

Log of Borehole No. 4

Project No: SM 301553-G
Project: Proposed Residential Development
Location: Highway 11 and Menoke Beach Road
Client: LIV Communities
Project Manager: Ian Shaw, P. Eng.
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4949593
E: 626704

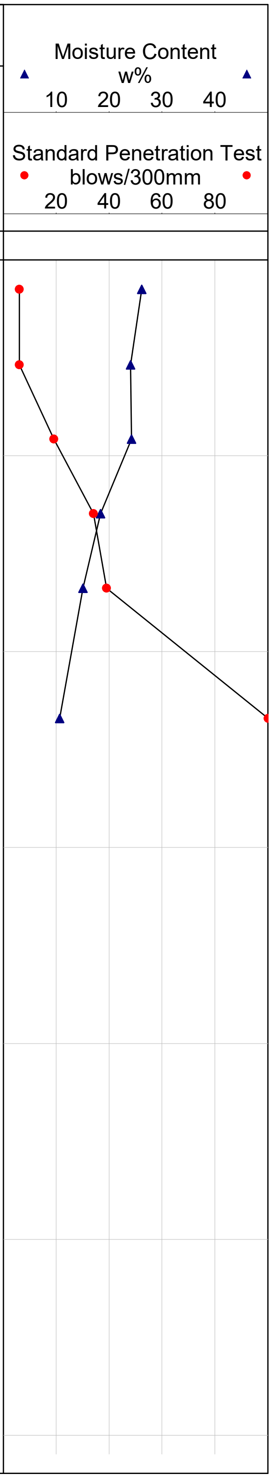
Depth (ft / m)	Elevation (m)	Description	Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
0 / 0	100.91	Ground Surface							
		Topsoil Approximately 100 millimetres of topsoil.	SS	1	2 2 4 5	6	▨		
		Silt Greyish brown, trace sand and gravel, with some clay, traces of black staining, firm to hard.	SS	2	2 3 3 4 moist spoon	6	▨		
			SS	3	5 9 10 12 moist spoon	19	▨		
			SS	4	9 14 20 28 moist spoon	34	▨		
			SS	5	18 18 21 26 moist spoon	39	▨		
	96.10		SS	6	7 50/3" moist spoon	100	▨		
		End of Borehole Practical auger and spoon refusal on assumed bedrock							

NOTES:

1. Borehole was advanced using solid stem auger equipment on April 8, 2021 to termination at a depth of 4.8 metres.

2. Borehole was recorded as open and 'dry' upon completion and backfilled as per Ontario Regulation 903.

3. Soil samples will be discarded after 3 months unless otherwise directed by our client.



Drill Method: Solid Stem Augers
Drill Date: April 8, 2021
Hole Size: 150 millimetres
Drilling Contractor: Walker Drilling

Soil-Mat Engineers & Consultants Ltd.
130 Lancing Drive, Hamilton, ON L8W 3A1
T: 905.318.7440 F: 905.318.7455
E: info@soil-mat.ca

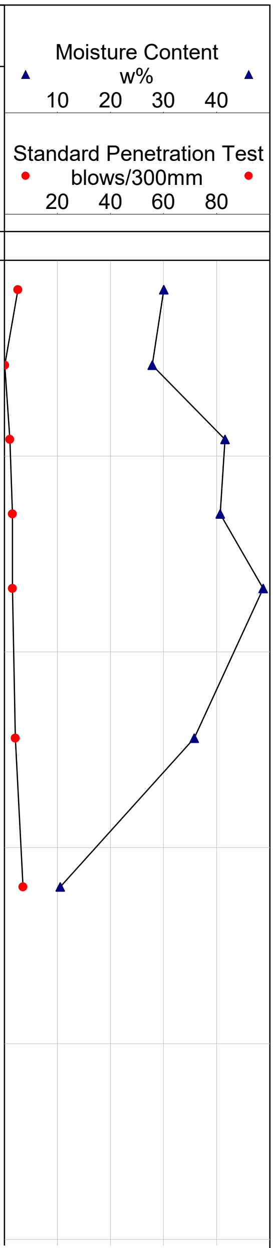
Datum: Temporary
Field Logged by: SW
Checked by: IS
Sheet: 1 of 1

Log of Borehole No. 5

Project No: SM 301553-G
Project: Proposed Residential Development
Location: Highway 11 and Menoke Beach Road
Client: LIV Communities

Project Manager: Ian Shaw, P. Eng.
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4949250
E: 626858

Depth (ft / m)	Elevation (m)	Symbol	Description	Well Data	SAMPLE Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
0 / 0	95.66		Ground Surface								
	95.41		**Topsoil** Approximately 250 millimetres of topsoil.		SS	1	1 2 3 5	5	▨		
			Silt Greyish brown, trace sand and gravel, with some clay, traces of black staining, firm.		SS	2	0 0 0 1 moist spoon	0	▨		
	93.90		Increased clay content		SS	3	2 1 1 3 moist spoon	2	▨	<1.0	
					SS	4	2 1 2 1 moist spoon	3	▨	<1.0	
					SS	5	2 1 2 3 moist spoon	3	▨	<1.0	
	91.60		Transition to grey								
	91.10		High clay content		SS	6	3 1 3 3 moist spoon	4	▨	<1.0	
					SS	7	2 5 2 2 moist spoon	7	▨	<1.0	
	86.60		End of Borehole Practical auger refusal on assumed bedrock								



NOTES:

1. Borehole was advanced using solid stem auger equipment on April 8, 2021 to practical auger refusal at a depth of 9.1 metres.

2. Borehole was recorded as open and 'dry' upon completion and backfilled as per Ontario Regulation 903.

3. Soil samples will be discarded after 3 months unless otherwise directed by our client.

Drill Method: Solid Stem Augers
Drill Date: April 8, 2021
Hole Size: 150 millimetres
Drilling Contractor: Walker Drilling

Soil-Mat Engineers & Consultants Ltd.
130 Lancing Drive, Hamilton, ON L8W 3A1
T: 905.318.7440 F: 905.318.7455
E: info@soil-mat.ca

Datum: Temporary
Field Logged by: SW
Checked by: IS
Sheet: 1 of 1

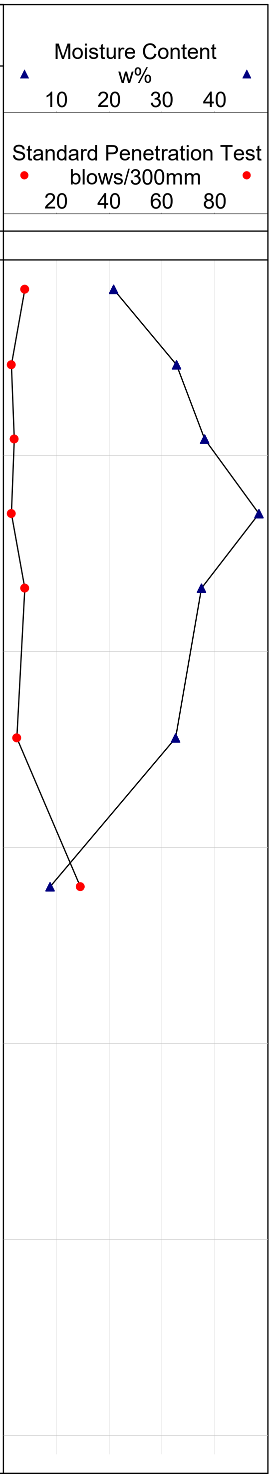
Log of Borehole No. 6

Soil-Mat

Project No: SM 301553-G
Project: Proposed Residential Development
Location: Highway 11 and Menoke Beach Road
Client: LIV Communities

Project Manager: Ian Shaw, P. Eng.
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4949096
E: 626907

Depth (ft / m)	Elevation (m)	Symbol	Description	Well Data	SAMPLE Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
0 / 0	94.13		Ground Surface								
			Topsoil Approximately 150 millimetres of topsoil.		SS	1	2 3 5 7	8	▨		
			Silt Greyish brown, trace sand and gravel, with some clay, traces of black staining, firm to very stiff.		SS	2	2 1 2 3 moist spoon	3	▨		
	92.60		Increased clay content		SS	3	2 2 2 2 wet spoon	4	▨		
					SS	4	2 2 1 2 wet spoon	3	▨	<1.0	
	90.90		Transition to grey		SS	5	4 3 5 4 wet spoon	8	▨		
					SS	6	2 3 2 3 wet spoon	5	▨		
	87.40				SS	7	4 8 21 50/4" wet spoon	29	▨		
			End of Borehole Spoon refusal on assumed bedrock								



NOTES:

1. Borehole was advanced using solid stem auger equipment on April 8, 2021 to termination at a depth of 6.7 metres.

2. Borehole was recorded as open until 4.3 metres and 'wet' upon completion and backfilled as per Ontario Regulation 903.

3. Soil samples will be discarded after 3 months unless otherwise directed by our client.

4. A monitoring well was installed at this location upon completion and equipped with a data logger to monitor long-term groundwater fluctuations.

Drill Method: Solid Stem Augers
Drill Date: April 9, 2021
Hole Size: 150 millimetres
Drilling Contractor: Walker Drilling

Soil-Mat Engineers & Consultants Ltd.
130 Lancing Drive, Hamilton, ON L8W 3A1
T: 905.318.7440 F: 905.318.7455
E: info@soil-mat.ca

Datum: Temporary
Field Logged by: SW
Checked by: IS
Sheet: 1 of 1

Log of Borehole No. 7

Project No: SM 301553-G
Project: Proposed Residential Development
Location: Highway 11 and Menoke Beach Road
Client: LIV Communities

Project Manager: Ian Shaw, P. Eng.
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4949329
E: 627095

Ground Surface: Elevation (m) 93.27

Topsoil

Approximately 150 millimetres of topsoil.

Silt

Greyish brown, trace sand and gravel, with some clay, traces of black staining, firm to very stiff.

89.90 — Transition to grey

82.30 — End of Borehole

Dynamic cone refusal on assumed bedrock

NOTES:

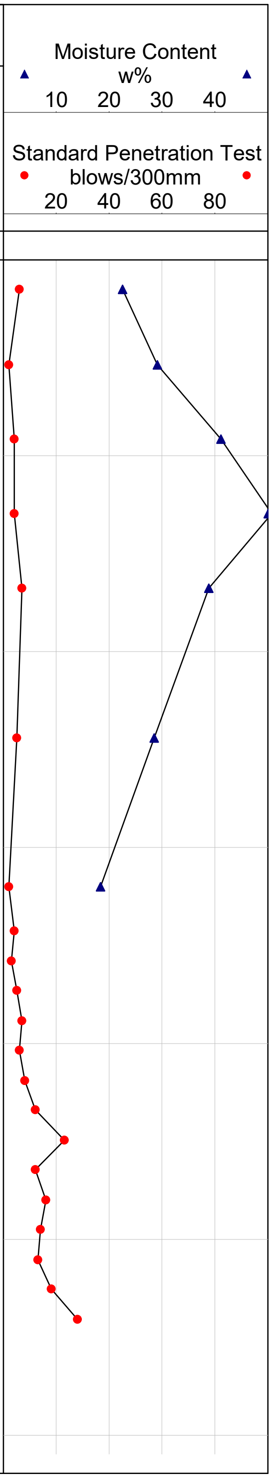
1. Borehole was advanced using solid stem auger equipment on April 8, 2021 to termination at a depth of 6.7 metres. A dynamic cone was then driven to a depth of approximately 11.0 metres.

2. Borehole was recorded as open until 4.0 metres and 'wet' upon completion and backfilled as per Ontario Regulation 903.

3. Soil samples will be discarded after 3 months unless otherwise directed by our client.

4. A monitoring well was installed at this location upon completion and equipped with a data logger to monitor long-term groundwater fluctuations.

Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
SS	1	2 2 4 6	6	▨		
SS	2	1 1 1 1	2	▨		
SS	3	1 2 2 2	4	▨	<1.0	
SS	4	1 1 3 3	4	▨	<1.0	
SS	5	2 3 4 6 wet spoon	7	▨	<1.0	
SS	6	2 3 2 4 wet spoon	5	▨		
SS	7	1 0 2 3 wet spoon	2	▨		
DC	8		4			
DC	8		3			
DC	9		5			
DC	10		7			
DC	11		6			
DC	12		8			
DC	13		12			
DC	14		23			
DC	15		12			
DC	16		16			
DC	17		14			
DC	18		13			
DC	19		18			
DC	20		28			



Drill Method: Solid Stem Augers
Drill Date: April 9, 2021
Hole Size: 150 millimetres
Drilling Contractor: Walker Drilling

Soil-Mat Engineers & Consultants Ltd.
130 Lancing Drive, Hamilton, ON L8W 3A1
T: 905.318.7440 F: 905.318.7455
E: info@soil-mat.ca

Datum: Temporary
Field Logged by: SW
Checked by: IS
Sheet: 1 of 1

Log of Borehole No. 8

Project No: SM 301553-G
Project: Proposed Residential Development
Location: Highway 11 and Menoke Beach Road
Client: LIV Communities

Project Manager: Ian Shaw, P. Eng.
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4949384
E: 626701

Depth (ft / m)	Elevation (m)	Symbol	Description	Well Data	SAMPLE Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
0 / 0	99.28		Ground Surface								
			Topsoil Approximately 200 millimetres of topsoil.		SS	1	1 2 3 5	5	▨		
	98.20		**Silt** Greyish brown, trace sand and gravel, with some clay, hard to firm.		SS	2	5 8 11 15	19	▨		
					SS	3	15 23 27 17 moist spoon	50	▨		
			Transition to grey								
	97.00		Increased clay content		SS	4	2 1 1 2 wet spoon	2	▨	<1.0	
					SS	5	2 1 3 2 wet spoon	4	▨	<1.0	
					SS	6	7 5 5 7 wet spoon	10	▨	<1.0	
	92.80		End of Borehole								

End of Borehole

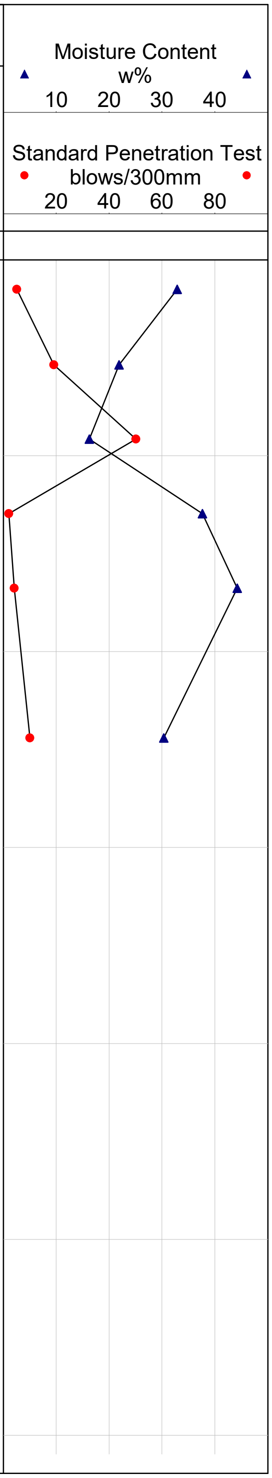
Practical auger refusal on assumed bedrock

NOTES:

1. Borehole was advanced using solid stem auger equipment on April 9, 2021 to practical auger refusal at a depth of 6.5 metres.

2. Borehole was recorded as open and 'wet' at a depth of 2.7 metres upon completion and backfilled as per Ontario Regulation 903.

3. Soil samples will be discarded after 3 months unless otherwise directed by our client.



Drill Method: Solid Stem Augers
Drill Date: April 9, 2021
Hole Size: 150 millimetres
Drilling Contractor: Walker Drilling

Soil-Mat Engineers & Consultants Ltd.
130 Lancing Drive, Hamilton, ON L8W 3A1
T: 905.318.7440 F: 905.318.7455
E: info@soil-mat.ca

Datum: Temporary
Field Logged by: SW
Checked by: IS
Sheet: 1 of 1

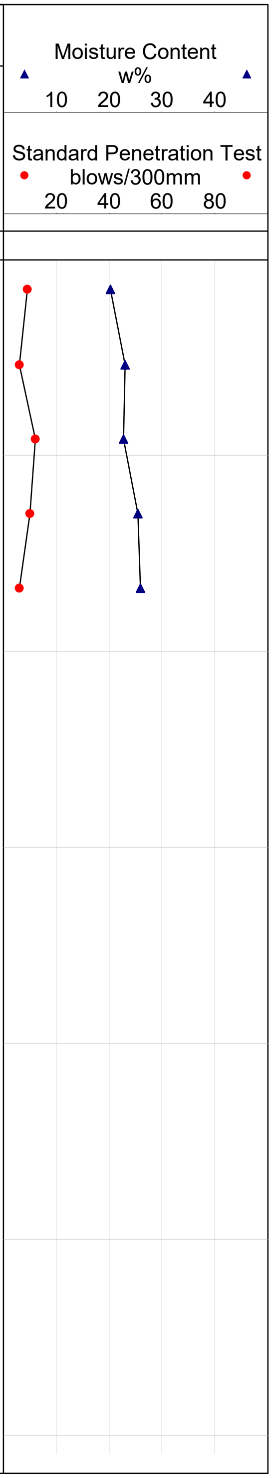
Log of Borehole No. 9

Project No: SM 301553-G
Project: Proposed Residential Development
Location: Highway 11 and Menoke Beach Road
Client: LIV Communities

Project Manager: Ian Shaw, P. Eng.
Borehole Location: See Drawing No. 1
UTM Coordinates - N: 4949700
E: 626905

Depth (ft / m)	Elevation (m)	Description
0	96.07	Ground Surface
0		**Topsoil** Approximately 200 millimetres of topsoil.
		Silt Greyish brown, trace sand and gravel, with some clay, firm to stiff.
	93.90	Transition to grey
	93.20	Increased clay content
	91.80	End of Borehole Practical auger and spoon refusal on assumed bedrock

Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
SS	1	2 3 6 7	9			
SS	2	2 3 3 4 wet spoon	6			
SS	3	4 6 6 5 wet spoon	12			
SS	4	3 4 6 6 wet spoon	10			
SS	5	4 3 3 6 wet spoon	6			



NOTES:

1. Borehole was advanced using solid stem auger equipment on April 9, 2021 to termination at a depth of 4.3 metres.

2. Borehole was recorded as open and 'dry' upon completion and backfilled as per Ontario Regulation 903.

3. Soil samples will be discarded after 3 months unless otherwise directed by our client.

4. A monitoring well was installed at this location upon completion and equipped with a data logger to monitor long-term groundwater fluctuations.

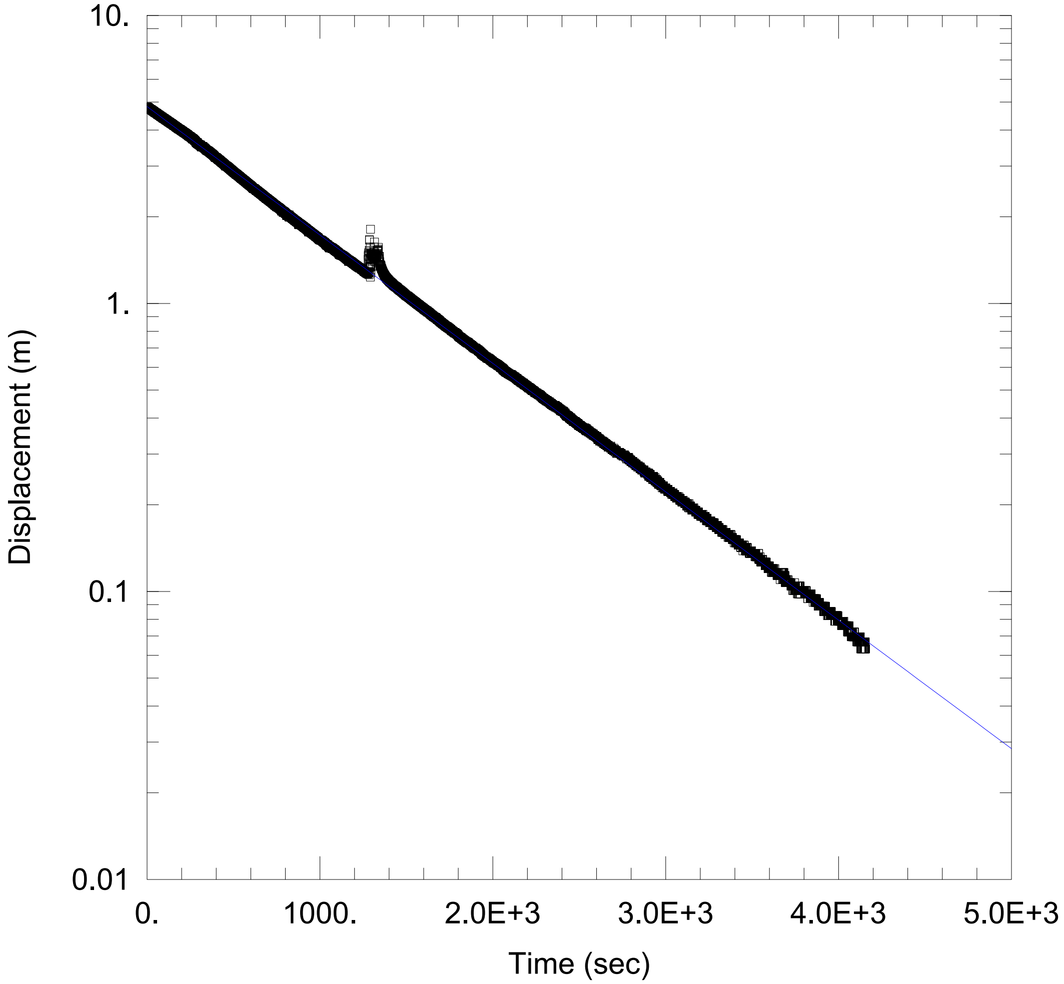
Drill Method: Solid Stem Augers
Drill Date: April 9, 2021
Hole Size: 150 millimetres
Drilling Contractor: Walker Drilling

Soil-Mat Engineers & Consultants Ltd.
130 Lancing Drive, Hamilton, ON L8W 3A1
T: 905.318.7440 F: 905.318.7455
E: info@soil-mat.ca

Datum: Temporary
Field Logged by: SW
Checked by: IS
Sheet: 1 of 1

APPENDIX F

Slug Testing Results



WELL TEST ANALYSIS

Data Set: M:\...\BH3 Slug Test.aqt
Date: 12/02/21 Time: 10:51:24

PROJECT INFORMATION

Company: Azimuth Environmental
Project: 21-098
Test Well: BH3
Test Date: November 11, 2021

AQUIFER DATA

Saturated Thickness: 4.91 m
Anisotropy Ratio (Kz/Kr): 1.

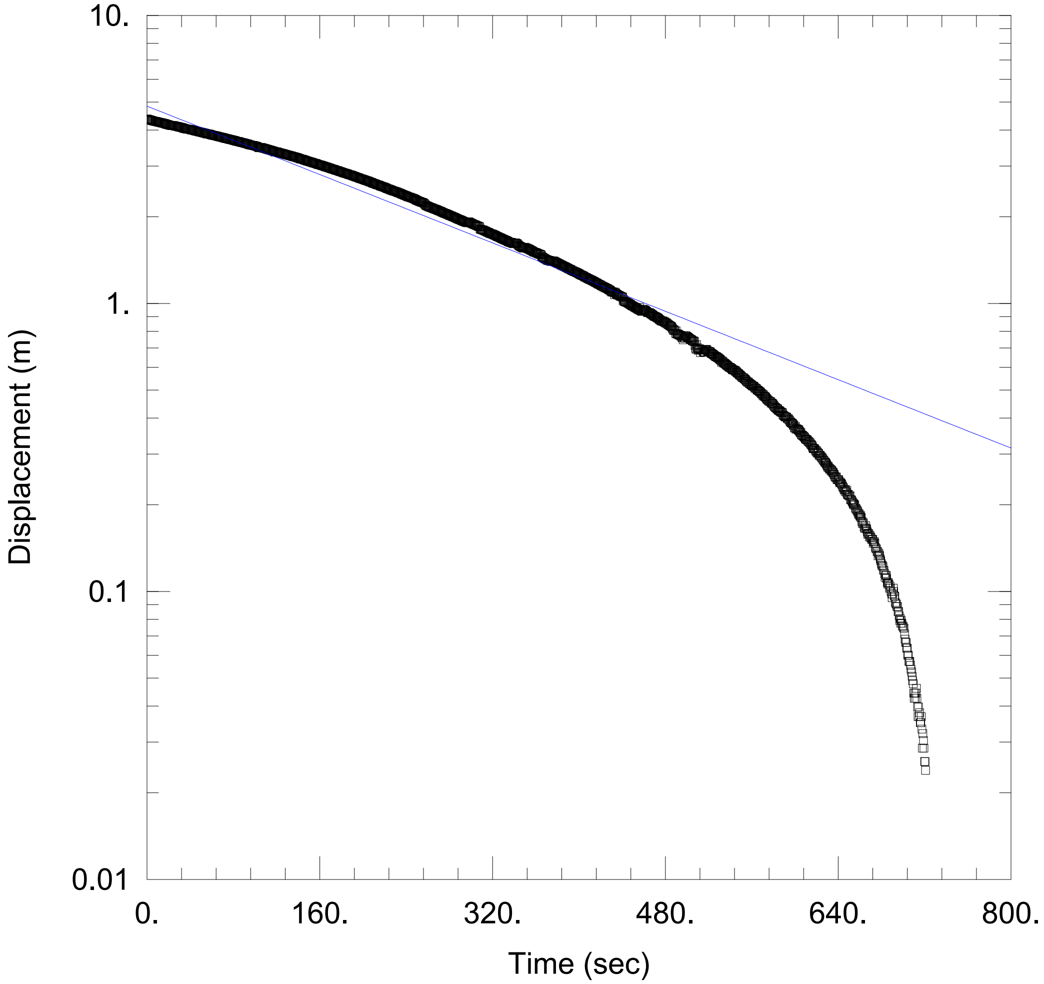
WELL DATA (BH3)

Initial Displacement: 4.811 m
Total Well Penetration Depth: 4.91 m
Casing Radius: 0.0254 m
Static Water Column Height: 4.91 m
Screen Length: 1.5 m
Wellbore Radius: 0.075 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 8.145E-7 m/sec
y0 = 4.825 m



WELL TEST ANALYSIS

Data Set: M:\...\BH6 Slug Test.aqt
Date: 12/02/21
Time: 10:57:54

PROJECT INFORMATION

Company: Azimuth Environmental
Project: 21-098
Test Well: BH6
Test Date: November 11, 2021

AQUIFER DATA

Saturated Thickness: 5.15 m
Anisotropy Ratio (Kz/Kr): 1.

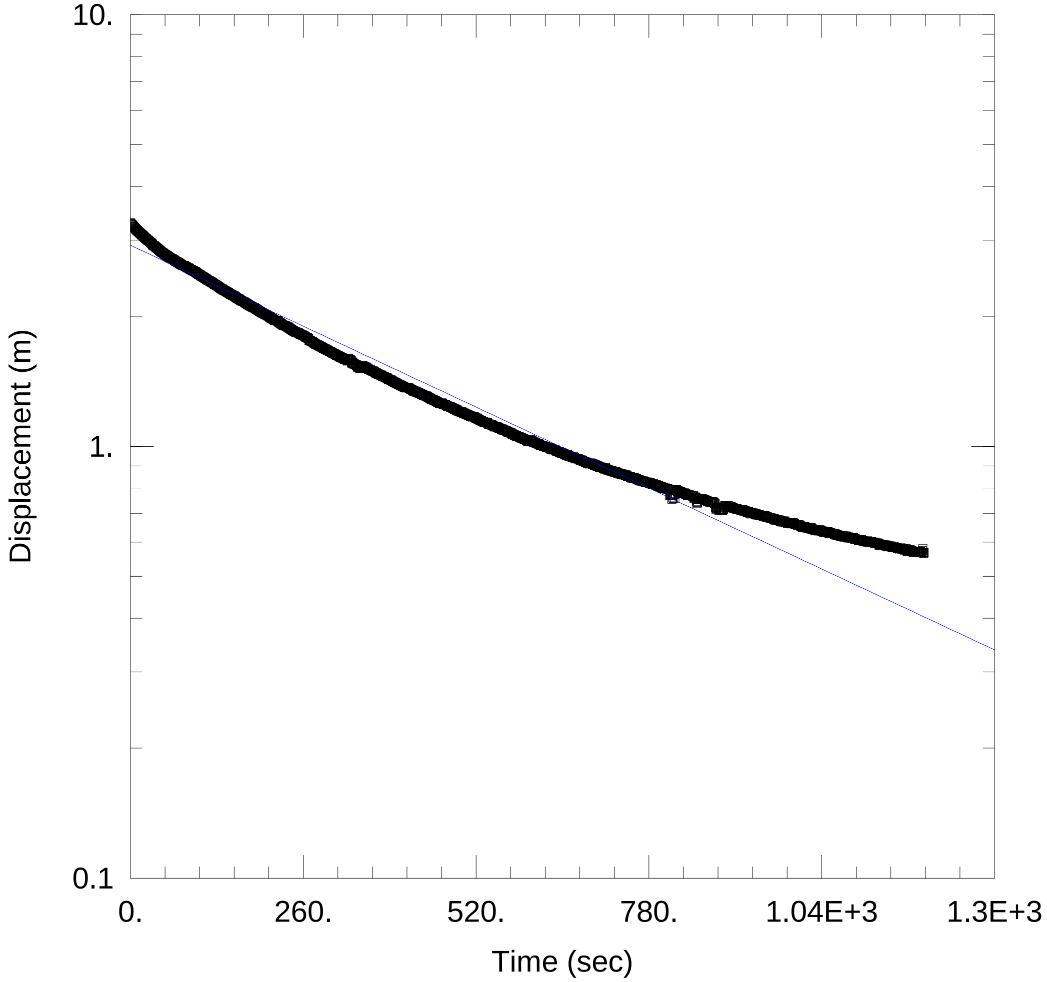
WELL DATA (BH6)

Initial Displacement: 4.367 m
Static Water Column Height: 5.15 m
Total Well Penetration Depth: 5.15 m
Screen Length: 3. m
Casing Radius: 0.0254 m
Wellbore Radius: 0.075 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 1.61E-6 m/sec
y0 = 4.841 m



WELL TEST ANALYSIS

Data Set: M:\...\BH9 Slug Test.aqt
Date: 12/02/21 Time: 11:01:33

PROJECT INFORMATION

Company: Azimuth Environmental
Project: 21-098
Test Well: BH9
Test Date: November 11, 2021

AQUIFER DATA

Saturated Thickness: 3.44 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH9)

Initial Displacement: 3.29 m Static Water Column Height: 3.44 m
Total Well Penetration Depth: 3.44 m Screen Length: 1.5 m
Casing Radius: 0.0254 m Wellbore Radius: 0.075 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 1.317E-6 m/sec y0 = 2.92 m

APPENDIX G

Guelph Permeameter Testing Data

Guelph Pereameter Infiltration Test Results

Investigator: Alan Turner & Spencer Yerbury
Date: 09-Nov-21
Location: Menoke Beach
TP ID: TP-1
Depth of Hole: 20 cm
Radius: 3 cm
Reserviors used during test: Combined
(Combined or Inner)
Reservior constant used: 35.39
Ground Surface Elevation: 226.30 masl

Water Level in Well: 5 cm

Time ***t*** (min)	**Δ*t*** (min)	Water level in Reservoir ***h*** (cm)	**Δ*h*** (cm)	Rate of Change **Δ*h*/ Δ*t*** (cm/ min)
0	--	10.0	--	--
0.5	0.5	10.0	0.0	0.000
1	0.5	10.0	0.0	0.000
2	1	10.0	0.0	0.000
3	1	10.0	0.0	0.000
8	5	10.0	0.0	0.000

Steady rate for 3 consecutive readings (**R_1**): 0.000

Water Level in Well: 5 cm

Time ***t*** (min)	**Δ*t*** (min)	Water level in Reservoir ***h*** (cm)	**Δ*h*** (cm)	Rate of Change **Δ*h*/ Δ*t*** (cm/ min)
0	--	2	--	--
0.5	0.5	2	0.0	0.00
1	0.5	2.0	0.0	0.00
1.5	0.5	2.3	0.3	0.60
2	0.5	2.3	0.0	0.00
3	1	2.3	0.0	0.00
5	2	2.3	0.0	0.00

Steady rate for 3 consecutive readings (**R_2**): 0.600

Guelph Permeameter Calculations

🟩 Input

🟨 Result

Support: ali@soilmoisture.com

Head #1

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): 1
Enter water Head Height ("H" in cm): 10
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc.

Steady State Rate of Water Level Change ("R" in cm/min): 0.0000

Res Type	35.22
H	10
a	3
H/a	3.333
a*	0.12
C0.01	1.218
C0.04	1.29
C0.12	1.288
C0.36	1.288
C	1.288
R	0.000
Q	0
pi	3.142

$\alpha^* =$ 0.12 (cm^{-1})

$C =$ 1.287543
$Q =$ 0

$K_{fs} =$	0.00E+00	cm/sec
	0.00E+00	cm/min
	0.00E+00	m/sec
	0.00E+00	inch/min
	0.00E+00	inch/sec
$\Phi_m =$	0.00E+00	(cm^2/min)

Head #2

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): 1
Enter water Head Height ("H" in cm): 5
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.6000

Res Type	35.22
H	5
a	3
H/a	1.666667
a*	0.12
C0.01	0.809485
C0.04	0.842059
C0.12	0.803154
C0.36	0.803154
C	0.803154
R	0.600
Q	0.3522
pi	3.1415

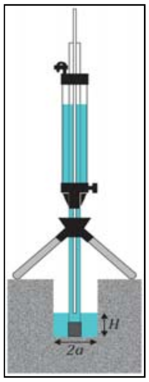
$\alpha^* =$ 0.12 (cm^{-1})

$C =$ 0.803154
$Q =$ 0.3522

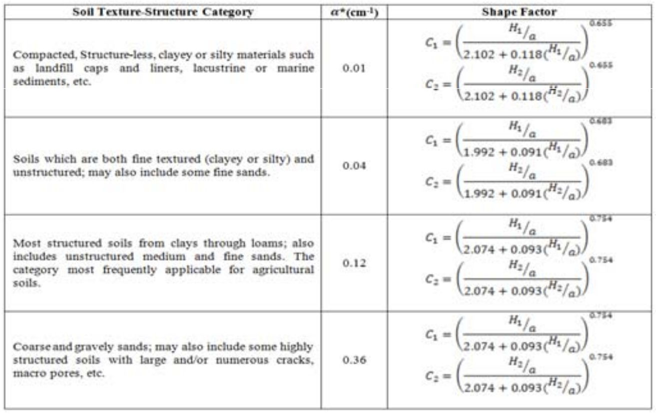
$K_{fs} =$	6.41E-04	cm/sec
	3.84E-02	cm/min
	6.41E-06	m/ses
	1.51E-02	inch/min
	2.52E-04	inch/sec
$\Phi_m =$	5.34E-03	(cm^2/min)

Average

$K_{fs} =$	3.20E-04	cm/sec
	1.92E-02	cm/min
	3.20E-06	m/s
	7.57E-03	inch/min
	1.26E-04	inch/sec
$\Phi_m =$	2.67E-03	(cm^2/min)

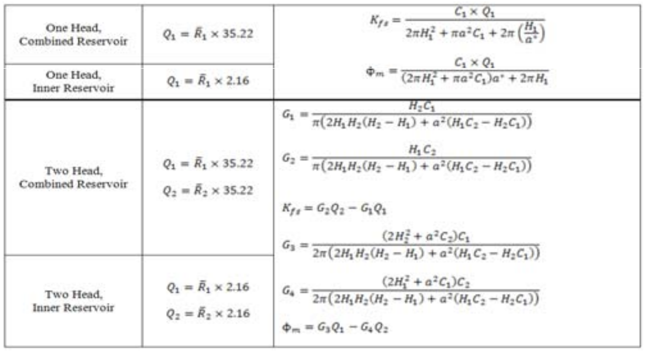


Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and a^* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).



Soil Texture-Structure Category	$\alpha^*(cm^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_1/a}{2.102 + 0.118(H_1/a)}\right)^{0.655}$ $C_2 = \left(\frac{H_2/a}{2.102 + 0.118(H_2/a)}\right)^{0.655}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091(H_1/a)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where $\bar{R}$ is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm²/s), α^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm) , H_2 is the second head of water established in borehole (cm) and C is Shape factor (from Table 2).



One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{a^*}\right)}$ $\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)a^* + 2\pi H_1}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $G_2 = \frac{H_1 C_2}{\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $K_{fs} = G_2 Q_2 - G_1 Q_1$ $G_3 = \frac{(2H_2^2 + a^2 C_2)C_1}{2\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $G_4 = \frac{(2H_1^2 + a^2 C_1)C_2}{2\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $\Phi_m = G_3 Q_1 - G_4 Q_2$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	

Guelph Pereameter Infiltration Test Results

Investigator: Alan Turner & Spencer Yerbury
Date: 09-Nov-21
Location: Menoke Beach
TP ID: TP-2
Depth of Hole: 22 cm
Radius: 3 cm
Reserviors used during test: Inner
(Combined or Inner)
Reservior constant used: 2.14
Ground Surface Elevation: 224.80 masl

Water Level in Well: 5 cm

Time ***t*** (min)	**Δ*t*** (min)	Water level in Reservoir ***h*** (cm)	**Δ*h*** (cm)	Rate of Change **Δ*h*/ Δ*t*** (cm/ min)
0.0	--	24.0	--	--
1.0	1.00	26.1	2.1	2.100
2.0	1.00	27.0	0.9	0.900
3.0	1.00	28.1	1.1	1.100
4.0	1.00	28.9	0.8	0.800
5.0	1.00	29.9	1.0	1.000
6.0	1.00	30.9	1.0	1.000
7.0	1.00	31.9	1.0	1.000
8.0	1.00	32.9	1.0	1.000
9.0	1.00	33.8	0.9	0.900
10.0	1.00	34.6	0.8	0.800
			Steady rate for 3 consecutive readings (**R_1**):	1.000

SOILMOISTURE Guelph Permeameter Calculations

🟩 Input

🟨 Result

Support: ali@soilmoisture.com

Head #1

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): 2
Enter water Head Height ("H" in cm): 5
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc.

Steady State Rate of Water Level Change ("R" in cm/min): 1.0000

Res Type	2.16
H	5
a	3
H/a	1.667
a*	0.12
C0.01	0.809
C0.04	0.842
C0.12	0.803
C0.36	0.803
C	0.803
R	1.000
Q	0.036
pi	3.142

$\alpha^* =$ 0.12 (cm^{-1})

$C =$ 0.803154
$Q =$ 0.036

$K_{fs} =$	6.55E-05	cm/sec
	3.93E-03	cm/min
	6.55E-07	m/sec
	1.55E-03	inch/min
	2.58E-05	inch/sec

$\Phi_m =$ 5.46E-04 $(\mathrm{cm}^2/\mathrm{min})$

Head #2

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): 2
Enter water Head Height ("H" in cm): 5
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.0000

Res Type	2.16
H	5
a	3
H/a	1.666667
a*	0.12
C0.01	0.809485
C0.04	0.842059
C0.12	0.803154
C0.36	0.803154
C	0.803154
R	0.000
Q	0
pi	3.1415

$\alpha^* =$ 0.12 (cm^{-1})

$C =$ 0.803154
$Q =$ 0

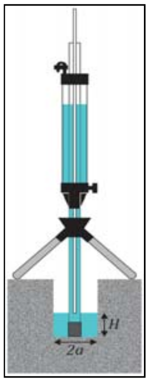
$K_{fs} =$	0.00E+00	cm/sec
	0.00E+00	cm/min
	0.00E+00	m/ses
	0.00E+00	inch/min
	0.00E+00	inch/sec

$\Phi_m =$ 0.00E+00 $(\mathrm{cm}^2/\mathrm{min})$

Average

$K_{fs} =$	6.55E-05	cm/sec
	3.93E-03	cm/min
	6.55E-07	m/s
	1.55E-03	inch/min
	2.58E-05	inch/sec

$\Phi_m =$ 5.46E-04 $(\mathrm{cm}^2/\mathrm{min})$



Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α^* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	$\alpha^*(\mathrm{cm}^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_1/a}{2.102 + 0.118(H_1/a)}\right)^{0.655}$ $C_2 = \left(\frac{H_2/a}{2.102 + 0.118(H_2/a)}\right)^{0.655}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091(H_1/a)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where $\bar{R}$ is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm²/s), α^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm), H_2 is the second head of water established in borehole (cm) and C is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{\alpha^*}\right)}$ $\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)\alpha^* + 2\pi H_1}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_2 = \frac{H_1 C_2}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $K_{fs} = G_2Q_2 - G_1Q_1$ $G_3 = \frac{(2H_2^2 + a^2C_2)C_1}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_4 = \frac{(2H_1^2 + a^2C_1)C_2}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $\Phi_m = G_3Q_1 - G_4Q_2$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	

Guelph Pereameter Infiltration Test Results

Investigator: Alan Turner & Spencer Yerbury
Date: 09-Nov-21
Location: Menoke Beach
TP ID: TP-4
Depth of Hole: 28 cm
Radius: 3 cm
Reserviors used during test: Combined
(Combined or Inner)
Reservior constant used: 35.39
Ground Surface Elevation: 225.20 masl

Water Level in Well: 20 cm

Time ***t*** (min)	**Δ*t*** (min)	Water level in Reservoir ***h*** (cm)	**Δ*h*** (cm)	Rate of Change **Δ*h*/ Δ*t*** (cm/ min)
0	--	25.0	--	--
1	1	25.8	0.8	0.800
2	1	26.1	0.3	0.300
3	1	26.6	0.5	0.500
4	1	27.4	0.8	0.800
5	1	28.0	0.6	0.600
6	1	28.6	0.6	0.600
7	1	29.3	0.7	0.700
8	1	29.5	0.2	0.200
9	1	29.9	0.4	0.400
10	1	30.2	0.3	0.300
15	5	32.0	1.8	0.360
20	5	33.2	1.2	0.240
25	5	34.6	1.4	0.280
			Steady rate for 3 consecutive readings (**R_1**):	0.300

SOILMOISTURE Guelph Permeameter Calculations

🟩 Input

🟨 Result

Support: ali@soilmoisture.com

Head #1

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir):	1
Enter water Head Height ("H" in cm):	20
Enter the Borehole Radius ("a" in cm):	3
Enter the soil texture-structure category (enter one of the below numbers):	3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.3000

Res Type	35.22
H	20
a	3
H/a	6.667
a*	0.12
C0.01	1.755
C0.04	1.903
C0.12	1.98
C0.36	1.98
C	1.98
R	0.300
Q	0.176
pi	3.142

$\alpha^* =$ 0.12 (cm^{-1})

$C =$ 1.980192

$Q =$ 0.1761

$K_{fs} =$	9.64E-05	cm/sec
	5.79E-03	cm/min
	9.64E-07	m/sec
	2.28E-03	inch/min
	3.80E-05	inch/sec

$\Phi_m =$ 8.04E-04 (cm^2/sec)

Head #2

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir):	1
Enter water Head Height ("H" in cm):	10
Enter the Borehole Radius ("a" in cm):	3
Enter the soil texture-structure category (enter one of the below numbers):	3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.0000

Res Type	35.22
H	10
a	3
H/a	3.333333
a*	0.12
C0.01	1.21841
C0.04	1.290234
C0.12	1.287543
C0.36	1.287543
C	1.287543
R	0.000
Q	0
pi	3.1415

$\alpha^* =$ 0.12 (cm^{-1})

$C =$ 1.287543

$Q =$ 0

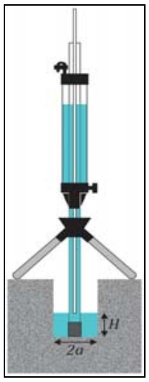
$K_{fs} =$	0.00E+00	cm/sec
	0.00E+00	cm/min
	0.00E+00	m/ses
	0.00E+00	inch/min
	0.00E+00	inch/sec

$\Phi_m =$ 0.00E+00 (cm^2/sec)

Average

$K_{fs} =$	9.64E-05	cm/sec
	5.79E-03	cm/min
	9.64E-07	m/s
	2.28E-03	inch/min
	3.80E-05	inch/sec

$\Phi_m =$ 4.02E-04 (cm^2/sec)



Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α^* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	$\alpha^*(cm^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_1/a}{2.102 + 0.118(H_1/a)}\right)^{0.655}$ $C_2 = \left(\frac{H_2/a}{2.102 + 0.118(H_2/a)}\right)^{0.655}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091(H_1/a)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm²/s), α^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm), H_2 is the second head of water established in borehole (cm) and C is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{a^*}\right)}$ $\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)a^* + 2\pi H_1}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_2 = \frac{H_1 C_2}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $K_{fs} = G_2Q_2 - G_1Q_1$ $G_3 = \frac{(2H_2^2 + a^2C_2)C_1}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_4 = \frac{(2H_1^2 + a^2C_1)C_2}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $\Phi_m = G_3Q_1 - G_4Q_2$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	

Guelph Pereameter Infiltration Test Results

Investigator: Alan Turner & Spencer Yerbury
Date: 09-Nov-21
Location: Menoke Beach
TP ID: TP-5
Depth of Hole: 28 cm
Radius: 3 cm
Reserviors used during test: Combined
(Combined or Inner)
Reservior constant used: 35.39
Ground Surface Elevation: 221.98 masl

Water Level in Well: 20 cm

Time ***t*** (min)	Δ***t*** (min)	Water level in Reservoir ***h*** (cm)	Δ***h*** (cm)	Rate of Change **Δ*h*/ Δ*t*** (cm/ min)
0	--	10.0	--	--
1	1	14.3	4.3	4.300
2	1	14.5	0.2	0.200
3	1	14.7	0.2	0.200
4	1	14.9	0.2	0.200
5	1	15.0	0.1	0.100
10	5	15.9	0.9	0.180
15	5	16.4	0.5	0.100
20	5	17.0	0.6	0.120

Steady rate for 3 consecutive readings (**R_1**): 0.100

SOILMOISTURE Guelph Permeameter Calculations

🟩 Input

🟨 Result

Support: ali@soilmoisture.com

Head #1

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir):	1
Enter water Head Height ("H" in cm):	20
Enter the Borehole Radius ("a" in cm):	3
Enter the soil texture-structure category (enter one of the below numbers):	3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc.

Steady State Rate of Water Level Change ("R" in cm/min): 0.1000

Res Type	35.22
H	20
a	3
H/a	6.667
a*	0.12
C0.01	1.755
C0.04	1.903
C0.12	1.98
C0.36	1.98
C	1.98
R	0.100
Q	0.059
pi	3.142

$\alpha^* =$ 0.12 (cm^{-1})

$C =$ 1.980192

$Q =$ 0.0587

$K_{fs} =$	3.21E-05	cm/sec
	1.93E-03	cm/min
	3.21E-07	m/sec
	7.59E-04	inch/min
	1.27E-05	inch/sec
$\Phi_m =$	2.68E-04	$(\mathrm{cm}^2/\mathrm{sec})$

Head #2

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir):	
Enter water Head Height ("H" in cm):	
Enter the Borehole Radius ("a" in cm):	
Enter the soil texture-structure category (enter one of the below numbers):	

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.0000

Res Type	0
H	0
a	0
H/a	#DIV/0!
a*	0
C0.01	#DIV/0!
C0.04	#DIV/0!
C0.12	#DIV/0!
C0.36	#DIV/0!
C	0
R	0.000
Q	0
pi	3.1415

$\alpha^* =$ 0 (cm^{-1})

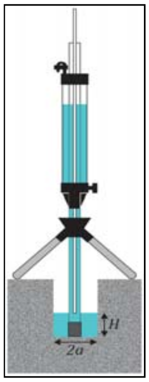
$C =$ 0

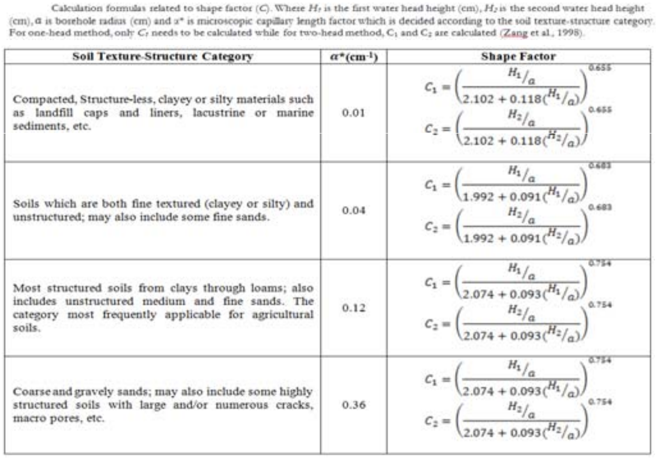
$Q =$ 0

$K_{fs} =$	#DIV/0!	cm/sec
	#DIV/0!	cm/min
	#DIV/0!	m/ses
	#DIV/0!	inch/min
	#DIV/0!	inch/sec
$\Phi_m =$	#DIV/0!	$(\mathrm{cm}^2/\mathrm{sec})$

Average

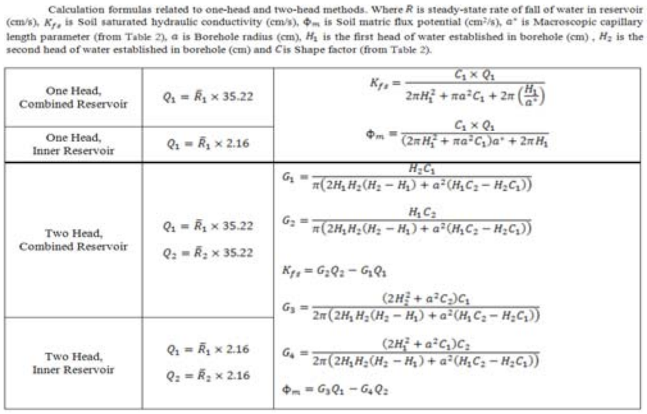
$K_{fs} =$	3.21E-05	cm/sec
	1.93E-03	cm/min
	3.21E-07	m/s
	7.59E-04	inch/min
	1.27E-05	inch/sec
$\Phi_m =$	2.68E-04	$(\mathrm{cm}^2/\mathrm{sec})$





Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α^* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	$\alpha^*(\mathrm{cm}^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_1/a}{2.102 + 0.118(H_1/a)}\right)^{0.655}$ $C_2 = \left(\frac{H_2/a}{2.102 + 0.118(H_2/a)}\right)^{0.655}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091(H_1/a)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$



Calculation formulas related to one-head and two-head methods. Where $\bar{R}$ is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm²/s), α^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm) , H_2 is the second head of water established in borehole (cm) and C is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{a^*}\right)}$ $\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)a^* + 2\pi H_1}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_2 = \frac{H_1 C_2}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $K_{fs} = G_2Q_2 - G_1Q_1$ $G_3 = \frac{(2H_2^2 + a^2C_2)C_1}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_4 = \frac{(2H_1^2 + a^2C_1)C_2}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $\Phi_m = G_3Q_1 - G_4Q_2$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	

November 24, 2021

Azimuth Environmental Consulting Inc.
642 Welham Road
Barrie, Ontario
L4N 9A1

Attn: Alan Turner

RE: Ref. No 21-098
T-Time Analyses

Dear Mr. Turner

GEI Consultants (GEI) was provided with five (5) soil samples on November 10, 2021 to conduct grain size analyses to determine the percolation rates of the tested soils (T-Time analysis).

The delivered samples were identified as follows.

- Ref. No. 21-098, TP 1, 0.4 m
- Ref. No. 21-098, TP 2, 0.7 m
- Ref. No. 21-098, TP 3, 0.8 m
- Ref. No. 21-098, TP 4, 0.7 m
- Ref. No. 21-098, TP 5, 0.4 m

Five grain size distribution curves were developed by testing the above referenced soil samples in accordance with applicable Ontario Laboratory Standards in reference to ASTM D6913 (sieve analysis) and ASTM D7928 (sedimentation / hydrometer analysis). The result of the laboratory test and graphical representation of the grain size analyses are enclosed.

Determination of percolation rate are based on the "*Ministry of Municipal Affairs and Housing (MMAH) Supplementary Guidelines SB-6, Percolation Time and Soil Descriptions, September 14, 2012*". Based on this document, a summary of the result and the estimated percolation rate of the soil is as follows:

Client ID	GEI Sample ID	Soil Description (MIT)	USCS Soil Classification	Estimated Percolation Rate or "*T-Time*" (mins/cm)	Estimated Infiltration Rate (mm/hr)
2795	TP 1, 0.4 m	SILT, Some Sand, Some Clay	M.L.	50 mins/cm	12 mm/hour

Client ID	GEI Sample ID	Soil Description (MIT)	USCS Soil Classification	Estimated Percolation Rate or "*T-Time*" (mins/cm)	Estimated Infiltration Rate (mm/hr)
2796	TP 2, 0.7 m	SANDY SILT, Trace Clay	S.M.	40 mins/cm	15 mm/hour
2797	TP 3, 0.8 m	SILT, Some Sand, Trace Clay	M.L.	50 mins/cm	12 mm/hour
2798	TP 4, 0.7 m	CLAYEY SILT, Trace Sand	M.L.	>50 mins/cm	<12 mm/hour
2799	TP 5, 0.4 m	SILT, Trace Clay, Trace Sand	M.L.	50 mins/cm	12 mm/hour

It is noted that percolation time not only varies based on the grain size distribution but is also influenced by other soil characteristics such as the density of the soil, the structure of the soil, the percentage/mineralogy of clay, the plasticity of the soil, the organic content of the soil, and the groundwater table level which are not expressly calculated as part of a grain size analysis.

No field investigation was conducted by GEI in conjunction with the above testing and did not witness the depth or location in which these samples were obtained. GEI is providing the percolation rates as factual information, to be used in design by a qualified professional with due regard to the limitations as indicated above.

We trust this information is sufficient for your present purposes. Should you have any questions concerning the above, or can be of any further assistance, please do not hesitate to contact the undersigned.

Yours truly,
GEI Consultants

LICENSED PROFESSIONAL ENGINEER
A.WINKELMANN
100150146
21-Nov-24
PROVINCE OF ONTARIO

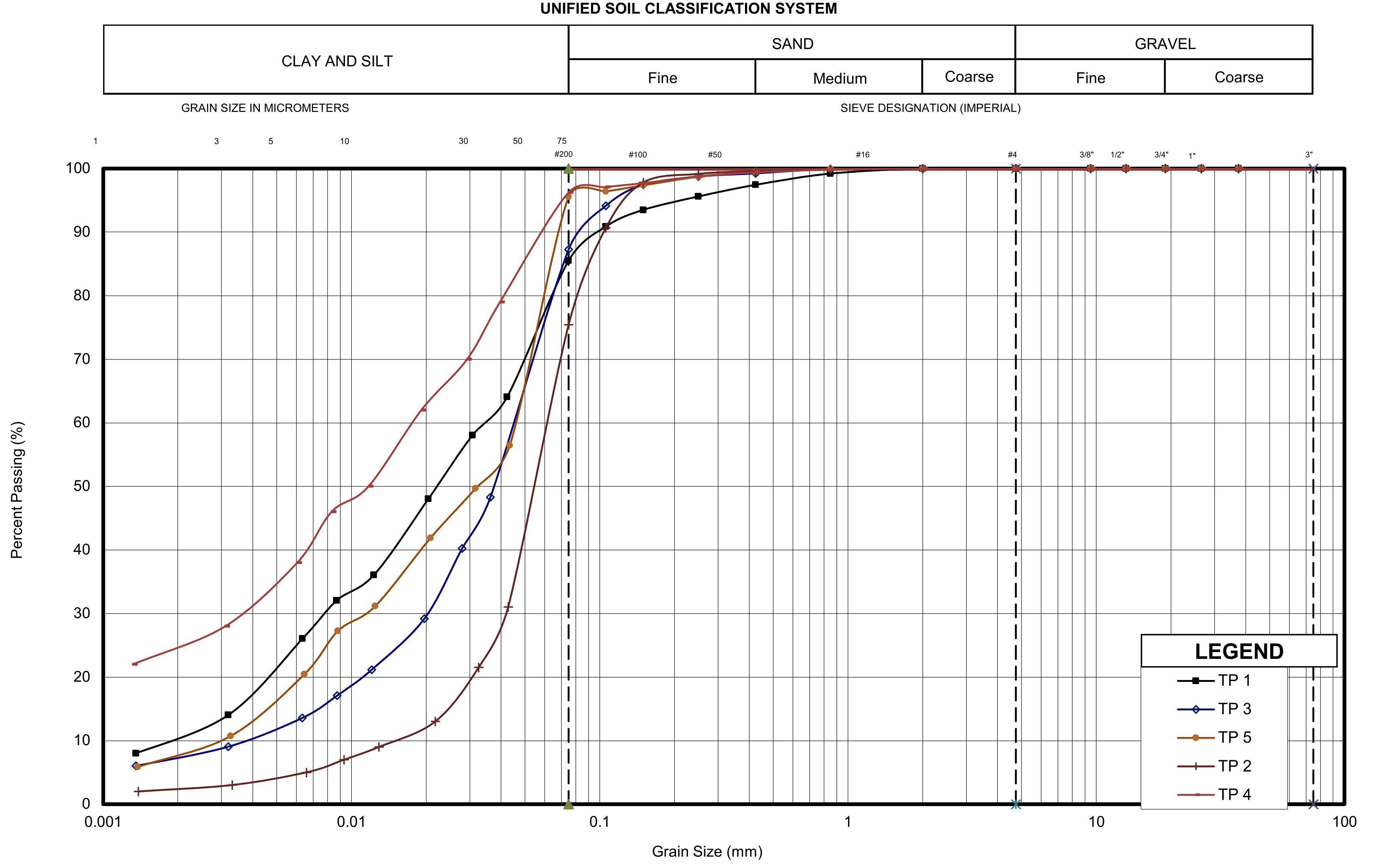
Alexander Winkelmann, P.Eng.
Geotechnical & Earth Sciences Manager
(705) 229-4298
awinkelmann@geiconsultants.com

Enclosures (1)

Grain Size Analysis (T-Time)

ENCLOSURE 1

Grain Size Analysis (T-Time)



Sample	Description	Gr.	Sa.	Si.	Cl.	D_{10}	D_{30}	D_{60}	C_u	C_c
TP 1, 0.4 m	SILT, Some Sand, Some Clay	-	15	74	11	0.002	0.008	0.034	17	0.941
TP 2, 0.7 m	SANDY SILT, Trace Clay	-	25	73	2	0.015	0.042	0.062	4.133	1.897
TP 3, 0.8 m	SILT, Some Sand, Trace Clay	-	13	80	7	0.004	0.020	0.045	11.25	2.222
TP 4, 0.7 m	CLAYEY SILT, Trace Sand	-	4	71	25	-	0.040	0.018	-	-
TP 5, 0.4 m	SILT, Trace Clay, Trace Sand	-	4	88	8	0.003	0.011	0.046	15.33	0.877

GEI Consultants

GRAIN SIZE DISTRIBUTION - Azimuth (21-098)

VARIOUS SOILS

FIGURE No.	Graph
REF. No.	2005133
DATE	November 2021